Towards a Circular Economy

Corporate Management and Policy Pathways

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Foreword

Fast-growing economies of the ASEAN and East Asia are at a critical juncture today, needing more energy and other material resources to continue their rapid economic growth while facing the challenges of developing a consumption pattern in a more sustainable manner than it is now. This daunting task of balancing energy security and resource use is compounded by the region's increasingly affluent population, higher commodity prices, and more market volatility. We need to conceive an economy that operates within the physical boundaries of limited resources, which are declining due to rapid consumption. Such economy is possible by increasing the share of renewables and recyclables while reducing the consumption of raw materials and energy at the same time cutting emissions and material losses.

The circular economy aims to eradicate wasteful use of raw materials and energy from the manufacturing process as well as systematically throughout the various life cycles, and to reuse the by-products. It replaces the linear consumption pattern of take-make-dump with a closed loop cycle of production and consumption. The transition to a circular economy is a unique opportunity for our economies and companies to be resource efficient, competitive, and innovative. However, it is our choice how best and how fast we can manage this inevitable transition. Good policy frameworks offer short-term economic incentives and long-term social and environmental benefits. But the ultimate success depends on the private sector's ability to adopt and profitably develop relevant corporate models. Indeed, this region is already demonstrating certain elements of circular economy transition as seen from the growing number of waste-to-energy projects.

However, the current knowledge base on circular economy is rather fragmented or evolving. Better insights are needed into various aspects of policy dynamics and corporate functions that trigger circular economy. This book investigates the complex challenges and extraordinary opportunities of how countries and corporations can strike a better balance between economic growth and resource efficiency in the context of the emerging paradigm on circular economy policy. With case study analysis, this book highlights immediate and relatively easy-to-implement circular thinking based on current policy approaches and market trends. Through compiling and interpreting, it touches on the key dimensions of circular economy: the concepts and benefits; enabling factors and transition approaches; a framework for measuring progress; and other contextual issues that require attention from policy, business, and research communities.

Current government guarantee systems enable the banking sector to finance innovative waste-to-energy projects that are relevant for circular economy. Expanding the spectrum and creation of innovative financing mechanisms for enhanced social impact would allow the emergence of a broader range of projects under community–corporate partnerships. In view of circular economy's systematic nature and its overarching importance to emerging Asia's sustainable growth, the creation of an ASEAN-wide circular economy platform bringing together the ASEAN Social Cultural Community and ASEAN Economic Community merits further investigation for mobilising the effect for the private sector. Such platform could play an important role in supporting the systematic transition that is needed to make the circular economy reality.

As you read this book, I urge you to consider where and how you can contribute to further understanding and implementation of the circular economy concepts that will bring prosperity to all.

H. Nishimura

Hidetoshi Nishimura
President
Economic Research Institute for ASEAN and East Asia
September 2016

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List of Abbreviations

3R	reduce–reuse–recycle
ANA	All Nippon Airways
ANAHD	ANA Holdings Ltd
ASEAN	Association of Southeast Asian Nations
CAGR	compound annual growth rate
CDM	Clean Development Mechanism
CDM	Clean Development Mechanism
CER	certified emission reduction
CO_2	carbon dioxide
DEDIR	Downer EDI Rail
ELT	end-of-life tyre
ERP	Energy Recovery Programme
ETS	Emission Trading System
EU	European Union
GDP	gross domestic product
GHG	greenhouse gas
GIR	Greenhouse Gas Inventory & Research Center of Korea
HVAC	heating, ventilation, and air-conditioning
IATA	International Air Transport Association
ICAO	International Civil Aviation Organization
KAU	Korean allowance unit
KCER	Korea certified emissions reduction
KCU	Korea Credit Unit
KPI	key performance indicator
kW	kilowatt
kWh	kilowatt-hour
MW	megawatt
NSW	New South Wales
OECD	Organisation for Economic Co-operation and Development
PPP	public–private partnership
PV	photovoltaic
R&D	research and development
REC	renewable energy certificate
REP	Resource Efficiency Programme
ROC	rate of change
RPS	Renewable Portfolio Standard
RTP	Recycling Technology Programme
SOx	sulphur oxides
SPV	special purpose vehicle
TLS	through-life-support

TMS	Target Management System
TPES	total primary energy supply
VAT	value-added tax
VOC	volatile organic compounds

Chapter 1

Introduction – Business and Policy Rationale for Circular Economy in ASEAN and East Asia

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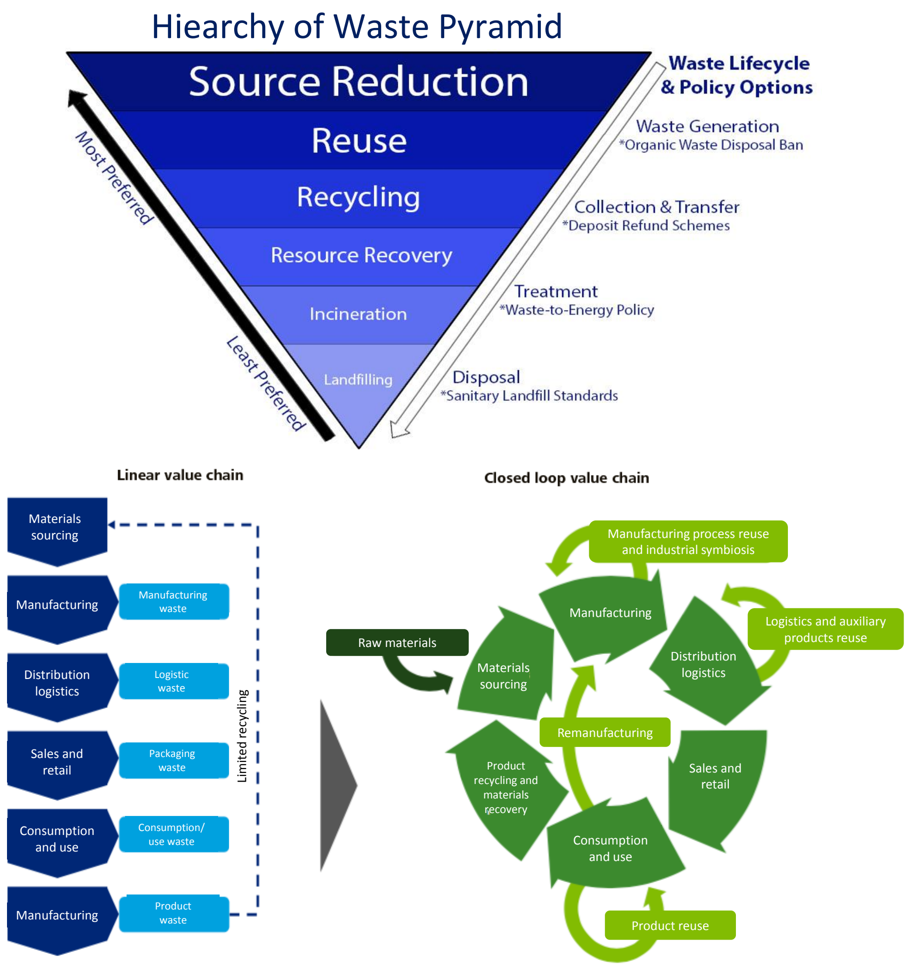
1. Introduction

Over the last 2 decades, regional attention has been paid to the new concept and development model called circular economy, considered to be an alternative to the dominant industrial development model, 'take, make, and dispose'. The negative effects caused by this linear model of production and consumption are threatening the stability of the fast-growing Asian economies and the sustainability of raw material and energy resources essential for economic growth. Sustainable development requires a balanced and simultaneous consideration of economic, environmental, technological, financial, and social aspects of the country-, sector-, firm-level process as well as interaction among different stakeholders. In that context, circular economy is seen as a new business model expected to lead to a more sustainable and harmonious society.

Current trends in global consumption of natural resources such as materials, energy, and water are unsustainable and socially unjust. Sustaining high levels of economic growth in a business-as-usual scenario is not an option, as economic systems already consume more resources today than the planet can provide in a sustainable manner (ADB, 2011). Emerging economies of the Association of Southeast Asian Nations (ASEAN) and East Asia will need further economic growth to satisfy demand for higher material welfare. However, in light of increasing resource scarcities, intensifying international competition over these resources, and growing environmental problems such greenhouse gas (GHG) emissions related to their use, these countries need to follow a pattern of economic growth that is significantly more resource efficient than those industrialised earlier. Increasing the resource efficiency of production will also be a key determinant for economic competiveness in a world of rising prices of raw materials and energy.

The concept of circular economy is not completely new. It is often a pursuit of waste prevention and waste reduction (Figure 1.1). But such very limited point of view may lead circular economy to fail. Indeed, circular economy aims not only to eradicate waste but also to find new value for them; often what might otherwise be called waste becomes valuable feedstock for successive usage. Indeed, product cycles of use and reuse, aided by the product design, help define the concept of circular economy and distinguish it from recycling, which loses a large amount of embedded resources, energy, and labour. It inspires technological, organisational, and social innovation across and within value chains.

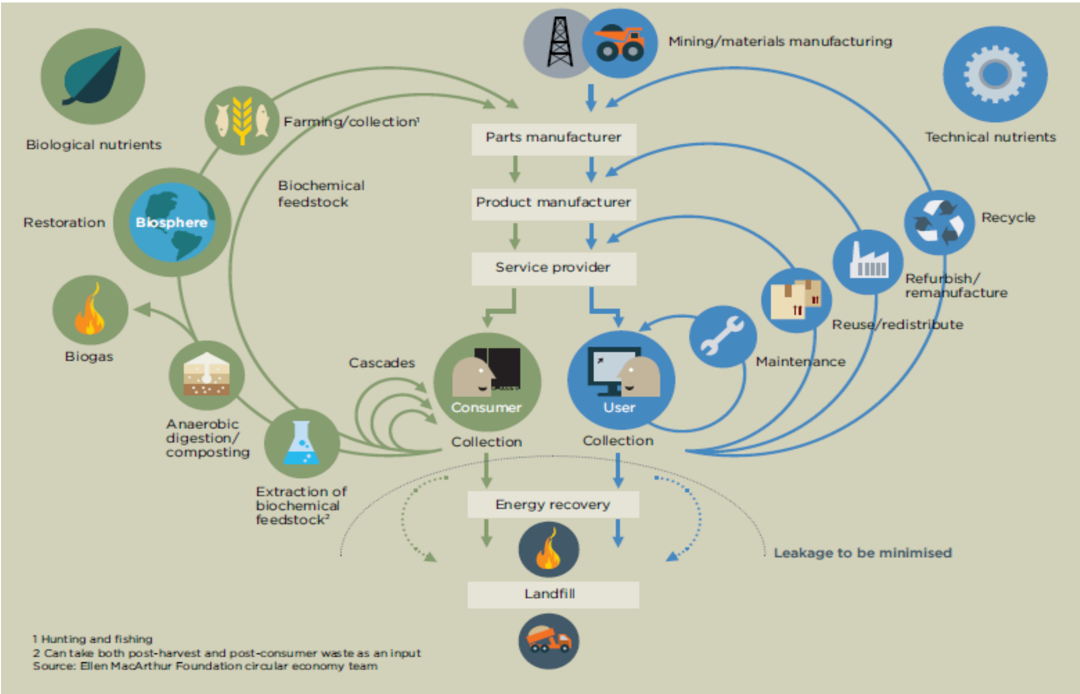
Figure 1.1. Basic Principles of Circular Economy – A Cycle of Resource Efficiency Improvements



Source: ERIA (2015).

Moreover, an expanded circular economy introduces systems wherein production of consumable components are differentiated. Manufacturers in traditional economy often do not distinguish between the two. In a circular economy, a strict differentiation between products in terms of consumable and durable components is being introduced. The goal of consumables is to reuse non-toxic components, which can have a replenishing effect. The goal for durable components is to reuse them. The goal for consumables is to use non-toxic components so that these could eventually be returned to the biosphere where they could have a replenishing effect (Figure 1.2). The goal for durable components such as metals, water, energy, etc. is to reuse or upgrade them for other productive purposes through as many cycles as possible. This circular thinking approach contrasts sharply with most current industrial operations.

Figure 1.2. Broader View of Circular Economy as a Restorative and Regenerative Industrial System



Source: Adopted from McCarther Foundation (2013).

Inclusion of circular economic patterns require not only innovative production process but also committed actors. The complexity of transforming circular economy vision into business excellence models most often need innovation designers and corporate leaders who are not averse to take risks.

The aim of the book is to examine the critical driving forces of the private sector to get engaged in circular economy, and summarise and evaluate the policy pathways pertaining to circular economy experiences and compare them, to grasp similarities and differences among the approaches. Our purpose in this regard is to understand the following questions: (i) What are the opportunities for, and barriers to, large-scale transition to circular economy such as material efficiency, energy efficiency, waste reduction, particularly with an eye on corporate strategy? (ii) Which new institutional and policy frameworks and perspectives does circular economic thinking involve or suggest? (iii) What can be learned about change pathways dealing with corporate behaviour, such as product innovation, process innovation, and evolutionary leaderships? (iv) What can be learned from the regulatory approaches of government policies and specific features of market creation? (v) Which public–private partnership models and solutions pertain to conflicts and barriers that change pathways involve at the corporate and government levels? Analysis of five country and corporate case studies also brought in immediate and relatively easy-to-implement circular thinking based on current policy approaches and market trends.

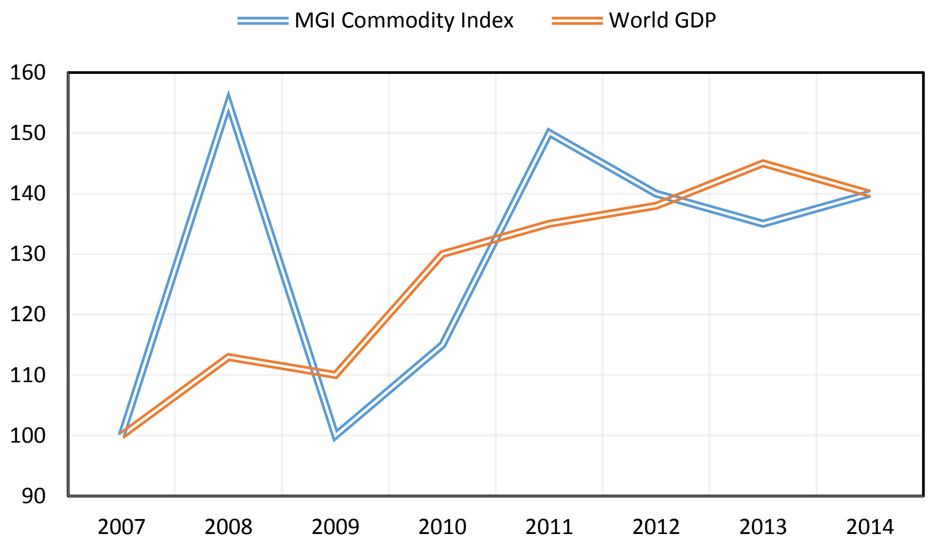
2. The Principles and the Need for Policies on Circular Economy

The current industrial systems of the world direct high consumption of materials and energy from resource-rich countries to manufacturing powerhouses in Asia, and distribute the resulting products to the advanced and other emerging economies of the world, where these materials are used, discarded, and replaced. Increasingly, this linear way of industrialisation has come under strain. Some 1 billion new consumers from ASEAN, China, and India will enter the middle class by 2030 (ERIA, 2014). The magnitude of this market shift is squeezing companies between less predictable commodity prices on the one hand and blistering competition on the other. The global financial crisis briefly dampened the demand but the commodity prices have rebounded faster than the global gross domestic product (GDP) as illustrated in Figure 1.3. It also indicates the era of ignoring resource cost is over, and worries about depletion. In response, some countries and companies are questioning the current patterns of production and consumption, and are calling for a new economic model.

Academically, the concept of circular economy traces back to different schools of thought. Among them is industrial ecology, which promotes the transition from open to closed cycles of materials and energy, thus leading to less wasteful industrial process (Anderson, 2007). In circular economy, products and processes are redesigned to maximise the value of resources through the economy with the ambition to decouple economic growth and resource use (UTS, 2015). The Ellen Macarthur Foundation (2013) attributes to more recent theories such a regenerative design, performance economy, cradle to cradle, and bio-mimicry as an important contribution for the further refinement and development of the concept of circular economy. Circular economy also emerges in the literature through three main actions, i.e. the so-called 3R principle – Reduce, Reuse, and Recycle. This 3R principle becomes 5R to include Remanufacture and Repurpose components. These principles are applied to study the motives, implementation of policies and corporate strategies, and public–private partnerships in Australia, China, Germany, India, Japan, and Korea under the thematic areas of economic, institutional, and management approaches to circular economy.

Japan implemented circular economy in 1991 with the Law of Effective Utilisation of Recyclables (IES, 2015) and later on the Japanese Circular Economy Initiative. Circular economy concepts emerged in Germany in the mid-1970s with the Waste Disposal Act. Australia still lacks a relevant federal policy initiative, in spite of past regulations as the Resource Conservation and Recovery Act of 1990. Most Australian states also have adopted since the 1980s a solid waste management hierarchy placing reduction and reuse at the top of the hierarchy. Korea issued the Waste Management Act (2007) and the Act on Promotion of Resources Saving and Recycling (2008) as the bases for material reuse, a fee system for waste treatment, regulations on the use of one-way packing of goods, a food waste reduction and extended producers' responsibility. China's Circular Economy Promotion Law defines circular economy as a generic term for reducing, reusing, and recycling activities conducted in the process of industrial production, circulation, and consumption. The broader goal of circular economy in India is the achievement of synergistic efforts with national targets towards landfill prevention, attainment of energy efficiency targets, and management of municipal solid waste.

Figure 1.3. Rebound Effects of Resource Prices Compared to Economic Output



Source: Author, based on data from IMF (2015) and MGI (2014).

Although circular economy is predominantly identified with the recycling principle, in these five countries, this may be the least sustainable solution compared to other circular economy principles, such as reduction and reuse, in terms of resource efficiency and profitability. These policies can be integrated with three additional principles developed in the circular economy report developed by the European Environment Agency (EEA, 2015). The first principle, appropriate design, stresses the importance of the design stage in finding solutions to avoid wasteful material use. The second reintroduces the classification of materials into technical and nutrients. The technical materials are designed to be reused at the end of the life cycle whereas the biological nutrients can be safely returned for consecutive use. The third additional principle, renewability, places renewable energy as the main energy source for circular economy to reduce fossil energy dependence and enhance the adaptability of economic systems towards energy security risks. Table 1.1 summarises the main limits and challenges to circular economy as observed from the country policy studies.

Table 1.1. Main Limits of Circular Economy in the Study Countries

Principles of Circular Economy	Limits and Challenges	Countries of Reference
Product Design	Design for disassembly, reuse, recycling Design of durable products, design of new models of consumption	China, India
Reduction	Overcome the rebound effect of resource efficiency strategies	Japan, Korea
Reuse	Increase consumer demand towards reuse of products and materials Development of take-back mechanism from companies	Germany, Australia
Recycle	Creation of local markets for recycled materials Risks in global trade of materials Appropriate decision tools	China, India, Australia
Repurposing of Materials	Reuse of materials and safe return to ecosystems	China, India
Waste to Energy	Increase in share compared to fossil fuel	China, India, Japan, Korea, Australia

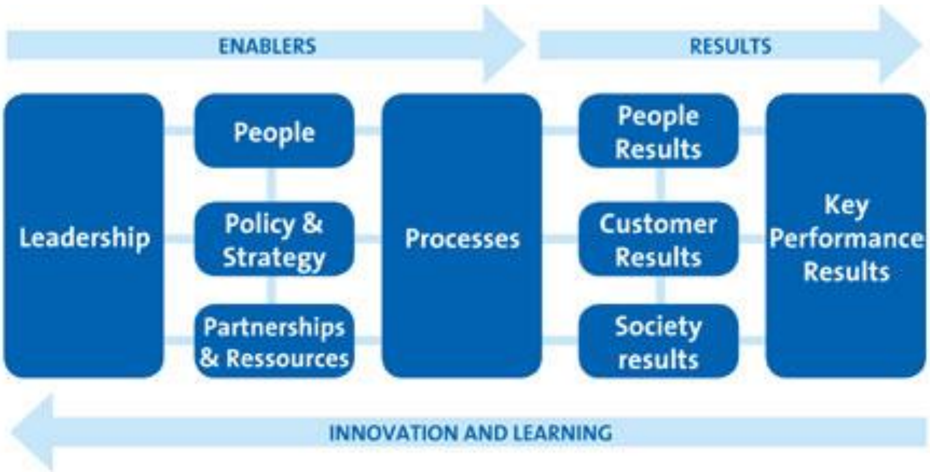
Source: Author.

3. Circular Thinking in Corporate Management Strategies

Circular economy is a system that is designed to be restorative and regenerative. Instead of discarding assets after only one product cycle, companies are developing ways to continually reacquire and reintroduce the assets to the markets. As discussed earlier, in the volatile markets for resources and even worries about their depletion, the call for circular thinking is getting attention by the corporate leaders. The case studies of the All Nippon Airways (ANA) (Japan), BMW (Germany), Bridgestone (Japan), POSCO (Korea), Datong Coal Mine (China), Ambujah Cements (India), and Waratah Train (Australia) indicate these corporations are finding novel ways to reuse products and components. Their successful initiatives also provoke bolder questions. Could economic growth be decoupled from resource constraints? Could an industrial system that is regenerative by design, which restores material and energy, be good for business?

Corporate excellence is about developing and strengthening the management systems and processes of an organisation to improve performance and create value for stakeholders. While variation exists, if the experience of these companies is any indicator, the answer appears to be affirmative. BMW remanufactures automotive engines and other parts for resale and reuse. Its plant remanufacturing operations use less energy and raw materials than other players in the market. Bridgestone redesigns its products to make them easier to use again. It also targets components for closed loop reuse, essentially converting worn-out tyres into inputs for new ones. All Nippon Airways (ANA) works with suppliers and consumers to distribute circular benefits that distribute value across its chain of activities. The result is less use of materials and energy and reduction in the volume of waste. The commonality among these cases is service design thinking, which is designing and marketing services that improve customers' experience, and the interactions among policymakers, service providers, and customers. Inclusion of circular economy requirements in corporate excellence models using collaborative service design thinking also brings a tool to determine the enablers, key performance indicators, and benchmarks for innovation and learning (Figure 1.4).

Figure 1.4. A Corporate Excellence Model for Achieving Circular Economy Goals



Source: Author.

Exploratory approaches to resource efficiency, including eco-design methods specifically to encourage participation from a broad array of stakeholders, proto typing, incorporating rapid feedback loops from customers to evaluate and evolve ideas all become key performance indicators. Their experiences are just samples in a growing body of evidence suggesting that the business opportunities in circular economy are real and sometimes large. Nevertheless, it will not be easy for many other corporate enterprises. The in-depth analysis on corporate case studies show that they go through four distinctive stages in operationalising the concept of circular economy. During that process, they also faced different challenges which could be categorised into four stages as described in Table 1.2, and developed capabilities to tackle them.

Table 1.2. Corporate Challenges and Business Competencies for Circular Economy

Stage 1: Viewing circular economy as an business opportunity	Stage 2: Making value chains circular	Stage 3: Designing new products and services	Stage 4: Developing new business models
Corporate Challenge			
To ensure that compliance with regulations becomes an opportunity for innovation	To increase resource efficiency throughout the value chain	To develop new production processes or redesign existing ones to become circular	To find new ways of delivering and capturing value, which will change the basis of competition
Competencies Needed			
The ability to anticipate and shape regulations The skills to work with other companies to implement creative solutions	- Expertise in techniques such as life cycle assessment, resource accounting - Ability to redesign operations to use less raw materials and energy and generate less waste - Capacity to ensure that suppliers and consumers make their choices circular	- Skills to know which process, products, and services are resource efficient - Ability to generate real public support for circular offering and not to be considered as green washing - Management knows how to scale both the use of reused materials and the manufacture of recycled materials	- Capacity to understand what consumers want and to figure out different ways to meet those demands - Ability to understand how partners can enhance the value of circular offerings
Innovation Opportunity			
Using compliance to induce the company and its partners to experiment with technologies for resource efficiency, raw material use, and process	- Developing sustainable sources of raw materials and components - Increasing the use of recycled, and reuse of, materials and clean energy sources - Finding innovative uses for returned materials	- Applying innovative techniques in product development - Decoupling compact and resource-efficient services	- Creating monetisation models that relate to services rather than products - Devising business models that combine technologies and physical infrastructure to allow industries to use the waste-to-energy products

Source: Author.

In stage 1, *viewing compliance on regulations for circular economy*, the corporate executives feel the pressure to abide by regulations and standards as well as voluntary codes. It is tempting to adhere to lower standards; however, smarter companies comply with more stringent internal rules to avoid further strict regulations. Companies that focus on meeting emerging norms gain more time to experiment with materials, technologies, and financing resource efficiency. This also yields substantial first mover advantage in terms of fostering innovation within the firms. Once companies have learned to keep pace with regulations and standards, they become more proactive about circular economic practices. In stage 2, *making values chains circular*, multinational firms such as Bridgestone and ANA focus on reducing the consumption of raw materials and non-renewable energy sources. The drive to be more resource efficient also extends from manufacturing facilities and offices to the value chain. At this stage corporations work with suppliers, retailers, and consumers to develop eco-products and components to reduce waste. The preliminary aim is usually to create a better image, but most corporations end up reducing the costs or creating new businesses as well. That is particularly helpful in difficult economic times when corporations are desperate to boost profits.

Stage 3 in corporate strategy is *designing sustainable products and services*. At this stage, companies start to realise the fact that a sizeable consumer market prefers recyclable products and service offerings, and that their business can score over competitors by being the first to redesign existing products or develop new ones. In order to identify product and service innovation priorities, enterprises have to use competencies and tools they acquired in the earlier stages of their evolution. To design new recyclable products, corporations such as Bridgestone also understand consumer concerns and carefully examine product life cycles. They must learn to combine marketing skills with their expertise in scaling up raw material supplies. As they move up in the markets that lie beyond their traditional expertise, they team up with knowledge institutes and non-governmental organisations. *Developing new business model* is stage 4. A successful model includes novel ways of capturing revenues and delivering circular services in tandem with other companies. New technologies provide pioneering companies with the ability to challenge conventional wisdom. At this stage corporate executives learn to question existing business models to act entrepreneurially to develop new delivery mechanisms. As companies become more adept at this, the experience will lead them to the final stage of circular innovation, where the impact of new product or production process extent ends beyond a single market.

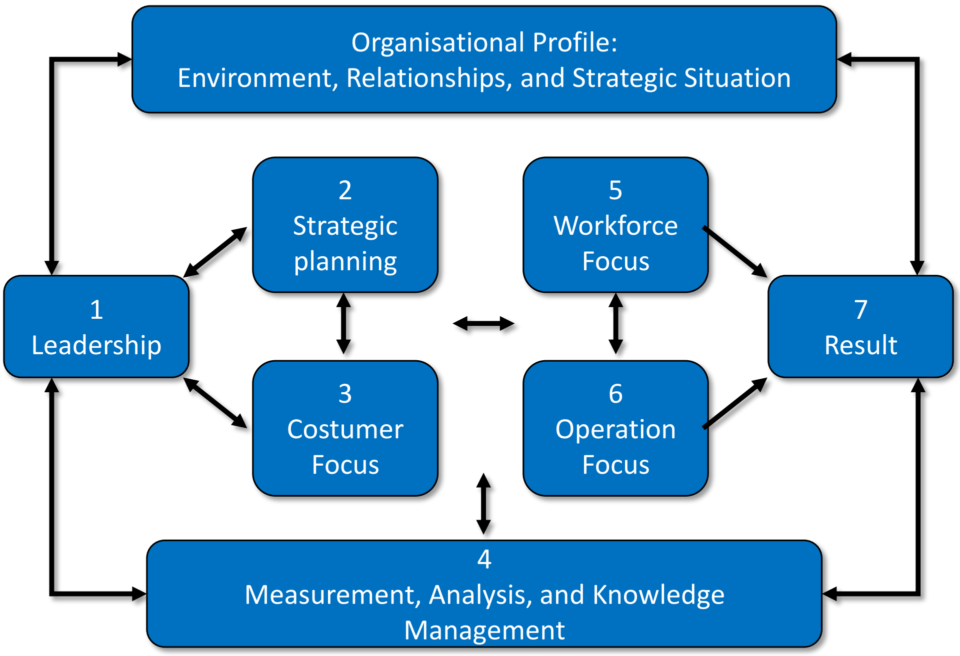
4. Designing Public–Private Partnerships for Circular Economy

Public–private partnerships (PPPs) are a mechanism through which government authorities and private entities come together for the delivery of specified services on mutually agreed terms and conditions. Through this partnership, the benefits of private sector's dynamism, access to finance, knowledge of technologies, managerial efficiency and entrepreneurial spirit become available. Risk is allocated among parties which are best suited to manage the risk. PPPs as an efficient mode of implementation of public projects have already been demonstrated in several sectors such as highways, airports, powers, railways, etc. Operationalisation of circular economy concepts such as waste-to-energy can be enhanced through PPPs. For that, public authorities should determine the functions to be performed on a PPP mode. They may also take into account functions that can be outsourced or can be performed through PPP mode. Having determined these, public authorities should carefully access the most appropriate technological options and business models.

PPPs in circular economy–related projects are relatively new in Asian countries; Australia offers some new insights on PPP as a tool to achieve circular economy. The Waratah Train PPP project in New South Wales illustrates some key performance indicators to incorporate circular economy principles in PPPs. Innovative capacity within the PPP framework is understood here in the broad sense as covering the procurement of raw materials, designing the production process and services, and creating consumer awareness. The corporate excellence models resemble those of the Baldridge criteria proposed by Nanda (2015) that sees compliance, resource conservation, and waste disposal as part of corporate social responsibility.

This kind of sophisticated PPP approach also captures additional complexities in incorporating circular economy. It also describes strategic planning as a process of matching technical possibilities with customer needs and operational focus to make use of opportunities involving multiple stakeholders and differentiate between incremental and radical actions.

Figure 1.5. A Public–Private Partnership Model Based on Balridge Performance Criteria



Source: Nanda (2015).

5. Comparing and Contrasting the Economic, Institutional, and Management Approaches

The chapters in this volume represent a wide range of corporate strategies and different public policy instruments to achieve circular economy. They help understand the external drivers and internal barriers in achieving the goals of circular economy. They also provide complementary insights by focusing on particular economic institutional or management factors. In addressing the policy objectives and choice of instruments or corporate pathways, it is helpful to consider these insights. In particular, the three approaches differed in their ways by which the pathways for circular economy are projected, risks are tackled, and uncertainties are addressed, and in the importance they assign to different factors in creating incentives for concerted action.

The economic, institutional, and management approaches discussed under country policies and corporate stories aim to change the linear model of industrial process, and seek to examine the range of actions and actors involved in the interactions, the role of uncertainty and bounded rationality within the decision-making process of learning and expectations, and the role of institutional drivers and barriers. However, as the five country cases and six corporate strategies indicate, these approaches differ in their focus on different aspects of the circular economy, and their application of its principles. The economic approach tends to focus on particular policy instruments and investigate how corporate strategy responds to these and reduce costs. The institutional approach focuses on wider system rules and actions and investigates how these influence corporate strategies. The management approach focuses on the role of macro policies and responses of the firms involved in the national move towards circular economy. A combination of these different approaches are useful in that they highlight different aspects of the overall complex dynamic process of technological, behavioural, and financial innovation needed to activate the circular economy. Comparing and contrasting the different approaches help to understand the challenges and opportunities with circular economy as illustrated in Table 1.3.

These approaches should help business leaders and policymakers to be more effective, if they seek to influence the rate and direction of circular economy. It starts from the recognition that circular economy is an endogenous feature of completive economies and, hence, resource efficiency could be induced by integrated economic, energy, and environmental policies.

Table 1.3. Comparing and Contrasting the Challenges with Different Approaches for Circular Economy

Perspective	Perspective	Business	Social	Technological	Leadership	Efficiency
Economical	Risks	Potential challenges vary by products and services	Health concerns around reuse of toxic materials	Building robust data on firm-level material and resource use	Lack of integrated policies and planning	Delays in customers accepting new products and service schemes
	Cost	Extended life cycle requires additional design and validation increases product costs	Perceived and actual costs of circular activities	Added cost of upgrading technologies	Total cost of ownership increases. Long-lasting products substitute new models and decrease sales	Recovery and return of products for refurbishment are not easy and cost more
Institutional	Feasibility	Reuse and recycling are not feasible in all industries	Influences behavioural patterns of consumers	Accommodating CE at different levels of manufacturing and procurement	Industry structure is not aligned with the economic structure	Difficulty in obtaining financial support
	Support system	Bidding and other supplementary process changes	Ease of availability for buying and selling goods	Lack of complete system support	Lack of overall governance structure and integrated policies	Customers' aversion to new products and services
Management	Awareness	Lack of awareness among stakeholders	CE follows a push for sustainable consumption	Consumers lack understanding and acceptance of 3R	Lack of awareness about CE	Unavailability of knowledge on how to implement CE
	Guidance	Unavailability of knowledge on the right purpose of use of resources	Lack of focus on circular economy in formal and vocational education	Lack of measurement system to baseline resource usage	Lack of appropriate incentive system impacting resource recovery	Unavailability of key performance indicators and final target setting throughout the process

3R = reduce, reuse, recycle; CE = circular economy.
Source: Author.

6. Conclusion

The papers presented in this book highlight not only the opportunities but also the complexity of circular economic systems and the drivers for, and barriers to, innovation within corporate management systems and policy pathways. Ultimately, the systematic nature of barriers means that individual corporate actions, while necessary, will not suffice to create circular economy at scale. The real payoff will come only when multiple players across the business and research communities, supported by policymakers and investors, come together to reconceive key manufacturing processes and flows of materials and products. Should that happen, as the country papers and corporate strategies indicate, the benefits would be huge; these include net raw material saving, mitigated supply risks, increased innovation potential, and creation of new markets. More detailed studies are needed to quantify these benefits at the regional level.

Nevertheless, focusing a collective effort on the leverage points of circular economy that would have a systematic impact is the key to unlocking these potentials. Many of the case studies presented in this volume suggest that the place to start is raw material consumption and energy flows, as these represent the most universal industrial assets. The ultimate objective is to close material loops on a regional scale and to achieve tipping points that would bring major streams of material and energy back into the system, at high volume and quality levels, through established markets. It also implies that different policy packages, employed at different stages of resource efficiency, will be required for each different market.

The papers and the resulting analysis also demonstrate the richness of public and private initiatives currently being undertaken and, if executed to a full scale, will reconcile prosperity and sustainability and overcome the trade-offs. This report also indicates the benefits of public–private partnership to accelerate the transition that warrants further study and analysis. There are also significant gaps in our understanding on circular economy. The role of destructive technology, finance, and business model also need attention. It may not be possible or even desirable to try to achieve a grand regional blueprint. However, it is possible to make progress at the national and corporate levels that different approaches remain open to integration of new ideas and to provide useful policy insights to transition to secure circular economy.

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PART I

Economic Approaches to Circular Economy

Chapter 2

Circular Economy Potential and Public–Private Partnership Models in Japan

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1. Introduction

Circular economy is an ideal economic model in a world facing climate and resource constraints. Departing from 'mass production, mass consumption economy' and linear economic model, it is now considered necessary to give fair price on both resources and waste, like hydrocarbon energy and carbon dioxide (CO_2) emissions, when seeking for circular economy through market-based approach. Putting price on waste removes certain externalities.

Three drivers direct circular economy.

1.1. Stable Resource Procurement

Mostly importing its energy and mineral resources, Japan puts higher priority on using resources efficiently and recycling materials to reduce its dependence on imports.

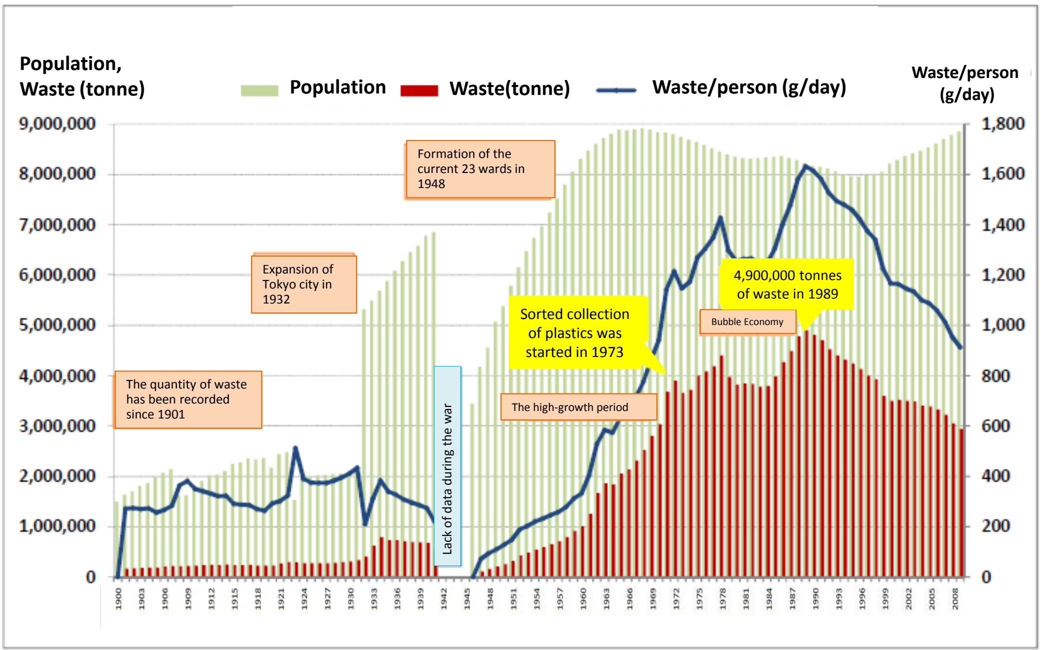
A conventional recycling business model in Japan is paper production, where waste paper, particularly newspapers and magazines, are collected by small businesses and local governments to produce new paper. In 2013, 80.8 percent of waste paper was collected and shared 63.9 percent to the total production of recycled paper. By recycling paper, import of virgin pulps is minimised and fluctuation of prices in the international commodity market is mitigated.

1.2. Cost of Waste Disposal

In the 1970s, the Tokyo Metropolitan Government faced a conflict among cities disposing municipal waste. Because municipal waste was being dumped in landfill sites in Tokyo Bay in those days, residents living near dumping sites suffered from environmental nuisance and heavy traffic caused by garbage trucks.

The then governor of the metropolitan government decided that 'waste from the city shall be disposed in the area of the city'. Although waste incineration was a common practice at the time, incineration residues and unburnable solid wastes were still to be disposed at landfill sites. The cities then adopted, in addition to incineration, the reduction, reuse, and recycle (3R) of waste. Per capita waste was reduced to 0.9 tonne from over 1.6 tonnes in 20 years.

Figure 2.1. Waste from Tokyo's 23 Cities



Source: Tokyo 23 Cities Clean Association and author.

1.3. New Business Model

The amount of wastes reduced and the products and materials recovered by 3R still have some value as energy. Municipal wastes of food and beverage and unrecycled paper and plastics have calorific value high enough to generate power. Thermal recycling by power generation is the last measure for recycling. In the case of Tokyo, biomass components account for 55 percent of total wastes. Power from waste provides additional value as low carbon energy. The premium electricity generated from waste-to-energy mitigates climate change and reduces cost of waste management.

With increase in income, consumers are purchasing more electronic appliances and, as a result, stocks of waste accumulate. These stocks contain valuable metals like gold, copper, cobalt, rare metals, and rare earth elements. For instance, the gold content of electronic substrates is higher than that of gold ores. As technology develops, many resources can be extracted from waste at reasonable cost. These are called 'urban mines'. The development of urban mines in Japan is pushed by regulations on waste disposal, such as the Home Appliance Recycling Law. Waste-to-power schemes or urban mines generate cash flow and could be public–private partnership (PPP) projects once boosted by financial support.

2. Structure of Policy Framework

2.1. National Legislation

Regulations drive proper waste disposal. In Japan, such regulations are created or promulgated and implemented at national and municipal levels. The principle of circular economy in Japan is defined by the Basic Law for Establishing the Recycling-based Society (2000). The Japanese government also decides and regularly updates the basic plan for implementing the Basic Laws. It determines numerical targets and allocates budgets for measures to be taken.

Figure 2.2. National Legal Setting in Japan

<Basic Law>
The Basic Law for Establishing the Recycling-based Society (2000)
- **Follow Environmental Impact Assessment Law (1993)**
- **Encourage reduce waste and reuse and recycle of products, materials, resources and energy**
- **Partnership with national government, local government, corporate and citizens**

<National Laws>
- **Containers and Packaging Recycling Law**
- **Home Appliance Recycling Law**
- **Food Recycling Law**
- **Construction Materials Recycling Law**
- **Automobile Recycling Law**
- **Electronic Appliance Recycling Law**

The Fundamental Plan for Establishing a Sound Material-Cycle Society
<2020 Target (from 2010)>
- **Resource productivity ; 85% improvement**
- **Circular ratio : 17% points increase**
- **Final disposal : 70% reduction**

Source: Author.

2.2. Municipalities

Japan’s municipalities are responsible for providing services following national laws and developing necessary laws for implementation. Some municipalities have initiated plans and targets to realise a circular economy. For instance, Kyoto City, in March 2010, announced the Basic Plan for Promoting Circular Society and targeted waste reduction by half from its peak level by 2020. The city also promotes de-carbonisation through waste-to-energy schemes.

A serious concern regarding the implementation of these measures is the weak budget capacity of Japan’s municipalities. They expect budgetary support from the national government.

2.3. Beyond Recycling Regulations

Recycling certain items is stipulated in Japan’s recycling laws and should be followed by manufacturers, sellers, and consumers. Corporates sometimes do more than what regulations require. For instance, the automobile recycling law does not cover waste rubber tyres but tyre manufacturers reuse and recycle them anyway. In 2012, 56 percent of tyres were thermally recycled, 16 percent were reused, and only 1 percent was reclaimed. The costs of collection and recycling and fees paid by tyre manufacturers were cheaper than if the tyres were reclaimed. Thus, both tyre manufacturers and users for thermal recycling, such as paper mills and cement and steel companies, benefitted from the scheme. This is a 'win–win' model.

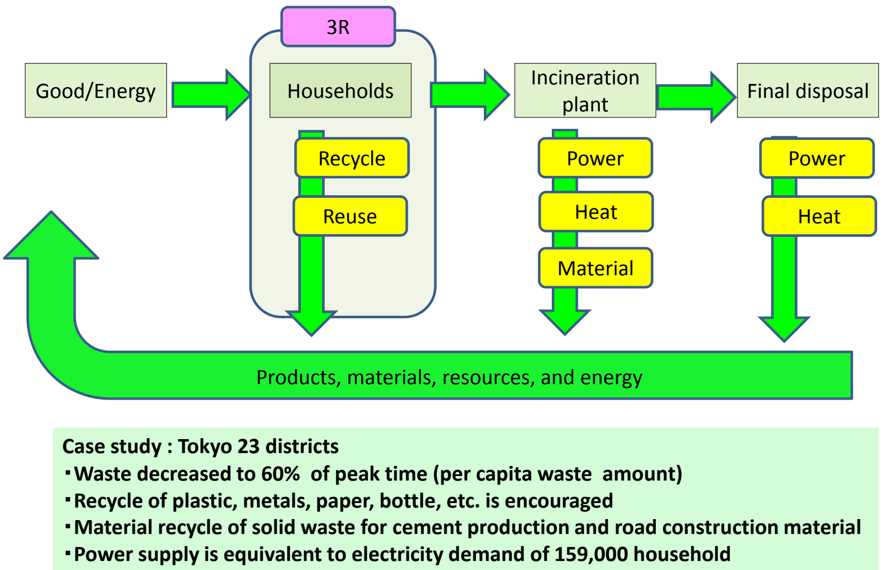
3. Public to Public–Private Partnership

3.1. Waste to Power, the Tokyo Model

Waste to power, particularly of municipal waste, has become very common in Japan. More than 300 waste incineration plants generate electricity with a total capacity of 1700 Mh or almost equivalent to the generating capacity of 17 units of a nuclear power station.

Figure 2.3 shows the basic flow of waste-to-power scheme. 3R has higher priority while thermal recycle is considered the last option for 3R.

Figure 2.3. Concept of Material Flow Under 3R



Source: Author.

The concept of power generation at waste incineration plants goes back to the mid-1940s although it was not realised due to World War II. In the 1970s, the calorific value of waste was over 1,400 Kcal/kg and incineration for power generation became feasible from technology's perspective.

At present, all waste incineration plants in Tokyo generate 10 GWh of electricity a year or a supply equivalent to the consumption of 159,000 households.

Some lessons learned from Tokyo's 23 cities:

Technology

In the case of Tokyo's 23 cities, the calorific value of municipal waste with 40 percent moisture content is around 2,200 kcl/kg. In general, lignite coal with 30 percent moisture content has a calorific value of 4,500–5,500K cl/kg, while peat with 50 percent or more moisture content has 2,300 Kcl/kg or more. At present, incineration technology uses waste with calorific values of 1,700–3,400 Kcl/kg for power generation without additional fuel. In addition to technology, waste-to-power generation requires proper management system and well-trained operators as the property of waste varies day by day.

Various substances are found in garbage. Without appropriate pollution control devices, pollutants such as particulates, dioxins, and heavy metals are likely to be emitted to the atmosphere by incineration. Also, public acceptance is crucial and Japan's municipalities require lower toxic elements emissions than that regulated by national standard.

Collection system

Garbage separation at collection system is an essential condition for efficient and safe waste incineration. Waste classification varies by municipality, but most are categorised as burnable, unburnable, paper, plastics, bottles and cans for recycling, and hazardous waste. Incineration plants are obliged to stop operation, clean up, and replace filters once toxic materials, like mercury, are found at emission control devices. Such incidents are caused by improper separation, as when a significant amount of fluorescent lamps, for instance, is mixed in the waste. Clean-ups and change of filters are very expensive (¥280 million at an event in June 2010, not a negligible amount considering that the annual electricity sale is around ¥5,000 million).

Tokyo provides information on waste separation through various channels, including education programmes at schools.

Dialogue with local people

Although technology reduces the risk of pollution, unexpected things could still happen. Thus, dialogues are important in improving mutual understanding.

This combination of technology, service provision system, and local community involvement is called the 'Tokyo Model' and is presently shared with governments and municipalities in Asia, South America, and the Middle East.

3.1.1. Low-carbon energy incentives for waste-to-power

From 2011, Japan has adopted the feed-in-tariff (FiT) programme and offered premium price on electricity from renewable wastes. Waste-to-power generation is eligible for FiT but tariff depends on the types of waste. In the case of plants in Tokyo, the cost for recovering investment is calculated at ¥12.72/kWh, ¥14.99/kWh, and ¥16.47/kWh. In general, FiT tariff for waste is ¥17/kWh, determined by taking into account estimation of investment recovery cost and CO_2 emissions-reduction contribution (cost and environment value).

Figure 2.4. Tariff of Power Generation under FiT in Japan April 2015

	Tariff (¥/Kwh)	Contract period (year)
Waste (general)	17	20
Industrial waste (construction)	13	20
Industrial waste (wood)	24	20
Photovoltaic (10Kw over)	29	20
Wind (20Kw over)	22	20
Geothermal (15Mw over)	26	20

Analysis of cost of power generation from waste
・Cost of power generation from incineration power plant in Tokyo
¥ 12.72/Kwh – ¥ 16.47/Kwh Average of 3 plants are ¥14.45 Kwh
・Biomass contents
55.5% (assumption)

FiT = feed-in-tariff, kW = kilowatt, MW = megawatt, PV = photovoltaic.
Source: Ministry of Economic, Trade and Industry.

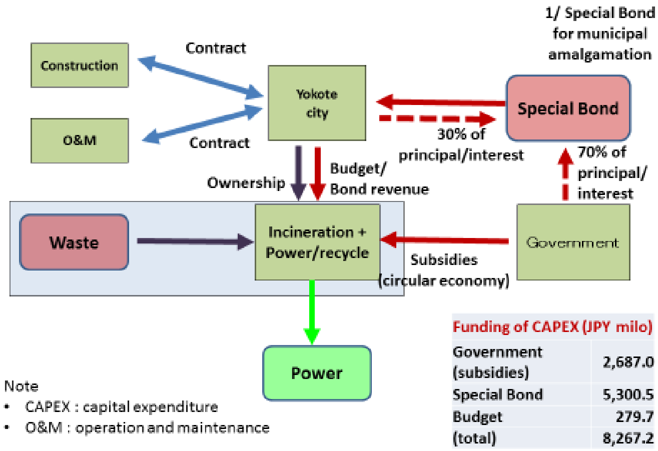
3.1.2. Public–private partnership for municipal waste: the case of a local city

Although many cities have introduced power generation at waste incineration plants, they are not financially strong enough to make large-scale investment. Discussed below is the case of Yokote, a city located in an agricultural area with a population of 100,000.

Firstly, after evaluating the costs of different business models, including conventional engineering, procurement, construction (EPC model) and design, build, and operate (DBO model), the city chose the latter. The city offered a tender and concluded contracts with a private consortium for construction operation and management for ¥8,267 million and ¥7,070 million, respectively, for 20 years.

The city prepared the funding for the construction of the plant, using the Special Bond for Municipality Amalgamation where about 70 percent of principal and interest payment was shouldered by the national government, and a government subsidy programme for promoting investments that contribute to circular economy. More than three quarters of capital expenditure were directly or indirectly paid by the national government. The DBO model is a standardised approach in Japan.

Figure 2.5. Funding of a Waste-to-Power Project – Case of Yokote City



CAPEX = capital expenditure, O&M = operation and management.
Source: Author.

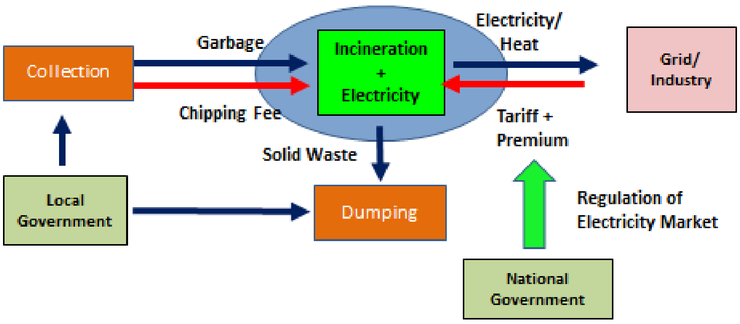
3.1.3. Diffusion of the PPP model for the Asian market

Incineration technology, both for construction of facilities and operation and management, is available and could be implemented through the PPP model. A study group formed by the Tokyo's 23 Cities Clean Association (Clean Authority of Tokyo) is analysing the potential of the PPP model in Asia and other developing countries and the necessary condition for PPP approaches.

For private investors, an ideal option of the PPP model is the energy conversion model where a private entity, for example, constructs and operates an incineration plant with power generation and receives garbage as fuel for electricity generation. Its revenue is to come from electricity sales and chipping fee from municipalities. When premium price is given to power from garbage as low-carbon electricity, cash flow from plant operation is boosted.

Waste collection and final disposal are to be shouldered by the municipalities because relationship with local people and land acquisition for plants and landfill sites are tough for private companies, particularly non-local entities. Crucial for the success of the PPP model is a stable collection system.

Figure 2.6. Conceptual PPP Model for Waste-to-Power Scheme



Different responsibility
Private : Energy conversion
Municipality : Collection of garbage and dumping of solid waste
National government : Premium for electricity

Source: Author.

3.1.4. Industrial waste

In Japan, industrial waste is handled separately from municipal waste. Many waste incineration plants are constructed and operated by private companies. The capital expenditure incentive, offered as low-carbon power source, and sale of electricity with premium price drive the waste-to-energy initiatives at industrial waste plants. Power from wood industry waste and construction waste is purchased at ¥24/kWh and ¥13/kWh, respectively. Some industrial waste incineration plants are reported to have eliminated over 10,000 tonnes of CO_2 emissions.

Figure 2.7. CO_2-Emission Reduction at an Industrial Waste Treatment Plant (Case Study)

Waste	Outline	CO_2 Reduction
Industrial waste	Combination of Gasification Melting Process and	16,100t PA
Medical waste	Combination of Gasification Melting Process and	5,000t PA
Biomasswaste	Using tinned wood, pruning waste from fruit farm, construction waste and other wood materi-als for biomass chip production	9,507t PA
Solid waste from waste water treatment	Using biogas from solid waste treatment process for co-generation.	1,000t PA
Solid waste from waste water treatment	De-watering of solid waste by using waste heat from cement kiln and use it for fuel for kiln.	3,900t PA
Food waste and beverage waste	Biomass fuel production using waste	31,554t PA

Source: Author, using data from the Ministry of Environment Japan.

Figure 2.8. Modality of Incentives for Waste-to-Energy in Japan

1. Incentive for capital expenditure of heat recovery from waste
   - Eligible entities
     - Private sector and administrative agency (excluding local authority)
   - Incentive
     - Incremental capital expenditure for energy recovery and use, but limited up to 1/3 of total capital expenditure
   - Eligible equipment
     - Heat recovery from incineration plant (23% or above energy recovery ratio)
     - Biomass heat supply
     - Biomass co-generation
     - Fuel from waste (60% or above energy recovery ration)
     - Biomass fuel supply

2. Incentive for power from waste
   - Under Feed-in-Tariff system, preferred tariff is applied for power generation from incineration plant
     - ¥16.5/Kwh for 25-30 years

Source: Author.

3.2. Urban Mines

As a result of increase in income and drop in prices of appliances, demand for electronic home appliances in Japan is increasing. However, this also leads to increased burden of waste disposal. Waste appliances contain various types of valuable metals like gold, copper, steel, cobalt, lithium, rare metals, and rare earth elements. For instance, the total amount of gold contained in appliances is enormous and, in Japan, is estimated at 6,800 tonnes or the equivalent of 16.3 percent of the world's gold reserves. As waste is considered an important source of resources, a new business model known as 'urban mines' is emerging as a private initiative driven by regulations on waste disposal.

Table 2.1. Potential of Urban Mines

	World Reserves	Urban Mines Japan	Share (ton %)
Gold	42,000	6,800	16.2
Silver	270,000	60,000	22.2
Lithium	4,100,000	150,000	3.7
Cobalt	7,000,000	130,000	1.9
Tantalum	43,000	4,000	9.3

Source: National Institute for Materials Science.

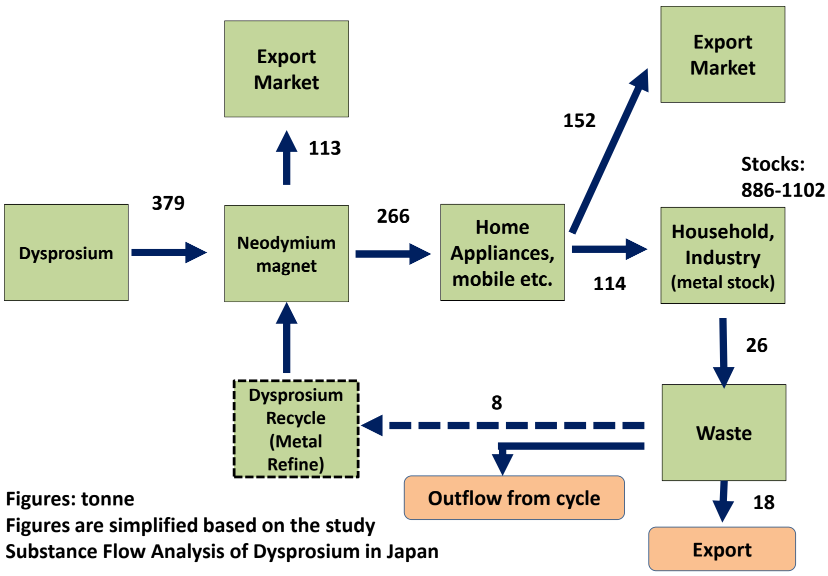
The DOWA group, a leading Japanese company, uses electronic appliances to reproduce base metals and precious metals. It separates electronic parts containing metals from electronic appliances and other waste products and then smelt and extract metals and other valuable materials from them. The company has metal-refining technology that efficiently extracts valuable materials from low-quality and mix-metal ores, and technology for controlling air and water pollution and containing hazard waste. Japanese metal-producing companies, including the DOWA group, have been losing international competitiveness due to severe competition from global non-ferrous metal companies as well as national resource development companies. Urban mining is a new business model that could make them competitive through the use of technology.

Figure 2.9 shows the material flow of recycling neodymium magnet and dysprosium as key material for it. Neodymium magnet, which has strong magnet force, is used for compact and efficient motors of personal computers, hybrid cars, and other devices. A key raw material to it is dysprosium, a type of rare earth element of which 99 percent is produced in China. In 2013, its price jumped tenfold due to China's restriction on exports. As a result, various countermeasures were taken in Japan to reduce the use of dysprosium, including switching to other material elements, diversifying the supply source, and recycling.

As Figure 2.9 shows, recycled neodymium magnet and dysprosium could be an import resource once the lifetime of products that contain it is over and it has come to waste material market.

Figure 2.9. Material Flow of Metals

(Case of Neodymium Magnet)



Source: Sakae Shirayama and Toru H. Okabe (data) and illustrated by author.

4. Lessons Learned

Legal Settings

Waste collection is a key factor in legal settings, and regulations on waste disposal, including 3R, are needed. For instance, thermal recycling is economically feasible when waste collection is done by another party and disposal fee is paid to the company that recycles. Environmental regulations on air pollution, water pollution, and solid wastes from waste treatment plants are also needed for sustainable operation.

Technology and Supporting System

For the waste-to-energy scheme, pollution-control technology is needed in addition to incineration and refining. Also, although technology is crucial, waste-to-energy cannot be realised without an efficient collection system. Once the PPP model is applied, stable collection of waste becomes a higher hurdle for private investors and is expected to be implemented by or in cooperation with local municipalities.

Government Support

Although waste may generate cash through extraction of energy and valuable metals, revenue from it is unlikely to recover the whole investment cost. Financial gaps should be covered by the public, through chipping fee or capital expenditure support. Also, a legal framework for financial support by the national government is needed because the financial capacity of municipalities, in general, is not strong enough.

International Material Flow

Stable supply of waste is an important element of waste-to-energy and resources-from-waste schemes. As products are traded internationally – more than half of neodymium, for example, is exported – waste should be collected internationally or regionally.

5. Recommendations

Waste-to-energy and resources-from-waste schemes contribute to sustainable economic growth and national security by reducing dependence on import of resources. This model should be diffused globally to realise circular economy. Public–private partnership could be applicable when investment climate improves.

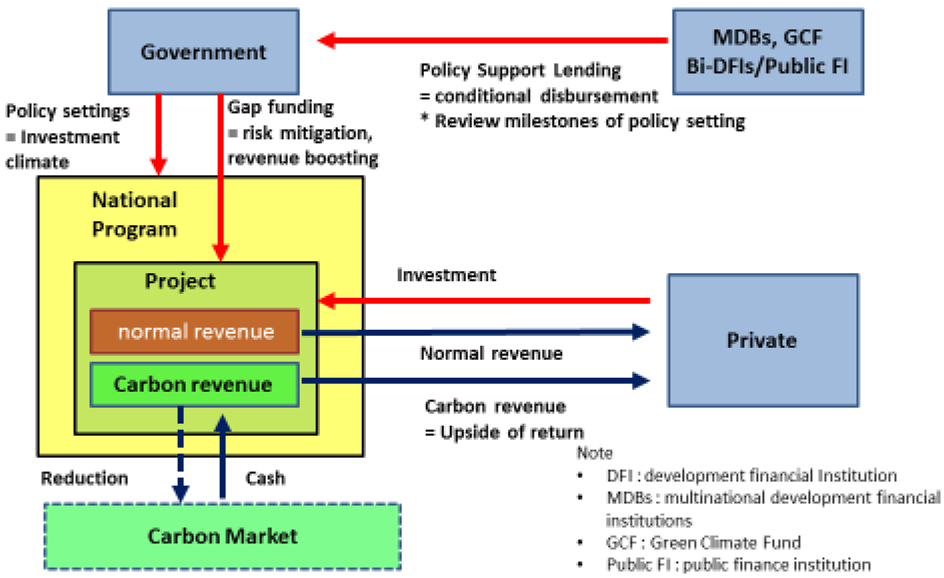
- **Legal setting.** Legal setting is crucial. Waste externalities can be removed by regulations on waste disposal. The implementation of Basic Laws and its by-products as national law for circular economy is recommended. Also, implementation of a national plan, including financial support mechanisms, should be followed and updated regularly (revolving plan).

- **Technology and system.** Advanced technology for converting waste to energy and recovering resources from waste is required. Although technology is indispensable, it is not enough. An integrated and comprehensive system, including waste collection, should be set up by municipalities. Also effective is education to put value on proper waste disposal by municipality.

- **Cooperation among municipalities.** Many public services are provided by municipalities and, therefore, expertise and knowledge accumulate at that level. Municipality-to-municipality cooperation, both international and domestic, is recommended for sharing experiences and know-how and setting up service systems. This should be supported by the national government through financial assistance and/or official development assistance.

- **National incentive mechanism**. The PPP model is possible when an integrated waste management system is developed. Financial incentive programmes, such as waste disposal fee or capital expenditure incentive, are recommended to improve investment cash flow and make the system financially viable. As many municipalities do not have sufficient budget capacity, financial gap measures by the national government, such as the viability gap fund, are recommended. An idea to push the host government's effort is policy support finance. Policy settings, like regulations on waste disposal and financial incentives for investment, are supported by international finance but its disbursement is linked with the progress of policy reform.

Figure 2.10. Combination of Policy Setting and Finance



Source: Author.

- **New framework for regional cooperation for waste management**. Scale-up of waste- to-energy market is an import measure to reduce the cost of waste-to-energy. Cross-border waste flow for reuse and recycling should be considered because a certain amount of waste is needed to recover valuable materials. International frameworks, such as the Basel Convention, which regulate 'export of waste' should be reviewed and amended if necessary.

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Chapter 3

Bridgestone's View on Circular Economy

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1. Introduction

1.1. About Bridgestone

Bridgestone is the world's largest tyre manufacturer. Producing approximately one in six tyres, the Bridgestone Group, with headquarters in Tokyo, Japan, has more than 200 production and development centres in 25 countries, conducts business in more than 150 countries, and has more than 145,000 employees worldwide. While majority of its business focus is on tyre sales, 20 percent of its sales is derived from diversified products such as belt conveyors, air springs, roofing materials, bicycles, and golf balls.

1.2. Building a Sustainable Society

The world population is expected to be more than 9 billion by 2050 while the number of automobiles will increase to 2.4 billion. With the increase in population, improved living standards, and increased demand for automobiles, the world is expected to face significant problems concerning climate change, resource shortages, and biodiversity loss. As a global company, the Bridgestone Group is aware of its responsibilities of meeting various needs in the world and assuring the stable supply of high-quality products. Thus, efforts to contribute to building a sustainable society by balancing the company's operations with the earth's capacity and being in harmony with nature are in progress. Based on this philosophy, the Bridgestone Group has prepared a long-term environmental vision to carry out activities.

2. Bridgestone's Environmental Mission Statement

Bridgestone's shared Environmental Mission Statement engages its employees from a wide range of backgrounds to work together towards established environmental goals. Its unchanging vision is 'to help ensure a healthy environment for current and future generations.' This ensures that, together with its stakeholders, the group is committed to continually work towards a sustainable society with integrity. Realising the large impact the group's operations may have on the global environment, initiatives to create stronger balance and harmony between its business and the environment are underway. Specifically, the focus is on reducing CO_2 emissions, valuing natural resources, and achieving harmony with nature. In each area, an environmental vision for 2050 and beyond has been created while midterm targets are currently being considered. With regard to the long-term vision, back casting was used to formulate the midterm targets set to be accomplished by 2020.

In pursuing its biodiversity goals, Bridgestone is taking steps to minimise the impact of its operations on ecosystems while simultaneously working to preserve and restore ecosystems. In 2014, a goal was set to reduce the company's average water intake rate by 35 percent by 2020, with the 2005 level as baseline. This midterm target will help ensure that the impacts to ecosystems of the company's water usage will be reduced.

Also, a long-term target is to reduce CO_2 emissions by 50 percent or more by 2050, a goal that aims to contribute to the realisation of a low-carbon society. To give further direction to this effort, midterm targets for 2020 give specific numeric goals for reducing CO_2 emissions from the company's operations, including tyre usage, by lowering tyre rolling resistance, a significant contributor to a vehicle's fuel consumption. In 2013, the Bridgestone Group's global carbon management initiatives reduced 27 percent of CO_2 emissions in operations and about 10 percent in tyre rolling resistance.

Figure 3.1. Bridgestone's Environmental Mission Statement

Source: Bridgestone (2014).

With regard to valuing natural resources, a long-term environmental target is to work towards 100 percent sustainable materials by advancing technological developments while defining and passing midterm milestones.

To achieve the environmental vision for 2050 and beyond, efforts beyond current activities will be necessary and issues from new perspectives must be tackled. The company's operations extend from the upstream region of the supply chain, which includes in-house raw material production bases, to the downstream, which includes retail sales networks and service-based operations.

A vertical and horizontal approach to the business, one of the company's strengths, will continue to be developed while advancing technical and business model innovation. Endeavours to create innovative new technologies, products, and services will be continuously made to help further realise a balance between the business and the environment.

A prime example of activities in this area is the second generation Air Free Concept Tire™, announced at the 43rd Tokyo Motor Show in 2013. A revolutionary departure from the standard approach of supporting a vehicle's weight with the internal air pressure of tyres, the Air Free Concept Tire uses a unique structure of spokes stretching along the inner sides of the tyres to support the weight of the vehicle. This eliminates the fear of punctures. Moreover, the resin used in this technical innovation is recyclable.

Another technical innovation is Bridgestone's ologic™ technology, developed in 2013, featuring an unprecedented tyre design that substantially reduces rolling resistance. Bridgestone's business model innovation is evident in the solution-based business that was launched to help customers reduce their CO_2 emissions while simultaneously realising more efficient resource usage by combining new tyres, retread tyres, and maintenance services.

To achieve the long-term environmental targets, the initiatives should span the entire supply chain. Bridgestone encourages and challenges its business partners and customers to join in these important environmental activities. In the upstream areas of the supply chain, technologies for improving the productivity of natural rubber will be developed and support to small-scale rubber farmers will be provided. Also, new raw materials for use in the products to move towards 100 percent sustainable material are being explored. In the downstream areas, reduction in CO_2 emissions is pursued by encouraging as many customers as possible to use fuel-efficient tyres.

3. Initiatives to Exist in Harmony with Nature

Since 2013, the Bridgestone Group has conducted a materiality analysis on the footprint on and contributions to biodiversity made by its operations. Towards minimising the footprint on biodiversity, the Bridgestone Group is committed to reduce the impact of its water intake. Since water resources are used in the production processes as cooling water and steam, the company has been working to enhance their efficient use through the cyclic use of cooling water, improvement of production processes, and water recycling. The target of reducing water intake is set at 35 percent per unit of production by 2020 throughout the group, based on the 2005 levels.

Bridgestone has implemented water management and promoted the efficient use and recycling of water in its locations worldwide. As a result, water intake was reduced by 10.7 percent per unit in 2013 compared to the 2005 level.

3.1. Example: Introducing Closed Drainage at Plant

The Kitakyushu Plant recycles water discharged from the manufacturing process by building a closed drainage system. Also, the plant uses a real-time water monitoring system to manage water intake and recycle volume.

Figure 3.2. Water Recycling System

Source: Bridgestone (2014).

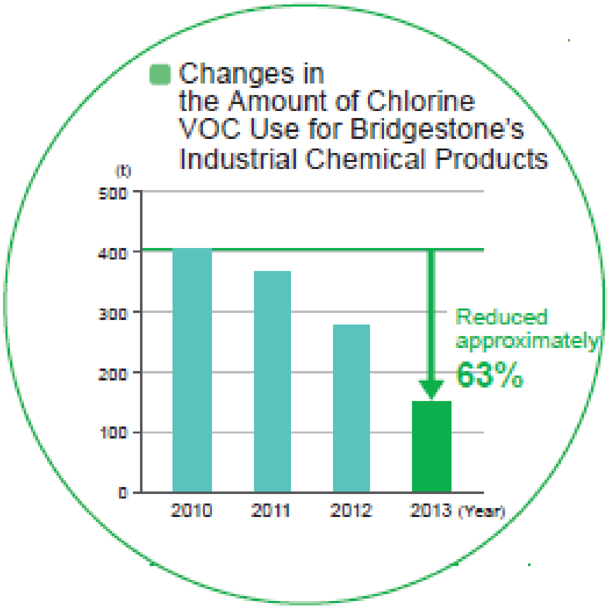
3.2. Example: Utilising Rainwater

Rainwater is utilised in some of the Bridgestone Group's plants. At these plants, rainwater is collected and used for operations or watering plants within the site.

3.3. Example: Improved Reduction of VOC in Manufacturing Processes

The Bridgestone Group is working to replace volatile organic compounds (VOCs) with alternative materials and continuing to reduce the amount of VOC use. For example, between 2010 and 2013, Bridgestone's chemical and industrial manufacturing operations achieved a 63 percent reduction in VOC use. The group is also conducting VOC-reduction activities in Europe to meet or exceed the laws and regulations of each of its countries. Bridgestone Europe NV/SA has reduced VOC emissions per tyre weight by nearly 25 percent over the last 10 years. The amount used in 2013 was less than 2 kg/1 tonne of tyres. Reduction of the amount of VOC use will be continued on a global basis.

Figure 3.3. Reduction of Volatile Organic Compounds



Source: Bridgestone (2014).

3.4. Example: Reduced SOx and NOx Emissions into the Air through Fuel Conversion

To reduce emissions of sulfur oxides (SOx) and nitrogen oxides (NOx) at the plants, Bridgestone is working to convert heavy fuel oil into natural gas. In 2013, the total SOx emission was reduced by 59 percent and the total NOx emission by 81 percent compared to 2005. Heavy fuel oil was replaced by natural gas in 2013 in the Chitose Plant of Bridgestone BRM Corporation, which manufactures retread tyres, and in the Cuernavaca plant in Mexico where passenger tyres are produced.

3.5. Example: Social Forestry Support Activities around Natural Rubber Farm

Forest fires and other factors have devastated national forests around the rubber farms of the P.T. Bridgestone Kalimantan Plantation (BSKP) in South Kalimantan, Indonesia. Support activities by W-BRIDGE, Waseda University, and Japan International Forestry Promotion and Cooperation Center have included a joint project using the residents' forestry system since 2012 in cooperation with BSKP, Lambung Mangkurat University, and the Forestry Department of Tanah Laut Regency. In this project, local residents develop land for Para rubber trees and plant durian and species of local trees in the surrounding forests with biodiversity preservation in mind. It is anticipated that developing forests with significant economic value for local communities will encourage members of the communities to continue caring for them over long term. BSKP aims to conduct activities advantageous to the Indonesian government and area communities by supporting this project through technical assistance, training, and contributing healthy young trees.

4. Initiatives to Value Natural Resources – (1) Reduce–Recycle–Reuse

The Bridgestone Group is committed to value natural resources through the efficient use of the planet's resources throughout the whole life cycle of its products – from raw material procurement to disposal and recycling. Important activities include reducing waste production, promotion of zero waste to landfill status, and the reduce–reuse–recycle (3R) concept.

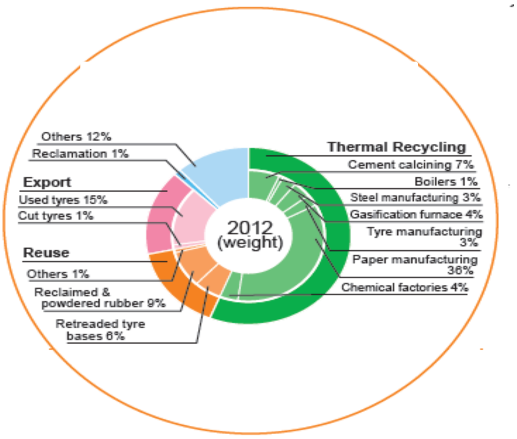
4.1. Example: Reducing Waste

In all its tyre plants, the Bridgestone Group is working to reduce the volume of waste produced during manufacturing processes. It is also committed to recycling waste, either within the company or through other organisations. For example, the Bridgestone Americas Inc. tyre manufacturing plant achieved the Underwriters Laboratories' Zero Waste to Landfill claim validation in December 2013. Since increasing focus on recycling in 2006, recycling by the Bridgestone Americas tyre plants has progressed from nearly half of all waste going to landfills to less than 15 percent overall today. The Bridgestone Americas Aiken passenger tyre plant also achieved zero waste to landfill in December 2012. All of the Bridgestone Group's plants in Japan and four tyre plants in China have also achieved zero waste to landfill status.

4.2. Example: Recycling of Used Tyres in Japan

The Japan Automobile Tyre Manufacturers Association (JATMA) and many others in the tyre industry are working towards reducing (controlling the emergence of used tyres) and recycling used tyres. More specifically, they monitor reduction factors, focusing on making tyres lighter and lasting longer, tyre recycling status, and measures against illegal accumulation and dumping of waste tyres. According to a JATMA survey, the 2012 recycling rate of used tyres in Japan was 87 percent.

Figure 3.4. Recycling of Used Tyres in Japan (2012)



Source: Japan Automobile Tyre Manufacturers Association (2013).

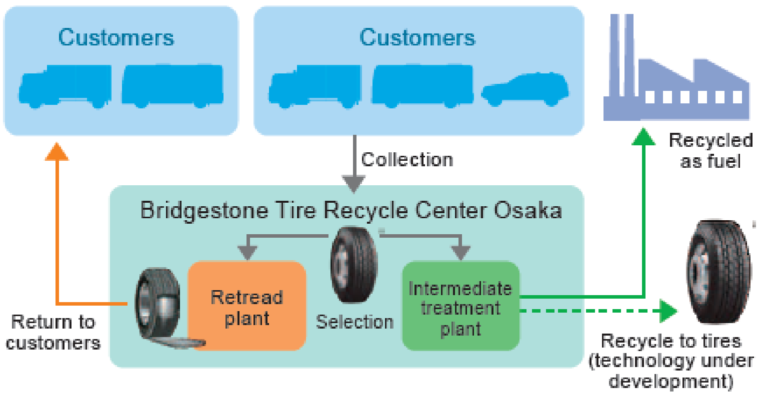
4.3. Example: Activities to Reduce Environmental Impact of Used Tyres through WBCSD

Approximately 1 billion used tyres emerge worldwide each year. Reducing the environmental impact of used tyres is a common issue in the tyre industry. Bridgestone has been involved in the Tire Industry Project of the World Business Council for Sustainable Development (WBCSD), established in 2006. Through the publication of 'End-of-Life Tires: A Framework for Effective ELT Management Systems' and disclosure of survey results, this project aims to develop an effective management system for used tyres by encouraging governments and related industries in various countries to appropriately manage used tyres and reduce their impact to the environment (WBCSD, 2012). Issued by the top 10 tyre companies at the supervision of WBCSD, this report is an excellent and comprehensive guide for ASEAN countries wishing to promote tyre recycling. According to the report, the positive environmental impacts of end-of-life tyres (ELTs) as a resource are significant, particularly as tyre-derived fuel for cement kilns or paper mills. Also, according to the report, most industry organisations in developed countries have ELT programmes. Transferring expertise and know-how from these bodies to developing countries is key to encouraging better ELT management since various efforts are underway in many countries to increase tyre recycle ratio and to find environment-friendly use for ELTs.

4.4. Example: Reusing and Recycling All Used Tyres

In July 2013, the Bridgestone Tire Japan Co., Ltd established the Bridgestone Tire Recycle Center Osaka, integrating a retread-tyre (tyres reused by replacing tread rubber) manufacturing plant and an intermediate used-tyre treatment plant (crushing of waste tyres that cannot be re-treaded). The centre combines functions of a retread-tyre manufacturing plant and an intermediate used-tyre treatment plant, and enables collection (collection areas are whole of Osaka prefecture and parts of Kyoto, Hyogo, and Wakayama prefectures) of customers' used tyres, and reusing and recycling of collected tyres.

Figure 3.5. Tyre Recycle Centre



Source: Bridgestone (2014).

4.5. Example: Initiative to Recycle 100 Percent of Used Products

Bridgestone Americas, Inc. has launched the Tires4ward programme, an initiative to create a waste-free tyre industry. Tires4ward aims to ensure that for every tyre Bridgestone America sells in the US, a spent tyre goes to another valuable purpose. At the end of 2012, Bridgestone Americas set a new standard by repurposing 100 percent of all spent tyres collected at its company-owned retail stores and keeping 10 million tyres out of landfills. Valuable next uses for spent tyres include use as materials in rubberised asphalt, rubberised playground equipment, construction materials, landscaping mulch, or as tyre-derived fuel for valuable energy.

Bridgestone Americas also supports volunteer organisations to help ensure that tyres collected in organised community clean-up events of public spaces, rivers, and waterways are sent to valuable next use.

Figure 3.6. Initiatives to Collect Discarded Tyres

Source: Bridgestone (2014).

5. Initiatives to Value Natural Resources – (2) Sustainable Materials

The Bridgestone Group believes that sustainable materials are not simply renewable resources. To continue its operations in a sustainable manner, raw materials derived from resources with continual supply that can be used as part of the group’s business over long term and have low environmental and social impact across the whole life cycle from procurement to disposal are defined as sustainable materials.

5.1. Example: Improvement of Natural Rubber Production

Natural rubber is an indispensable biological resource for Bridgestone’s business and is a renewable resource that can be produced from the Para rubber tree that grows in tropical rainforests such as those in Southeast Asia. Unlike synthetic rubber from petroleum, rubber from the Para rubber tree can be a sustainable resource. However, as tyre demand rises, indiscriminate expansion of Para rubber tree farms is undesirable from the perspective of biodiversity. The Bridgestone Group is conducting activities to improve productivity of rubber farms and increase production volumes of natural rubber. In Southeast Asia, the Para rubber tree is currently suffering from the spread of white root disease, affecting the production volumes of natural rubber. In Indonesia, damage accounts for multi-billion yen per year, and 6 percent of production volumes is estimated to be damaged. If the disease spreads, developing new Para rubber farms will require forest development and, thus, will affect biodiversity.

In a collaborative research project with the New Energy and Industrial Technology Development Organization between 2010 and 2011, Bridgestone developed a technology to diagnose diseases at an early stage. As a result, four diagnosis technologies have been developed: (i) satellite image analysis developed from remote-sensing technology, (ii) measurement of optical spectrum and temperature of leaf surface, (iii) component analysis of latex, and (iv) detection of pathogens at DNA level.

Regarding increase in rubber production, efforts are underway to find good cultivars that yield a higher amount of latex. With a well-defined breeding programme, the production per unit area of land is expected to improve.

In June 2012, a genomic analysis of the Para rubber tree was conducted and complete genome base sequences in the chromosomes of good cultivars were successfully decoded. In the future, if cultivars that are strong against dryness or disease are found, they will be selectively bred so they can be cultivated in lands previously inappropriate for cultivation.

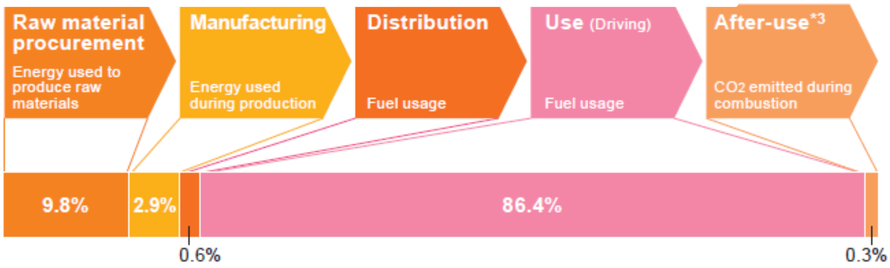
Throughout Indonesia, natural rubber is produced mostly by small-scale farmers, and there are many concerns in terms of productivity. For example, domestic yield per unit area is said to be about half that from all farms of the Bridgestone Group. With increased yields, the area of development necessary for rubber planting can be reduced, thus minimising the associated ecological impacts.

One factor causing stagnant productivity is the tapping process used in incising the trunk of Para rubber trees to collect sap. Because small-scale farmers can't afford to buy adequate tools and have little technical knowledge and know-how of the process, it is difficult to collect latex efficiently. Thus, Bridgestone provides the local community with highly productive young trees cultivated at its farms, tools for tapping, and tapping workshops.

6. Initiatives to Reduce CO_2 Emissions – (1) Reduction of Tyre Rolling Resistance

Within the life cycle of a tyre, the largest CO_2 emissions occur during the usage stage due to automobile exhaust emissions. A key way to reduce CO_2 emissions from automobile exhaust is by increasing fuel efficiency. Tyre rolling resistance is a significant factor in fuel consumption and reducing it can significantly reduce CO_2 emissions from automobile exhaust.

Figure 3.7. Greenhouse Emissions by Tyre Life Cycle Stage



*2 Greenhouse gas emissions throughout the life cycle of one fuel-efficient passenger car tyre (195/65R15): 243.9kgCO2e.
Source: Bridgestone (2014).

6.1. Example: Fuel-Efficient ECOPIA Tyres (Public–Private Partnership)

A 2013 survey shows that Bridgestone's ECOPIA tyres are 'fuel-efficient tires selected by the largest number of people in Japan' and contribute to the improvement of automobile fuel efficiency through reduced tyre rolling resistance. More people have been using the tyres since common voluntary standards in the industry were formulated in 2010. Bridgestone has worked on the development of reduced rolling resistance tyre technology for decades, following the principle of improving fuel efficiency without sacrificing safety and tread life performance. As a result, shipments of fuel-efficient tyres in Japan increased by 3.5 times between 2010 and 2013. In general, savings in fuel by using ECOPIA pay back in 2 to 3 years.

This technology was developed in a public–private partnership where the New Energy and Industrial Technology Development Organization, a semi-governmental entity, jointly conducted a research project with Bridgestone, Japan Synthetic Rubber, and the academia.

6.2. Example: Environmental Activities in Collaboration with Sales of Fuel-Efficient Tyres

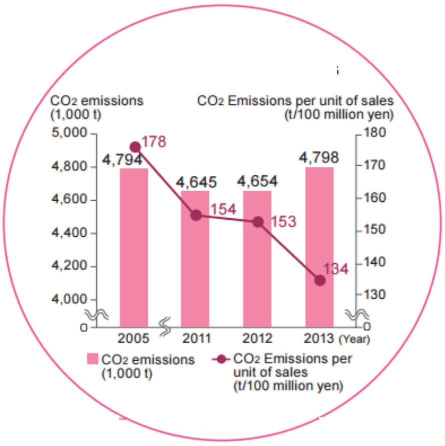
Since 2010, Bridgestone Tire Sales Malaysia has been conducting a One Tire, One Good Deed Campaign as a way to contribute to CO_2-emissions reductions through tyre sales. This project makes one ringgit (Malaysian currency) contribution per unit sales of fuel-efficient tyres to the Global Environment Centre, a non-governmental organisation. The collected fund is used for the development of the North Selangor Peat Swamp Forest. In addition, Bridgestone Tyre Sales Malaysia is planting trees with the help of its employees, local residents, and Bridgestone retail stores. Through these activities, Bridgestone contributes to both dissemination of fuel-efficient tyres and preservation of local natural ecosystem.

7. Initiatives to Reduce CO_2 Emissions – in Tyre Manufacturing

7.1. Example: Reduced CO_2 Emissions at Tyre Plants

The Bridgestone Group is working to reduce CO_2 emissions from its facilities by using energy more efficiently and switching to alternate forms of energy that result in lower emissions. As a result, CO_2 emissions per unit of sales was 25 percent lower in 2013 than in 2005. Going forward, the company is working to introduce more energy-efficient equipment and implement stringent energy management measures to further reduce CO_2 emissions.

Figure 3.8. CO_2 Emissions at Bridgestone Group Plants



Source: Bridgestone (2014).

7.2. Example: Conducting Energy Surveys to Improve Energy Consumption

To reduce CO_2 emissions while manufacturing to the volume that meets expanding demands, it is necessary to reduce energy usage by a greater amount year over year.

Since 2009, Bridgestone's technical centres have been conducting energy surveys to quantify wasted energy at plant facilities, expand awareness, and identify areas for improvement. Energy surveys were conducted in 22 locations in six countries over 5 years. The company continually develops the capacity and competence of their personnel to recognise energy-saving opportunities and undertake activities to continually improve so those who demonstrate proficiency may earn the distinctive role of 'energy diagnosis technician'. Bridgestone has assigned an 'energy diagnosis technician' in every tyre plant in Japan and will continue to increase their numbers throughout Asia, the Americas, and Europe.

8. Implication for Policy and Practice

It is indispensable that governments provide full support to industries to promote sustainability development, in particular, circular economy. Government incentives through public–private partnerships are a good mechanism to encourage industries to work on circular economy. The case of Japan’s New Energy and Industrial Technology Development Organization (NEDO) is a useful example to look at as a model, as it promotes networking between the government, the private sector, and the academia. As Japan's largest public research and development management organisation, NEDO undertakes technology development and demonstration activities to address energy and global environmental issues and enhance industrial technology by integrating combined efforts of the industry, the academia, and the government. Another example is the National Science Foundation grant in the US which ASEAN nations can use as a model.

The second recommendation is to encourage policymakers to work together to reach consistency among nations regarding circular thinking in environmental policy. International firms often face challenges in meeting policies of many countries where they conduct business and where policies significantly differ from one to another. It would help if more consistent policies exist. For instance, ASEAN could proactively take the lead in the region to establish a coalition among governments for a consolidated policy or common guiding principles to ensure consistency among its member nations. Alternately, the United Nations Environment Programme or the United Nations Environment Organization could take this role to ensure global consistency.

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Chapter 4

The ANA Group's Circular and Environment Strategy

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1. All Nippon Airways Co Ltd and ANA Holdings Ltd

Japan's airline industry is structured with two full-service carriers with combined market share of 90 percent. The All Nippon Airways (ANA) represents one of them. The industry as a whole generates approximately ¥34,000 trillion (US$29,000 million) in revenue. Of the 11 carriers that provide regular scheduled service domestically and internationally, ANA is the largest by revenue, passengers flown, and cargo carried. ANA ranks 23rd in the world in scheduled passenger kilometres and 20th in scheduled freight revenue tonne-kilometres.

Founded in 1952, ANA was primarily operating in the domestic market before it entered in 1986 into scheduled international service. ANA has over 242 aircraft (as of 31 March 2014) providing services for domestic Japan and international routes between Japan and Asia, China, North America, and Europe. ANA's portfolio of revenue consists of 57.7 percent domestic routes, 39.5 percent international operation, and 2.7 percent cargo.

In 2013, ANA reformed its group structure and ANA Holdings Ltd (ANAHD), the holding company of the ANA Group and ANA's parent company, was created. A 100-percent subsidiary of ANAHD, ANA, as air transportation provider, remains the core of the group. Currently, ANAHD is a 100-percent privately owned company listed in the first section of the Tokyo Stock Exchange and the London Stock Exchange.

Since 1999, ANA has been a member of the Star Alliance, a global airline alliance created in 1997. By becoming a member of this alliance, ANA has concurred with Star Alliance's Environmental Commitment Statement issued in 1999.

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[*] Author is seconded from ANA Holdings since 2014. The views and opinions expressed in this chapter are those of the author and do not necessarily state or reflect those of ERIA, ANA Holdings Ltd, or All Nippon Airways Co Ltd.
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Since 1993, ANA has been annually issuing the Environmental White Paper (in Japanese) and, from 1998, the ANA Environment Report (in English). In 2003, ANA announced its first midterm environmental plan called the 'ANA Group Ecology Plan for 2003 to 2007'. Its latest midterm plan is ANA FLY ECO 2020, which aims to provide security to society and earn its trust through actions and communication with diverse stakeholders and active participation in sustainable growth efforts.

In this chapter, we will walk through ANA FLY ECO 2020 and illustrate how the ANA group contributes to circular economy. We will also look at the challenges and dilemmas surrounding the circular economy of air transportation.

1.1. ANA's History of Environment Engagement and Circular Thinking

ANA's engagement in environment issues dates back to 1974 when it formed the Environment Preservation Committee as an advisory body to the company president. It was the time when *kogai* (pollution) was a highly recognised issue in Japan and noise pollution was one of the biggest agenda for the airline industry. Noise footprints in Itami Airport in Osaka, for example, had been a big issue since the first jet aircraft landed there in 1964 and resulted in restrictions such as night ban (curfew) and limits on jet aircraft operating there.

Although present technology cannot yet eliminate noise pollution, it has made dramatic advances in making aircraft quieter than before. It is said that aircraft in the 1990s are 1/15 quieter than those of the 1970s. Boeing's latest aircraft, the 787, is even quieter with 60 percent less noise footprint compared to other aircraft of the same size operating today.

As noise footprint is a typical external diseconomy, the industry has made big strides to lessen it. Whereas efforts to decrease noise pollution are progressing steadily, the airline and aviation industries are facing new challenges with increasing concerns over scarcity of fossil energy, volatility of jet fuel prices, and sustainable growth at the global level. If one looks at ANA's 1998 Environmental White Paper, noise pollution was the first topic featured whereas it was second to last in the company's white paper in 2005. Global warming, the second to the last topic in the 1998 white paper, became the main concern in the 2005 white paper.

At the same time, broader and common responsibilities as an airline and as corporate citizens are being realised in the ANA group. For example, the ANA group has contributed to sustaining biodiversity though forestation and coral regeneration programmes.

In this chapter, we will illustrate ANA group's environmental programmes from its core initiative of reducing carbon dioxide (CO_2) emissions to its 3R (reduce–reuse–recycle) activities, and the drivers of such activities to promote circular economy.

1.2. Drivers to Becoming an Environment-Friendly Airline

As a private company, what does it take to introduce and enforce environment-friendly policies?

The answer is probably the following drivers: regulatory requirements, cost incentives, and social responsibility needs as driven by the first two.

Many ANA initiatives are derived from the above drivers although some overlap multiple categories and some may not belong to any of the categories at all. Nevertheless, among these many initiatives, we will focus on those that the ANA Group has implemented proactively or directly linked to the concept of circular economy.

1.2.1. Regulatory requirements

As with other industries, the airline and aviation industries are covered by laws and rules and regulations by global bodies such as the International Civil Aviation Organization (ICAO) as well as local governments. These regulations range from what types of aircraft an airline can fly to how aircraft maintenance centres should be managed. These regulations are to be observed and complied with in full and groups such as ANA are obliged to follow them. The ANA Group's activities are governed by over 24 laws whose coverage ranges from 3R to noise and air pollution.

Taxes and mandatory transactions such as carbon-emissions trading can be considered as falling under such regulations as well. To meet the challenges of managing carbon emissions, ICAO is proposing market-based measures that, should it be mandatory for airlines in the future, will fall under this category.

1.2.2. Cost incentives

The simplest way to embed the concept of circular economy in a private entity is to look for measures that could make the operation less costly. Like any other company, ANA appreciates cost-cutting measures if given strong incentives. Other than this, the International Air Transport Association (IATA) encourages the use of voluntary initiatives to address environmental impacts from aviation as these can be tailored to the specific needs of governments, industry, and other stakeholders and can provide more flexibility and cost savings than regulatory measures (IATA website).

The most effective area of cost reduction would be fuel consumption. ANAHD's 2014 financial reports show that approximately 23 percent of operation cost is fuel cost or fuel-related taxes. As such, it is natural for ANA to reduce and stabilise fuel cost as much as possible. On the other hand, the large impact of fuel cost should translate into the use of alternative fuels at prices lower than or competitive to the price of existing jet fuel and that can be mass-produced. Currently, the price of alternative fuels are three to five times higher than that of conventional jet fuel. Thus, it would be very difficult for an airline to buy such expensive fuels even if their ecological advantages are warranted.

Following are the initiatives ANAHD and ANA have implemented in their common and unique efforts to save on fuel.

1.2.3. Social responsibility

With environment issues becoming more global, corporates have felt the need to themselves address these challenges. In 1999, ANA renamed its Environment Preservation Committee to Global Environment Committee. Although environment-related activities do not give direct positive impact on balance sheets, pressures from public opinion calling for more attention to global environment make a great incentive for corporations to participate or organise programmes addressing such concerns.

For example, ANA's sales departments, especially in Europe, are frequently asked of the group's ecological credentials. A report by the Global Business Travel Association Foundation in January 2015 reveals that 57 percent of Europe-based companies have sustainability initiatives included in their travel policies and, with regard to their business, nearly all companies measure the impact of air travel (GBTA, 2015). Corporate customers wish to know how ANA minimises its business's impact on the environment – what innovations/technology ANA uses; how ANA promotes the reuse, reduction, and recycling of materials; what ecologically responsible programmes the company is involved in; and how it is very important for airlines to undertake a myriad of initiatives in a multitude of areas to reduce the burden on the environment. Some of the frequently asked questions are:

- Do you have an ISO 14001 certification and/or any other environmental certificate?
- Can you regularly provide reports showing the CO_2 emissions directly linked to the company's business travel?
- What is the average age of the airline's fleet?
- What is the airline's kerosene consumption in tonnes per 100 passenger miles?
- What is the airline's CO_2 emissions per 100 passenger miles?
- How much waste is generated in kg per passenger?
- What percentage of waste is recycled?
- What is the airline's energy consumption on the ground?
- What is the airline's average percentage of energy consumption from renewable energy?

In recognising its social responsibility, ANA has taken direct measures in its core business and through various programmes such as coral restoration in Okinawa, forestation in areas near the airports, and the carbon offset programme for domestic air travel, among others.

ANA's initiatives on environmental issues has earned it a certification in 2008 from the Eco First programme of Japan's Ministry of Environment in recognition of the firm's environmental actions compliant with the Kyoto Protocol. ANA was the first company in the aviation and air transportation industries to receive this accolade.

2. ANA FLY ECO 2020

The ANA FLY ECO 2020, announced in 2012 as the ANA Group's third midterm environmental action plan, has six main pillars: (i) efforts to reduce CO_2 emissions, (ii) measures related to alternative fuels, (iii) resource conservation and recycling, (iv) conservation of biodiversity, (v) carbon offset programmes, and (vi) environmental compliance.

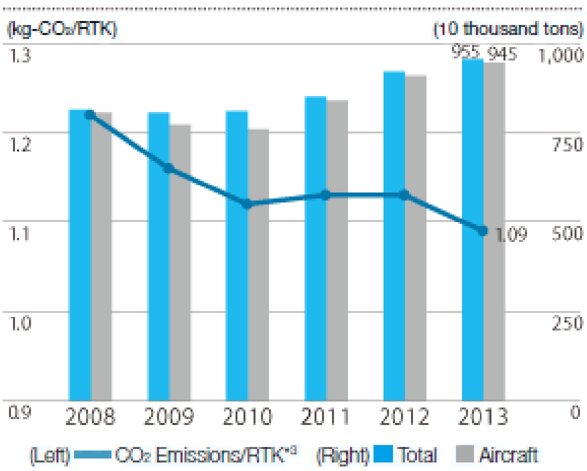
This plan, which succeeded the ANA Group's Ecology Plan for 2008–2011, includes strategies such as the introduction of Boeing 787, a more fuel-efficient aircraft with less noise footprint. The plan's awareness of 2020 is in line with IATA's aim of achieving carbon-neutral growth by 2020 or a 1.5-percent average annual improvement in fuel efficiency from 2009 to 2020 (IATA, 2009a). The IATA declaration includes a 50-percent absolute reduction in carbon emissions by 2050. The year also coincides with the end of the second commitment period of the Kyoto Protocol.

2.1. Efforts to Reduce CO_2 Emissions and Fuel Consumption

The airline industry is estimated to contribute 2 percent of total global emissions (IPCC, 1999). Within the ANA Group, 98 percent of CO_2 emissions come from fuel burn by aircraft with the rest coming from its maintenance facilities and vehicles on the ground.

The ANA Group targets a 20-percent CO_2-emissions reduction per revenue RTK in 2020 compared to 2005 and hopes to maintain 4.4 million tonnes per year of CO_2 emissions in its domestic route from 2012 to 2020.

Figure 4.1. CO_2 Emissions by the ANA Group



Source: ANA Annual Report (2013).

The first goal is for both international and domestic routes and is in line with IATA's goal of 17 percent (1.1 percent per year) industry-wide reduction by 2020 compared to the 2008 level. In 2013, ANA emitted approximately 9.45 million tonnes of CO_2, which was 13.3 percent less than the 2005 level, although it increased in gross volume by 4 percent compared to the previous year because of growth in operation.

The latter target was unique as it was the first of its kind in the industry to set a goal of gross CO_2 emissions. First adopted in 2008, the goal achieved more at 4.36 million tonnes in 2013, despite a 4.3-percent growth in available seat kilometres.

2.1.1. Launch customer of Boeing 787

Reducing CO_2 emissions means reducing the use of jet fuel, increasing the efficiency of fuel consumption, or both. These measures mean cost savings and can be rationalised easily.

Reducing the traditional ways of using energy such as using non-recyclable and non-reusable jet fuel will support the circular way of doing business.

As of 31 March 2015, the ANA Group has been operating 242 aircraft, 54.5 percent of which are fuel efficient. The average age of ANA's fleet is 11.3 years (as of 31 March 2013).

Table 4.1. Aircraft in Service of the ANA Group

Aircraft in Service		Mar 31, 2014	Mar 31, 2015	Change	Owned	Leased
Wide-Body	Boeing 747-400 (Domestic)	1	0	- 1	0	0
	Boeing 777-300ER	19	20	+ 1	17	3
	Boeing 777-300	7	7	–	7	0
	Boeing 777-200ER	12	12	–	6	6
	Boeing 777-200	16	16	–	14	2
	Boeing 787-9	0	2	+ 2	2	0
Mid-Body	Boeing 787-8	27	32	+ 5	30	2
	Boeing 767-300ER	26	26	–	9	17
	Boeing 767-300	21	16	- 5	16	0
	Boeing 767-300F	2	3	+ 1	0	3
	Boeing 767-300BCF	7	7	–	7	0
Narrow-Body	Airbus A320-200	19	20	+ 1	12	8
	Boeing 737-800	24	31	+ 7	24	7
	Boeing 737-700ER	2	2	–	2	0
	Boeing 737-700	11	10	- 1	7	3
	Boeing 737-500	15	17	+ 2	17	0
Regional	Bombardier DHC-8-400 (Q400)	21	21	–	15	6
	Bombardier DHC-8-300 (Q300)	1	0	- 1	0	0
	Total	231	242	+ 11	185	57

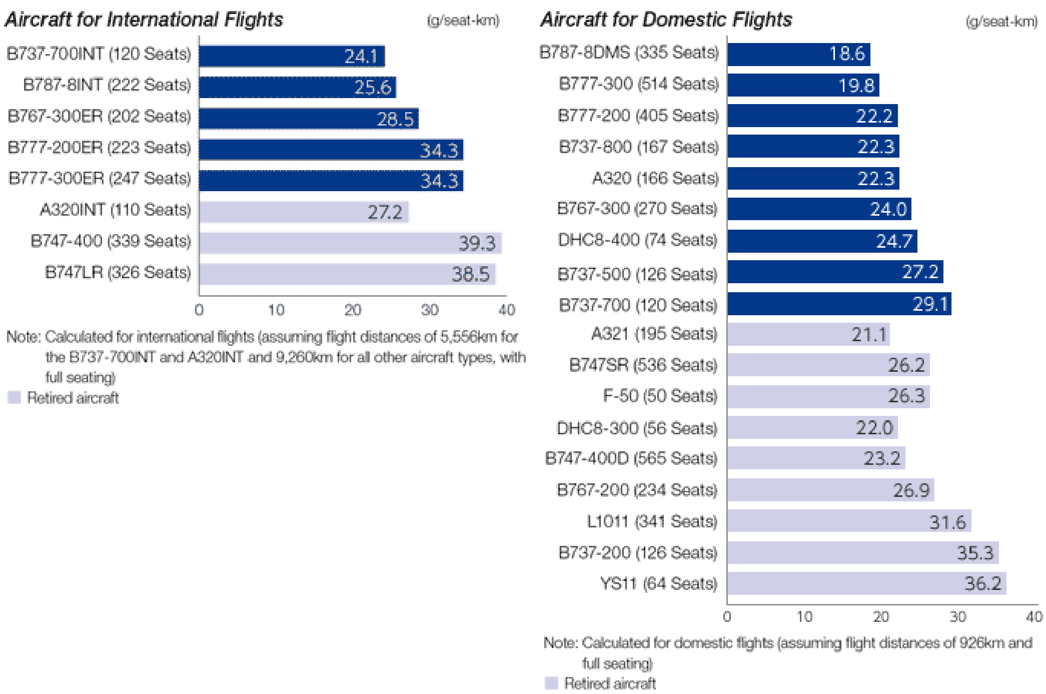
Source: ANA Annual Report (2014).

The Boeing 787, developed as the next-generation aircraft with signature carbon fibre composite frame and other features, is 20 percent more fuel efficient than the Boeing 767, one of ANA's major aircraft. As of 31 March 2013, ANA has been operating 34 Boeing 787s with two variants.

ANA, the launch customer and the first airline to fly Boeing 787, has a total order of 83 of this aircraft (including those already delivered) with three types of variants and has the largest order as of 31 April 2015. The 787 is set to become ANA's strategic aircraft.

The 787 features engines that incorporate the latest technologies, and more aerodynamically efficient wings with lighter structure. Manufactured with more environment-friendly considerations to noise and air footprints, the 787 is the only aircraft in the world with most of fuselage made of carbon fibre composite and designed with end-of-life stage consideration for recycling.

Figure 4.2. Fuel Consumption by Aircraft Type



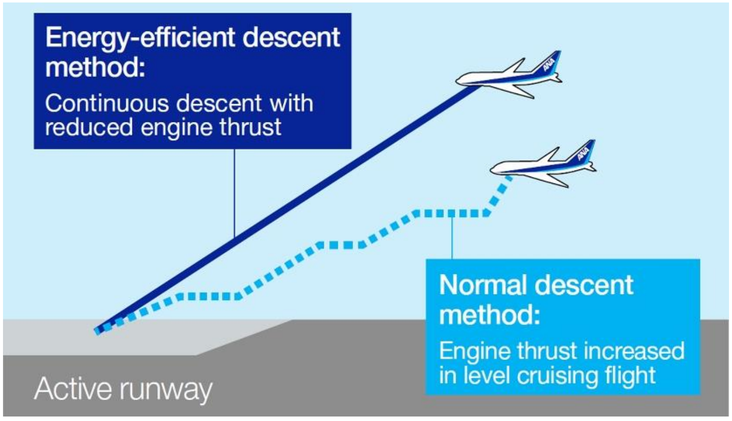
Source: ANA Annual Report (2013).

2.1.2. Fuel-reduction efforts in route operation

Other than introducing fuel-efficient aircraft, ANA has been vigorously searching for and implementing various measures to reduce fuel use. Its Fuel Efficiency Plan (FEP), launched in 2003, seeks ways to reduce fuel use and make the aircraft lighter in operation. In ANA FLY ECO 2020, another 3-year FEP was introduced.

In 2002, ANA, with support from Japan's Ministry of Land, Infrastructure, Transportation and Tourism, started to use aRea NAVigation (RNAV), a method of instrument flight rules navigation that allows an aircraft to choose any course within a network of navigation beacons rather than navigating directly to and from beacons. This method can shorten flight distance by choosing a direct path, reducing congestion, and allowing flights into airports without beacons.

Figure 4.3. Energy-Efficient Descent



Source: ANA Annual Report (2015).

Another notable measure to conserve fuel is the continuous descent approach (CDA), a method that allows smoother approach to the airport and makes possible less carbon emissions and noise footprints. This method though is not applicable to all airports nor possible during congested times.

Provided all safety measures warrant the continuous descent approach, a pilot can reduce the use of thrust reversers during landing, thus reducing engine output which, in turn, reduces both CO_2 emissions and noise. CO_2 emissions are further reduced by shutting down one engine as the plane is taxiing toward gate after landing.

Lastly, when making flight plans, ANA has revised the method for calculating and planning the aircraft's gravity. Provided the total fuel on board is unchanged, this revision makes 1 percent gravity to the rear of the aircraft yield approximately 0.05 percent fuel saving.

These measures require a pilot's expert thinking based on established rules and a range of factors, including airport, weather, runway, and aircraft conditions as well as instructions from the control tower.

2.1.3. Fuel-reduction efforts on the ground

When an aircraft's engine is running, its engine compressor collects fine dust, decreasing fuel efficiency. About three times a year, ANA washes its fleet's engine compressors with warm water to remove dust and restore performance, improve fuel efficiency, and reduce CO_2 emissions, thus improving by 1 percent their fuel efficiency. Another effort is to use ground power units instead of the aircraft's auxiliary power units to supply electricity while the aircraft is parked at the gate.

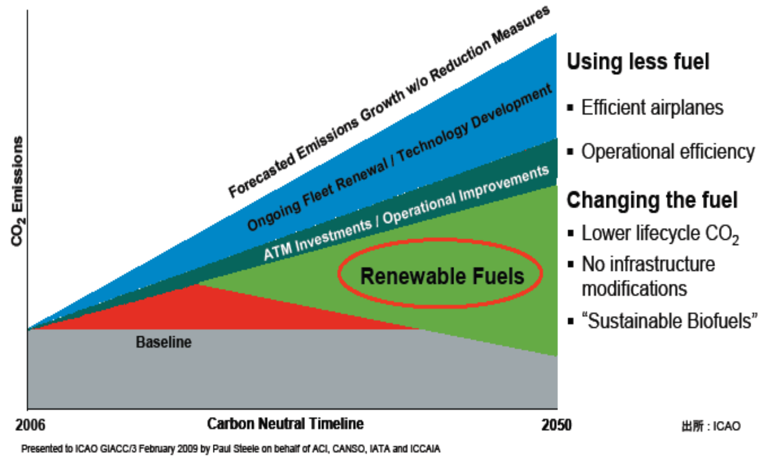
2.1.4. Other efforts

To reduce the weight of load an aircraft carries, ANA is reviewing the amount of potable water on board, changing the type of paper of inflight magazines, and adjusting the amount of utensils, beverages, etc. loaded based on reports from cabin attendants. It has also introduced lighter plates, cups, and baggage containers.

2.2. Future of Alternative Fuel

In considering the aviation industry's eco-friendly practices or circular economy, the issues of fuel efficiency or of lesser use of fossil fuel cannot be ignored. To reach IATA's goals, developing biofuel or alternative fuels is the key to success.

Figure 4.4. Timeline to Reach Carbon Neutrality



Source: ICAO.

Figure 4.4 illustrates IATA's carbon-reduction options with emphasis on renewable fuels. The technology for the use of biofuel to power aircraft has already been established. ANA first tested it with the delivery flight of its first 787 from Seattle to Tokyo by using a Dutch company's biofuel made from feedstock of used cooking oil mixed with kerosene.

ANA has also invested ¥571 million in Euglena Co, a Japanese firm that raises and uses algae to produce biofuels aside from other products, such as synthetic paraffinic kerosene and hydro-processed esters and fatty acids. The firm announced in April 2015 its collaboration with Chevron and the joint research they will conduct with the University of California San Diego on the outdoor algae cultivation technology.

2.3. Resource Conservation and Recycling

The concept of reduce–reuse–recycle or 3R, the main course for resource conservation and recycling, was very common in Japan in the 1970s as the country was experiencing the oil crisis. It can be said that the Law for the Promotion of Sorted Collection and Recycling of

Containers and Packaging enacted in 1997 (amended in 2006) has, in Japan's everyday life, elevated activities not only in areas covered by this law.

Within the ANA Group, an annual bulletin reminds employees of 3R activities where they are expected to participate. Unique in these 3R activities is ANA's effort to involve its customers in many of the measures discussed in this case study, such as requesting passengers to surrender plastic covers of their baggage, baggage tags, and boarding pass paper, thus encouraging them to be part of circular economy.

Another good example is ANA's treatment of water. For example, the remaining water from aircraft arriving at Haneda Airport used to be just discarded. After a proposal from an employee, however, it is now repurposed for cleaning aircraft maintenance facilities, etc. Since this initiative began in 2009, approximately 8,300 tonnes of water have been put to more effective use.

2.3.1. In-flight recycling

As early as 2000, ANA has been separately collecting recyclable cans and bottles and has added PET bottle collection in international flights arriving at Haneda and Narita airports.

Of the 22,500 tonnes total waste generated in the two airports in 2013, over 70 percent was collected from flights.

2.3.2. Recycled and reused items

The ANA group recycles waste generated on board, at airports, and offices and promotes resource conservation and recycling. Apart from water reuse, it recycles used paper generated by office equipment and old inflight magazines, etc. into timetables, envelopes, and business cards for its offices in Japan. The airline's headrest covers are made from reusable materials.

Used uniforms of cabin attendants, ground staff, and flight crews are broken down into fibre and reused as automotive soundproofing material. The uniforms themselves are made of materials produced from plastic bottles and other recyclables.

ANA's other initiatives include recycling aircraft engine parts into their component metals, recycling vinyl sheets used to protect cargo from rain and dust into solid fuel and garbage bags, using rainwater and treated kitchen wastewater, etc.

2.4. Conservation of Biodiversity

As part of its broader activities in social responsibility, the ANA Group has contributed in forestation and coral restoration in Japan.

2.4.1. Okinawa coral restoration

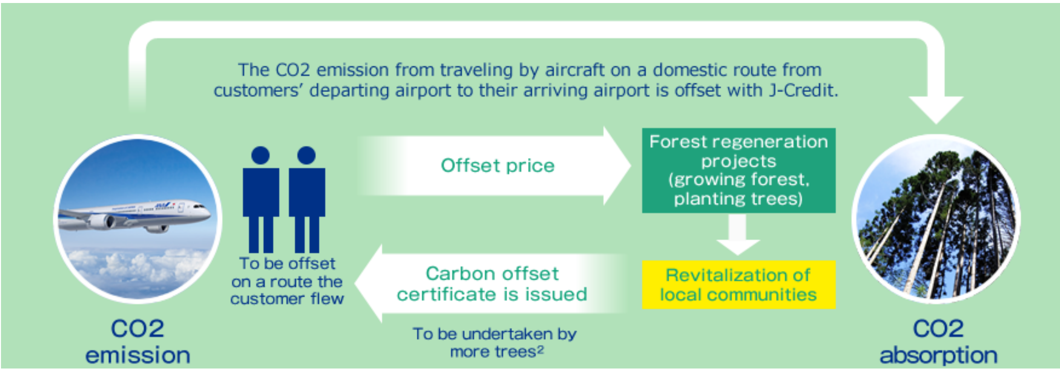
Since 2004, the ANA Group has joined other businesses in Okinawa and other prefectures to form Team Tyura Sango, an industry–government project to protect and regenerate the coral reef community near Onnason, Okinawa.

2.5. Carbon Offset Programmes

On 1 October 2009, the ANA Group launched the ANA Carbon Offset Program in all its domestic routes as part of its customer-related environmental contribution initiatives. In 2014, 24 tonnes of carbon were offset through this programme.

This programme enables passengers to donate money to tree planting activities to help absorb the CO_2 emitted by the aircraft they are traveling on. The donations are directed to 'more trees' (a general incorporated association), which uses them to cultivate forests in Japan.

Figure 4.5. Scheme of ANA Carbon Offset Programme



Source: ANA Carbon Off Set Home Page.

Passengers can calculate CO_2 emissions generated on domestic flights through a dedicated website (https://anaoffset.com). Donations can be made via credit cards. Customers can also participate in the programme any time, including retroactively offsetting the emissions of previous trips and making donations to offset emissions of future trips.

The scheme is unique because it is not a direct contribution of the ANA Group or its employees but a way of bridging customers and environmental activities through the group's business platform.

3. Challenges

Although the ANA Group continues to be an environmentally conscious company, its activities need coordination and support from various stakeholders, from the government to air traffic controllers, airport operators, and suppliers. Also, as a private company, ANA needs to sustain its growth while it pursues its objective of creating less negative impact on the environment.

From the perspective of circular economy, the following are some of challenges facing the commercial aviation industry.

3.1. How to Cope with Growing Demand

With economy growth materialising all over the world, the demand for air travel is also growing, especially in Asia. Although it can be argued that less travel will help lessen impact on the environment, it is important to note that commercial aviation is a collective activity where people move for various reasons and the airlines are there to serve their needs. History shows, however, that people are not always after speed and their awareness of the environment helps push for innovations to make air travel better. The phasing out of the Concorde is a very good example. Introduced in 1976, the supersonic jet that made transatlantic travel less than half of conventional aircraft's capability proved to be economically and environmentally unsuccessful. Aside from fuel inefficiency, the aircraft's noise footprint and the so called sonic boom effect were a real challenge to the environment. With only 20 units produced including two prototypes, the Concorde was retired in 2003. It is interesting to note that in 2002, Boeing selected its 7E7 programme (later renamed to 787) over the sonic cruiser, a concept aircraft that would carry passengers at shy the speed of sound. Boeing chose efficiency over speed (Boeing, 2013).

3.2. Mass Production of Biofuels

Although the technology and the product of aviation biofuel have already passed approval, the challenge remains whether airlines can procure the necessary amount to make it an integral part of their fuel use.[1] For example, ANA has used biofuel diluted to 15 percent although it could have accommodated less-diluted one if only the airline was able to obtain it. Boeing estimated in 2010 that one percent of its global aviation fuel could be biofuels (Bloomberg Business, 2010) but it is unlikely it could meet that projection. IATA estimates that three percent of total aviation fuel can be provided by biofuels under certain sets of policies required by both the industry and governments (IATA, 2014a), still a very small share and still a long road ahead. Companies from a broad range of fields, including airlines, energy, manufacturing, and trading have joined together to form the Initiatives for Next Generation Aviation Fuels (INAF) to establish the necessary supply chains and promote wider use of next-generation fuels. The ANA Group is participating in INAF as a steering member and will be working to formulate the road map that will enable the commercial use of next-generation aviation fuels, including biofuels, by 2020.

[1] Besides the regulations and rules on the use of biofuel, the biggest challenge facing the producers of alternative biofuels is the investment required to scale up their production. The airlines, in turn, are faced with scarce supply of biofuels sold at extremely high prices. The prices of biofuels are expected to come down as more feedstocks become available. Case Study ANA, The Sustainable Aviation Fuel Users Group, http://www.safug.org/case-studies/ana/

3.3. Can a Second-Hand Aircraft Market Be Justified?

Just like cars, aircraft also have second-hand market. Although ANA had procured second-hand aircraft in the past, its current fleet consists of new airplanes except for a Boeing 767 that was procured from another airline and converted into a freighter aircraft and another that had been sold to a third party but was bought back to fill ANA's short-term aircraft shortage.

As ANA procures new aircraft, it phases out older aircraft to be more competitive and to bring down cost. Since ANA's phased-out aircraft are supplied to the second-hand market, the question comes whether buyers of these older aircraft are justified in flying less eco-friendly aircraft.

The industry is facing a trade-off issue as far as eco-friendliness is concerned because of the introduction in the market of fuel-efficient aircraft. To some experts, the second-hand market is shrinking because people want newer aircraft for many reasons and the recent low-interest rate in the financial market has enabled second-tier carriers to tap into cash for more expensive new aircraft.

The second-hand market is ideal for the recycling and reuse concept of circular economy. When an aircraft reaches its end of life, 85 percent of its components can be still recycled (UAM website).

3.3.1. Aircraft conversion programme

One way to recycle and reuse is to convert passenger aircraft into cargo-only aircraft or freighters. Passengers do not want aircraft with tired-looking interiors and worn exteriors. In many cases, the life cycle of aircraft is longer than what passengers can endure. With less or no depression for the aircraft, it is still very economical to invest in conversion programmes as long as demand is there.

3.4. Fuel-Price Volatility May Affect Aircraft Purchases

The recent drop in fuel prices have some experts wondering whether airlines may lose interest in newer, economical but expensive aircraft. The background is that new fuel-efficient aircraft have not come to enjoy the scale merit of production as they are new to the market and catalogue prices are still relatively higher.

ANA is determined not to change its aircraft-procurement plan because of fuel price getting lower. However, with lower fuel price bringing the break-even point lower, it may consider deferring the retirement of some aircraft should market demand warrant it.

4. Policy Recommendations

In considering the promotion of circular economy in the airline industry or in any industry for that matter, it is more effective and efficient to find solutions that can serve as economic incentives to stakeholders. Policies that can supplement economic incentives should be welcomed.

4.1. Supporting Distribution of Biofuels

As the basic technology for biofuel production is already widely acknowledged in the industry, it is critical to give incentives to further the technology for mass production and to reward airlines that promote the use of biofuels. Although IATA has outlined many proposals (IATA, 2015), the need for public–private partnerships should be highlighted to create and maintain supply chains of biofuels to bring down distribution cost. The prices of conventional jet fuel and biofuels still have a significant gap due to the low production and distribution together with far less than needed supplies of the latter. Economic incentives or rewards for developing solutions require public funding support during its infancy.

Furthermore, among a variety of biofuels developed, biofuel from cooking oil and waste is an easy-to-understand means from the perspective of circular economy as it creates a feeling of engagement by consumers (= air travellers). This may be easier to justify when the price gap between conventional fuel and biofuels becomes marginally acceptable. The policies to support development and distribution of biofuels should be drawn not just from the supply side (manufacturers and airlines) but, ultimately, from the demand side or the consumers.

Many countries have launched study projects to tackle the issue of distribution of biofuels. In Japan, the Committee for the Study of a Process Leading to Introduction of Bio Jet Fuel for the 2020 Summer Olympic Games and Paralympic Games in Tokyo was formed by the Ministry of Land, Infrastructure, Transport and Tourism and the Ministry of Economy, Trade and Industry in July 2015. Other countries have set up similar projects/groups like the Commercial Aviation Alternative Fuels Initiative and the European Advanced Biofuels Flightpath, to name a few.

In ASEAN countries, the Southeast Asia Sustainable Aviation Fuel Initiative was formed in 2013 and has since partnered with expert organisations and ASEAN. For this initiative, Indonesia should be highlighted as its government has set a target to airlines to use 2 percent biofuel as jet fuel by the end of 2016.

Although this will unlikely materialise, it is worth noting that a country experiencing rapid growth in air traffic is setting a challenging target. It will require significant international and domestic support to move toward that milestone.

4.2. Comprehensive Recycling Structure along the Value Chain in the Air Travel Industry

Like most developed countries where management of waste has somewhat been done in many ways through various regulations and incentives, there is room to explore at each value chain. For example, recycling on many international routes is hindered due to quarantine issues in Japan, itself a very important global agenda. Japan requires that most waste offloaded from an aircraft be burned, thus making it difficult to recycle. Any industry development that allows not only the burning of waste generated in the sky but also its safe recycling and/or reuse should be welcomed.

4.3. Institutionalisation and Formalisation of Waste Management

In many developing countries, people engaged in recycling or reuse are part of the informal sector. To reduce or recycle waste, it is strongly recommended that people who belong to the group of the most poor be formalised as labour and the process to be institutionalised. The cost of such work should be covered by consumers through taxes or terminal fees. In addition, refund of collected recyclable materials should be considered to help support institutionalisation.

4.4. Co_2 Emissions Regulations by International Bodies

The International Council on Clean Transportation (Kharina, 2015) has reported that a meaningful and ambitious CO_2 standard is needed to provide an extra incentive for development of new technology and deployment of new aircraft. It estimates that manufacturers remain 12 years behind the technology goals of ICAO. ICAO is looking forward to the crafting of CO_2-emissions regulations by 2016 with prevailing high hopes similar to the significantly mitigated noise pollution problems after rules were implemented by ICAO.

5. Conclusion

Under the Long-Term Strategic Vision announced in January 2015, ANAHD and the ANA Group plan to increase its aircraft fleet to approximately 305 aircraft. They estimate that 75–80 percent of the new-generation aircraft will be fuel efficient. To fulfil its environment target, ANA is striving to attain two goals within 2020 as this is a critical and special year. Tokyo is hosting the 2020 Summer Olympics and demand to travel to Japan is expected to grow significantly. Under such circumstances, steadily continuing the current measures and innovations within ANA and the industry is highly expected to make the airline more environmentally friendly while achieving sustainable growth.

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Chapter 5

Circular Economy Policies and Strategies of Germany

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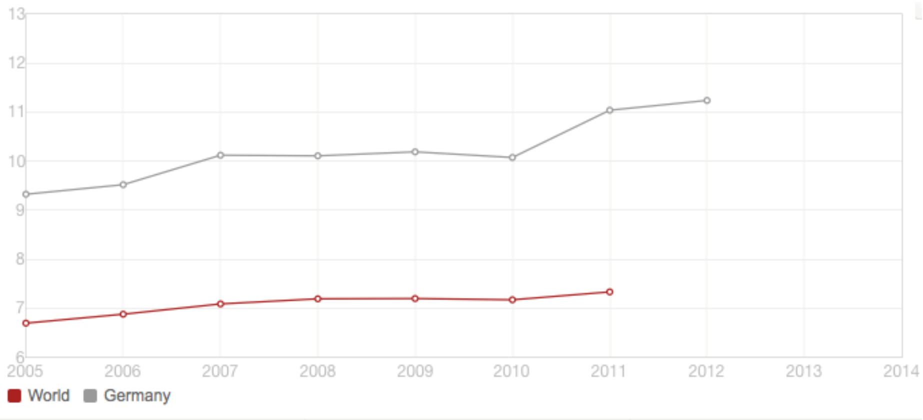
Introduction

Germany had an early start on its pathway towards a more efficient and sustainable growth. During the last decades, it developed ambitious energy, industrial, and environmental policies at the national level and played a very strong role in these areas at the European level. According to the Organisation for Economic Co-operation and Development (OECD), the country's strong environmental framework makes Germany a pioneer in sustainable development, which shows that a more efficient and low-carbon economy is compatible with growth (OECD, 2012). Germany's National Strategy for Sustainable Development, adopted in 2002, sets the guiding principles for national policies across all sectors. Despite several changes of government, the strategy has remained alive and in place, serving as basis for concrete targets and actions and is evaluated regularly. Over the last decades, Germany had managed to substantially increase energy efficiency and decouple energy consumptions and greenhouse gas emissions from economic development. This is shown by the units of gross domestic product (GDP) per kg of oil equivalent generated in Germany, which are well above the world average, an indicator of the energy efficiency of the German economy from environmental and economic perspectives.

Figure 5.1: GDP per Unit of Energy Use
(Constant 2011 PPP US$ per kg of Oil Equivalent)

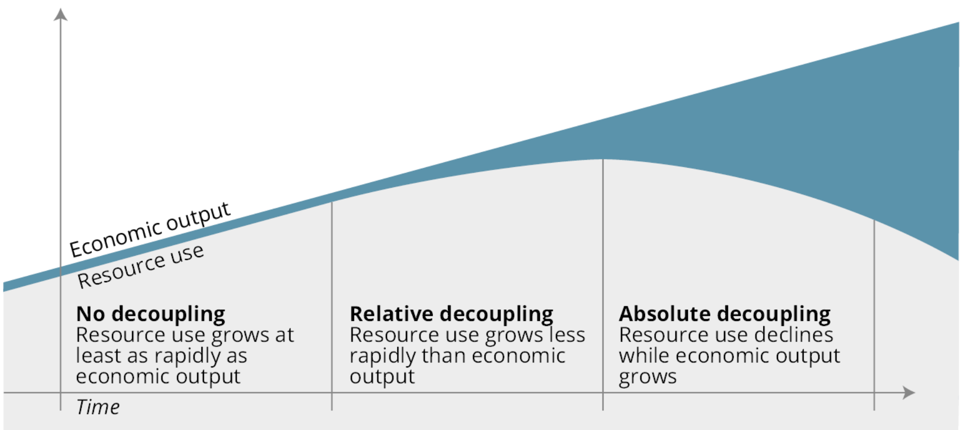


Source: World Bank.

1. Resource Efficiency and Circular Economy Strategies and Policies

An important element in Germany's transition to a sustainable society is the adoption of a circular economy approach. Over the past decades, there has been reasonable progress in decoupling resource consumption from economic output. At the European level, several legislations have been adopted to boost a European circular economy, such as the Waste Framework Directive, the Landfill Directive, and the Packaging and Packaging Waste Directive. The main focus of these measures is the reuse, repair, refurbishing, and recycling of existing materials and products among the 28 member states of the European Union (EU). This reflects the shift in thinking on what used to be called waste being considered now as resource. The core objective of this approach is to substantially decouple economic development from resource consumption (Figure 5.2).

Figure 5.2. Decoupling Stages



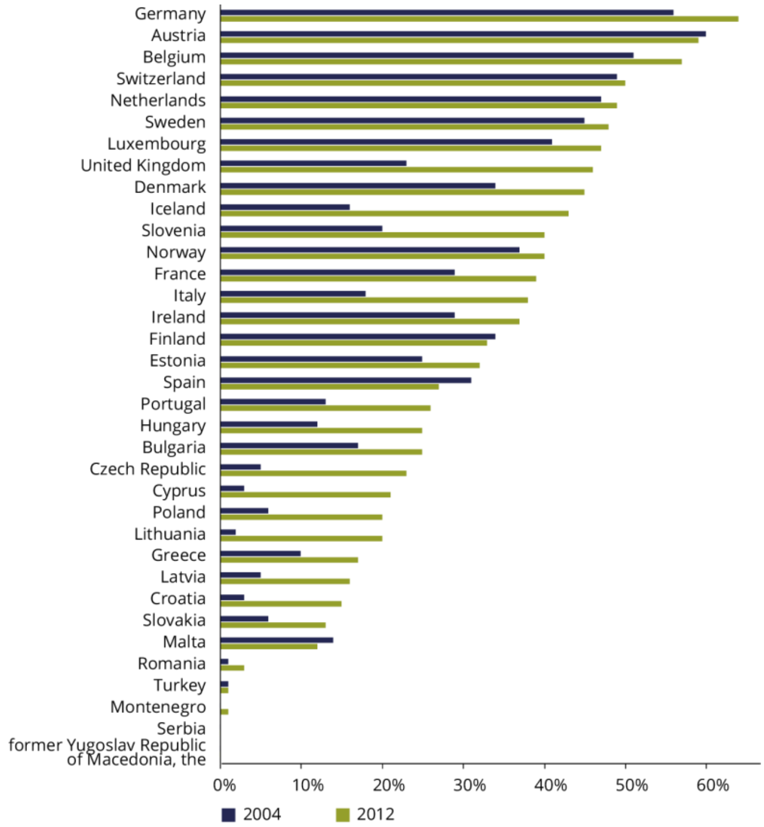
Source: European Environment Agency (EEA).

The more efficient use of resources is considered to generate new growth and job opportunities. Ecodesign, waste prevention, reuse, and recycling can bring net savings of up to €600 billion for EU businesses, while also reducing total annual greenhouse gas (GHG) emissions. Additional measures to increase resource productivity by 30 percent by 2030 could boost GDP by nearly one percent, while creating 2 million additional jobs (EC, 2013).

At the national level, Germany applies a number of strategies to foster a circular economy approach, including waste minimisation, reuse, recycling, and waste incineration for electricity and heat generation.

A cornerstone of the German recycling policy framework is the packaging law (Verpackungsverordnung), adopted in 1991, which requires manufacturers to recycle all packaging materials they sell. In response, the German industry has developed a collection system of recyclable materials alongside the regular waste-collection systems. This industry-funded system, operated by the Duales System Deutschland, is tasked to help improve the recycling rate from the current level of 62 percent (Figure 5.3) of the municipal waste (EEA, 2013).

Figure 5.3. Municipal Waste Recycling Rates in European Countries, 2004 and 2012



Source: EEA.

While this rate is already very high, a substantial amount of precious materials are not being recycled and only used for the so-called thermal reuse or waste incineration for electricity and heat generation. Although a sub-optimal use of resources, it ensures, nevertheless, that there is virtually no landfilling in Germany.

1.1. Research and Innovation

Box. 1 Resource Efficiency in Practice: Examples from Europe

Umicore has been demonstrating that efficient recycling is a profitable and sustainable business model, offering investment, innovation, and employment opportunities. Close to 50 percent of Umicore's metal supply requirements comes from in-house recycling. This also reduces CO_2 emissions substantially.

Suez Environment has established 278 sorting centres, 99 composting platforms, and 85 recovery facilities for electronic waste, producing 12 million tonnes of secondary raw materials, while eliminating 2.8 million tonnes of CO_2 emissions.

Renault's plant in Choisy-le-Roi, near Paris, remanufactures automotive engines, transmissions, injection pumps, and other components for resale. The plant's remanufacturing operations use 80 percent less energy and almost 90 percent less water than those of comparable new production, with high operating margins. Renault redesigns certain components to make them easier to disassemble and reuse.

The European Network on Industrial Symbiosis, established in 2013, brings together organisations responsible for up to 10 established industrial symbiosis programmes (collectively engaged with more than 20,000 companies across Europe).

Source: Adapted from EC.

With regard to innovation in the areas of climate change, resource efficiency, and sustainable development, the EU's Framework Programme for Research and Innovation, called Horizon 2020, is playing a major role, being the world's largest research programme with nearly €80 billion of funding available over 7 years (2014–2020), which will be invested in societal challenges, industrial leadership, and excellent science. An important element of the programme is the promotion of a more circular economy. Similarly, Germany has several research and innovation funding programmes at the national level, such as the research for sustainability programme (www.fona.de/en/).

2. Low-Carbon Development Strategies and Policies

Germany is committed to reduce GHG emissions by 40 percent if the other EU member states would agree to the EU's 30-percent reduction target for 2020. The framework of this economy-wide target is Germany's Integrated Climate and Energy Program, which sets out policy measures for the energy sector. Germany and the EU as a whole have already shown some reasonable progress on reducing GHG emissions. A number of policies to deliver on these targets include key measures such as the Renewable Energy Act (Erneuerbare-Energien-Gesetz, EEG) and the ecological tax reform.

The Renewable Energy Act not only boosts domestic generation of renewable energies, wind power, and photovoltaics, in particular, but also fosters innovation in renewable energy industries in Germany. It provides incentives to businesses and individuals to generate renewable energy for which they will receive preferential tariff, which is well above the average price and which aims to bridge the gap in the current price of thermal-powered electricity renewable energies and provide a long-term incentive for investors. On the demand side, the ecological tax reform plays a vital role in encouraging energy efficiency and discouraging energy consumption. Most of the funds generated by this tax on electricity and fuel use are redistributed to society to reduce social security costs that will, in turn, increase disposable incomes of individuals (more on this in the next section).

3. Description of the Key Policies Related to the Industry Case Study: National Policies for Reducing GHG Emissions from Road Transport in Germany

The transport measures aim to reduce GHG emissions by 30 million metric tonnes per year by 2020 compared to 2005 (ITF, 2010). As reductions in other sectors might be smaller as initially estimated, CO_2 emissions from transport need to be reduced by 40 million metric tonnes per year by 2020 to ensure that Germany's climate protection objective is achieved (UBA, 2010b).

Currently, the federal government, together with stakeholders from science, industry, politics, and civil society, is developing a mobility and fuel strategy in a participative process. The strategy aims to define fields of action and integrate measures for low carbon transport to reach the reduction targets (BMVBS, 2012).

Table 5.1 provides an overview on some key measures that have been reported to the United Nations Framework Convention on Climate Change as part of Germany's National Communication on observed and projected changes in GHG emissions and policy initiatives. The measures were implemented between 2000 and 2007 and continue to be operational. By expanding the use of biofuels, the federal government aims to reduce by 7 percent the CO_2 emissions related to petrol and diesel consumption. This translates to a 12-percent aimed share of biofuel by 2020. The expansion of biofuel use is projected to be one of the most important measures for reducing CO_2 emissions in the transport sector. However, as the total effect of the measures will not be sufficient to achieve emissions-reduction target in transport, additional measures have been implemented or are under discussion. For instance, the tightened vehicle emissions standard (95 g CO_2/km by 2020) will lead to additional reduction of 3 million metric tonnes. The combined measures are estimated to account for GHG-emissions reductions of 28 million metric tonnes or about 18 percent below the 2005 levels (IEA, 2012).

Table 5.1. Estimated Emissions Reductions Based on Germany's Integrated Energy and Climate Programme and Other Transport Measures (metric tonne)

Measure	Type of Instrument	Estimated CO_2 Reduction by 2020 Compared to 2005
CO_2 Strategy for Automobiles	Regulatory, efficiency	-6 million metric tonne
Expansion of Biofuels Use	Regulatory, fuels	-10,5 million metric tonne
Conversion of Motor Vehicle Registration Tax to CO_2 Basis	Fiscal, efficiency	-3 million metric tonne
CO_2 Labelling for Cars and Light Trucks	Information, efficiency	- 4 million metric tonne
Additional CO_2 Reduction from Heavy Vehicle Toll	Fiscal, efficiency, demand	-0,3 million metric tonne
Air Transport in EU ETS (EU directive)	Regulatory, efficiency, demand	not accounted
Promotion of Electric Vehicles (Electro mobility plan)	Research, investment, efficiency	not accounted
Other measures		
Ecological Tax Reform (1999–2003)	Fiscal, efficiency, demand	-2 million metric tonne
Subtotal		**-26** million **metric tonne**
Additional Effects Due to Synergies of Several Measures		**-2** million **metric tonne**
Total		**-28** million **metric tonne**

Source: Federal Environmental Agency (UBA).

3.1. Fuel and Vehicle Taxation and Standards

Germany has implemented relevant measures in recent years that combine fuel and vehicle taxation to improve the efficiency of vehicle fleets as well as vehicle use and influence modal choice. The following sections briefly explore the key policies that shape Germany's vehicle fleet and use.

Fuel taxation

As part of Germany's Ecological Tax Reform ('Ökosteuer', discussed in more detail later), petrol and diesel prices increased by 3.07 cents per litre and year (totalling an increase of 15.34 cents per litre as of 2003) from 1999 to 2003. This aimed to internalise a part of the external costs and increase energy efficiency in the transport sector. By 2012, the energy tax on transport fuels was 65.45 cents per litre of petrol, 47.04 cents per litre of diesel, and 18 cents per kg of CNG or LNG (BMF, 2012).

Vehicle taxation

Since January 2009, the motor vehicle tax (annual circulation tax) has included a CO_2-based calculation. The new system applies only to newly registered automobiles. This tax, which takes account of typical CO_2 emissions of vehicles and has lower rates for vehicles with especially low emissions, supplanted the mineral-oil-taxation advantage that favoured diesel engines. In addition to taxation based on engine size, the CO_2 taxation accounts for 2 euros per gram of CO_2, above the margin of 110 grams in 2012–2013 and above 95 grams in 2014. The implementation of the CO_2-based motor-vehicle taxation is estimated to lead to a reduction of about 3 million tonnes of CO_2 per year by 2020. For vehicles in service as of 31 December 2008, motor vehicle taxes are not directly related to CO_2 emissions but on engine size and European emission standards. Tax rates were increased for the Euro 2, Euro 3, and Euro 4 emission categories in relation to emission-dependent taxation of other vehicles and, for old vehicles in Euro 1 category and below, higher tax rates were retained (ITF, 2010).

Box. 2. Tax Policies that Negatively Affect Road Transport Energy Efficiency

Some suggest that tax policies in Germany have a potentially counterproductive effects on energy efficiency of road transport. Deducting commuter travel from income tax has this potential. Until 2001, only travel by car was eligible for income tax deduction, then considered as boosting urban sprawl as it fiscally incentivised long distances between home and work (UBA, 2010). A fixed rate by kilometres travelled can be deducted. Now applicable to all modes of travel, this tax deduction option is still considered as providing unjust benefits for car-based commuter travel. The maximum limit of deductible costs, for instance, can be increased if the commuter uses a private car (UBA, 2010). Tax incentives for home ownership and building are also considered to contribute to urban sprawl and incentivise commuting by car.

Source: Hirte and Tscharaktschiew (2012).

Vehicle energy efficiency standards

CO_2 emissions targets have been introduced to implement the European CO_2-oriented strategy for automobiles. Passenger cars are required by EU regulations to achieve, on the average, an emission level of 130 g CO_2/km by 2015 and a tightened level of 95 g CO_2/km by 2020. Since the requirement calls for the average amount of carbon of the fleet, manufacturers can have a number of higher-emitting vehicles in the fleet as vehicles emitting less carbon balance out the average. With the relatively high shares of heavier cars in Germany, the European limits are expected to lead to an average CO_2-emissions level of 143 g CO_2/km in 2015 and 105 g CO_2/km in 2020 for all new automobiles registered in Germany. In addition to these reductions, which are to be achieved via improvements of engines/power plants, cuts in emissions of 10 g CO_2/km are expected from implementation of non-engine-related measures.

Vehicle fuel efficiency labelling

Emission labelling based on fuel consumption and CO_2 emissions for new automobiles was introduced in January 2008. Energy efficiency is given as the relation of CO_2 emissions and vehicle weight. The efficiency classification, ranging from A+ (best) to G (worst), is dependent on the deviation of a particular vehicle model from a reference value for the respective vehicle class. The efficiency classification allows less than 111.5 g CO_2/km for automobiles with 1,000 kg of empty weight in efficiency class A and the limit raises with weight to 171.5 g CO_2/km with 2,000 kg empty weight. UBA (2012) suggests, however, that this measure by itself has only a limited effect on CO_2 mitigation.

Table 5.2. CO_2 Efficiency Classes (Pkw-Energieverbrauchskennzeichnung)

CO_2 Efficiency Class	Deviation from the Reference Value
A +	≤ -37 %
A	-36,99 % bis -28 %
B	-27,99 % bis -19 %
C	-18,99 % bis -10 %
D	-9,99 % bis -1 %
E	-0,99 % bis +8 %
F	+8,01 % bis +17 %
G	> +17,01 %

Source: UBA.

3.2. Alternative Energy Carriers (Biofuels and Electro Mobility)

As part of its second Economic Stimulus Package, the German government has invested heavily in the development and commercialisation of electric mobility. Part of this programme is the establishment of pilot regions for electric mobility, which included the establishment of test sites and basic infrastructure. Research programmes to evaluate the effectiveness of the individual projects accompany the scheme. A study by the Wuppertal Institute on the electro-mobility model regions suggests that a substantial net climate benefit may not be achieved before 2030 considering the dependence on the electricity mix (Schallaböck et al., 2012).

Natural gas is supported as transport fuel through the application of a reduced tax rate on natural gas for passenger cars or duty vehicles. A reduced tax rate is also applied to liquefied petroleum gas. Although the reduced tax level is valid until the end of 2018, an extension up to 2030 is under discussion. However, the Federal Environmental Agency has stated that natural gas has very limited potential as far as GHG mitigation in the transport sector is concerned as its extraction and transport are associated with leakage of methane. As supply distances for natural gas are very far (mainly from Russia), leakage rates are high.

Although biofuels have long been considered to play a vital part in Germany's low-carbon transport policy, this view has somewhat changed in recent years. The federal government has subsidised biodiesel by imposing lower taxes on it compared to other fuels. The reduced tax level made Germany the biggest producer of biodiesel in the EU with more than 3 billion litres produced in 2007, mainly from rapeseed. The biodiesel production in Germany, however, slightly declined to 2.7 billion litres in 2011 (Flach et al., 2012). One factor that triggered this decline is the phaseout of the tax exemptions for biodiesel, which led to an increase in tax to 45.03 cents per litre from only 18.6 cents before 2011.

Several blending regulations are in place for petrol (10 percent) and diesel (7 percent). Biofuels, however, are increasingly treated with more caution with regard to their emission benefits over their life cycle and are also perceived less positively by the general public (Anderson-Teixeira, Snyder, and Delucia, 2011). In 2009, the government released a regulation to ensure the sustainability of biofuels under consideration of life-cycle emissions (Biokraftstoff-Nachhaltigkeitsverordnung). The regulation states that biofuels can only be declared as sustainable if they result in emission reductions of at least 35 percent over the production and supply chain compared to fossil fuels. Biofuels that do not meet these standards are not eligible for tax reductions and the biofuel quota.

A key vehicle for future activities of the federal government on alternative energy carriers and mobility options is the Mobility and Fuel Strategy. The strategy, currently being developed by the federal government, builds on a broad-based dialogue process with about 400 businesses; associations; and experts from society, industry, politics, and scientific community (BMVBS, 2012). In 18 workshops and expert discussions in 2012, the stakeholders expressed their points of view on current challenges and future needs for political action in the different fields of the transport sector, with focus on fuels. The first stage of the process had stakeholders addressing relevant challenges and identifying unresolved issues. The second stage introduced expert knowledge on these issues, while on the final stage, the stakeholders proposed political measures for the development of a sustainable transport system.

3.3. Freight Transport and Urban Logistics

One of the measures to improve the efficiency of long-haul road freight transport in Germany that received international recognition is that the road-use toll rates for trucks were assessed based on the vehicle's emission class and number of its axles. For a three-axle heavy vehicle, the charge per kilometre ranges from 10 to 23 cents, depending on the emission standard of the vehicle. In 2010, the heavy-vehicle road-user charge (LKW-Maut) generated €4.48 billion, of which €600 million are earmarked for the reduction of light-duty vehicle taxes (€100 million) and the promotion of low-emission vehicles, driver trainings, and environmental programmes (€450 million). It is estimated that the heavy-vehicle toll will lead to reductions of 0.3 million tonnes of CO_2 by 2020 compared to 2005 (UBA, 2009). So far, no detailed ex-post evaluation with a focus on its climate change mitigation aspects has been carried out.

Table 5.3. German Heavy Vehicle Road User Charges (€/km)

Year	Axle configuration	Exhaust emission standard			
		EURO IV and cleaner	EURO II and EURO III		Pre-EURO and EURO I
2003	Up to 3 axles		€0.10	€0.13	€0.15
	4 and more axles	€0.12	€0.15	€0.17	
2005	Up to 3 axles		€0.11	€0.14	€0.16
	4 and more axles	€0.12	€0.16	€0.18	
2010	Up to 3 axles		€0.10	€0.23	€0.15
	4 and more axles	€0.12	€0.15	€0.18	

Source: Doll and Schaffer (2007).

City logistics concepts have been applied in Germany with varying degrees of success. In general, they aim to improve efficiencies in the delivery and collection of goods, consolidating trips, increasing load factors, and reducing handling and transaction costs. Among the solutions that have been implemented in Germany are regulations (traffic restrictions, low emissions zones), transport pricing and taxes, transport planning, and the development of infrastructure dedicated to urban freight (lorry lanes, delivery and loading spaces, urban consolidation centres). Many cities in Germany have dedicated loading zones, either as zones where private parking is restricted or as separate space with dedicated infrastructure. Often, delivery or loading in these zones is time-restricted. Some public authorities provide research and development funds and regulative support for urban consolidation centres where deliveries can be consolidated for the last kilometres of the trip into the target area. The consolidation of deliveries is intended to lead to a high level of vehicle utilisation and to alleviation of local environmental and traffic concerns. However, the effectiveness of city logistics concepts has very often been negatively affected by competition between shippers and by conflicting objectives. Consequently many urban consolidation centres either closed down or operate below capacity.

4. Outcomes and Impacts

A cornerstone of Germany's policy approach, sustainable development is widely accepted by all major parties, business community, and labour unions. While it is acknowledged that current measures will not be sufficient to bring transport on a 2-degree pathway, some countries have shown reasonable progress. Germany, France, and Japan are three of the few developed countries that have seen a policy-led decline in GHG emissions in recent years. These countries stand out as they have seen their energy-use-related GHG emissions stabilise or even decrease despite economic growth over the same period (IPCC, 2014). Germany has committed to reduce GHG emissions by 40 percent if the other EU member states would agree to the EU's 30-percent reduction target for 2020. The framework of this economy-wide target is Germany's Integrated Climate and Energy Program, which sets out policy measures for the energy sector.

Among the industrialised countries that have already achieved a relatively low level of per capita CO_2 emissions in the transport sector, France, the United Kingdom, and Germany have made noticeable progress in recent years with well below 2 tonnes of CO_2 emissions (Figure 5.3), still far from stabilisation levels consistent with a 2-degree scenario, but lower than those of many OECD countries.

While environment and climate change are the core elements of the policy framework now, the development towards a more efficient economy started with the 1970s oil crisis. After the first decade of energy efficiency and conservation policies, the outcome was already becoming distinguishable. By 1985 or 12 years after the first oil price shock, the total primary energy consumption was about the same as in 1973. While the economy grew by nearly one quarter over the same period, the number of licensed cars increased by 8.8 million to 25.8 million, and the number of centrally heated dwellings rose by about 3 million units to some 25 million (Schiffer, 1986). Not only did the numbers increase, but cars also attained larger engines and homes became larger and more comfortable. Despite this significant increase, total energy consumption practically remained constant. During the years of setting the political and policy course from the first oil price shock through the decline of the oil price in the mid-1980s, the German case shows a picture of a combination of oil substitution and conservation of energy (Hohensee, 1996). In these years (1973–1984), the primary energy consumption of petroleum decreased from 208.9 million tonnes coal equivalent (MTCE) to about 161 MTCE, representing a decline of almost one quarter (Statistisches-Bundesamt, 2006). This development had provided a good basis from a societal and economic perspective for more ambitious measures that culminated in the Energiewende, the transition to a low-carbon energy system, which included the phaseout of nuclear power in Germany and the shift towards renewable energies, increasing the share from 17 percent today to more than 80 percent in 2050 and reducing GHG emissions by 40 percent by 2020 and at least 80 percent by 2050.

5. Implications for Policy and Practice

Political continuity and integration

Germany is a typical consensus democracy where political decisions are often based on a broad coalition between major political parties and relevant stakeholders. German legislators have a manageable number of negotiating partners who represent large constituencies. Consultations with the major peak organisations leave the German members of Parliament and ministers with a relatively high level of certainty about the positions of relevant stakeholders, which helps shape policies and paves the way for successful implementation. The policymakers' perception translates into tangible numbers when comparing the consultation process of the German Eco-Tax legislation. In Germany, 45 chief executives of the key interest organisations (unions, employers, energy industry, environment, energy consumers, tenants, landlords, etc.) are heard by the members of the select committee. Each interest domain is represented by no more than three individual organisations; some are even represented by only one, with sufficient mandate to bargain on behalf of a large group. The

German approach to sustainable development is based on the concept of political balance and broad policy coalitions to ensure durability. As in other corporatist countries, Germans are used to being regulated and German legislators are used to regulating (Scruggs, 2001). It is important to note that corporatist structures alone do not necessarily lead to better environmental outcomes. Until the 1970s, the German corporatist structures, particularly unions and employers, resulted in more negative environmental performance. The focus of the unions was to ensure high employment rates through economic growth, often at the expense of environmental sustainability. However, when environmental and energy resource pressures increased, sustainability issues were incorporated and a new consensus was formed.

Policy integration

The German policy approach is driven by a systemic approach that aims to generate synergies among policy objectives, which link to the desire to build coalitions among stakeholders. For example, from the perspective of climate change mitigation, while vehicle efficiency and low-carbon fuels may have the biggest potential to reduce CO_2 emissions, these do not fully reflect a broader sustainable development perspective. A multimodal and integrated policy approach can minimise rebound effects, overcome split incentives, and achieve a higher level of socio-economic co-benefits (Givoni, 2014). Energy efficiency and low-carbon fuels have a key role to play in decarbonising the transport sector. However, the strategies are the measures that yield substantial opportunities to contribute to sustainable development.

From the perspective of climate change, the considered co-benefits of sustainable transport measures such as air quality, safety, energy efficiency, access to mobility services, and other factors are in fact the driving factors, particularly at the local level, for policy intervention (Goodwin, 2004; Hultkrantz, Lindberg, and Andersson, 2006; Jacobsen, 2003; Rojas-Rueda, Nazelle, Tainio, and Nieuwenhuijsen, 2011). As transport relies almost entirely on petroleum products, energy security is a major issue for the sector products (Sorrell and Speirs, 2009; Costantini et al., 2009; Cherp et al., 2012). Energy security is directly linked to climate-change mitigation actions that focus on fuel switch options, such as biofuels and electrification (Leiby, 2007; Shakya and Shrestha, 2011; Jewell, Cherp, and Riahi, 2013) and demand-side measures, such as fuel efficiency, shift to more efficient transport modes, and compact urban design (Cherp et al, 2012; Leung, 2011; Sovacool and Brown, 2010). These strategies are also likely to improve access to mobility services and reduce transport costs, which positively affect productivity and social inclusion (Banister, 2008; Miranda and Rodrigues da Silva, 2012) and provide better access to jobs, markets, and social services (Banister, 2011; Boschmann, 2011; Sietchiping, Permezel, and Ngomsi, 2012). Improved access is likely to have positively impact employment. A major cost factor generated by inefficient transport systems is congestion. Time lost in traffic was valued at 1.2 percent of GDP in the UK (Goodwin, 2004); 3.4 percent in Dakar, Senegal; 4 percent in Manila, Philippines (Carisma and Lowder, 2007); 3.3–5.3 percent in Beijing, China (Creutzig and He, 2009); 1–6 percent in Bangkok, Thailand (World Bank, 2002), and up to 10 percent in Lima, Peru, with daily travel times of almost 4 hours (JICA, 2005; Kunieda and Gauthier, 2007). The combination of various policy objectives that can be addressed by an integrated multilevel policy and governance approach provides a solid basis for durable policies that can have long-lasting impacts. Climate change, air quality, noise prevention, safety, energy security, and productivity are key policy objectives for local and national policymakers, even if in varying degrees (De Hartog, Boogaard, Nijland, and Hoek, 2010; Jewell et al., 2013; Rabl and de Nazelle, 2012; Tiwari and Jain, 2012).

Both the integrated political and policy approaches are vital factors to the (relative) success of Germany's sustainable development over the last decades. While institutional structures are not easily transferable to Southeast Asian countries, the general approach might at least be of some guidance when developing policies in the region. This would include the development of a wider strategic framework and the aim to build broader coalitions to create policy continuity, in particular in sectors that rely on long-term infrastructure and investment.

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Chapter 6

Germany BMW's Sustainability Strategy of Evolution and Revolution towards a Circular Economy

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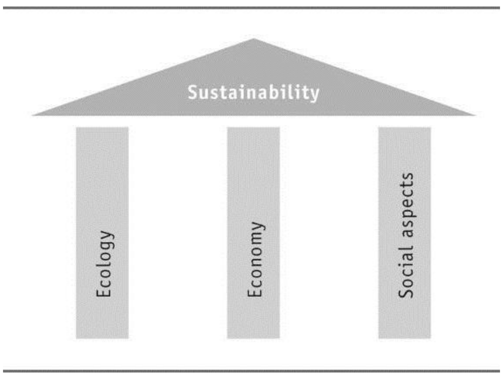
1. Introduction

When talking about sustainability in the academic context of Germany, at least three dimensions of the so-called 'triple bottom line' are considered: economic, social, and ecological.

Figure 6.1. Three-Pillar Model of Sustainability



Source: Ernst and Sailer (2015).

This is in line with internationally accepted sustainability and corporate social responsibility reporting principles such as the Global Reporting Initiative and the Dow Jones Sustainability Index. This chapter will emphasise the circular aspects of the ecological pillar. Nonetheless, the interrelations to other dimensions, if useful, will be briefly explained.

Within the ecological dimension, three basic strategies can be distinguished: (i) Efficiency; (ii) Consistency, also known under the terms of 'Cradle to Cradle' (Braungart, McDonough, 2002); and (iii) Sufficiency (also through Share Economy, e.g. car sharing).

BMW was chosen as example partly due to its comprehensive approach to sustainability and partly due to its role as one of the leading companies in the passenger vehicle industry and with regard to electro-mobility. The holistic approach is reflected in BMW's description of its sustainability management approach:

> For us (BMW), sustainable operations constitute a long-term business case: sustainability means making a lasting positive contribution to the company's economic success. However, we don't measure success by financial indicators alone but rather in terms of the solid integration of the company into society. Taking social and environmental responsibility for all we do is an integral part of our corporate image. We are convinced that the lasting economic success of any enterprise these days is based increasingly on acting responsibly and ensuring social acceptance. We also believe that the manufacturer with the most efficient and resource-friendly production processes will be the future industry leader, offering its customers state-of-the-art solutions for sustainable individual mobility (BMW, 2014).

BMW is also an example for the transition process of the German premium car industry towards sustainability, especially ecological sustainability. Other premium car companies are in a similar transformation mode although following different strategies to reach the targets defined by the market, policymakers, and society.

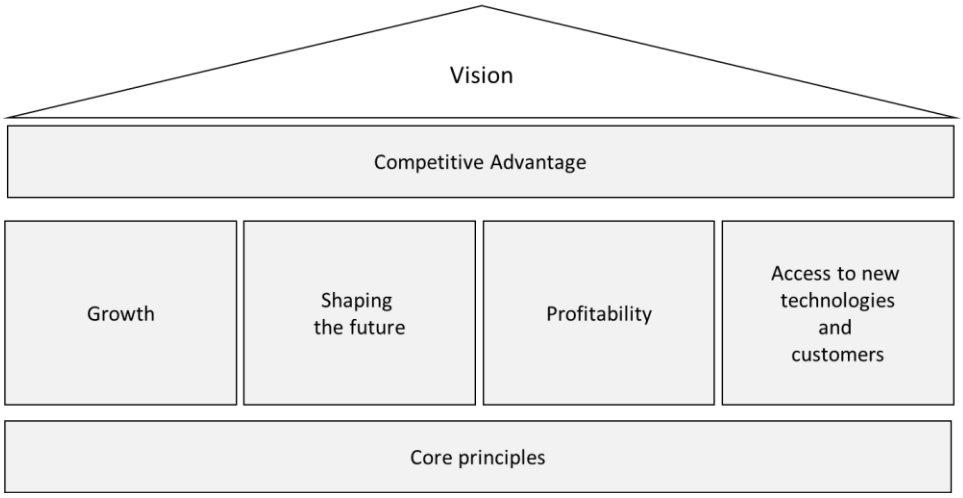
2. Case Context: Background Information About BMW and the German Premium Car Industry

A total of 73 million cars were sold worldwide in 2014. About six percent of those were considered premium cars from the three leading German car makers: BMW, Audi, and Mercedes-Benz. Among the three companies, BMW is considered to be the market leader as proven by various indicators such as total sales, profitability, or employees (Automobilwoche, 2015a). In 2012, BMW was leading the automotive industry with an estimated brand value of US$24 billion (BrandZ, Millward Brown, 2012).

2.1. Motivation of the Firm for a Circular Strategy

BMW's sustainability strategy, passed in 2009, was derived from its previously created and agreed strategy programme called 'Strategy Number ONE' and is its overarching strategy for all its corporate divisions worldwide. BMW's main aim is to establish sustainability along the entire value chain and in all its basic processes, and thus create added value for the company, the environment, and society.

Figure 6.2. BMW's Strategy Number ONE



Source: Author's illustration based on BMW.

Sustainability has been the BMW Group's strategic corporate objective since 2009. Each of its major projects is, therefore, measurable in terms of sustainability. This ensures that, in addition to economic factors, environmental and social aspects are considered in the decision-making process. By taking this into account, BMW is convinced that the value of a company is not measured solely by direct financial indicators but also by its non-financial performance.

2.2. Current Concerns, Issues, and Potential Opportunities

The automotive industry is transforming traditional combustion engine concepts into new drive concepts that promise lower emissions and, therefore, reductions of emissions that cause climate change and global warming.

To reach the goals of CO_2-emissions reductions agreed in cross-national agreements such as the Kyoto Protocol to the United Nations Framework Convention on Climate Change (UNFCCC), governments have stated goals towards carbon-neutral mobility. The German government, for its part, has been pushing for e-mobility by stating, through Germany's Chancellor Angela Merkel, a clear objective: 1 million e-drive cars on the road in Germany by 2020 and 6 million e-drive cars by 2030 (Automotive IT, 2011). Besides the initiative to make the German car industry a 'leading supplier' in that technology (*Leitanbieter*), the intention is also to make Germany a 'leading market' (*Leitmarkt*). So far, government incentives are rather limited to be able to support this goal with a policy. Thus, additional measures are being discussed between policymakers and industry associations.

Furthermore, consumers are still hesitant to buy e-cars, partly due to higher cost and current limitations (e.g. charging duration, range limitations, availability of charging stations) and to limited long-term experience with that technology (e.g. battery lifetime).

But as can be seen in the various efforts of the industry players, different technological and commercial approaches for cleaner mobility options are being tested for market success. Besides e-mobility are approaches on fuel cells and biogas and combined approaches using hybrid technology, range extenders, etc.

Some industry observers are also concerned about the consequences to the German car industry of the transition towards e-mobility as the technological know-how needed is much different from that of traditional combustion engine technology. The demand for traditional expertise in mechanical engineering and metal works is expected to be replaced by a need for know-how in electronics, battery technology, and lightweight composite technology materials.

Another key driver for the car industry strategy are the regulations of the European Union (EU) on CO_2 and NOx emissions for diesel engines. Here, the current testing methods are being discussed due to their irrelevance to real driving conditions. A new EU proposal is being developed to redefine the testing to measure the so called 'real driving emissions' (Becker and Vieweg, 2015; Mock, 2014).

The EU regulations measure the average CO_2 emissions of a car company and require car manufacturers to adjust their product offerings and product mix. In China, emission problems in major cities have led to laws making e-mobility mandatory. Examples can already be seen in Beijing, Tianjin, and other big cities where small motorcycles run on electricity. The American and Norwegian governments are supporting e-mobility with incentives. This has led to more than 280,000 electric or hybrid cars registered in the US, mainly in California (Automobilwoche, 2015b).

Beyond the environmental requirements are the changes in society. An issue, as reported, is the increasingly reduced interest of younger generations in automobile products, especially in urban regions. These changes and other aspects of sustainability have lead BMW to anticipate future mobility needs with future mobility projects such as the BMW i360 degrees ELECTRIC, the car-sharing platform DriveNow, locating and paying at ChargeNow charging points, parking at ParkNow and ParkatmyHouse, navigating with the smartphone app MyCityWay, and Life360 to bring together family members across the city (BMW, 2014). A variety of research projects are looking into various issues of future mobility including Future City Planning, long-distance commuters, wind energy, mobility cultures in World's Megacities, as well as the contribution of information and communication technologies (BMW, 2014).

To identify issues that may represent risks and opportunities, BMW has established a so-called 'materiality process' to find out what those issues mean for the different stakeholders and, internally, for BMW. The results of the materiality analysis, inserted into a two-dimensional materiality matrix with the two dimensions 'Importance for BMW Group' and 'Importance for Stakeholders', are the input for the further development of the sustainability strategy (BMW, 2014).

BMW is responding to those challenges with a strategy of parallel evolution and revolution, which means that BMW is improving efficiency and emissions of combustion engines (evolution) and introducing a revolutionary product line of e-cars (i-series i3 and i8).

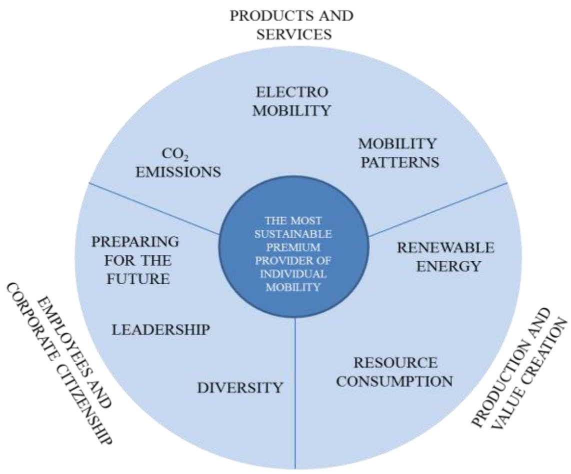
3. Description of Actual Steps and Strategies Adopted

3.1. BMW's Sustainability Strategy

For BMW, leadership in premium mobility also means excellence in sustainability issues:

> Our understanding of the term 'premium' is now being taken to a new level with the BMW i brand. Inspired through and through by the desire for even greater sustainability, the BMW i epitomizes the vehicle of the future – with its electric drivetrain, revolutionary lightweight construction, exceptional design and an entirely newly designed range of mobility services (BMW, 2015a).

Figure 6.3. BMW's Sustainability Goals and Strategy



Source: Author's illustration based on BMW.

3.2. Product Responsibility – 'Evolution and Revolution'

In response to the changes in the marketplace, BMW is pursuing a proactive strategy. Rather than react to a changing environment, the company intends to pioneer and drive the transformation process. BMW describes this proactive strategy as a combination of evolution and revolution. Evolution refers to the further development of the combustion engine technology, the construction of lightweight cars, hybrid drivetrains, and increased resource efficiency in the production processes. Revolution refers to carbon-free mobility with new types of drivetrains and ambitious targets in the area of new materials, resource-efficient production, and mobility service innovations (BMW, 2014).

The revolutionary part of BMW's sustainability strategy materialises primarily with the launch of the BMW i family, following its intention of positioning BMW as an innovation leader in the area of e-mobility to take the integration of sustainability along the value chain to a new level. The company's differentiation is based on the claim of being the only premium manufacturer that offers, since 2013, purpose-built vehicles for electric drivetrains using a carbon body technology that significantly reduces vehicle weight. Beyond those technological differences, a service concept called 'BMW i services' is creating sustainable mobility on the premium level (BMW, 2014).

The BMW i8 is supposed to combine the driving performance of a sports car with the fuel consumption of a compact-class model. The plug-in hybrid system developed for the BMW i8 is designed to meet the highest specifications in terms of driving dynamics, efficiency, practical usefulness, and quality, with the target to underline the BMW Group's pursuit for technological leadership in the field of drive system development. In the long term, the BMW Group plans to transfer the eDrive technology to its other core brand models (BMW, 2015a).

In line with BMW's holistic understanding of sustainability, the electricity for the assembly of the BMW i3 and BMW i8 at their Leipzig factory is coming completely from renewable resources (BMW, 2014).

The evolutionary part of the sustainability strategy is what the company is branding as 'efficient dynamics'. This means that the organisation is working continually to optimise the range of combustion engines featuring the so-called TwinPower turbo technology. The efficient dynamics family of engines, comprising 3-, 4-, and 6-cylinder power units, reflects the output of a systematic development process. Higher aluminium content plus the use of the lighter magnesium has enabled BMW to reduce the average weight of its latest range of engines. The first of a new generation of engines is a 1.5-litre, 3-cylinder petrol engine which found its first release in the BMW i8. BMW also presented the first 4-cylinder versions of the new engine family in 2014.

The possible integration of a plug-in hybrid system is part of BMW's thinking when new BMW and MINI models are being developed, thus ensuring, among other things, that future model variants equipped with hybrid drive technology will be just as suitable for everyday use as their standard counterparts. The BMW Group took a further step forward in the field of power train electrification with its presentation in 2014 of the newly developed range of hybrid drive systems intended for high-performance electric drives based on Power eDrive technology. In future-generation plug-in hybrid vehicles, around two-thirds of the drive system's output should come from the Power eDrive electric system and around one-third from the so-called TwinPower turbo technology combustion engine. Furthermore, the BMW Group is developing battery-powered drive systems (as in the BMW i3) and plug-in hybrids, as well as fuel-cell electric technology and high-voltage electrified systems (the so-called Power eDrive). The BMW Group intends to continue to be able to react flexibly to the needs of customers and new legislative regulations by using its wide range of drive systems (BMW, 2015b).

To summarise and relate this to the three basic strategies towards ecological sustainability through a circular economy, those improvements in the evolutionary part of the strategy can be categorised mainly as an efficiency strategy. The revolutionary part of the strategy of e-mobility can also be related to a consistency strategy, especially when using electricity from renewable resources. This is implemented by an innovative materials concept.

3.2.1. Lightweight construction

Lightweight construction is an essential component of the BMW Group's efficient dynamics strategy and embedded in its basic understanding of modern manufacturing. The consistent use of lightweight materials in vehicle design is particularly important with electrically powered cars, as not only the battery capacity but also the total weight of the vehicle restrict their range. To compensate for the added weight of the electrical components, the BMW Group has developed a so-called LifeDrive concept for the BMW i series vehicles.

In this context, the BMW Group has achieved an innovative combination comprising an aluminium chassis and a carbon-fibre-reinforced-plastic (CFRP) passenger compartment. By doing so, the material used helps reduce total vehicle weight, improves its point of gravity, and increases the stability of the car's body. The BMW Group is currently working on further possible applications, such as hybrid wheel rims made of a mixture of aluminium and CFRP.

After more than 10 years of research work and continual optimisation of the processes, materials, systems, and tools involved, the BMW Group is claiming to currently be the only automotive manufacturer with the required know-how to utilise carbon-fibre-reinforced-plastic on a large-scale production basis (BMW, 2015a). This approach to alternative drive can also be summarised under the term 'purpose-build approach', whereas other car manufacturers follow a 'conversion approach' by replacing the combustion engine with an electric drive (BMW, 2014).

3.2.2. BMW i 360°ELECTRIC for charging

Another important aspect for the successful conversion towards e-mobility is the charging infrastructure. With BMW i 360°ELECTRIC, BMW currently offers a package of products and services for purely battery-powered and plug-in hybrid vehicles in 38 countries worldwide.

The package is based on four features: comfortable, rapid, emissions-free charging at home; simple comprehensive access to public charging stations; flexible mobility for long-distance journeys; and an assistance service for maintenance and repairs (BMW, 2015b).

BMW offers two types of products for charging at home. In addition to the Wallbox Pure for simple, safe charging, the Wallbox Pro has been available since 2014 for faster charging. Furthermore, BMW is offering a service contract for electric power from renewable energies (PV, wind power, water power, biomass) provided by the energy partner company Naturstrom in Germany (BMW, 2015b).

3.2.3. Premium services for individual mobility

Beyond its innovative electric and hybrid cars, BMW i also stands for sustainable mobility concepts. The aim of the mobility services is to promote urban mobility, irrespective of the means of transport used. Some examples of those services will be described in subsequent paragraphs.

MINI and the rental car company Sixt enable users to rent BMW and MINI vehicles according to their needs. Through an app, website, or directly on the road, users can find, book, and park cars again in another part of the city. BMW's car-sharing service DriveNow is currently available in Munich, Berlin, Düsseldorf, Hamburg, Cologne, San Francisco, Vienna, and London. By the end of 2014, the fleet was consisted of about 2,800 cars and over 390,000 customers had subscribed to the car-sharing service. Under the brand name AlphaCity, BMW also offers a car-sharing scheme for businesses (BMW, 2015a).

ParkNow is an app- and web-based service that helps solve parking problems for users by having available parking spaces in partner car parks that can be booked online and making it easier to find roadside parking spots (BMW, 2015a).

ChargeNow is a BMW i mobility service that simplifies finding and using public charging stations run by various suppliers belonging to an international network. In 2014, many BMW i customers opted for this service. ChargeNow currently has over 24,000 charging points in 19 markets (BMW, 2015a).

To ensure optimum conditions for the use and promotion of innovative mobility services, BMW i Ventures was founded in 2011. Based in New York, BMW i Ventures facilitates access to new technologies and opens up new customer groups, thereby reinforcing the strategic approach adopted by BMW i. Life360, MyCityWay, JustPark, ChargePoint, and ChargeMaster are examples of BMW i Ventures' strategic investments (BMW, 2015a).

Some of the above-mentioned service concepts can be referred to the category of reaching sustainability by a sufficiency strategy, which means, in the terminology of circular economy, to 'reduce consumption of physical materials'. This is especially valid when talking about the car-sharing concepts of DriveNow.

3.3. Resource Efficiency and Recycling Management

Intelligent design and the use of secondary and renewable raw materials enable the company to reduce the consumption of valuable resources. By optimising recycling structures, the car producer is preparing for the future. BMW earned recycling experience with the German and European markets in the early 1990s and its recycling system is gradually being rolled out internationally. In 2013, this was established in 30 countries (BMW, 2014).

Legally required recycling rates for end-of-life vehicles, components, and materials with a quota of 85 percent for reuse and recycling and 95 percent for overall recovery by 2015 were already fulfilled by BMW in 2008 (BMW, 2014).

The secondary use of raw materials is another aspect of a circular economy. BMW’s recyclates quota of thermoplastic materials increased in some products, from 15 percent in 2011 to 20 percent in 2013. With the new lightweight carbon-fibre-reinforced plastics, BMW is facing new challenges in the use of resources. Pure fibre material from manufacturing waste can be reused directly, whereas plastic-reinforced carbon fibres have to go through a separation process like pyrolysis and can then be processed further (BMW, 2014).

3.4. Group-Wide Environmental Protection

BMW aims to be the most resource-efficient premium provider of individual mobility, a goal being approached by a comprehensive, group-wide environmental management. BMW tracks and monitors relevant environmental indicators and its major investment decisions are also based on environmental considerations (BMW, 2014).

Environmental protection started in the early 1970s and BMW’s environmental guidelines were established in 1993 based on the ICC Charta for Sustainable Development and Agenda 21. BMW’s manufacturing processes are designed for minimum resource consumption and environmental impact. The International Declaration on Cleaner Production of the UN Environmental Programme was signed in 2001. BMW is aiming to contribute towards combating climate change by limiting greenhouse gas (GHG) emissions (mainly CO_2 emissions) through the manufacture of efficient vehicles, implementation of effective production processes, use of renewable energy sources, and selection of production locations (BMW, 2014).

In 2007, BMW defined a goal for 2006–2012 of reducing the consumption of resources and emissions per vehicle by an average of 30 percent. This was over-achieved with a reduction of 35.7 percent using the parameters of energy, water, process wastewater, waste for disposal, and solvent emissions. The new target for 2020 set by BMW is the reduced consumption per vehicle by 45 percent compared to 2006 (BMW, 2014).

Key performance indicators for 2013 were energy consumption of 2.36 MWh (2012: 2.41 MWh) per vehicle produced, waste for disposal per vehicle of 5.73 kg (down from 6.47 kg), water consumption of 2.18 cubic metres (down from 2.22 cubic metres) per vehicle produced.

Share of renewable energy increased from 36 percent to 48 percent as percentage of total power produced (BMW, 2014).

To improve energy efficiency, five strategic areas of action have been identified: (i) integrated energy management system; (ii) continuous improvement of ongoing operations; (iii) planning, implementation of energy-efficient properties, plants, and technologies; (iv) implementation of renewable energy projects; and (v) raising awareness, training, and motivating managers and employees on energy and energy efficiency (BMW, 2014).

The total CO_2 emissions were reduced from 0.94 tonne per vehicle produced in 2009 to 0.68 tonne per vehicle produced in 2013. Compared to the base year of 2006, BMW reached a reduction of 35.2 percent in 2013 (BMW, 2014).

Also, logistics is managed in a way to keep the environmental impact as low as possible. This is reached by expanding the use of low-carbon modes of transportation such as rail shipping. The share of vehicles shipped by rail was increased from 47 percent in 2009 to 60.7 percent in 2013 (BMW, 2014).

When BMW recycles materials or waste, the company is following the five-step hierarchical model defined by the EU: prevention, reuse, recycle, recovery, and disposal.

The action by the company resulted in a 69.7 percent waste reduction in 2013, compared to 2006 (BMW, 2014).

Other important environmental considerations at BMW are water as a scarce resource, emissions of volatile organic compounds (VOC), and biodiversity. Water consumption was reduced by 33.1 percent compared to the base year 2006. The target until 2020 is 45 percent reduction in comparison to 2006. In 2013, VOC emissions were reduced by 36.7 percent and for 2020, the target is 45 percent reduction (BMW, 2014).

3.5. Supplier Management

BMW's global supply chain network plays an important role in the success of the group's contribution to value creation, quality, and innovation to reach the company's sustainability goals. The company management focuses on managing and minimising risk as well as utilising opportunities and leveraging potential. Sustainability is also improved in the supplier network by providing sustainability trainings for purchasing managers. Another contributor to sustainability is related to internationalisation of sourcing to increase local sourcing (BMW, 2014).

To attain the sustainability goals, other important areas are to declare what principles and standards are mandatory to partners in the industry as well as the engagement of the company in industry initiatives and networks (BMW, 2014).

A really difficult issue is the management of the sourcing of raw materials. With today’s multi-layered global and dynamic supply chains with their intermediate trade and processing stages and commodity trading on stock exchange, the tracing of materials from the source to the finished end product is a very complex endeavour. Establishing and pursuing sustainability standards in raw material production are therefore a challenge (BMW, 2014).

BMW’s approach to that issue is to focus on selected, relevant, and critical supply chains and raw materials. Those supply chains are assessed and analysed to identify the need for action and, together with suppliers, measures are taken. BMW is participating in cross-industry initiatives such as the Aluminium Stewardship Initiative (ASI). Aluminium plays an important role in lightweight construction and BMW was the first car maker to join this initiative. ASI is the first comprehensive initiative for creating sustainability standards for the entire value chain of a metallic resource (BMW, 2014).

3.6. Sustainability Over the Whole Vehicle Life Cycle

BMW applies a comprehensive accounting method to assess the environmental, economic, and social impact of products across the entire life cycle. The method complements BMW’s Life Cycle Assessment System according to ISO 14040/44. To improve the environmental impact of next-generation products, life cycle engineering is applied (BMW, 2014).

3.7. Goals or Outcomes Expected

As also stated by *Automobilwoche* (2015a), the magazine for car industry insiders, the main challenge for premium car manufacturers is the environmental impact. Managing this challenge includes investing in alternative drives as well as offering small cars besides the rather heavy and large cars.

BMW has defined its long-term sustainability goal to be ‘the most successful and sustainable premium provider of individual mobility’. This overall goal is broken down into three subcategories: (i) products and services (CO_2 emissions, electromobility and mobility patterns); (ii) production and value creation (renewable energy and resource consumption); and (iii) employees and corporate citizenship (diversity, leadership, and preparing for the future) (BMW, 2014).

3.8. Key Stakeholders Involved and Perspectives of Various Actors

When looking at its customer base and positioning of the brand in the market, BMW has been famous for the claim *Freude am Fahren*, translated into English as ‘Sheer Driving Pleasure’ (US, South Africa) and ‘Ultimate Driving Machine’ (the UK, Australia), signifying a high affinity to sporty driving (BMW website, 2015). For traditional BMW customers, the replacement of large-volume 6- and 8- cylinder combustion engines by downsized 3- and 4-cylinder engines or even by a nearly noiseless electric drive was and is considered a major challenge, especially when taking into account the pricing premium on BMW automobiles compared to standard cars.

BMW's shareholders are classified into two major groups: the larger Quandt family who has a total share of 47 percent of all shares and who has held this investment since 1960, and the general public holding broadly distributed and traded shares. This means the BMW management is strongly influenced by a family with an unusual long-term perspective, which can be also described as the pursuit of economic sustainability. This is even more unusual, as Susanne Klatten, as part of the Quandt family (27 percent), together with BMW (18 percent), has also a major share in the composite material supplier SGL Automotive Carbon Fibres (*Automobilwoche,* 2015c).

Regarding suppliers, the case of SGL is especially interesting. To ensure the availability of innovative composite materials, BMW and the Quandt family have invested in SGL Carbon. This investment has gone through non-profitable phases and is still proving to be a major challenge in reaching economic sustainability (*Automobilwoche,* 2015c). This can be seen as an example of a trade-off between BMW's objective of profitability and the need for a reliable and performing supplier of innovative lightweight materials. This continues to be an implementation challenge, especially since the demand and production volumes are still limited to rather smaller figures.

The same applies to the other end of the vertical supply chain, where BMW has decided to work with selected distribution partners for the sales of the new i series and to pursue an innovative online distribution concept in some countries such as Japan. This trend has to be seen in the context of gaining access to new target groups who might not be attracted by the rather traditional retail concept of a car dealer. One success indicator is the claim that 75 percent of current BMW i3 customers had never previously driven a BMW (Wortmann, 2015).

BMW can be described as an attractive employer (it received various awards in 2013 like being fifth on the list of Universum World's most admired employers, being first in the automotive category) (BMW, 2014). The group-wide employee survey in 2013 indicated an overall satisfaction rate of 89 percent (BMW, 2014). The success of the company is also reflected in the additional hiring of employees, which led to increased employment from 105,000 in 2005 to 116,000 in 2014 (after a 10-year low of 95,000 in 2010).

Government as a key stakeholder has to be distinguished by country or region as policies and requirements differ in Europe, the United States (US), and Asian countries. This refers to varying incentives for electric cars and mandatory emissions standards for fleets. Efforts for coordinated regulations by region (within EU, the North American Free Trade Agreement [NAFTA] or Association of Southeast Asian Nations [ASEAN]) could be beneficial to successfully create a company's sustainability strategy.

4. Outcomes and Impacts

4.1. Accomplishments and Changes as Outcomes

In looking at the outcomes of BMW's sustainability strategy from the perspective of an independent third party, the data of the industry-independent International Council on Clean Transportation (ICCT) will be used. CO_2 emissions in the EU are reported based on the 2014 edition of *European Vehicle Market Statistics,* a statistical portrait of the passenger car, light commercial, and heavy-duty vehicle fleet in the EU from 2001 to 2013. For this region, 2013 was the first year in which the average CO_2 emissions from newly registered passenger cars fell below 130 g/km, the EU target for 2015 (Mock, 2014).

Within the European context, BMW, Mercedes Benz, and Audi are some of the brands with the highest CO_2 emissions in 2007, mainly due to vehicle weight and size, engine power, and engine displacement of the car fleet (Mock, 2014). Whereas the average engine power is 89 kW for all car brands in the EU member states, BMW is producing cars with an average engine power of 135 kW, higher than Mercedes (126 kW) and Audi (121 kW). Also, its engine displacement of 2,130 cm^3 is way above the average of all other brands (1,616 cm^3) (Mock, 2014).

Improved combustion processes and turbocharging allow manufacturers to extract more power from smaller engines. In the case of BMW, this has led to a decrease of engine displacement of 11 percent from 2,368 cm^3 in 2007 to 2,130 cm^3 in 2013, whereas the industry average decreased only 7 percent from 1,729 cm^3 to 1,616 cm^3 (Mock, 2014).

The EU average CO_2 emissions (also equivalent to the improvements of fuel efficiency) were reduced from 159 g/km to 127 g/km in 2007–2013, a reduction of 20 percent. The CO_2 emissions of the BMW car fleet went down from 176 g/km in 2007 to 136 g/km in 2013, a reduction of 23 percent. However, the reductions of its direct competitors, Mercedes Benz and Audi, are even bigger. Mercedes managed a 26-percent reduction from 189 to 139 g/km. Audi's fleet emissions were reduced from 184 to 135 g/km in the same period, a 27-percent reduction (Mock, 2014).

There are many possible interpretations for the reasons behind those reductions (composition of supply and demand by product categories, mix of engine technologies, etc.). As these data were results from the past, the reductions were related to the evolutionary strategy of efficient dynamics and not yet related to the revolutionary part of the strategy of electric mobility.

In 2014, the volume of carbon emissions produced by BMW's vehicle fleet sold in Europe decreased slightly to 130 gs CO_2/km (2013: 133 g CO_2/km; – 2.3 percent). The scale of the decrease in fleet emissions in 2014 was therefore not as pronounced as originally forecast, mainly reflecting the impact of a higher-value model mix on the one hand and the later-than-planned availability of the new MINI on the other (BMW, 2015a).

Another outcome from the recent introduction of the i series is that BMW became the market leader in e-mobility in Germany with 2,231 units of i3 sold in 2014. Worldwide, BMW ranks third in e-mobility sales after Tesla and Nissan Leaf with 16,000 units of i3 and 1,741 units of the Plug-in-hybrid sports car i8 sold. A key market in 2014 was the US with 6,000 units of i3 sold. In Norway (a country with less than 5 million inhabitants), BMW sold about the same amount of BMW i3 as in Germany due to tax incentives (no value-added tax) and cost-free charging infrastructure.

More holistically, a different way of looking at the outcomes beyond CO_2 emissions are sustainability awards. BMW has been awarded by various sustainability indices such as the Dow Jones Sustainability Index, the Carbon Disclosure Project, and the SAM Sustainability Award. The BMW Group achieved a strong result in the Global 500 Ranking Carbon Disclosure Project published in September 2013. With the maximum number of points possible, the company is described as an industry leader and listed on the Carbon Disclosure Leadership Index.

4.2. Concerns and Challenges that Still Remain

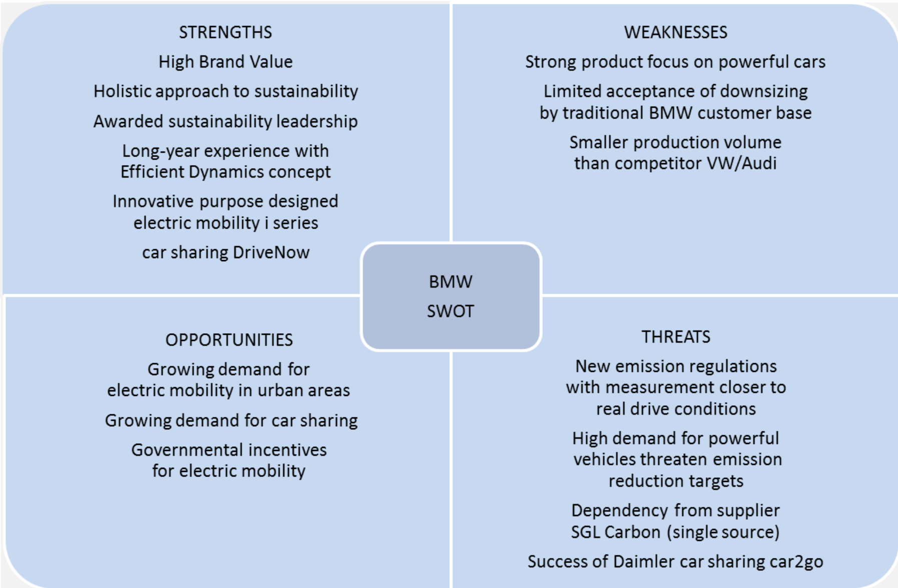
BMW's strategy of offering purpose-built electric and hybrid vehicles has to prove commercially viable. Other car companies are focusing on a manufacturing strategy that offers the production of different drivetrain technologies on the same production line. The advantage of such a strategy is that it can flexibly react to market demands for the various drivetrain technologies (petrol, diesel, hybrid, electric only). In comparison, BMW has created dedicated manufacturing facilities for the i series and its materials and components, which implies the risk of low capacity usage of those facilities.

Another challenge for BMW in meeting the EU emissions target is the ongoing strong demand for large, powerful, and heavy sports utility vehicles. Even if the company is changing their offering towards more energy-efficient and smaller vehicles, the final decision is taken by the customer. This is even more so if e-mobility is not yet cost-competitive with regard to total cost of ownership of such a product.

4.3. Lessons Learnt

To be a pioneer in certain technology always involves some risks of choosing the wrong approach or of entering the market too early. BMW is addressing those risks by following a combined strategy of evolution and revolution, which ensures economic stability by revenues and cash flow from the traditional car business while at the same time pioneering into future markets like e-mobility. A high-level SWOT (strengths–weaknesses–opportunities–threats) analysis briefly summarises BMW's current situation with regard to sustainability.

Figure 6.4. Sustainability SWOT Analysis for BMW



Source: Author.

5. Implications for Policy and Practice

5.1. What could have been done to further enhance outcomes? How could this experience be adapted or replicated?

The BMW example shows that emissions regulations by the EU and other regions impact the strategy of a car company. Furthermore, the case study shows that a proactive and innovative strategy towards sustainability and corporate responsibility contributes to a positive brand reputation and business success. If changes in the regulatory environment are to be expected anyway, such a forward-looking company strategy can lead to benefits in reputation and business success.

BMW has shown that environmental sustainability can be fun without necessarily stopping people from doing things or pursuing their preferred lifestyle.

On the other hand, BMW's sustainability strategy can be viewed in a critical way, especially in congested urban areas where the future individual mobility cannot only rely on automobiles and motorbikes but on public transport options as well. Whereas other mobility companies are pursuing a strategy with broader product range such as buses for public transport and trucks for logistics transportation, BMW is focusing on cars and motorbikes.

5.2. Principles for Policymakers

For policymakers, harmonising policies across regions should be pursued. Currently negotiated trade agreements between the US and the EU can contribute to this as these might serve as informal standards as well for other regions in Asia and Africa. At the same time, such agreements may also lead to lowering the standards to less ambitious and challenging levels due to lobbying efforts of corporations and governments.

Such coordination provides corporations with a stable environment for investments in innovations for a more sustainable business model. Global players like BMW can no longer base their product decisions on regulations by individual countries but have to do this on a regional, if not on a global, basis.

BMW has shown that a sustainability strategy is a long process that would take many years to implement. A stable ownership structure with a long-term perspective on investment and an interest in the long-term success of the company would be very helpful in the process. Furthermore, as shown by BMW, success and leadership position are based to a large extent on the experience and know-how of a company's employees.

5.3. Conclusion: Policy Recommendations

1. Create incentives for pioneering companies to introduce industry innovations (such as viable electric mobility) and new mobility patterns (such as car sharing) for sustainability by sufficiency.

2. Set ambitious but reliable fuel-saving and emissions-reduction targets that would allow companies to consistently work on reaching those targets and do the right investments in research and development. Harmonising country-specific regulations can prevent non-productive double certifications which could instead be used to invest in true ecological improvements.

3. The transition process to a circular economy requires that a company have a sustainable economic condition. A key element in a company's economic success is the support customers lend to the company's sustainability strategy and demand for its innovative and sustainable products.

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PART II

Institutional Approaches to Circular Economy

Chapter 7

Circular Economy Policies in China

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1. Circular Economy Development in China

1.1. Background of Circular Economy

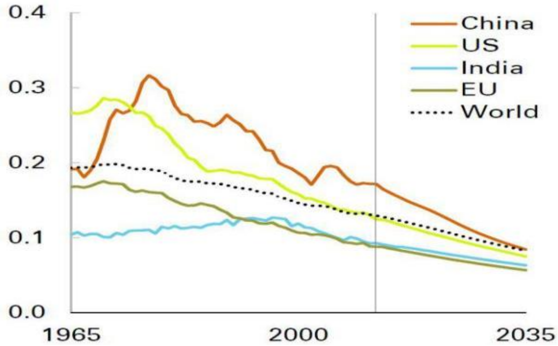
Since reforming and opening up, China's economy has developed rapidly with its GDP increasing significantly. However, its traditional extensive economic growth mode, with industrial production at the core, has relied on high investment and high consumption of resources, resulting in contradiction between limited environmental resources and economic development. The contradiction mainly includes the following aspects.

Firstly, China's resources per capita are scarce and its resource-utilisation efficiency is relatively low. China's major resources per capita are far below the world's average level and its extensive economic growth mode has rapidly increased the demand for resources (Figure 7.1). In 2012, China's gross domestic product (GDP) accounted for 11.6 percent of the total global GDP, but the country consumed 21.3 percent of energy, 54 percent of cement, and 45 percent of steel in the world.

Emissions of major pollutants are high and environmental pollution is still serious in China. In recent years, the country's environmental situation has continued to deteriorate. Pollution of its key waters is serious, with the proportion of Grade-V water increasing from 10 percent to 30 percent. Air pollutant emissions are in the overall rise and air pollution is very serious (Figure 7.2). One of the main reasons for the environment deterioration in China is the significant emissions of three industrial wastes. According to statistical data, economic losses caused by environmental pollution in the country account for 2.1–7.7 percent of GDP and economic losses caused by ecological destruction account for 5–13 percent of GDP (You and Qi, 2004).

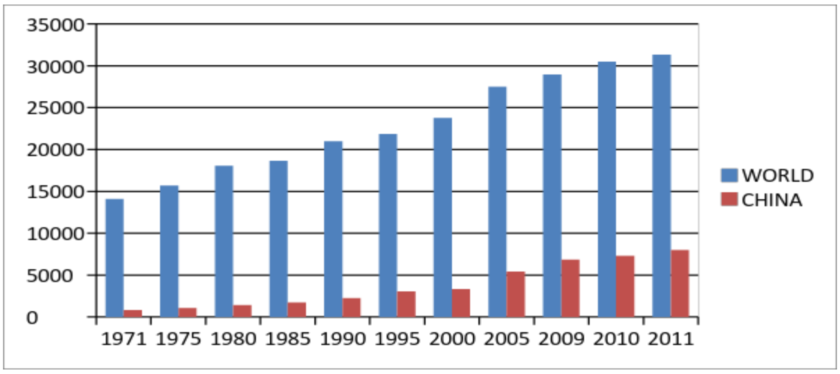
Since 1978, with rapid industrial development, total energy consumption in China has increased five times while its greenhouse gas emissions have risen rapidly.

Figure 7.1. Energy Intensity
(TOE per thousand $ 2012 GDP)



EU = European Union, GDP = gross domestic product, TOE = tonne of oil equivalent, US = United States.
Source: BP.

Figure 7.2. CO_2 Emissions in China (million tonnes)



CO_2 = carbon dioxide.
Source: International Energy Agency.

Under pressure of limited environmental resources, China must change its traditional economic growth mode and optimise its industrial structure. With circular economy as a new economic development model, China can reduce its energy consumption and pollution emissions, improve resource-utilisation efficiency, and solve the development bottleneck in resources and environment.

1.2. The Development Process of Circular Economy in China

In the Circular Economy Promotion Law issued by China in 2008, circular economy refers to the reduction, reuse, and recycling (3R) activities in the production, circulation, and consumption of products. The first of the 3R refers to the reduction of resource consumption and waste generation while reuse and recycling mainly involve wastes. Circular economy in China has two purposes. Firstly, scarcity of resources should be partly solved by improving energy efficiency and reducing the consumption of resources and energy. Secondly, emissions of pollutants and greenhouse gas should be reduced by mitigating pollution caused by rapid industrial development.

Driven by strong policy, the development of circular economy in China has experienced the following four stages.

The first stage (before 1992) was characterised by the comprehensive utilisation of resources. China had accumulated abundant experiences in establishing a system of waste recycling and comprehensive utilisation of waste gas, waste water, and waste solid (three wastes). At this stage, the main purpose of the comprehensive resource utilisation was to remedy the shortage of various products and indirectly increase resource supplies. In 1985, the government issued Interim Provisions on Several Issues of Comprehensive Utilization of Resources Approved by State Council and Transferred to National Economic Commission and proposed the Directories of Sources for Comprehensive Utilization. The comprehensive utilisation of three wastes was encouraged through a series of preferential policies. For example, in 1986, the output value, profit, and retention profit of the products in the comprehensive utilisation of three wastes in the metallurgical industry were 34.6 percent, 38.2 percent, and 97 percent higher than the corresponding values in 1985, respectively. The average annual recycling rate of industrial waste water in 1986 was 2.74 percent higher than that in 1985. Also, the amount of recycled gas increased threefold and the rate of fly ash utilisation increased by 9 percent.

The second stage (1991–2002) was characterised by cleaner production. In 1992, the Chinese State Council formulated the Top 10 Strategies for Environment and Development and formally proposed cleaner production. In 1993, the Chinese State Environmental Protection Administration, supported by the World Bank, started the B-4 Demonstration Project, the first systematic cleaner production project in China. Through the project, the government audited the cleaner production plans of 27 companies and 29 projects. Results of the audit showed many companies achieving cleaner production through rectification. For example, after investing CNY68,500 and implementing 10 programmes, Yantai No. 2 Brewery gained CNY2.89 million economic benefit and reduced its use of coal to 810 tonnes (21 percent), power to 134,000 kWh (18 percent), food to 3.56 tonnes (18 percent), water to 98,000 tonnes (28 percent), and discharge waste stillage to 20,000 tonnes (27 percent). Subsequently, a number of Sino–Foreign cooperative cleaner production projects were successively carried out, thus effectively promoting the development of clean production. In 2002, with the implementation of the Cleaner Production Promotion Law of the People's Republic of China, cleaner production entered a new era. Environmental pollution control mode has gradually shifted from end treatment to source prevention, thus greatly promoting the increase in resource utilisation rate and reduction in pollutant emissions in industrial sectors and laying the foundation for the development of circular economy.

The third stage (2002–2008) was the pilot stage of circular economy. In 2002, the State Environmental Protection Administration launched the circular economy programme, and Guiyang City and Liaoning Province were selected as China's first circular economy pilot city and province, respectively. In 2005, the Chinese State Council issued The Opinions of State Council on Accelerating the Development of Circular Economy, indicating circular economy as the new development model. In 2005 and 2007, the Chinese State Council launched the first and second sets of circular economy pilot projects in targeted provinces and cities, sectors, areas, and industrial parks.

The fourth stage (from 2009 to the present) is the rapid development of circular economy. On 1 January 2009, the Circular Economy Promotion Law of People's Republic of China was implemented, indicating the entry of China's economic development into the legislation process. With the rapid increase in the number of pilot projects and scope, circular economy has covered 27 provinces and numerous industries, indicating a widespread trend in implementation (Ren and Zhou, 2009).

1.3. Practices of Circular Economy in China

China's circular economy practices are primarily implemented at the enterprise, regional, and social levels. At the enterprise level, cleaner production is promoted to reduce the consumption of materials and energy in products and services. In this way, resource-utilisation efficiency is improved and emissions are minimised. At the regional level, in eco-industrial parks, as eco-industrial chains are established, industrial metabolism and symbiosis relationship are formed among enterprises. At the social level, the recycling and reuse of various industrial wastes promote the recycling of waste materials.

China has also launched circular economy pilot projects in provinces and cities, industries, fields, and industrial parks. In 2005 and 2007, the National Development and Reform Commission and other six ministries jointly organised the first and second sets of circular economy pilot projects (Table 7.1).

Table 7.1. Pilot List of China's Circular Economy

Key industries	Steel, nonferrous metals, coal, electricity, chemicals, building materials, light industry, papermaking, textile, machinery manufacturing, agro-processing, agriculture (forestry), and processing and utilisation base of renewable resources
Main fields	Renewable resource–recycling system, remanufacturing, scrap metal recycling, recycled metal utilisation, recycling of waste household appliances, recycling of electronic wastes, tyres, batteries, and packaging recycling
Industrial parks	20 eco-industrial parks over the country
Provinces (or cities)	27 provinces (or cities) in China.

Source: Qi Jianguo et al. (2010).

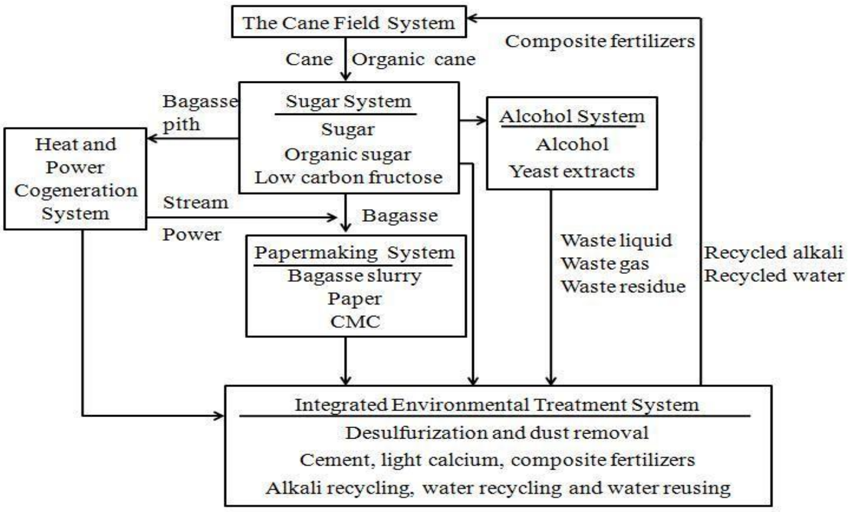
Box 1. Guigang Eco-Industrial Park in Guangxi Zhuang Autonomous Region

Guigang City is the major sugar production city in Guangxi Province. Since 1990, Guigang's annual sugar production has always been above 200,000 tonnes and ranks first in Guangxi Province. Sugar, papermaking, and alcohol production constitute the pillar economic industries in Guigang. However, these three industries are also the major pollution-causing industries. To solve the longstanding serious structural and regional pollution in the sugar industry in Guigang, the Guigang National Eco-Industrial (Sugar) Demonstration Park was constructed in 2001.

As shown in Figure 3, the Guigang National Eco-Industrial (Sugar) Demonstration Park is composed of cane field system, sugar system, alcohol system, papermaking system, heat and power cogeneration system, and integrated environmental treatment system (Wu, 2007). Through optimisation and combination, the interface between input and output of various systems has been connected to realise optimal resource configuration and efficient waste utilisation and reduce environmental pollution. Through this, the relatively complete combined ecological system of industry and farming has been established to form an efficient, safe, and stable sugar industrial park.

Source: Liu Hongci (2011).

Figure 7.3. Overall Circular Economy Structure in Guigang Eco-Industrial Park



Source: Wu (2007) and Liu Hongci (2011).

About 93 percent of molasses production in Guangxi Province is consumed in the demonstration park to produce alcohol. Moreover, waste alcohol solution is utilised to produce compound fertilisers. Waste alcohol solution discharge in Guangxi Province has decreased by about 93 percent. Annual organic pollutant reduction in waters has reached 134,000 tonnes.

2. Analysis of China's Circular Economy Policy

Since the 1980s, China has successively issued a series of laws and regulations, comprehensive policies, industrial policies, economic policies, and related environmental policies on circular economy. Laws and regulations are legal protection and play supporting role in the development of circular economy. These include the Cleaner Production Promotion Law, the Energy Conservation Law, the Circular Economy Promotion Law, etc. The Circular Economy Promotion Law focuses on development plans, extended producer responsibilities, supervision management systems for key enterprises with high energy and water consumptions, circular economy indices, statistics, and other management systems. In the Circular Economy Promotion Law, the requirements for circular economy development are proposed, covering production techniques, equipment, resource exploitation, recycling of waste materials, comprehensive resource utilisation, reduction, and other aspects. As proposed in the law to stimulate circular economy, the government shall encourage circular economy through special funds, technical support, tax incentives, investment, finance, price, government procurement, and other aspects.

Comprehensive policies play the general guiding role and include action plans, programmes, and opinions such as the Opinions on Accelerating the Implementation of Cleaner Production, the Notice on Building a Conservation-Oriented Society by the State Council, the Opinions on Accelerating the Development of Circular Economy, the Comprehensive Energy Reduction Program, and the Notice of the State Council on Issuing the Circular Economy Development Strategy and Near-Term Action Plan.

Box 2. Notice of the State Council on Issuing the Circular Economy Development Strategy and the Near-Term Action Plan

The Circular Economy Development Strategy and the Near-Term Action Plan issued in 2013 provides the development target and the detailed explanation of circular economy development. The development target of circular economy in the 12th Five-Year Plan is described as follows. The main resource productivity should be 15 percent higher than that in the 11th Five-Year Plan and total output value resource of the recycling industry should reach CNY1.8 trillion. Meanwhile, the detailed guidance for the development and safeguard measures of circular economy is proposed for key sectors and fields. In the policies on circular economy, the coal industry should be improved on five aspects: green mining, comprehensive exploitation and utilisation of coal and associated minerals, energy-saving and consumption reduction, ecological environment protection, and construction of industrial chains. The following targets should be realised by 2015: 60 percent higher coal washing rate, 75 percent comprehensive utilisation rate of coal gangue, 60 percent coal bed methane extraction rate, 2.85 million kWh power-generation capacity obtained through the utilisation of coal bed; 76 million kWh power-generation capacity obtained through comprehensive utilisation of coal of low calorific value, 75 percent comprehensive utilisation rate of mine water, and 60 percent land reclamation rate.

Source: The State Council of the People's Republic of China.

Environmental policies are mainly to promote the development of circular economy through the reverse transmission pressure mechanism. For example, China's Environmental Protection Ministry has developed pollutant emission standards for different industries. For those industries, pollutants should be treated according to the emission standards before being discharged, so that enterprises would be forced to develop strategies for low material consumption and low emissions.

Industrial and economic policies are to promote the development of circular economy. Economic policies can be roughly divided into tax, fiscal, monetary, and price policies. The following key economic and industrial policies may promote the development of circular economy (Table 7.2).

Table 7.2. Analysis of Major Industrial and Economic Policies

Policy Classification	Policy	Policy Measure	Main Points of the Policy
Upgrading industrial structure	Lists of Backward Production Capabilities, Processes, and Products to Be Eliminated (the First, Second, and Third Batches in 1999, 2000, and 2002)	Command-control	Backward production capabilities, processes, and products to be eliminated have the following features: violation of national regulations, backward production methods, poor product quality, serious environmental pollution, and high consumption of materials and energy.
	Interim Regulation for Promoting Industrial Structure Upgrade and Guiding Lists for Upgrading Industries (2005)	Command-control	Encourage and support key technologies, devices, and products beneficial to environmental protection and energy saving; gradually eliminate backward technologies that consume too much resources and energy and pollute the environment.
	Notice of the State Council on Accelerating the Structural Upgrading of the Industries with Excessive Production Capability (2006)	Command-control	Legally close small enterprises that destroy resources, pollute environment, and have no safe production conditions; eliminate backward production capabilities; dispose devices to be eliminated; improve policies and measures restricting resource products with high energy consumption and high pollution.
	Notice on Accelerating the Structure Adjustment of the Steel Industry via Controlling Total Production Capability and Eliminating Backward Production Capability (2006)	Command-control	Close enterprises with backward production capability and high resource consumption, serious environmental pollution, and unqualified production conditions; eliminate, before 2007, a series of backward devices including blast furnaces with capacity below 200 m^3 and converter furnaces with capacity below 20 tonnes; eliminate, before 2010, backward devices including blast furnaces with capacity below 300 m^3.
	Notice on Accelerating the Structure Adjustment of Power Generation Industry for Healthy and Smooth Development (2006)	Command-control	Gradually close, according to local situation, thermal power units with high energy consumption; restrict power generation of units with high energy consumption and serious consumption.
	Guiding Advices on Improving and Enhancing Financial Services for Environmental Protection Industries (2007)	Financial measures	Simplify the lending procedure for projects that encourage investment according to the Guiding Lists of the Industries to Be Adjusted; stop lending credit and withdraw loans to projects to be eliminated.
	Guiding Advices on Financial Services for Supporting and Promoting Key Industrial Adjustments and Suppressing Excessive Production Capability (2009)	Financial measures	Do not provide loans to projects not consistent with the policies on supporting and promoting key industrial adjustments or relevant industrial policies, especially backward projects for elimination by related regulations and laws.
	Advices on Financial Services for Supporting Energy Saving and Emission Reduction and	Financial measures	Do not provide loans to projects under construction and not consistent with the policies on energy-saving and emissions reductions or are for elimination; do not provide additional

	Eliminating Backward Production Capability (2010)		loans for illegally constructed projects.
	Management Method of the Central Financial Rewarding Fund for Eliminating Backward Production Capability (2011)	Fiscal measures	Reward enterprises that eliminate their backward production capability for resettlement of laid-off workers, production conversion, and debt payment.
Cleaner production	Interim Method for Auditing Cleaner Production Projects (2004)	Command-control	Perform compulsory audit on enterprises that violate local or national emission standards, use poisonous materials, or discharge poisonous matters.
	Preferential Income Tax Lists of the Enterprises for Producing Special Safety Production Devices (2008)	Tax measures	If an enterprise purchases and utilises special equipment for environmental protection, energy- and water-saving, and safety production, related equipment purchase cost may be deducted from income tax.
	Interim Management Method of the Central Financial Rewarding Fund for Energy-Saving Technologies (2011)	Fiscal measures	In East China, after the construction of energy-saving projects, the reward standard is CNY240 per tonne of standard coal, and in Middle and West China, it is CNY300 per tonne of standard coal.
Comprehen-sive resource utilisation	Notice on Comprehensive Resource Utilization Measures Approved by the State Council and Transferred to State Economic Trade Commission (1996)		**The scopes of comprehensive resource utilisation and preferential policies are clarified to enhance comprehensive resource utilisation and prevent resource waste and environment pollution for the purpose of supporting the comprehensive utilisation of thermal energy and power in power-generation plants and promoting the recovery of waste materials.
	Notice on the Policy of Preferential Income Tax of Enterprises (1994)	Tax measures	For enterprises that use waste water, waste gas, and waste solid as main production materials, income tax may be decreased or waived for 5 years.
	Notice on the Interpretation of Regulation Tax Rating of Fixed Asset Investment for Comprehensive Resource Utilization and Warehouse Facilities (1994)	Tax measures	The regulation tax rate for fixed asset investment consistent with the requirements of comprehensive resource utilisation is zero.
	Notice on Exemption of VAT for Partial Products of Comprehensive Resource Utilization Projects (1995)	Tax measures	Enterprises that use materials containing more than 30 percent waste solids (coal gangue, limestone coal, fine coal dust, and boiler slags) or waste liquids to produce construction products may be exempted from VAT until 1995.
	Notice on Consumption Tax Policy of Soap and Tires (2000)	Tax measures	Exemption from consumption tax for radial tyres or retread tyres.
	Notice on Preferential VAT Policy for the Products Produced through the Comprehensive Utilization of Three Residues or Secondary Woods (2001)	Tax measures	Enterprises which use the three residues or secondary woods as materials should be exempted from VAT immediately after taxation.
	Notice on the VAT Policy for the Business of Waste Recovery (2001)	Tax measures	Enterprises of waste materials should be exempted from VAT.
	Notice on the VAT Policy for Comprehensive Resource Utilization and Related Products (2008)	Tax measures	Enterprises that sell reclaimed waste water, retread tyres, or produce rubber powder with the material of waste tyres or produce construction products with material containing more than 30 percent waste solid, should be exempted from VAT; enterprises on waste water treatment should be exempted from VAT; enterprises that sell CO_2 of high purity produced with industrial waste gas, power, or heat generated with the garbage fuel, and regenerated asphalt cement produced with waste asphalt should be exempted from VAT immediately after taxation; enterprises that sell power or heat generated with coal gangue, silt coal, limestone coal, and bituminous shale should be exempted from 50 percent VAT immediately after taxation; enterprises that sell biodiesel generated through comprehensive

			resource utilisation should be exempted from VAT after taxation.
	Notice on Preferential Income Tax for the Catalogue of Materials of Comprehensive Resource Utilization (2008)	Tax measures	After 1 January 2008, the revenue of enterprises that sell products generated with the materials in the catalogue and included in the catalogue should be deducted by 10 percent during income calculation.
	Notice on the VAT Policy for the Products Produced with Agricultural And Forestry Residues (2009)	Tax measures	Products produced with four types of agricultural and forestry residues (three residues, secondary woods, crop stalks, and bagasse) should be exempted from VAT immediately after taxation. Tax ratio exemption was 100 percent in 2009 and 80 percent in 2010.
	Notice on Exemption of Consumption Tax for Biodiesel Produced with Waste Animal and Vegetable Oils (2010)	Tax measures	Biodiesel produced with waste animal and vegetable oils are exempted from consumption tax.
Exploitation and utilisation of resources and energy	Notice on Further Implementation of the Policy on Differential Power Pricing and Charging Issues Related to Own Power Plants (2004)	Price measures	Based on basic industrial power price, the prices of power for enterprises to be restricted or to be eliminated should be increased by CNY0.02/kWh and CNY0.05/kWh, respectively. These enterprises are mainly concentrated in the electrolytic aluminium, ferroalloy, calcium carbide, caustic soda, cement, and steel industries.
	Opinions on Improving the Differential Power Pricing Policy (2006)	Price measures	Based on basic industrial power price, the prices of power for the yellow phosphorus and zinc smelting industries should be increased by CNY0.05/kWh and CNY0.2/kWh, respectively, for the enterprises to be restricted or to be eliminated.
	Pilot Scheme of Pricing and Cost-Sharing Management of Power Generation with Renewable Energy (2006)	Price measures	For renewable energy-generation projects, the amount exceeding the electricity purchase price of local coal-fired power generation plants may be compensated through additional power price fee from power users in China.
Composite	Catalogue of Encouraged Technologies, Processes, and Equipment of Circular Economy (the First Batch) (2012)		The catalogue covers reduction, reuse and remanufacture, recycling, and industrial symbiosis and linkage, and includes 42 key circular economy technologies, processes, and devices.
	Interim Management Method Circular Economy Development Funds (2012)	Fiscal measures	Special funds should support national urban minerals demonstration bases, kitchen waste recycling and safe disposal, circular transformation in parks, remanufacture, and demonstration and promotion of cleaner production technologies. Taking cleaner production as an example on the basis of verification by experts, the government should freely promote mature and advanced cleaner production technologies by purchasing the technology.
	Notice on Opinions of Supporting Policies and Measures of Circular Economic Development Investment and Financing (2010)	Financial measures	Circular economy-related projects should receive credit support. No additional credit should be provided and original credit should be reduced or withdrawn for enterprises that adopt technologies, processes, equipment, materials, or products in the catalogue to be eliminated.
	Interim Management Method of Energy Conservation and Emission Reduction Funds (2015)	Fiscal measures	The allocation of energy-conservation and emission-reduction funds should be based on properties, objectives, investment costs, energy-saving and emission-reduction effects, energy and resource utilisation levels, and other factors of the projects. Fund support mainly includes subsidies, rewards, discounts, and true settlements. Rewards are mainly allocated based on energy conservation performance. In truly settled projects, funds are first disbursed and settled later.

VAT = value-added tax.

Source: Zhang Lu (2013) and Xie Haiyan (2010).

Circular economy policies mainly include command-control, tax, fiscal, financial, and pricing measures, and focus on upgrading industrial structures, cleaner production, recycling and comprehensive utilisation of waste materials, and exploitation and utilisation of resources and energy.

Upgrading industrial structures is mainly based on command-control measures aimed at compulsory elimination of backward production capability, process, and products in violation of national regulations, backward production modes, poor quality, serious environmental pollution, and extensive consumption of materials and energy under financial and fiscal measures. Cleaner production is mainly based on the Interim Method for Auditing Cleaner Production Projects and implemented through command-control measures. Moreover, preferential tax and financial incentives are also adopted to stimulate the development of cleaner production in enterprises. Preferential tax rating is implemented in enterprises dedicated to waste material recycling and comprehensive resource utilisation. Price measures are adopted to regulate industries with high-energy consumption for utilisation of resources and energy.

3. Implementation Effects of Circular Economy Policies in China

Based on the background and purpose of circular economy development, the effects of implementing circular economy policies in China can be divided into the following.

3.1. Improvements in the Comprehensive Utilisation Rate of Resources

In implementing circular economy policies in China, the rate of comprehensive utilisation of resources is mainly improved in three aspects: (i) the rates of resource mining and comprehensive recovery in the mining of mineral resources, (ii) the utilisation rates of three wastes, and (iii) recycling waste materials. The total amount of recycled renewable resources increased from 52.38 million tonnes in 2001 to 148.899 million tonnes in 2010. In the 10th Five-Year Period, the total amount of recycled renewable resource was more than 400 million tonnes with an average annual growth above 12 percent. Gross output value of primary recycled renewable resource was more than CNY650 billion. In the 11th Five-Year Period, the total amount and gross output value of recycled renewable resource increased further. At the same time, renewable resource recycling brought ecological benefits to China. From 2001 to 2009, renewable resource recycling was equivalent to 915,708,500 tonnes of the accumulated savings of standard coal; 51,222,440 tonnes of waste water–emission reduction; 13,454,990,000 tonnes of solid waste reduction; 20,646,500 tonnes of sulphur dioxide–emission reduction; and 2,866,380,300 tonnes of carbon dioxide–emission reduction. Statistics of renewable resource recycling and energy conservation from 2011 to 2012 are provided in Table 7.3.

Table 7.3. Statistics of Renewable Resource Recycling and Energy Conservation in China (2011–2012)

Waste	Recycled amount (10,000 tonnes)		Saved energy (10,000 tonnes of standard coal)		Waste water–discharge reduction (10,000 tonnes)	
	2011	2012	2011	2012	2011	2012
Scrap steel	9100,0	8400,0	3194,2	2948,5	79853,9	73711,3
Scrap ferrous metals	455,0	530,0	4734,5	5514,9	305667,5	356052,3
Waste plastics	1350,0	1600,0	442,1	524,0	122812,9	145556,0
Wastepaper	4347,0	4472,0	6866,9	7064,4	508655,8	523282,4
Waste tyres	329,0	370,3	74,0	83,3	6163,6	6937,3
Waste electrical and electronic utensils	370,6	190,7	730,1	375,7	8980,8	4621,3
Disposed cars	285,0	249,0	191,5	167,3	10260,0	8964,0
Disposed ships	225,2	255,0	239,9	271,6	6877,2	7787,2
Total	16461,8	16067,0	16473,1	16949,7	1049271,7	1126911,8

Waste	Emission Reduction (10,000 tonnes)					
	Waste solid		Sulphur dioxide		Carbon dioxide	
	2011	2012	2011	2012	2011	2012
Scrap steel	26617,6	24570,1	177,4	163,8	7666,0	7076,3
Scrap ferrous metals	245794,4	286310,0	80,6	93,9	11362,9	13235,9
Waste plastics	3779,0	4478,8	58,5	69,3	1061,2	1257,7
Waste paper	9838,8	10121,7	12,1	12,4	16480,6	16954,5
Waste tyres	369,9	416,3	4,5	5,1	177,6	199,9
Waste electrical and electronic utensils	5043,2	2595,1	17,1	8,8	1752,4	901,7
Disposed cars	7695,0	6723,0	7,3	6,4	459,7	401,6
Disposed ship	3365,1	3810,4	13,2	14,9	575,7	651,9
Total	302503,0	339025,4	370,7	374,6	39536,1	40679,5

Source: Xie Zhenhua (2013).

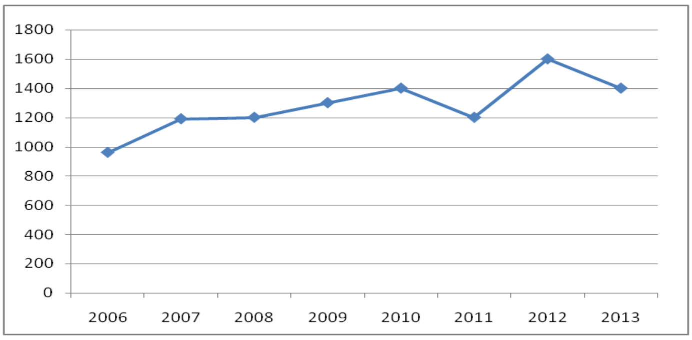
Box 3. Waste Tyre Recycling in China

With the rapid development of the automotive and the transportation industries in China, the volume of scrap tyres has also increased. The annual average growth rate of scrap tyres in 2001–2006 reached 18 percent. Daily production of waste tyres in 2013 reached about 10 million tonnes.

To promote the recycling of scrap tyres, the Ministry of Industry and Information Technology in 2011 developed the Opinions on the Guidance of Comprehensive Utilization of Waste Tires, the first industrial policy for the comprehensive utilisation of waste tyres specifically issued by the Government of the People's Republic of China. In 2012, the government issued the Conditions for the Access to Tire Retreading Industry and the Conditions for the Access to Comprehensive Utilization Industry of Waste Tires. Industrial policies play a guiding and leading role in the development of comprehensive utilisation of waste tyres. The Notice on the VAT Policy for Comprehensive Resource Utilization and Related Products (2008) requires that enterprises retreading tyres or producing rubber powder from waste tyres be exempted from VAT. Until 2013 more than 1,000 enterprises were dedicated to the comprehensive utilisation of waste tyres (Figure 7.4). The established comprehensive utilisation system is mainly composed of the tyre retreading industry and the production industry of rubber and rubber powder from waste tyres (Figure 7.5).

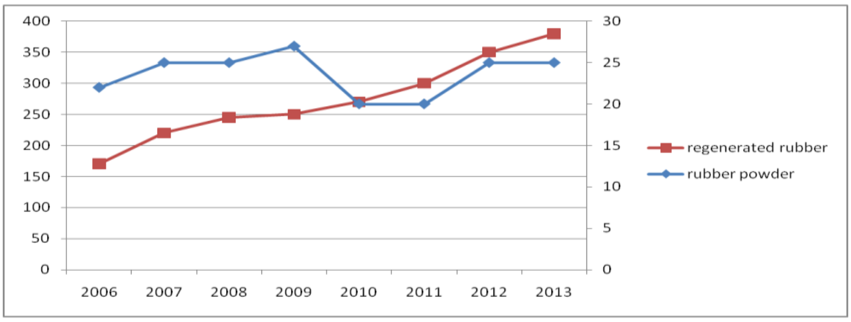
Source: National Development and Reform Commission.

Figure 7.4. Retreaded Tyre Quantity in China (10,000 pcs)



Source: National Development and Reform Commission (2014).

Figure 7.5. Comprehensive Utilisation Production of Waste Tyres in China (10,000 tonnes)



Source: National Development and Reform Commission (2014).

3.2. Promoting Energy Saving and Emission Reduction

In implementing circular economy policies in China, upgrading industrial structures and cleaner production in enterprises have played a major role in energy conservation. The environmental benefits of implementing cleaner production from 2007 to 2010 are shown in Table 7.4. With the scope of cleaner production and technological innovation continuously expanding, energy-saving and emission-reduction effects and economic benefits will further increase.

Table 7.4. Environmental Benefits of Cleaner Production

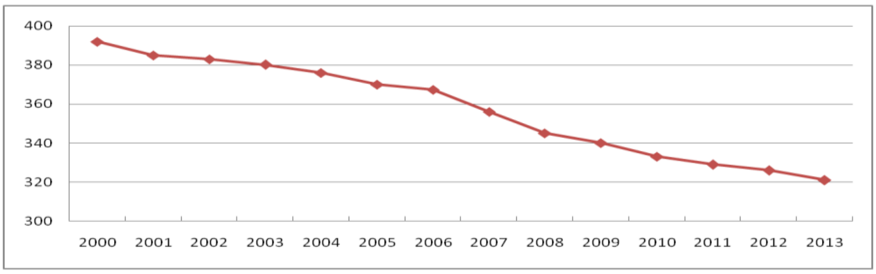
Year	COD reduction (10,000 tonnes)	SO_2 emission reduction (10,000 tonnes)	Water savings (10^8 tonnes)	Power savings (10^8 kWh)	Economic profits (CNY10^8)
2007	9.5	7.1	3.8	36.9	58.9
2008	7.3	32.3	15.2	43.1	102.2
2009	6.4	27.7	4.1	26.2	115.3
2010	6.2	14.0	10.2	37.2	128.0

COD = chemical oxygen demand; kWh = kilowatt-hour; SO_2 = sulphur dioxide.
Source: Ministry of Environmental Protection of the People's Republic of China.

3.3. Reducing Greenhouse Gas Emissions

In circular economy, carbon emissions are mainly reduced through improvement of utilisation efficiency of energy and resources. According to the International Energy Agency, CO_2 emissions are still rising in China. Although per capita CO_2 emissions in China in 2011 were only about 60 percent of the OECD average level, these were still three times of the 1990 level. The electricity industry is the largest contributor for the rise of CO_2 emissions. Therefore, to reduce carbon emissions it is necessary to further improve energy efficiency especially in the power industry.

Figure 7.6. Coal Consumption of Thermal Power–Generation Units (g/kWh)



g = gram kWh = kilowatt hour.
Source: Qi Jianguo et al. (2010).

Box 4. Circular Economy Policies of the Thermal Power Industry and their Effects in China

China's power industry is dominated by thermal power-generation units (PGUs) which account for more than 70 percent of the country's total installed capacity in 2011. Coal consumption in thermal power plants accounts for more than 50 percent of total coal consumption. The power industry has the biggest energy consumption and the biggest SO_2 and CO_2 emissions. CO_2 emissions in the electricity and heat-generation industries accounted for 50 percent of total CO_2 emissions in 2011 in China.

The Notice on Accelerating the Structure Adjustment of Power Generation Industry for Healthy and Smooth Development, promulgated in 2006, requires that thermal power units with high energy consumption be gradually closed down. Moreover, the government is striving to shut down small coal-fired condensing steam PGUs with below 50,000 kW (15 million kW in total) capacity and fuel PGUs with 7 million kW capacity. The Opinions on Accelerating Shutting Down Small Thermal Power Generation Units promulgated in 2007 calls for the shutting down of small thermal PGUs. These mainly include thermal PGUs with capacity below 50,000 kW and/or those with high coal consumption; conventional thermal PGUs with capacity below 100,000 kW; and those operating for more than 20 years. Through the command control of industrial policies, small thermal PGUs with high energy consumption and high pollution emissions should be eliminated to save efficient energy and reduce emissions. Until the end of 2009, the total capacity of closed thermal PGUs reached 55.45 million kW.

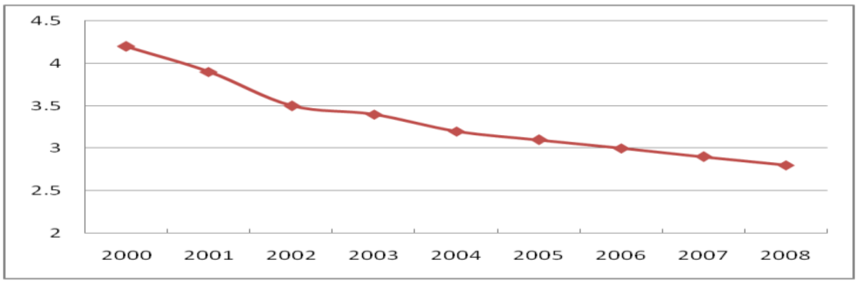
The Notice on Cutting Down Pool Purchase Price of Small Thermal Power Generation Units to Shut Down Small Thermal Power Generation Units (2007) requires that electricity purchase price of small thermal PGUs be decreased. Moreover, the quota of small thermal PGUs may be transferred to large thermal PGUs at a price not higher than its original price after small thermal PGUs are shut down. After quota is transferred and small thermal PGUs are shut down, the electricity purchase price of small thermal PGUs will no longer be cut down. Economic measures are adopted to promote the closing of small thermal PGUs. Moreover, the Interim Management Method of Electricity Purchase Price and Desulphurization Facilities of Coal-Fired Power Generation Units (2007) requires that CNY0.015 per kWh be added to the electricity purchase price of coal-fired PGUs after desulphurisation upgrading to encourage the desulphurisation transformation of thermal power plants.

The Ministry of Environmental Protection also promulgated the Emission Standard of Air Pollutants for Thermal Power Plants (2011), an improvement over the 2003 standard. For newly constructed coal-fired boilers, the SO_2 emissions standard was improved from 400 mg/m^3 to 100 mg/m^3; and for existing boilers, from 2100 mg/m^3 to 200 mg/m^3. Under the new pollutant emissions standard, power-generation enterprises are forced to find ways to reduce emissions.

With industrial economic and environmental policies synergized, the circular economy of the power industry has achieved considerable effects. In 2001–2012, coal consumption, water consumption, dust emissions, and SO_2 emissions of thermal PGUs decreased by 15.3 percent, 28.2 percent, 85.6 percent, and 66.3 percent, respectively (Figures 6–8). In 2006–2012, the total CO_2-emissions reduction was 3.56 billion tonnes. Although total CO_2 emissions are rising, emission intensity is declining.

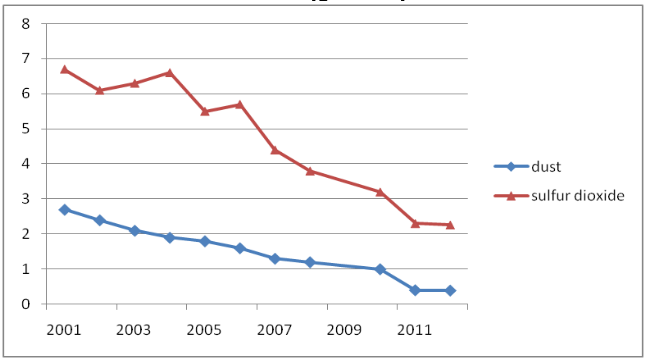
Source: Qi Jianguo et al. (2010).

Figure 7.7. Water Consumption of Thermal Power-Generation Units (kg/kWh)



kg = kilogram; kWh = kilowatt hour.
Source: Qi Jianguo et al. (2010).

Figure 7.8. Dust and Sulphur Dioxide–Emission Performance of Thermal Power–Generation Units (g/kWh)



g = gram kWh = kilowatt hour.
Source: Qi Jianguo et al. (2010).

Based on laws and regulations led by industrial policies, pushed by environment policies, and mobilised by economic policies, circular economy has gained significant developments in China and has positively promoted the improvement of resource-utilisation rate, emission reduction of major pollutants, and greenhouse gas-emissions reduction. At the same time, fiscal, financial, and investment policies have been developed to support the development of circular economy.

4. Implications for Policy and Practices

4.1. Construction of Related Systems

Related systems such as laws, regulations, and standards are the fundamental requirements of circular economy. Laws and regulations legally protect and support the development of circular economy. Comprehensive policies, such as action plans, programmes, and opinions, mainly play the general guiding role. Construction of related systems can provide a long-term mechanism to promote circular economy.

4.2. Composite Policies

Composite policies may drive the development of circular economy through the synergistic mechanism of industrial policies, reverse promotion of environmental policies, and the excitation of economic policies.

4.3. Pilot Projects in Multiple Levels

Pilot project demonstration is one of the most important practices of circular economy in China. Pilot projects should focus on enterprises, sectors, industrial parks, and areas which have development potential and could play a leading role in the development of circular economy. It is important for policymakers to recognise the characters of circular economy and set separate target policies for those levels.

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Chapter 8

The Datong Coal Mine Group Ltd and Its Tashan Circular Economy Park: A Business Case

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1. Introduction

Although circular economy has been introduced to China only in the last few years, it has gradually become a concrete practice in the country's economic and social life and a national development model.

The development mode of regional circular economy in China, determined by its development stage, technical and economic conditions, resources and environment, and external development, is shown in three different models: (i) the spontaneous strategic transformation model in the developed areas of the eastern coast (Shanghai, Jiangsu, Shandong, etc.); (ii) the regional strategic transformation from extensive development mode into sustainable development mode in the northeast areas (Liaoning, Jilin, etc.), China's old and heavy industrial bases that have economic and technical foundation; and (iii) a resource-based strategic transformation model in the midwest areas (Shanxi, Guiyang, etc.), rich in mining resources but have less-developed technology and weaker economic foundation. Moreover, China has carried out pilot work on circular economy at three levels: (i) vigorous promotion of clean production at the enterprise level, (ii) creation of eco-industrial parks at the industrial level, and (iii) circular economy demonstration projects in pilot provinces and cities.

From actual situations, the practice of circular economy in China is still at the stage of experiment and demonstration. The more successful cases are mostly concentrated at the enterprise level involving large enterprises offering good benefits and have relatively advanced technology. State-owned enterprises located in key areas and key nodes of circular economy and with relatively advanced technology and talent advantages are being considered to play a vanguard role in leading and promoting small and medium-sized enterprises in jointly developing circular economy. Some large state-owned enterprises are developing circular economy not only through clean production process but also through the formation of eco-industrial parks to achieve resource recycle and zero emission. The circular economy park is a concept based on clean production and consists of a series of manufacturing enterprises and service-oriented enterprises. They share resources and exchange symbiotic products through industrial chain networks to achieve material recycling, energy recycling, full utilisation of wastes, and, ultimately, zero emission.

This paper chooses the Datong Coal Mine Group Ltd, a large resource-based state-owned enterprise in China's midwest area, and its Tashan circular economy park as example of circular economy practice.

Coal is one of the major energy resources in China, accounting for approximately 70 percent of the country's primary energy consumption. Coal occupies more than half of China's energy structure and remains the main component in the country's energy structure in a long time. With an annual coal production capacity of 35 percent of the world's total annual capacity, China has become the largest coal producer in the world, with 11.67 percent of recoverable coal reserves of the world's total.

As the energy demand in China continues to rise dramatically, the demand for coal also continues to increase. With China's industrialisation and the fast development of its economy, the economic loss to the environment and resources has become even larger. Many environmental problems and risks to human health arise during coal exploitation, utilisation, and waste disposal, especially in the remote mountainous areas of China. In response to the record-high levels of air pollution in 2012 and 2013, the State Council issued in September 2013 the Action Plan for the Prevention and Control of Air Pollution as it reiterated the need to reduce coal's share in China's energy mix to 65 percent by 2017.

Under a low-carbon situation, the sustainable development of the coal industry faces great challenges as meeting carbon-intensity target requires a significant change in trajectory for carbon emissions and coal consumption. This requires China to adopt an integrated management approach to resolve the conflict between industrial development and environmental protection. The concept of circular economy serves this purpose.

The Datong Coal Mine Group Co Ltd is one of the hard-coal production leaders in China. Its green practice in the Tashan Circular Economy Park has been recognised as leading the development of the nation's coal industry and can be applied nationwide. Thus, in the case study, we analyse the development process of circular economy in resource-based enterprises, and summarise the basic experiences and challenges that a Chinese enterprise undergoes in developing circular economy. Several suggestions are then put forward.

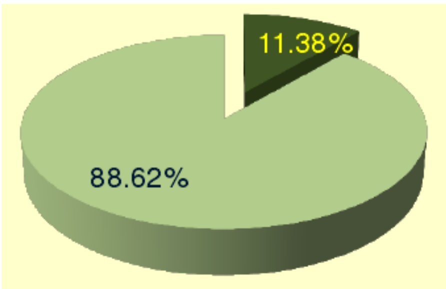
2. Circular Economy Development in the Datong Coal Mine Group Co Ltd: Strategy and Situation

2.1. Brief Introduction of the Datong Coal Mine Group Co Ltd

The Datong Coal Mining Administration, established in 1949, was the predecessor of the Datong Coal Mine Group before it was restructured as the Datong Coal Mine Group Co Ltd in 2000. It is located in the southwest part of Datong City, and its coal mines are scattered mainly in Shanxi Province and the Inner Mongolia Autonomous Region. It is a super-large comprehensive energy group, with coal production as its mainstay while featuring the simultaneous development of various industries such as power, coal chemical, metallurgy and coal machinery manufacturing, construction and building materials, logistics and foreign trade, etc. The Datong Coal Mine Group has a long history of coal mining, with the development and use of its coal resources dating back to the end period of the Ming Dynasty. Over the past 62 years since it was established, the company has turned out a total of more than 2.1 billion tonnes of coal.

The corporation mainly extracts weak caking coal from the Jurassic period. This coal has low ash and sulphur content, high calorific value, moderate volatilisation, and stable quality. In 1989, the company set coal industry standards to help develop itself into a modern enterprise. It won the National Golden Horse Corporate Management Prize and the National May Day Labor Prize. In 1992, it ranked first among the 100 best-known enterprises, according to the *China Enterprise News*, the *Enterprise Management* magazine, and the Enterprise Management Press. The company is a leader in scientific development and technologies for the coal industry and its technology centre is among the top 100 institutions, attaining the highest standards and gaining approval from the State Economic and Trade Commission.

Figure 8.1. The Proportion of Coal and Non-coal Industry in the Datong Coal Mine Group in 2002



Coal (88.62%) No coal (11.38%)
Source: Datong Coal Mine Group Data.

However, the group's extensive growth pattern of high input, high consumption, high pollution, and low benefit to the enterprise later led to resource depletion and environmental degradation. The group's development faced a serious threat as it was mainly dependent on extensive production. While the volume of coal production remained very big, the product conversion rate was low and associated with short industry chain with low value-added production.

Thus, the leaders of Datong Coal Mine, standing at the height of the enterprise strategy and the national development requirements, decided to develop a circular economy park to change the traditional mode of production and form a more environment-friendly development path by adopting a more scientific mode and method of production.

In 2003, Datong Coal Mine started to construct the Tashan Circular Economy Park about 30 km south of the city of Datong and 20 km from its headquarters. Put to use in 2009, it is the first park built by Datong Coal Mine in line with the 'reduce–recycle–reuse' principle. It is also the first of circular economy demonstration projects in Shanxi Province and is currently considered one of the typical and successful cases.

2.2. Circular Economy Park in the Datong Coal Mine Group Co Ltd: SWOT Analysis

The Tashan Circular Economy Park takes a sustainable development road and promotes the harmonious development of social economy and ecological environment. Based on the resource, environment, location, and social and economic conditions, the park aims to scientifically lay out the industry chain nodes in support of new energy-saving and emissions-reduction technologies, design multistage recycling circulation, and reuse wastes to protect the environment and reduce the hazards of emissions through clean and recycling production, with 'black coal mining, green park development, high carbon industry, and low carbon emission' as some sort of slogan.

The circular economy park mode is a kind of industrial symbiosis with the mining industry as the core and part of the middling cycle. It turns wastes, energy, and by-products that cannot be digested in one mining enterprise into raw materials or power of another enterprise. The mining industry couples transversely and shares resources with different industry departments – such as power generation, chemical, light, and construction industries – to form an enterprise network so that materials, energy, and information can flow harmoniously. A SWOT analysis, which measures the strengths, weaknesses, opportunities, and threats to an enterprise, can help understand the corporation's strategy and the challenges it faces in the development of circular economy.

(1) Strengths

- **Resource and location advantage:** The Datong Coal Mine Group is well known at home and abroad for its multipurpose soft coal with less than 10 percent ash, less than 1 percent sulphur, and a 28-megajoule/kg calorific capacity. It is of industrial fines and a quality brand steam coal in the world. The Datong coal, as it is known, has been chosen as one of 'China's 10 most internationally influential brands', one of the 'annual top-10 Chinese brands on the world market', and a 'national inspection-free product'.

- **Market advantage:** The Datong Coal Mine Group has a very high market ratio. Its clients include various industries in China, including power, metallurgy, building materials, and other industries. It also exports to many countries such as Japan, Republic of Korea, India, and Turkey. It annually exports 10 million tonnes of coal and, to date, has produced a total of 945 million tonnes of quality coal and paid CNY11.7 billion (US$1.85 billion) in taxes, the highest in China's industry sector, and 2.5 times the total government investment/spending. According to the company's annual operating income report, Datong Coal Mine ranked 341st of the World's Top 500 in 2015, 70th of China's top 500 companies, and 7th of China's top 100 coal mine enterprises in 2014.

- **R&D and human resource advantages:** The Datong Coal Mine Group enjoys a prominent position in the country's mining industry because of its professional, management, and technical teams. After years of investment in science and technology research and development (R&D), the company now boasts of advanced coal-mining technology, such as low-caving coal mining, short-range coal seam fully mechanised coal mining, thin-coal layer of plow mining, etc., and owns a large number of independent intellectual property rights, patents, and technological achievements. It has created more than 100 number one honours in China and was awarded 168 scientific and technological progress prizes above the provincial and ministerial levels. The company has a national technical centre and six postdoctoral mobile stations. Its science and technology contribution to coal production ranks first in the coal industry. Datong Coal Mine has 41 of its experts awarded the special allowance by the State Council, four awarded as 'national technicians', and a hundred senior personnel as recipients of provincial and ministerial awards.

- **Relatively complete industrial chain:** Datong Coal Mine's present setup includes major categories of coal, electricity, coking coal, coal chemical, carbon, fertiliser, and building materials. The main products of these categories include steam coal, washed coal, electricity, coke oven gas, coal tar, clumsy, synthetic ammonia, urea, methanol, compound fertiliser, super-high power graphite electrode, f brick, coal seam gas and cement, etc.

- **Capital comparative advantage:** The Datong Coal Mine Group has two publicly listed corporations: Zhangze Power Plant and Datong Coal Industry Co. Through issuance of corporate bonds, finance listing in capital market, establishment of financial companies, and enhanced strategic cooperative relations with large domestic commercial banks, Datong Coal Mine has increased its capital accumulation and attracted more and more investment-strategic partners.

However, we should also see that coal prices may drop because of the emergence of excess coal production capacity, and mining cost may increase because of the introduction of national resource tax laws. In certain circumstances, the Datong Coal Mine Group's financial comparative advantage may disappear.

(2) Weaknesses:

- **Possible depletion of coal reserves:** The Jurassic coal resources are now severely depleted. Half of the coal mines of the Datong Coal Mine Group are near to depletion and six have gone bankrupt because of resource depletion. Based on the present rate of coal mining, coal resources in 10 mines may be exhausted within 5 years and another 20 mines in 6–15 years. The coal resources the Datong Coal Mine Group is extracting at present are carboniferous resources. Due to their high ash and sulphur content, carboniferous coal resources are easily impacted by market fluctuations. Once the market demand is changed by the economic situation, product sales will be severely affected.

- **Relatively slow transformation of the industry**: The size and the unit capacity of the Datong Coal Mine Group's electric power plants are small and easily affected by the demand of electric power market. The production capacity of the coal chemical industry is backward. The market volatility of methanol-related products and semi-coke-related products is big, and the anti-risk ability is weak. Compared with domestic and foreign counterparts, Datong Coal Mine's coal machine equipment manufacturing industry is not competitive.

- **Heavy social burden:** As an old mining company, the Datong Coal Mine Group has a large ratio (up to 1:2.5) of retirees and in-service staff and needs to pay a huge amount of pension each year. The Datong Coal Mine Group bears the social burden of staff education and health care, community and logistics services, and others. Heavy social burden has become a big challenge for enterprise development. In the near future, through strengthened interaction with the government, the Datong Coal Group's existing weaknesses may turn into relative advantages.

(3) Opportunities

- **National development of circular economy:** In 2005, the State Council pointed out the future development direction of the coal industry by encouraging the integration of coal industry, accelerating the construction of large electric power plants, alleviating the pressure of coal transportation, and promoting clean coal technology industry development (Guo Fa, 2005). In the 12th Five-Year Plan, the state strongly supports the merger and reorganisation of coal enterprises, optimisation of industrial structures, elimination of backward production capacity, and improvement of coal production intensification. It gives priority to resource follow-up and coal project approval. To curb excessive investment, the central and local governments have made policies to integrate resources within the coal industry by closing down small coal mines and developing middle-sized and large ones.

- **Middle and Western Great Exploitation Strategy:** The central region has a comparative advantage in the energy and manufacturing industries, and will continue to play a crucial role in the industrial transfer from the eastern region. The Western Great Exploitation Strategy and the new Belt Road also provide new development opportunities in the eastern and western regions. The state will continue to increase support for policy, capital investment, and industrial development in the central and western regions.

- **A national resource-based economic transition testing area of Shanxi Province:** As a comprehensive transformation pilot area, Shanxi Province, China's largest resource-based economy, can obtain more policy space in developing circular economy. As Shanxi Province has accelerated transformation and development in recent years, it can provide Datong Coal Mine more funding and policy support in its green development progress.

- **China's industrial structure adjustment:** With the contradiction between supply and demand of coal prominently increasing, the joint mergers and acquisitions among coal and coal-associated industries such as electric power, iron and steel, and building materials are likewise increasing as both seek common development. This is bound to be a great opportunity for developing large coal industry innovation, financing, and capital operation.

- **Support to develop new coal chemical and other strategic emerging industries:** China has considered the development of new coal chemical industry as an important strategic measure for energy security. Furthermore, the state is pushing the cultivation and development of strategic emerging industries. The government is already entering into China's venture capital industry and establishing a CNY40 billion (US$6.5 billion) fund to help seed companies in emerging industries, mainly those into energy saving, environmental protection, emerging information industry, bio industry, new energy, new energy vehicles, high-end equipment manufacturing, new materials, etc. The Datong Coal Mine Group has the natural resource, financial advantage, and certain technical force in the new coal chemical industry development. If the new coal chemical demonstration projects are successful, the enterprise will face a major transformation and development opportunities. It will also provide new opportunities for the company to develop diversified industries, especially on new energy, new materials, energy saving, and environmental protection.

(4) Threats

- **The overall downturn in the coal industry:** In the past 10 years, an overheated market attracted too many investors to the coal industry. The integration of resources in China, through closing down of the small mines and expansion of the large ones, has lured more investment into the coal industry. This has caused overcapacity and low price. Excessive production may push current overcapacity situation to even more embarrassing levels. This will inevitably affect the coal enterprise's investment in clean coal technology.

- **External competition:** The aggregation of China's energy industry can greatly improve the degree of concentration of the coal industry and enhance the reliability of a steady supply of coal. But it can also challenge the Datong Coal Mine Group's possession of resource, expansion of traditional market scale, and maintenance of new market.

- **Heavy environmental pollution and ecological fragility pressure:** Due to long-term overexploitation, the damage to the ecological environment is very serious. Geological disasters, air pollution, water pollution, and solid waste pollution have directly affected the mining area's production and life (Figure 8.3). The amount of gangue as intractable solid waste adds up to 80 million tonnes, occupying 266.7 hectares, and forming hundreds of coal gangue hills. Spontaneous combustion of coal gangue has produced a large number of harmful gases, seriously threatening water, air, and soil. Thus, how to comprehensively utilise coal gangue has been given increasing attention (Guo and Zhu, 2011). Based on the industrial output per capita and waste discharge data in 1993, 1994, and 2000–2005, the waste water, waste gas, and solid waste emissions are exhibiting an uptrend with the increase in the per capita output.

Figure 8.2. Wasted Coal Gangue 'Mountain' and the Surface Crack Caused by Coal Mining

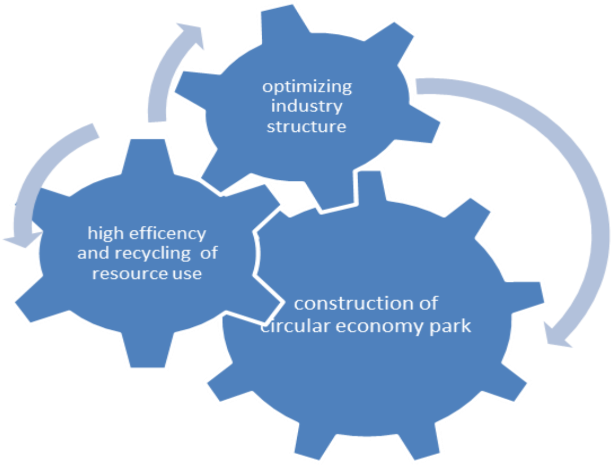
Source: Datong Coal Mine Group.

- **Low resource recovery rate:** A large number of abandoned secondary products and serous waste exist. Resource recovery rate on the average is less than 50 percent, with large waste of the residual coal reserves and associated secondary resources or coal gangue.

2.3. Development Strategy of the Datong Coal Mine Group Co.

Considering the strengths, weaknesses, opportunities, and threats that the Datong Coal Mine Group is currently facing, the enterprise development strategy is obvious: improve mining efficiency, diversify industrial structure, and achieve recycling of resources and green development.

Figure 8.3. Three Steps to Achieve the Green Strategy of the Datong Coal Mine Group Co Ltd



Source: Datong Coal Mine Group.

During the 12th Five-Year Plan (2011–2015) period, under the guidance of scientific outlook on development and centred on the overall deployment of transformative development of Shanxi province, the Datong Coal Mine Group's development thinking was to thoroughly carry out the corporate strategic development system of (i) renovating and upgrading the traditional industries, (ii) extending and expanding the pluralistic industries, and (iii) developing and strengthening the new industries. The development mode can be concluded as 'black coal, green mining; circular economy, full utilisation; high-carbon industry, low-carbon technology'. The development goal was to speed up the building of a modernised comprehensive energy group characterised by circulation, low carbon, environment friendliness, and harmony.

The most important means to achieve green development of the overall enterprise is to build circular economy parks. The Tashan Circular Economy Park is taking the lead in promoting the harmonious development of social, economic, and ecological environment.

3. Characteristics of the Datong Coal Mine Group's Tashan Circular Economy Park

Covering a floor space of 387 ha and with the total investment of CNY20.4 billion, the park had been planned to set up two coal mines, 10 factories, and one railway for coal exporting. Construction of the park started in 2003 and was finished in August 2009. It is the first circular economic park in nature with the most complete industrial chain, the fastest construction, and the most obvious effect on China's coal industry.

3.1. Clean Mining and Production

The park uses asymmetric mine development philosophy to achieve resource efficiency. It has an overall mining plan to exploit the coal resources in carboniferous Permian instead of the lower surface of the Jurassic mine area. The park has a supporting coal preparation plant for clean production of steam coal. The plan for improving efficiency and decreasing the environmental impact of mining is broken up into the following:

- Shutting down illegal and unregulated mines
- Choosing environment-friendly general mining processes
- Implementing recently discovered green mining technologies
- Cleaning up the sites of shut-down mines
- Re-evaluating cut-off grades
- R&D in green mining technology

3.2. A Closed-Loop Flow of Both Material and Energy

3.2.1. Complete industry chain

The park has 10 projects: two coal mines with annual output of 15 million tonnes; a coal-preparation plant; a kaolin-processing plant; a coal gangue brick factory; a sewage-treatment plant with daily processing capacity of 4,000 cubic metres; a methanol project with annual output of 1.2 million tonnes; a cement clinker production line; a pit-mouth power plant, and a coal gangue power plant. Furthermore, the park owns a self-support railway connected with the Beijing–Baotou Railway, the Datong–Puzhou Railway, the Datong–Qinghuangdao Railway, and several city expressways.

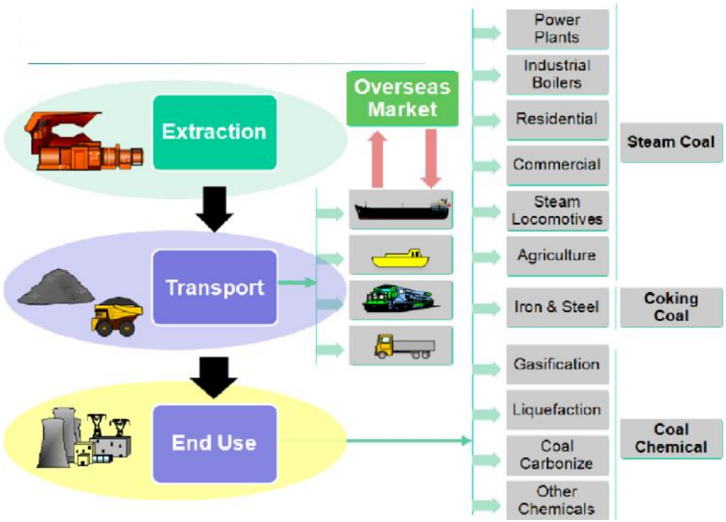
Figure 8.4. Tashan's 10 Projects to Achieve Closed-Loop Material Flow

Source: Datong Coal Mine Group document.

3.2.2. Waste to energy

The washed coal is transported via special railways. The middling and small coals are used in the chemical processing of coal to produce methanol. The coal gangue separated by the preparation is transported to the brickyard and the coal with low calorific value is transported to the power plant to generate electricity. Coal and coal products pass through all activities of the chain from upstream to downstream sectors and gain some value at each activity.

Figure 8.5. Value Chain of the Coal Industry



Source: Dan (2014).

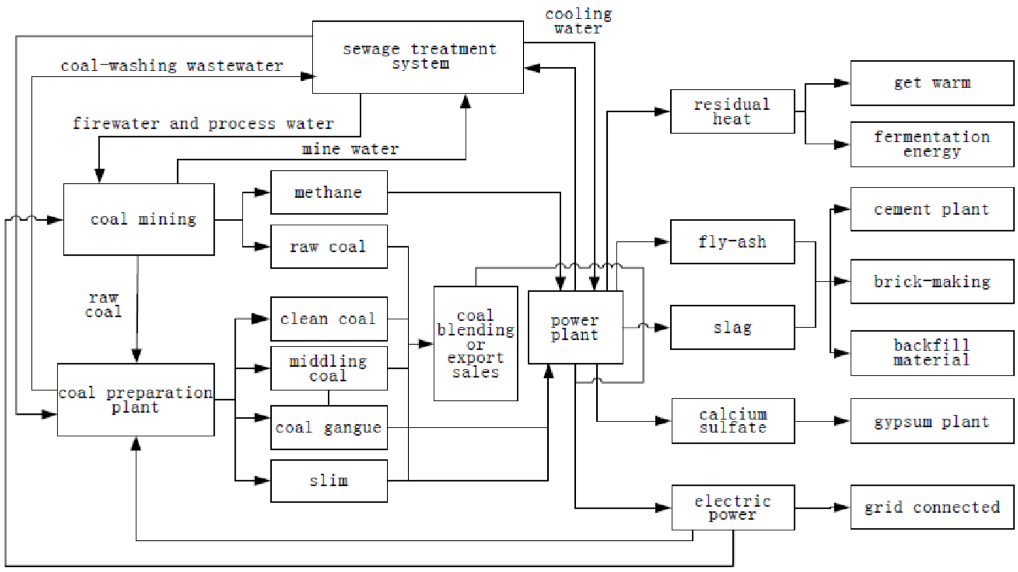
3.2.3. Waste and resource recycling

The park has two circular economic industrial lines: coal-electricity-building materials and coal chemical industry, where washed coal is transported by special railway. Residual coal pieces are used to produce methanol, coal rubble is separated and transported to a factory to make bricks, and low-value coal is used by the power plant to generate electricity. The excess heat from the power plant is used to heat residences in the area. The fly ash discharged by the pit-mouth power plant is used as raw material for the cement plant, and the kaolinic shale produced by the excavation of coal is raw material for kaolin.

In the circle, waste from the upstream plant is used as raw materials of the downstream. It constitutes a closed-loop material flow as 'mineral resources–mineral products–waste–renewable resources' according to mineral exploration, exploitation, processing, melting, deep processing, consumption, and other processes. In this way, the environmental, social, and economic benefits of the park are clearly demonstrated. Figure 8.6 illustrates how the solid coal waste can be reused.

Figure 8.6 also shows the compound purification treatment of mine waste water. Increased waste water is produced in coal mining, including underground geological water, natural groundwater for safety production, and grime waste water caused by sprinkling, falling dust, fire retarding grouting, and fire-fighting and hydraulic equipment. The mineral chemical composition and geological environment deeply affect the characteristics of mine waste water, especially hydrogeology condition and water-filling factor which determine water quality and quantity.

Figure 8.6. Circular Model of the Tashan Circular Economy Park



Source: Bin (2010).

3.3. Technology Innovation

Datong Coal Mine has a technology innovation platform and an environment-monitoring and evaluation system. Key technologies used in the park include sets of high-efficient exploitation technologies; kaolin rock-deep processing technologies; water-saving energy conservation and emissions-reduction technologies, i.e. power plant cogeneration technology; kaolin rock heat-drying technology; coal gangue and kaolin rock-burning technology; low-temperature waste heat power-generation technology; etc.

For the treatment of sewage and industrial waste water, Tashan park combines different technologies according to water quality requirements and drainage directions instead of the traditional treatment methods of coagulation–settlement and coagulation–settlement filtration.

To deal with the depleted land, the park builds eco-restoration projects in the discarded areas. Mining activities produce three types of depleted land: the dump formed by accumulation of peeled surface soil and various solid waste in open-cut coal mining, the coal mine subsidence land caused by the collapse of surface after coal mining, and the gangue dump accumulated by solid waste of coal gangue on surface along with coal mining. With the application of power-generation and waste-filling technology for comprehensive utilisation of coal gangue, existing and newly produced coal gangue are consumed at the annual rate of 5–20 percent.

3.4. Green Accounting and Flexible Management

Datong Coal Mine implements an internal green audit system that provides effective information for the enterprise's human and material resource adjustment and circular economy management, as well as favourable conditions for timely control of the resources market information. Also, the company has information-sharing platform in the park that can extract useful information based on the shared market, industry, and internal information to evaluate the status of circular economy and set development goals.

Datong Coal Mine has also established an ecological corporate culture that encourages its staff to instinctively protect the environment in their business activities and ensures that their own guidelines comply with the requirements of circular economy.

4. Outcomes and Impacts

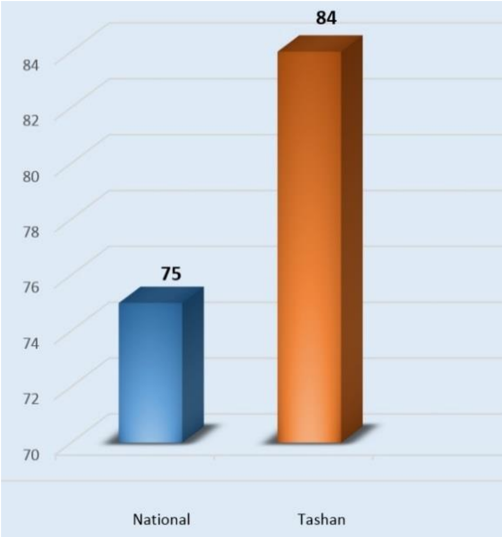
Fundamentally, the Tashan industrial park has transformed the resource-based enterprise's traditional economic growth mode into sustainable development. With the establishment of the park, the environmental, social, and economic benefits have been demonstrated simultaneously.

4.1. Economic, Environmental, and Social Impact of the Park

4.1.1. Economic benefits

As far as economic benefits are concerned, the Tashan industrial park has greater profitability. Based on its initial implementation scheme, the park may have an annual sales income of CNY6 billion, after-tax financial internal rate of return of 12.39 percent, return rate on investment of 10.57 percent, and profit and tax investment ratio of 14.78 percent. Although it may take 12 years to recoup the investment, this is still much better than the benchmark requirements of most construction projects.

Figure 8.7. Resource Recycling Rate (%)

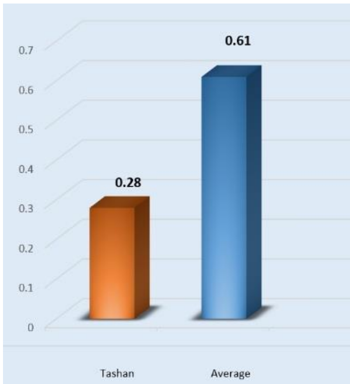


Source: Datong Coal Mine Group data.

Figure 8.8. Oil Consumption (t/a)

Source: Datong Coal Mine Group data.

Figure 8.9. Comprehensive Water Consumption ((t/a)



Source: Datong Coal Mine Group data.

4.1.2. Environmental benefits

With the increasing market demand and the expansion of the brickyard, the solid waste produced in the park, including coal gangue and pulverised fuel ash, can be reused. The domestic sewage and industrial waste water discharged into the sewage disposal plant can be recycled after treatment. With these, the park can achieve its goal of zero emission of waste water. Also, the company has built a garden-like new mining area that focuses on ecological vegetation, coal gangue treatment, and building of large-scale and full-range greenery projects.

Table 8.1. Main Economic and Social Indicators in the Tashan Circular Economy Park

Indicator	Unit	2010	2011	2012
Resource output indicator				
The main mineral resources output	CNY10,000 /tonne	0.346	0.415	0.429
Energy output	yuan/tonne of standard coal	0.969	1.123	1.181
Land output	CNY10,000 /ha	4,222.680	5,631.164	5,462.032
Water productivity	yuan/cubic metre	0.264	0.289	0.275
Resource consumption indicator				
Energy consumption per unit GDP	tonnes of standard coal/CNY10,000	1.032	0.891	0.847
Water withdrawals per unit GDP	cubic metres/CNY10,000	3.781	3.462	3.636
Energy consumption of mining plant	tonnes of standard coal/tonne	0.002	0.002	0.002
Water consumption of mining plant	cubic metre/tonne	0.125	0.145	0.138
Energy consumption of power plant	tonnes of standard coal/kWh	2.042	2.037	1.997
Water consumption of power plant	cubic metre/kWh	3.232	2.975	3.013
Comprehensive utilisation of resources				
Industrial solid waste comprehensive utilisation	%	4.701	4.941	5.918
Repeat utilisation rate of industrial water	%	59.564	55.513	55.621
Waste emissions target				
Industrial solid waste disposal	tonne	11,644,499	12,636,030	14,715,217
Industrial waste emissions	tonne	0	0	0
SO_2 emissions	tonne	3,148.14	4,039.94	3,004.19
COD emissions	tonne	0	0	0

CNY = yuan, COD = chemical oxygen demand, GDP = gross domestic product, ha = hectare, kWh = kilowatt hour, SO_2 = sulphur dioxide.
Source: Datong Coal Mine Group data.

Table 8.2. Components of the Tashan Power Plant Smoke Emissions (volume fraction %)

N_2	O_2	CO_2	SO_2	NO_2	CO	Dust
79	4.5	16.4	0.0046	0.0049	0.023	39.5 mg.m^3

CO = carbon monoxide, CO_2 = carbon dioxide, m^3 = cubic metre, N_2 = nitrogen gas, NO_2 = nitrogen dioxide, O_2 = oxygen, SO_2 = sulphur dioxide.
Source: Datong Coal Mine Group data.

The Tashan Circular Economy Park's other achievements include:

- Thick coal seam extraction rate that is 9 percent higher than the national standard
- Associated resources utilisation rate of 95 percent; solid waste disposal efficiency of 100 percent
- Mine water reuse rate of 100 percent; implementation of a closed-circuit circulation system of industrial water
- Zero emission; zero discharge park COD pollutants as a whole
- Power plant-desulphurisation efficiency of more than 95 percent
- Dust-removal efficiency of 99.85 percent.

(1) Harmonious 'symbiosis' of social and natural environment

By fully implementing the 'reduce–reuse–recycle' principle and turning waste into treasure, the park has fundamentally improved the mining area's production environment and its surrounding natural environment. Moreover, the park has separated the production area from the living area. In 2014, the Datong Coal Mine Group started its plan of 'adding green, managing green, loving green' by planting more than 90,000 trees and 180,000 shrubs in the mining area. Its main purpose is to restore the ecological environment by strengthening the green management of residential and public spaces.

4.2. Impact on the Overall Industry and Regional Development

Ten years ago, Tashan was poor and desolate and with a very serious environmental problem. The park's construction has attracted many high-technology industries through investment, technology transfer, and product acquisition. Also, the park has made significant spillover effect on the surrounding areas such as rise in employment. In 2008, the local tax increased by about CNY1 billion.

The Tashan Circular Economy Park is the first successful pilot zone of circular economy in China's coal industry and is considered as representing the development direction of China's coal industry, energy industry, and resource-based enterprises.

With the success of Tashan, the Datong Coal Mine Group has developed ambitious plans for the development of circular economy, starting from 'point circular' to 'line circular', then to 'plane circular', and finally forming a three-dimensional network structure architecture of circular economy for sustainable development in the whole enterprise and region. After the experience of Tashan Circular Economy Park, four more circular economic parks have been listed in the plan: (i) Dongzhouyao–Maodaotou–Panjiayao Park, (ii) Xuangang Park, (iii) Shuonan Park, and (iv) Baijiagou Park.

Other domestic coal enterprises are also actively implementing the circular economy development strategy. In Shanxi, the Lu'an Mining Group has built four new eco-industrial parks in Tunliu, Gaohe, Lucheng, and Tengku. The Shanxi Xishan Coal and Electricity Group Co has constructed the Xishan Park Circular Economy Park. The practice of circular economy park has also expanded to other resource-based regions.

4.3. Obstacles Facing Circular Economy Initiatives

During the circular economy development process, the Datong Coal Mine Group encountered a lot of difficulties in project application, technology and finance, human resource management, etc.

4.3.1. Weak policy support on circular economy

A power plant is an important node in the implementation of circular economy in coal enterprises. However, due to national macro-control and industrial policies, project application and approval for its construction took a long time and encountered many difficulties. The same was true in other cases. Most countries overemphasise the role of large power plants while ignoring the environmental and social functions of small mining power plants in improving mining area environment and comprehensive utilisation of waste.

4.3.2. Financial barriers

Another stumbling block is the lack of financial support to a project’s initial investment and infrastructure construction which are normally large and need a long period to develop the market. Relying on the enterprise alone to raise funds for the development of circular economy will often result in stagnation. Strong financial support at the start of a project is crucial.

4.3.3. Technology barriers

Compared with international circular economy parks and advanced domestic enterprises in the same industry, the technical level in China’s circular economy parks still needs improvement as the state has not given enough support and encouragement to construct and develop circular economy in industrial parks. Most parks were constructed based on enterprises’ own technology and development level.

4.3.4. Irrational human resource structure and outflow of special talents

The number of employees of the Datong Coal Mine Group is quite large. However, the professional technical and managerial personnel are extremely small, especially in the coal chemical industry, etc. Moreover, the relatively lower wages in midwest cities and their low attraction make it difficult for Datong Coal Mine to retain key talents, the outflow of which is becoming more and more serious. The comparative advantage of the company’s present talents may gradually lose its position and turn into a disadvantage in the future.

5. Implications for Policy and Practice

Establishing new development models of circular eco-industrial park has great significance for developing countries as it solves the problem of shortage of mineral resources, resource waste, and environment pollution while raising resource utilisation ratio. The Datong Coal Mine Group Co, from an enterprise perspective, is a good example of how building circular economy parks can achieve green development. The Tashan mode can be called a mode of green sustainable development, equally emphasising resource extraction and resource conservation, and striving to improve resource utilisation rate, reduce waste emissions, and achieve zero pollution by means of clean production and resource recycling in a ‘lateral coupling vertical closure’ industry chain. The driving forces in the process are technology and system innovations. The Tashan case also shows that establishing a circular economy system is a complex and massive project that needs the support of national policy and funding, and also requires enterprises and society to improve awareness of the importance of developing circular economy.

5.1. Suggestions for Policymakers

The development of circular economy cannot be achieved without government support. Better regulations generally precede cleaner green practices. The most important thing in accelerating the transformation of economic development mode in China is to set up a policy support system in the development of circular economy. From the government perspective, a series of policies, regulations, standards, and management systems can be used to encourage enterprises to save energy, materials, and water and to use resources synthetically.

5.1.1. Policy differentiation for new and old enterprises

For example, in newly constructed mining areas, the government must improve market access standards, abandon traditional extensive development modes, and promote the concept of recycling economy to achieve win-win-win solution for the economy, society, and nature. In old mining areas, the government should pressure and support enterprises to improve their rates of resource recovery rate, coal washing, and resource recycling through green mining, clean production, and resource recycling.

5.1.2. Improving the circular policy system and legal system

The government can play a crucial role in supporting the development of circular economy by encouraging the recycling of resources, restraining resources-wasting behaviours, and stopping environmental pollution through various economic incentives and legal measures, including taxes, fees, financial credit encouragement system, environmental labelling system, commission system, etc.

5.1.3. Increasing capital support for circular economy enterprises

Other than preferential fiscal and industrial policies, the state can establish special development funds or increase subsidies for the construction of circular economy infrastructure such as energy, transportation, communications, network, water supply and drainage, and other infrastructure. Previous stages of R&D in circular economy have involved large investment and high risk. The state can establish a circular economy industry fund to support initial investment and stage of operation of circular economy. Furthermore, to remove barriers of private investment, government can provide financial guarantees or insurance normally through government-owned or -controlled corporations, central banks, ministries, or other government departments.

5.1.4. Establishing technology cooperation platform and knowledge-sharing platform

The state can set up national or provincial circular economy research centres and integrated technology cooperation platforms for enterprises, academia, and research organisations to enhance capability in key technology research, technology innovation, and market implication and promotion. The government can also help set up knowledge and information-sharing platforms to optimise investment environment and accelerate technology and experience-sharing in the development of circular economy.

5.1.5. Encouraging international cooperation and international technology transfer

The state can help regions and enterprises to widen the financing channel through international cooperation with international organisations such as the Asian Development Bank, World Bank, Asian Infrastructure Investment Bank, and other potential international sources with lots of green projects and professional and technical personnel training programmes. The government can further encourage joint ventures and foreign direct investments to promote technology transfer, both into and out of China. It is also necessary to strengthen international cooperation and build an advanced technology transfer platform for enterprises.

5.2. Suggestions for Practitioners

Chinese enterprises have a long way to go in circular economy development. The Datong Coal Mine Group's Tashan industrial park is a successful case from which resource-based enterprises can learn:

(1) Strategic orientation

To develop circular economy, the company must strive to extend the industry chain and increase the added value of products. It is necessary for an enterprise to formulate a strategy of circular economy and design a scientific plan and construct complete industry chain to achieve clean production and resource recycling. The design plan should be guided by the direction of national circular economy and should offer recycling solutions to product obsolescence. Such effort would not only satisfy the government but also ensure the enterprise's competitiveness and the loyalty of employees.

(2) Technical transformation

Green technology and innovation are the key to achieve circular economy transformation. It is necessary to improve the level of technology and equipment. Enterprises should improve their investment in R&D and intensify inputs to the core technology of circular economy. Another way is to set up technology platforms to enhance communication with other enterprises, universities, and research institutes for key technology research. Furthermore, they can take advantage of advanced information network for rapid transmission of important information to improve communication and work efficiency among departments.

(3) Environmental governance and management innovation

Innovation helps an enterprise seize an opportunity and use it to introduce and create new ideas, processes, or products. The top management plays a crucial role in the process. Circular economy requires total innovation in the culture of the enterprise, i.e. arousing employees' awareness of environmental protection, energy saving, and knowledge and innovation. It is important for an enterprise to set up its green internal audit system to achieve environmental governance. The system covers monitoring, feedback and evaluation, rewards and punishments, and other detailed matters for implementation, and can help an enterprise set a reasonable goal of green development.

(4) Making a good human resource plan

Human resource planning is important to reduce cost and optimise the human resource of an enterprise. First, personnel structure should be optimised and operation skills of employees should be improved. Second, scientific planning should be made for career development through a promotions system to motivate employees to have a clear development direction and inspire work enthusiasm. Third, a performance-evaluation system should be perfected to harmonise the development goals of employees and enterprise and link their interests. Employees should be encouraged to have deeper understanding of theoretical and practical knowledge to lay a solid foundation for a knowledge- and technology-intensive human resource in the enterprise.

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Chapter 9

Creating Integrated Business, Economic, and Environmental Value within a Circular Economy in India

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1. Introduction

Increasing competitiveness in a circular economy should be driven by public and private investments that enhance resource efficiency and reduce pollution and emissions. A circular economy is not a luxury for developing countries like India. This transformation is akin to a revamped industrial revolution, one that seeks better use of resources. Economically this means changing the composition of the economy towards an increasing range of resource-efficient sectors. This chapter investigates the challenges and opportunities of how firms, sectors, and community organisations can and will be able to strike a better balance between economic growth and resource efficiency in the context of India's emerging circular economy paradigm. Based on meta policy analysis and case studies on resource recycling, we identify and demonstrate that blended business and economic value can be created by adopting a circular economy approach in an integrated way.

2. Targets, Monitoring, and Benchmarking for a Circular Economy in the Indian Context

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 progress towards achieving them through benchmarking (Park, Sarkis, and Wu, 2010). Quantitative targets and indicators are useful in determining the level of change required, while also allowing for comparisons between companies or different government initiatives. 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 fast-growing economies of Asia have shown that the definition of national quantitative targets is important to show ambition, create 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 avoid disjointed actions and provided a long-lasting context for energy efficiency policies. Setting energy efficiency targets can form the basis for monitoring the national policy outcomes and tracking the progress.

Resource efficiency targets must be sufficiently clear for key actors such as specific government agencies, industry, and consumers to understand and act on. 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 India along with several countries in the region have now adopted national energy efficiency programmes with quantitative targets. Yearly monitoring is usually a requirement of such programs.

India has initiatives to measure resource efficiency across its national economy. Table 9.1 presents the national targets for achieving material, energy, and water efficiency of selected countries. India has set ambitious resource productivity, recycling, and waste reduction targets in the water and energy sectors. The targets undergo yearly performance measurement and are supervised. Japan, China, and Singapore are the other countries that have set targets in all three key areas of resource efficiency that includes material efficiency. Overall, targets for achieving resource efficiency are more commonly used than material or water efficiency targets.

2.1. Policy Instruments

Comprehensive policies comprising both regulatory and market-based tools are needed to achieve greater resource productivity and thus a 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 India, over the past 2 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 policy instrument to operate in isolation in India. 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: (i) accounting for the multi-aspect nature of circular economy challenges, (ii) enhancing the effectiveness of one instrument with the help of another and vice versa, and (iii) reducing administrative costs and improving enforcement possibilities.

The challenge for policymakers in India 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 promote 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 in India try to shift companies' or householders' actions from a current wasteful practice to one that conserves resources. This attempt usually calls 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.

Four generic groups of policy instruments being adopted in India can be used to promote resource efficiency. It is important to note that it is usually difficult to categorise policy measures as being purely 'regulatory', 'economic', 'information-based', or 'voluntary' since they overlap.

2.1.1. 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.

Table 9.1. Resource Efficiency Targets of India Compared with Those of Other East Asia Summit Countries

Country	Material Efficiency	Energy Efficiency	Water Efficiency
Australia		Generate 20% of energy from renewable sources by 2020.	
China	▪ Increase GDP generated per tonne of 15 main resources consumed including energy, iron ore, non-ferrous metals, and non-metals by about 25% over 2003 in 2020. ▪ Increase the comprehensive use rate of solid industrial wastes from 55.8% in 2015 to 60% in 2025. ▪ Target the proportion of reused copper, aluminium, and lead in production output to reach 35%, 25%, and 30%, respectively, by 2020. ▪ Increase the amount recycled of major renewable resources by more than 65% by 2030 compared with the 2003 level. ▪ Limit the storage and treatment of industrial solid wastes to approximately 4,500 million tonnes. ▪ Constrain the growth rate of garbage to approximately 5% by 2010.	Reduce energy consumption per unit of GDP by 20% in 2010 compared with the 2005 level.	▪ Reduce water consumption per unit of industrial value added by 30% in 2015 compared with the 2005 level. ▪ Improve the effective utilisation coefficient of agricultural irrigation water from 0.45 in 2005 to 0.50 in 2010.
India	Realise waste conversion rate of at least 25% by 2025.	Achieve energy savings of 10,000 MW in 2020.	Increase water use efficiency by 20%.
Japan	▪ Improve resource productivity by 60% by 2020. ▪ Improve cyclical use rate by 40–50%. ▪ Reduce final waste disposal amount by 60%.	Improve energy efficiency by at least 30% in 2030.	
Republic of Korea	Increase recycling by 53% by 2015.	▪ Reduce energy intensity by 46% by 2030. ▪ Reduce energy consumption by 42	

Country	Material Efficiency	Energy Efficiency	Water Efficiency
		million tonnes of oil equivalent by 2030.	
New Zealand		▪ Generate 90% of electricity from renewable sources by 2025. ▪ Non-transport energy savings of 30 petajoules (PJ) by 2025.	
Philippines	Achieve waste conversion rate of at least 25% by 2016.	Reach average annual energy savings of 23 million barrels of fuel oil equivalent.	
Singapore	▪ Reach 60% of household waste recycling by 2012. ▪ Achieve 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 2012 and 2020.
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.

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 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 India can look into. They typically not only included standards on emissions or technologies and environmental liability, but also extended 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 the East Asia Summit region have introduced regulatory instruments to promote resource efficiency. These include (i) 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 [Box 1], China's Energy Conservation Law 1998 and 2008, India's Energy Conservation Act 2001); (ii) laws and regulations to promote resource efficiency and sustainable production and consumption (for example, Japan's 3R (reduce–reuse–recycle) laws and China's Circular Economy Law 2008 and Cleaner Production Law 2002); and (iii) laws to promote low-carbon and green growth (such as the Republic of Korea's Framework Act on Low Carbon and Green Growth 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.

Box 1. Japan's Top Runner Standard Programme

Japan's Top Runner Programme was introduced in 1998 as part of the country's Energy Conservation Law to improve energy efficiency in energy-using products. The programme is a regulatory approach administrated by the Japanese Ministry of Economy, Trade and industry and does not provide any kind of government incentives. One of the most important characteristics of the Top Runner Programme lies in its focus on the supply side of important markets. Stringent energy efficiency standards have been established for 21 product categories, including passenger vehicles, air conditioners, refrigerators, and television sets. Instead of setting a minimum energy performance standard, the current highest energy efficiency rate of a product in each category is taken as the standard (the 'Top Runner'). This standard represents the target value of energy efficiency that has to be reached by all products belonging to the category within a certain period. Since the introduction of the programme, each product category has achieved significant energy efficiency improvements. For example, the energy efficiency of air conditioners improved by 67.8 percent between 1997 and 2004. Energy efficiency improvements for other product categories include electric refrigerators, 55.2 percent (1998–2004); gasoline passenger vehicles, 22.8 percent (1995–2005); vending machines, 37.3 percent (2000–2005); and computers, 99.1 percent (1997–2005). Overall, the Top Runner Programme is expected to achieve 0.35 exajoules (EJ) of energy savings between 1998 and 2010.

Source: Authors.

2.1.2. Economic and market-based instruments

More recently, greater emphasis has been placed on the use of economic instruments to help correct the market failures in India. Perform, Achieve and Trade (PAT) is a programme introduced among the industrial units and works by encouraging certain behaviours through the use of market-based instruments that bring economic incentives. All identified industrial units are mandated to reduce their specific resource consumption. The reduction targets are based on their current efficiency (average plant reduction target is about 4.8 percent). Industrial units that are able to achieve their targets receive energy savings certificates, which can be traded on the power exchanges and bought by non-compliant units to meet their compliance requirements. Industrial units that are unable to meet the targets (through their own actions or the purchase of certificates) are liable to a financial penalty. In contrast to regulatory instruments, which force all regulated entities to comply with the same standards, the incentives and disincentives provided through economic instruments such as PAT can generate different behaviours depending on each actor's specific circumstances. This flexibility can often reduce the overall compliance costs quite significantly compared with uniform regulations.

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 the implementation; creating a well-functioning market may require a fairly large administration, and the regulated entities usually need training on 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.

Examples of the many different types of economic instruments are subsidies (including the removal of environmentally harmful subsidies); taxes (on emissions or products); rebates (on tax, purchase of resource-efficient products); tradable permits; and deposit refund schemes.

2.1.3. Information-based measures

Information-based measures have become more popular in India recently. This is partly because of the lower costs of dissemination brought by information technology. These policy instruments provide information on 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 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 advantage 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 types of information-based measures in India 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 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 impact 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 percent in terms of energy efficiency within their cohort.

Education of firms and consumers is another important information-based measure and is critical to the decision-making process. India has introduced educational programmes to enhance knowledge of the population on resource-efficient behaviour. For example, the state government of Tamil Nadu 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 revenues 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.

Box 2. Firm-Based Circular Economy Standards in India's Cement Industry

The cement industry is a very material-intensive (energy and water) industry and is responsible for large amounts of resource consumption, greenhouse gas (GHG) emissions and air pollution. Some of the larger multinational cement companies have moved to establish a set of firm-based global efficiency standards, which include uniform approaches to managing and reporting energy, water use, and pollution emissions.

The case study cement firm in India operates six cement plants with a total production capacity of about 12 million tonnes of cement per year. In 1999, a building conglomerate acquired the largest ownership stake in the firm. This conglomerate operates 129 cement plants in more than 30 countries around the globe and maintains various forms of firm-based global efficiency standards. These standards range from standardised management and reporting practices to performance standards for energy use and emissions.

The conglomerate uses a standardised set of economic and resource efficiency performance metrics that all plants must report on. Other standards relate to GHG emissions and the use of waste. The conglomerate as a whole has a stated target of reducing carbon dioxide (CO_2) emissions by 20 percent from the firm's baseline emissions in 1990 by the year 2010. All plants are required to follow a prescribed methodology to calculate and report CO_2 emissions, to develop a plan for reducing emissions, and to increase the use of waste materials as a source of fuel.

The introduction of firm-based global standards had significant impact on India's cement plants. For instance, the standards led to the introduction of computer-based, real-time monitoring of resource use and emissions, along with specific protocols for calculating and reporting air emissions, water use, and GHG emissions. The conglomerate helped these plants prepare a plan to reduce CO_2 emissions, which resulted in a 12 percent reduction in carbon emissions intensity by 2005. Furthermore, the Indian firms were able to benchmark their own resource efficiency targets because they had access to standardised performance information for other plants operated by the conglomerate. In addition, the firm introduced a standardised alternative fuels and raw materials programme, which resulted in a dramatic increase in the use of alternative fuels and raw materials. Finally, the plants have been able to bid on intra-firm contracts to provide technical assistance for other plants within the firm network. In 2002, the Indian plants earned over US$10 million by providing technical assistance to other plants operated by the conglomerate.

Overall, the implementation of firm-based global resource efficiency standards has proven to be a successful approach to performance-based continuous improvement towards a circular economy. Intra-firm benchmarking served as a platform for firm-wide learning and for creating an intra-firm marketplace for technical assistance.

Source: Jose (2015).

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 achievements.

Firm-based resource efficiency standards are also emerging as an important influence on the circular economy in India. 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 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 various end-market regulations. As a consequence, firms are adopting their own global standards as a necessary way to operate their global production networks (Box 2).

3. Current National Policies That Promote Resources Efficiency and Support Circular Economy in India

3.1. 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: (i) by reducing the amount of materials contained in the final product, and (ii) by reducing the amount of materials that enter the production process but end up in the waste stream. Numerous countries in the East Asia Summit region have implemented national policies to promote material efficiency (Table 9.2). Japan, China, and the Republic of Korea (henceforth Korea), in particular, have introduced comprehensive policies and legislation to reduce waste and resource consumption and to increase recycling.

India introduced rules on municipal solid waste in the 2000s which obligate municipalities to segregate organic from household waste to be treated through composting. The National Environmental Policy (2006) looked at the efficient use of resources by reducing use per unit of economic output and proposed actions for recycling and reuse of waste. The Plastics Manufacture and Usage Rules of 2003 set objective targets for the development of plastics recycling with the target of 1.7 million tonnes annually. Since the introduction of this legislative framework, India has made substantial progress in achieving greater recycling rates, while reducing final disposal amounts and dioxin emissions. For instance, after the introduction of these product-oriented recycling acts, the amount of waste for final disposal in 2012 was 44 percent lower than in 2000 (Zhou et al., 2013).

Resource efficiency has also developed into an important issue for the local governments, which introduced the smart city and eco-town concepts to support a 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 recognises that the development of a circular economy is an important strategy for the economic and social development of India. Industrial enterprises are required to reduce resource consumption and recycle waste materials. The Government of India also allocates funds for businesses to encourage innovation in recycling technologies. Furthermore, it provides tax breaks to enterprises using resource-efficient technologies and equipment. Enforcement of smart cities requires the enactment of supporting regulations; some of these have been enacted whereas 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 to achieving a circular economy. In addition, it will define indicators for rates of waste reuse and recycling.

Box 3. Volume-Based Waste Fee System in the Republic of Korea

The Government of the Republic of Korea introduced a volume-based waste fee system in 1995 in order to reduce waste generation at the source and maximise waste recycling. Households and small commercial operators are required to purchase designated bags to throw away their garbage and a waste collection fee is charged in proportion to the amount of waste thrown away. This way, the public has an incentive to generate less waste to minimise the costs. The cost for waste treatment is recovered from the sale of the designated bags. The average price for a 20-litre garbage bag was US$0.38 in 2004.

To avoid illegal dumping or waste burning, a fine of up to US$1,000 is imposed on violators. The government has also introduced a reward system for reporting illegal dumping activities. Anyone who reports such an activity is paid as much as 80 percent of the fine charged to the violator. These measures have successfully reduced illegal dumping in urban areas. However, waste burning by rural residents and dumping in public gardens and rivers are still problematic, and the government is devising new strategies to monitor and prevent these activities.

After 10 years of implementation, the system has proven to be very successful in reducing the generation of municipal solid waste and increasing the recycling rate. Between 1994 and 2004, municipal solid waste generation decreased by nearly 14 percent. In the same period, the national recycling rate increased from 15.4 percent to 49.2 percent.

Source: KLRI (1997).

Korea is another country in Asia that has implemented a number of national policies to increase material efficiency. India can look to Korea for lessons to be learnt for making the 'Made in India' policy more sustainable. The Act on the Promotion of Saving and Recycling of Resources of Korea (1992) seeks to contribute to sound development of the national economy by facilitating the use of recycled resources and by reducing the generation of wastes and facilitating recycling. It also includes product design provisions for vehicles and electrical goods. Producers of these goods are required to consider ways to use less material, adopt recyclable materials, curb the use of hazardous substances, reduce product weight, and make products easier to dismantle (KLRI, 1997).

The Government of the Republic of Korea also introduced a mandatory extended producer responsibility (EPR) system through amendments of the Act on the Promotion of Saving and Recycling of Resources in 2003. The EPR system applies to a specified list of products and packaging materials and imposes continuing accountability on producers over the entire life cycle of their products. Under the EPR system, the government sets mandatory take-back and recycling requirements for each product, and producers have to pay fees to join organisations that handle the collection and recycling obliged. Producers that do not meet their obligations are penalised (Walls, 2006). Other policy initiatives by the government to promote material efficiency include volume-based waste collection (Box 3), regulations for promoting recycling of construction waste, and a non-governmental organisation campaign to reduce food waste (Yoshida, Shimamura, and Aizawa, 2007).

Table 9.2. Examples of National Policies, Laws, and Regulations to Promote Material Efficiency in India Compared with Those of Selected East Asia Summit Countries

Country	Policy Details
Australia	National Waste Policy (2010): Aims to avoid waste generation, to reduce the waste amount, to reduce the waste for disposal amount, and to manage waste as a resource
China	▪ Circular Economy Law (2008): Promotes the development of a circular economy, improves resource utilisation efficiency, and protects and improves the environment, also realising sustainable development; refers to the reduction, reuse, and recycling of resources during production, circulation, and consumption ▪ Environmental industrial park policy: Established around 30 pilots of eco-industrial parks ▪ Solid Waste Act (1995, amended in 2004): Establishes a legal framework for product take-back and recycling ▪ Regulation on the Management of Electronic Waste: Regulates the mandatory recycling and treatment of waste electrical and electronic appliances (televisions, refrigerators, washing machines, air conditioners, and computers); intends to promote the circular use of resources
India	▪ National Environmental Policy (2006): One key objective is the efficient use of environmental resources by reducing use per unit of economic output, and proposes actions for recycling and reuse of waste ▪ Plastics Manufacture and Usage Rules (2003): Development of plastic recycling targets – amount recycled: 1.7 million tonnes in 2010
Japan	▪ Fundamental Law and Plan for Establishing a Sound Material-Cycle Society (2000 and 2003, amended in 2008): Framework law and implementation

Country	Policy Details
	programme to move the country towards a recycling-based approach in product design, manufacture, use, and disposal. Established targets to be achieved by 2015 in resource productivity, cyclical use rate, and the amount of final disposal. ▪ Individual product laws have set up targeted recycling regimes for containers and packaging, home appliances, food waste, construction materials, and end-of-life vehicles ▪ Law on Promoting Green Purchasing (2002) : Eco-labelling programs for appliances ▪ Law for Promotion of Effective Utilisation of Resources (2006): Deals with battery take-back, labelling, and reuse ▪ Waste Management and Public Cleansing Law (2003): Ban on waste incineration
Republic of Korea	▪ Waste Management Act (1995): Volume-based waste collection; extended the producers' responsibility for electronic appliances and vehicles with mandatory targets for product recovery and recycling ▪ Act on the Promotion of Construction Waste Recycling (2003): Construction work contracted by a public agency must use more than a certain level of recycled aggregate. ▪ Act on the Promotion of Saving and Recycling of Resources (1992, amended in 2003): Promotes the efficient use of resources, waste prevention, and resource reutilisation towards improving the environment. Amendments to the act introduced a mandatory extended producer responsibility (EPR) scheme. ▪ Second Comprehensive National Waste Management Plan (2002–2011): National framework for the promotion of waste reduction policies; includes waste reduction and recycling targets (e.g. increase recycling by 53% in 2011).
Malaysia	▪ Solid Waste and Public Cleansing Management Act (2007): Aims to improve the collection, recycling, and disposal of solid waste; prescribes 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
New Zealand	▪ Waste Minimisation Act (2008): Encourages waste minimisation and a decrease in waste disposal; requires product stewardship schemes for priority products; puts a levy on all waste disposed to landfills, introduces a waste minimisation fund to provide financial assistance for projects that increase resource efficiency ▪ New Zealand Waste Strategy (2002): Zero waste concept is the long-term goal. One major goal is to increase the economic benefit by using material resources efficiently. Contains 30 aspirational targets for improved waste management, minimisation, and resource efficiency
Philippines	▪ National 3R policies: Set the goal of achieving waste conversion rate of at least 25% by 2006. ▪ Ecological Solid Waste Management Act (2000): Mandates management for 'zero waste' as a national policy; requires local governments to recycle 25% of waste collected
Singapore	▪ Green Plan 2012: Has a 'zero landfill' objective. Includes a national recycling programme for households launched in 2001 with target 60% recycling by 2012. The recycling rate in 2009 was 57%, up 16% by 2030.
Viet Nam	▪ National 3R Strategy: Sets 3R targets for 2020 ▪ Environmental Protection Law (2005): Includes 14 provisions to promote 3R and related activities

Source: Compiled by the authors.

3.2. 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 India accounts for about 45 percent of total commercial energy consumption in the country (96.21 million tonnes of oil equivalent [Mtoe]). It is one of the largest contributors to CO_2 emissions after the power sector. A broad analysis of industrial energy-use patterns shows

Table 9.3. Examples of National Policies, Laws, and Regulations to Promote Energy Efficiency in India Compared with Those of Other East Asia Summit Countries

Country	Policy Details
Australia	▪ National Framework for Energy Efficiency (Stage 1 in 2004, Stage 2 in 2008): Stage 1: Addressing the barriers to the energy efficiency uptake; Stage 2: Implementing energy efficiency measures ▪ National Strategy on Energy Efficiency (2009): Provides a nationally consistent and coordinated approach to energy efficiency by transitioning Australia into a low-carbon economy and by reducing barriers for energy efficiency uptake ▪ Energy Efficiency Opportunities Act (2006): Encourages large energy-using businesses (those using more than 0.5 petajoules [PJ] of energy per year) to improve their energy efficiency by identifying, evaluating, and publicly reporting on cost-effective energy-saving opportunities
China	▪ 12th Five-Year Plan (2011–2016): Targets to reduce energy consumption per unit of gross domestic product (GDP) by 50–60% from 2000 levels by the year 2020 ▪ Energy Conservation Law (1998, amended in 2008): Seeks to encourage the rational use of energy and promote improvements in energy conservation technologies ▪ Energy conservation technologies: Includes an energy efficiency labelling scheme and establishment of energy conservation audit facilities in local governments ▪ National Climate Change Programme (2007): Proposes a range of measures to improve energy efficiency and energy conservation; includes an energy efficiency objective of reducing energy consumption per unit of GDP by 20% in 2010 ▪ Procurement Policy for Energy Efficient Products (2004): Requires government agencies to prioritise products that are certified as energy-efficient in the procurement process
India	▪ Energy Conservation Act (2001): Legal mandate for the implementation of energy efficiency measures ▪ National Mission for Enhanced Energy Efficiency (2008): Programmes are anticipated to result in savings of 10,000 megawatts (MW) by the end of 2012. As part of the National Action Plan on Climate Change, this national mission proposes four new initiatives: (i) market-based mechanism for trading in certified energy savings, (ii) accelerating the shift to energy-efficient appliances in designated sectors, (iii) demand

Country	Policy Details
	side management programmes, and (iv) developing fiscal instruments to promote energy efficiency. ▪ National Energy Efficiency Plan (approved August 2009): Sets up energy efficiency targets for industry by December 2010 ▪ Other initiatives for improved energy efficiency: Energy Conservation Building Code (2007); mandatory energy audits of large industrial consumers (2007), enhancing efficiency of power plants; and introduction of mandatory energy labelling programme for appliances (2006) ▪ National Hydro Energy Policy (2001): Electricity from renewable sources such as mini hydros and hydropower ▪ Clean Air Initiative (2008): 'Bachat Lamp Yojana' programme to promote energy-saving devices
Indonesia	National Energy Policy (2006): Framework policy that seeks to increase energy efficiency and promote renewable sources of energy
Japan	▪ Energy Conservation Law (1979, last amended in 2008): Provides the legal framework for improvements in energy efficiency and conservation. Regulatory measures include (i) Businesses need to report their energy use, employ an energy manager, and prepare the energy conservation targets; (ii) Transport service providers need to prepare energy conservation plans; (iii) Manufacturers need to enhance energy consumption efficiency of products; (iv) Building sector needs to implement energy conservation measures; and (v) Energy conservation labelling programme for air conditioners, televisions, and refrigerators ▪ Energy and Environment Policy (Progressive over the years): Includes measures for improved energy resource use efficiency and diversification of energy resources ▪ National Plan for Promoting Energy Efficiency and Conservation (Progressive over the years, last amended 2011): Aims to improve energy efficiency by at least 30% from 2003 levels in 2030
Republic of Korea	National Basic Energy Plan (2008–2030): Calls for increased energy efficiency – energy intensity target: 46% reduction by 2030 from the current levels and energy consumption target: reduction of 42 million tonnes of oil equivalent (MToe) by 2030 from the current levels
Malaysia	10th Malaysia Plan (2011–2015): Includes energy efficiency objectives such as intensifying energy efficiency initiatives in industry, transport, and commercial sector; also promotes greater use of renewable energy for power generation and by industry.
New Zealand	▪ Energy Efficiency and Conservation Strategy (2007): Detailed action plan for increasing the uptake of energy efficiency, conservation, and renewable energy programmes across the economy, and to make doing so part of the normal behaviour of the country's programmes; seeks to achieve a number of targets (e.g. 90% of electricity generated from renewable sources by 2025). Programmes are expected to achieve 20 petajoules (PJ) of energy savings in the transport sector by 2015 and 30 PJ of savings in non-transport energy per year by 2025.
Philippines	▪ National Energy Efficiency and Conservation Program (2004): Seeks to achieve the efficient use of energy to minimise environmental impacts; targets to achieve an average annual savings of 23 million barrels of fuel oil equivalent and 5,086 gigatonnes (Gt) of CO_2 emissions avoidance

Country	Policy Details
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 among 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% in 2008 and by 20% in 2009. ▪ 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 labelling of products
Viet Nam	▪ National Energy Efficiency Program (2006–2015): Seeks to coordinate efforts for improving energy efficiency, reducing energy losses, and implementing extensive measures for 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%.

Sources: Compiled by the authors.

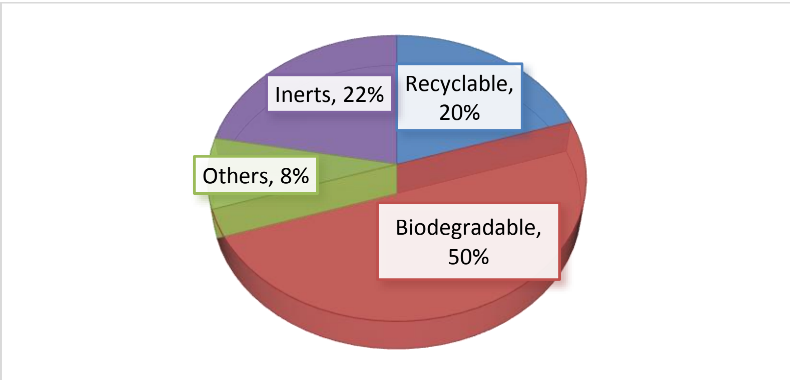
that seven sectors account for about 60 percent of industrial energy consumption: (i) cement, (ii) pulp and paper, (iii) fertilizer, (iv) iron and steel, (v) textiles, (vi) aluminium, and (vii) chlor-alkali. Most of the plants in these sectors are large units, few of them are operating under the public sector. These sectors have been included as 'designated consumers' by the Bureau of Energy Efficiency under the Energy Conservation Act 2001 (nearly 750 such consumers have been identified by the bureau). Although no detailed baseline of energy consumption data for industrial consumers is available from a single source, several individual studies reveal 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 an industrial sector.

For example, the specific thermal energy consumption for modern cement plants is as low as 663 kcal/kg (2,775 kJ/kg) of clinker, and for old plants, as high as 900 kcal/kg (3,768 kJ/kg) of clinker. Similarly, the specific power consumption of some modern cement plants is about 65 kilowatt-hour (kWh) per tonne of cement, whereas this figure is close to 90 kWh/tonne of cement for old plants. India's National Action Plan on Climate Change estimates that various schemes and programmes initiated by its government would result in energy savings of 10,000 megawatts in various sectors of India's economy. Table 9.3 provides an overview of the national policies to promote energy efficiency that have been implemented in India compared with other East Asian Summit countries.

4. Current Patterns of Resource Use and Waste Generation in India

The rate of waste generation in India is growing very quickly owing to industrial development and urbanisation. The current composition of waste carries a high potential for recycling that is barely exploited. Generally, about 15 percent of waste material, which consists mainly of paper, plastic, metal, and glass, can be retrieved from the waste stream for further recycling. Another 35–55 percent of waste material is organic waste, which can be converted into useful compost, leaving only 30–50 percent that needs to go to landfills (Asanani, 2006). Figure 9.1 shows the composition of municipal solid wastes in India. More than 50 percent are biodegradable and 20 percent are recyclable.

Figure 9.1. Composition of Municipal Solid Wastes in India



Source: Authors' compilation based on Central Pollution Control Board (CPCB) 2013 data

Table 9.4 highlights the amounts of waste generated in India's cities and states over a period.

Waste materials such as paper, plastic, metal, glass, rubber, leather, and rags are recycled mainly through private initiatives and the informal sector. In spite of different laws and targets, waste recycling is still neglected by industrial units because of its low value and the lack of a market. Composting is underdeveloped and remains the domain of the hundreds of small-scale schemes run by private initiatives. There exist several case studies, however, in which raw materials that formed part of the value chain are recycled and reused to improve the resource efficiency at different levels.

Table 9.4. Waste Generated in India's States in 2004 and 2014

State	Solid Waste Generated MT/day (1999–2000)			Solid Waste Generated MT/day (2009–2014)
	Class I cities	Class II towns	Total	
Andaman & Nicobar	–	–	–	50
Andhra Pradesh	3,943	433	4,376	11,500
Arunachal Pradesh				93,802
Assam	196	89	285	1,146.28
Bihar	1,479	340	1,819	1,670
Chandigarh	200		200	380
Chhattisgarh	–	–	–	1,167
Daman, Diu & Dadra	–	–	–	41
Delhi	4,000		4,000	7,384
Goa	-			193
Gujarat				7,378.775
Haryana	3,805	427	4,232	536.85
Himachal Pradesh	623	102	725	304.3
Jammu & Kashmir	35		35	1,792
Jharkhand	–	–	–	1710
Karnataka	3,118	160	3278	6,500
Kerala	1,220	78	–	5,200
Lakshadweep	–	–	–	21
Maharashtra	8,589	510	9,099	19,204
Manipur	40	–	40	112.9
Meghalaya	35	–	35	284.6
Mizoram	46	–	46	4,742
Madhya Pradesh	2,286	398	2,684	4,500
Nagaland	–	–	–	187.6
Orissa	646	9	655	2,239.2
Pondicherry	60	9	69	380
Punjab	1,001	265	1,266	2,793.5
Rajasthan	1,768	198	1,966	5,037.3
Sikkim	–	–	–	40
Tamil Nadu	5,021	382	5,403	1,2504
Tripura	33		33	360
Uttar Pradesh	5,515	445	5,560	11,585
Uttaranchal	–	–	–	752
West Bengal	4,475	146	4,621	12,557
Total	**48,134**	**3,991**	**52,125**	**127,485.107**

MT = megatonne.
Source: Central Pollution Control Board (2015).

4.1. Bangalore: Social Enterprise Initiatives on the Circular Economy

Bangalore has been the testing ground for various local level circular economy initiatives in the past 15 years. A number of organisations and firms have conceptualised the popularly termed decentralised resource and waste management system by involving the community residents. Essentially, these systems arose out of the need to compensate for inadequacies in the existing services. The initiatives included setting up systems for doorstep collection and localised composting. The system involved rag pickers and other employable men and women from the lower economic strata to find resaleable and recyclable items in discarded material. Education and awareness of neighbourhood cleanliness and experiments with the various composting methodologies were also carried out. Some activities are small scale, involving a number of blocks within a ward, whereas other activities cover various wards or are citywide initiatives. It is important to recognise that these local initiatives are responsible for bringing about the changes and improvements in the waste management system now enjoyed under Swachha, a solid waste management programme of clean Bangalore.

Through the Swabhimana, a solid waste management programme specialised in composting in Bangalore, a platform of stakeholders (different groups of companies in the electronic industry and governmental agencies) and waste retrievers were made aware of the circular economy problem. Residents and companies were motivated and formed into committees. Meetings and competitions were organised, as were camps and treks. Programmes in schools showed films and distributed posters, pamphlets, handbills, and songs. Through such programmes, many other methods of communicating the message relating to resource use were shared. Training programmes were also held for all levels of government officials working in the area. Meetings were also held with contractors who were in charge of clearing the garbage.

Priorities were set based on achieving maximum participation from citizens by involving them in the planning, in motivating their neighbouring firms, and in executing the project through committees. Both the Bangalore Development Authority and the Bangalore Industrial Development Corporation are fully involved as implementing agencies along with Swabhimana.

4.2. Citizens Charter in Namakkal: A 10-Point Charter to Achieve Circular Economy Status

By implementing the tasks on its 10-point charter, Namakkal became free of garbage. It announced its zero-garbage status in 2013. The charter has the following features:

- Extend the scheme of door-to-door collection with segregation to the entire town and make streets and industries free of garbage and waste.
- Remove encroachments from road and streets and prevent re-encroachments.
- Levy waste management service charges on industrial units, commercial complexes, and garbage-generating industries.

- Generate vermicompost from organic waste through eco-friendly techniques by involving voluntary organisations and private bodies on a build–operate–transfer basis, sell the inorganic recyclable recyclable garbage, and convert the compost yard into gardens.
- Engage two mop-up teams with two auto model carriers to remove waste around the clock and keep the town free of garbage all the time.

4.3. Mumbai: Construction Waste and Debris Recycling

Mumbai as the largest industrial city in India generates about 2,300 metric tonnes of construction waste every day (CPCB, 2015). In September 2012, the Municipal Corporation of Greater Mumbai issued the Demolition and De-silting Waste (Management and Disposal) Guidelines. However, the debris still ended up in dumping grounds, where it was mixed with other waste, thereby rendering it unfit for treatment. Youth for Unity and Voluntary Action (YUVA) came up with a decentralised solution for the problem of debris management. The initiative received support from the City and Industrial Development Corporation (CIDCO), the landowning and planning authority of Navi Mumbai municipality. The collaboration resulted in the formation of the CIDCO–YUVA Building Centre, which has recycled debris into construction material such as bricks and interlocking pavers.

However, the initiative has several setbacks:

- Most builders are not aware of the initiative. Those who are aware of it argue that they cannot use the recycled debris until an authorised government agency such as the Central Building Research Institute certifies it.
- Getting funds to set up debris-recycling plants has been a problem, and the unit should be supported by the municipal infrastructure.
- The delivery of debris by the local authority is inefficient.
- Escalating cement prices increase the cost substantially.

5. Financing Schemes to Support Circular Economy

5.1. The Role of Public Financing and Budget Outlays

The role of the private sector in financing resource recovery (e.g. waste-to-energy) facilities is growing in India. The Government of India has already earmarked more than US$650 million exclusively for waste management. The government has also earmarked approximately US$20 billion over a period of 7 years for the development of infrastructure in 63 cities under smart city development. The 12th Finance Commission has allotted approximately US$1 billion for supplementing the resources. The funds allocated under the 12th Finance Commission Scheme are 100 percent grants. Those under industrial waste reuse have a grant component of 37–80 percent, the grant component under small and medium-sized enterprises is 70 percent or more (GOI, 2013).

The central and state governments share the funding, with each contributing 25 percent. The other 50 percent is to be met by institutional financing and market funds. Funds flow from the central and state governments to the nodal agency as a grant. However, the amounts flowing from the nodal agency to the implementing agencies for projects are a mix of loans and grants such that 75 percent of the central and state shares are recovered into a revolving fund at the level of the megacity (AIILSG, 2012). The objective is to create and maintain a special fund for the development of resource recycling infrastructure assets on a sustained basis.

5.2. Public Subsidy for Waste-to-Energy Projects

The Ministry of Agriculture and the Ministry of Environment, Forests and Climate Change have been actively promoting waste composting, while the Ministry of New and Renewable Energy has designed schemes to promote waste-to-energy projects. The Ministry of Agriculture introduced a centrally sponsored plan for a balanced and integrated use of fertilisers, under which support is given to local bodies and the private sector for setting up composting plants to convert municipal solid waste into compost. This grant is available for up to a third of the project's cost, subject to a maximum of Rs5 million per project. The grant is provided for buildings, plants, and machinery only. The allowable treatment capacity of the plant ranges from 50 to 100 tonnes per day. The Ministry of Environment, Forests and Climate Change provides financial subsidies of up to 50 percent of the capital costs to set up pilot demonstration plants on municipal solid waste composting. The ministry also extends limited financial assistance for waste characterisation and feasibility studies. The scheme was first introduced in 1992. Subsequently, three pilot projects were sanctioned for qualitative and quantitative assessment of solid waste in the cities of Hyderabad, Shimla, and Ghaziabad.

5.3. Tax Holiday for Circular Economy Project Entities

As announced in the Union Budget 2014/15, an undertaking or enterprise that is engaged in resource recycling projects is allowed a deduction under section 801A of the act of profits and gains related to such projects (AIILSG, 2012). The deduction equals 100 percent of such profits for 10 consecutive assessment years in the years of the project. To qualify for a tax holiday under this provision, the enterprise must satisfy the following conditions:

- A company or a consortium of companies registered in India owns the enterprise carrying on the infrastructure business, including industrial waste management.
- The enterprise has entered into an agreement for developing, maintaining, and operating an infrastructure facility.
- The agreement is with one of the following: the central government, the state government, the local authority, and other statutory body, or such other entity or body as may be notified to the central government.
- The infrastructure facility shall be transferred to the government or local authority within a period stipulated in the agreement.

5.4. Sectoral Lending by Financial Institutions

Authorities and the private sector also take advantage of funding from financial institutions, which include the following at the national level:

- Housing and Urban Development Corporation
- Industrial Credit and Investment Corporation of India
- Infrastructure Development Finance Company
- Infrastructure Leasing and Financial Services
- National Bank for Agriculture and Rural Development
- India Renewable Energy Development Agency
- Industrial Development Bank of India
- Commercial banks, suppliers, creditors, and private venture capital funds

5.5. Carbon Finance

Carbon finance provides an opportunity for an extra source of revenue for waste resource recycling projects in developing countries. The main idea behind carbon finance is that industrial countries will pay for projects in developing countries that contribute to the improved resource efficiency and the reduction of GHG emissions. Carbon reduction credits at the prevailing market price to the industrial countries through the CDM allow the waste-to-energy projects to qualify for financing. The Ministry of Environment, Forest and Climate Change of India has a nodal officer to handle these issues. Anaerobic degradation in landfills generates biogas that contains nearly 50 percent methane is equivalent to 21 tonnes of CO_2. Hence, capturing landfill gas can produce quite a good amount of certified emissions reduction credits for which municipal authorities can receive money. These funds can pay for the system's installation and the operations carried out. The prevailing rate per tonne of carbon equivalent ranges from US$6 to U$9. The project authorities only have to specify that they have reduced emission levels by appropriately managing the landfill, compost plant, or waste-to-energy plant.

Waste-to-energy projects initiated in Chennai, Delhi, and Hyderabad exemplified the opportunities for CDM financing. Two waste-to-energy plants based on refuse-derived fuel were set up in the state of Andhra Pradesh in 2008. Each of the plants produces 6.5 MW of power, likely using predominately agricultural and municipal solid waste and not industrial waste. Finally, some small biomethanation (anaerobic digestion) plants are working successfully in the states of Andhra Pradesh and Maharashtra where methane energy is produced from waste.

6. Challenges to an Integrated Business, Economy, and Environment Model for a Circular Economy in India: An Assessment

Resource efficiency schemes at the city and sectoral levels in India generally serve only a limited part of the economy. Lack of financial resources and planning capacity to cope with the economy's increasing growth affects the availability or sustainability of material collection and reuse. Operational inefficiencies, inappropriate technologies, or deficient management capacity of the institutions involved also gives rise to inadequate uptake. More involvement of private companies is seen as an easy way out. However, an important factor in the success of private sector participation is the ability of the client to write and enforce an effective public–private partnership. Three key components of successful arrangements are competition, transparency, and accountability.

Nevertheless, in India, resource efficiency is the primary responsibility and duty of the authorities and environmental agencies. State legislation and the local acts that govern municipal authorities include special provisions for collection, transport, and disposal of waste. Most state legislation does not cover the necessary technical or organisational details of a circular economy. The acts do not specify in clear terms which responsibilities belong to whom. Moreover, they do not mention specific raw material use and waste collection systems, do not mandate appropriate types of waste storage depots, do not require covered waste transport issues, and do not mention aspects of waste treatment or sanitary landfills.

Given the absence of appropriate legislation and targets, or of any monitoring mechanism on the performance of authorities, the system towards a circular economy at local and sectoral levels has remained severely deficient and outdated, when compared to other East Asia Summit countries.

On the other hand, a significant number of states are in the process of establishing resource efficiency standards towards a circular economy. They need to have good indicator frameworks, technical expertise, and financing. This requires a whole-of-government approach, fostering inter-ministerial and inter-firm cooperation. Such an approach would lead into integration of circular economy considerations at all levels of decision-making. Coordinating bodies and institutions should also monitor the progress towards fixed targets through appropriate macro and micro indicators, identify win–win solutions for scaling up circular economy activities, and define the relevant trade-offs for decision makers.

7. Conclusion

With rapid economic growth, the resource consumption rate has increased greatly in India. In the near future, India will be facing formidable challenges in resource shortages. Therefore, implementing circular economy principles is crucial for India's process industries and municipal governments. Based on the meta-analysis in China, it is understood that the government has instituted the basic policies for developing a circular economy, aimed at improving efficiency of resources and energy and thereby achieving sustainable development. However, more attention is needed for setting the targets, identification process, and institutional integration towards a circular economy. Traditionally, creating economic value and promoting environmental stewardship have been regarded as a zero-sum game. An industry leader or administrator that has to choose to focus on environmental issue such as resource efficiency would naturally assume a sum loss of economic value. 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 India's progress in implementing circular economy concepts.

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PART III

Management Approaches to Circular Economy

Chapter 10

Circular Economy Policy in Korea

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1. Background Information

1.1. Background of Korea's Circular Economy

The linear approach to industrialisation has been successful in the Republic of Korea (henceforth, Korea) for decades. Korea's gross domestic product (GDP) currently ranks relatively high in the world. It also has a very high Human Development Index (HDI), used as the common measure of the quality of life in the world. However, because Korea faces environmental resource constraints, it needs to replace its linear approach to industrialisation with circular economy, a new economic model. The binding environmental resources of Korea have become a stringent constraint as a consequence of its accelerated economic growth.

Greenhouse gas (GHG) emissions have rapidly increased in the course of Korea's manufacturing-focused industrial development. Between 1990 and 2012, the country's GHG emissions more than doubled, from 295.5 million tonnes to 688.3 million tonnes of CO_2 equivalent. One of the largest energy consumers in the world, it has also become one of the largest emitters of CO_2. As of 2012, Korea's CO_2 emissions accounted for 4.9 percent of the OECD (Organisation for Economic Co-operation and Development) total,[1] making it the fourth largest of OECD's CO_2 emitters.

GHG emissions cause climate change,[2] which in turn can cause super typhoons, floods, severe heat waves, intense cold spells, super hurricanes, droughts, desertification, collapse of ecosystems, food shortages, water resource depletion, contagious disease outbreaks, climate refugees, etc. Without appropriate mitigation actions, climate change will damage up to 20 percent of the global GDP (Stern, 2006).

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[1] For more details, see IEA (2014).

[2] As much as 97–98 percent of climate scientists believe that GHG emissions cause climate change. For more details, see Anderegg et al. (2010).

Recognising that climate change is taking its toll on the globe, Korea has taken substantial actions to transit into a circular economy. Selected examples of historical, legislative, and country-specific actions may be categorised into target management system (TMS), resource efficiency programme (REP), energy recovery[3] programme (ERP), recycling technology programme (RTP), and emission trading system (ETS).

1.2. Motivation Underlying Policy Intervention

Korea has adopted various policy instruments to transform a linear economy into a circular one. Although each of the instruments appears independent from one another, all instruments are underlined by a common motivation. The Kaya identity[4] can be used to better understand the common underlying motivation. It decomposes per capita GHG emissions into three components,[5] generally presented in the form:

$$\frac{\mathrm{C}}{\mathrm{P}} = \frac{\mathrm{G}}{\mathrm{P}} \times \frac{\mathrm{E}}{\mathrm{G}} \times \frac{\mathrm{C}}{\mathrm{E}} \qquad \text{(Eq. 1)}$$

where C, P, G, and E represent GHG emissions, population, GDP, and primary energy consumption, respectively. The identity expresses, for a given time, per capita GHG emissions as the product of per capita economic output (G/P), energy intensity of the economy (E/G),[6] and carbon intensity of the energy mix (C/E). In this analysis, we use CO_2 emissions for C, GDP in 2005 thousand US$ using purchasing power parities (PPP) for G, and total primary energy supply (TPES) for E.

The rate of change (ROC) of each component could be useful to see how the current quantity changes in relation to the prior quantity. Because of possible non-linear interactions between terms, the sum of the percentage changes of the three components would not generally add up to the percentage change of per capita CO_2 emissions. However, ROC of per capita CO_2 emissions in time can be obtained from ROCs of three components as follows:

$$\frac{(C/P)_t}{(C/P)_s} = \frac{(G/P)_t}{(G/P)_s} \times \frac{(E/G)_t}{(E/G)_s} \times \frac{(C/E)_t}{(C/E)_s} \qquad \text{(Eq. 2)}$$

where t and s represent, for example, 2 different years.

[3] Energy recovery includes any technique or method of minimising the input of energy to an overall system by the exchange of energy from one sub-system of the overall system with another. The energy can be in any form in either subsystem, but most energy recovery systems exchange thermal energy in either sensible or latent form (https://en.wikipedia.org/wiki/Energy_recovery).

[4] For more details, see Yamaji et al. (1991).

[5] The three components should be considered neither as fundamental driving forces in themselves nor as generally independent from each other. For more details, see IEA (2014).

[6] Energy intensity of the economy (E/G) is a measure of the energy efficiency of a national economy, and is calculated as units of energy consumption per unit of GDP. High/low energy intensities indicate a high/low price or cost of converting energy into GDP.

Table 10.1 shows the ROC of per capita CO_2 emissions in Korea, compared with the OECD total. As of 2012, Korea's ROC of per capita CO_2 emissions was greater than 2. It means that Korea's per capita CO_2 emissions more than doubled in 2 decades. In contrast, OECD total's ROC was less than 1; that is, per capita CO_2 emissions in OECD total decreased over the period.

Table 10.1. Rate of Change in CO_2 Emissions per Capita

	Korea			OECD total		
	1990 (A)	2012 (B)	ROC (C=B/A)	1990 (A)	2012 (B)	ROC (C=B/A)
C/P[1]	5.34	11.86	2.22	10.41	9.68	0.93

CO_2 = carbon dioxide, OECD = Organisation for Economic Co-operation and Development, ROC = rate of change.
[1] In tonnes of CO_2 per head.
Source: IEA and authors' calculations.

The Kaya identity in Eq. 1 would help understand what caused the drastic increase of per capita CO_2 emissions (C/P) in Korea. Table 10.2 shows that the growth of per capita economic output (G/P) was a driving force behind it. Korea's ROC of the component outstripped OECD total's by a large margin. The force was more than offsetting the reduction of the other two components. Even more, Korea's energy intensity of the economy (E/G) decreased less than OECD total's.

Table 10.2. Rate of Change in Emission Drivers

	Korea			OECD total		
	1990 (A)	2012 (B)	ROC (C=B/A)	1990 (A)	2012 (B)	ROC (C=B/A)
G/P[1]	10.90	27.99	2.57	22.80	31.25	1.37
E/G[2]	0.83	0.79	0.95	0.78	0.56	0.72
C/E[3]	0.59	0.54	0.91	0.59	0.55	0.94

OECD = Organisation for Economic Co-operation and Development, ROC = rate of change.
[1] In thousand 2005 US$ using purchasing power parities per head.
[2] In petajoules per billion 2005 US$ using purchasing power parities.
[3] In thousand tonnes of CO_2 per petajoules.
Source: IEA and authors' calculations.

The result points out that Korea has relied on a linear approach to industrialisation. Kaya's identity suggests a strong correlation between C/P and G/P with all other factors held constant. An implicit trade-off exists between emission reduction and economic growth. Any effective regulation to reduce C/P is likely to hamper G/P in a linear approach. Thus, Korea should find novel ways of decoupling economic growth from environmental constraints. It is the underlying motivation why Korea tries pre-emptively to transform a linear economy into a circular one.

1.3. Framework of Analysis

The Kaya identity may serve well as a framework for this analysis. The decomposition points to the possibility that a well-designed mix of policy instruments would facilitate the shift to a circular economy. The goal is to search an optimal policy mix that would promote the transformation into a circular economy at a low cost. It explains why Korea has designed a national strategy which tries to implement various policy instruments in a cost-effective way.

Corresponding to Kaya's components, five critical policy instruments can be highlighted: TMS, REP, ERP, RTP, and ETS. Table 10.3 proposes the correspondence between Kaya's components and selected policy categories. TMS may be the most effective measure from the perspective of global warming. Penalty (or tax) issues in TMS may be an important matter of national policy. To mitigate the implementation cost of TMS, most countries make an effort to utilise policy categories addressed in this chapter.

Table 10.3. Correspondence between Kaya's Components and Policy Instruments

<table>
<tr><th>Component</th><th colspan="2">Policy Category</th></tr>
<tr><td>C/P</td><td>Target management system</td><td rowspan="4">Emission trading system</td></tr>
<tr><td>G/P</td><td>Recycling technology programme</td></tr>
<tr><td>E/G</td><td>Resource efficiency programme</td></tr>
<tr><td>C/E</td><td>Energy recovery programme</td></tr>
</table>

Source: Author

2. Description of Policies Adopted

2.1. Target Management System (TMS)

TMS is closely relevant in reducing per capita GHG emissions (C/P) and, thus, is the groundwork for the overall mitigation efforts. It could also serve to support REP, ERP, RTP, and ETS instruments.

2.1.1. Goals

A direct goal of TMS is to reduce GHG emissions. TMS first sets the national midterm target, then sets sectoral reduction targets for emissions-intensive sectors: power generation, manufacturing, construction, waste management, and transport. It then imposes facility-specific mitigation targets on preselected large-scale facilities belonging to emissions-intensive sectors. Companies that fail to meet the targets are subject to penalties.

An ultimate goal of TMS is to engage all parts of society in GHG mitigation efforts. To do so, TMS tries to advance regulations in collaborating with various stakeholders: agencies, industries, and civic communities. Conditions of domestic industries would be taken into account through negotiation with participations.

2.1.2. Implementation

The workflow of TMS is subject to the Framework Act on Low Carbon Green Growth and the Guidelines for the Operation of Target Management Scheme. As a starting point, sectors accounting for the majority of emissions are identified. Next, controlled entities are designated for such sectors.[7] They submit reports on previous emissions to the controlling departments. Controlling departments and the Greenhouse Gas Inventory & Research Center of Korea (GIR) review the reports for double counting or omission. They establish facility-specific GHG emissions targets. Then controlled entities submit implementation reports to meet mitigation targets. They also submit emissions reports to show the year's emissions. Both emissions and implementation reports are first confirmed by third-party verifying institutes and then reviewed by controlling departments. Finally, those reports are submitted to GIR. If their implementation reports do not comply with the monitor-report-verification standards, controlled entities may be subject to remedial measures. The whole process is rolled out through the national GHG management system. This system collects data related to facility-specific GHG statistics. Through the system, controlling departments can access to GHG emissions data reported by controlled entities.

Table 10.4 shows sectoral GHG reduction targets rate by 2020 for seven sectors.

Table 10.4. Sectoral Reduction Targets by 2020

Sector	Reduction rate (%)	Sector	Reduction rate (%)
Industry	18.2	Agriculture, Forestry & Fishery	5.2
Power Generation	26.7	Waste	12.3
Transport	34.3	Public	25.0
Buildings	26.9	Total	30.0

Source: Greenhouse Gas Inventory & Research Center of Korea.

2.1.3. Challenges

As a mandatory regulation, TMS brings in a number of challenges to be carefully dealt with. If implemented inadequately, it might cause a big burden to controlled entities. Consequently, economic growth could be hampered because of deadweight loss by poor regulation. For cost-effectiveness, adequacy of regulation should be ensured. Guidelines related to setting targets need to be clearly articulated in advance. Double-counting or omission of entities should also be minutely checked. Implementation plans should be set up as accurately as possible. Since the role of verifying institutes is critical, they should be quite well disciplined. Controlling departments should reasonably resolve objections against designations. Altogether, prudent

[7] As of 2014, controlled entities included companies with 50,000 tCO2eq of GHG emissions and 200 TJ of energy consumption. Facilities with 15,000 t2eq of GHG emissions and 80 TJ of energy consumption were designated as controlled entities. For more details, see GIR (2014).

responses to challenges would induce the efficient achievement of targets. As spotlighted in Kaya's identity, energy efficiency improvement and renewable energy deployment are significant to reduce emissions. The design of TMS compatible with promoting REP and/or ERP is another concern.

2.2. Resource Efficiency Programme (REP)

REP tries to manage the quantity of raw materials used to convert energy into GDP. Reducing resource use can reduce GHG emissions.[8] In that sense, REP corresponds to lowering the energy intensity of the economy (E/G).[9] Practically, the energy intensity could be controlled by saving units of energy consumption per unit of GDP. The fall of E/G would result in the drop of C/P, with all other factors held constant.

2.2.1. Goals

A direct goal of REP is to reduce the amount of resource required to provide products and services.[10] For that purpose, REP tries to adopt a more efficient production process and/or to recycle resources. REP tends to facilitate products embodying less resource input. For instance, energy savings are likely to reduce energy costs, but be accompanied by additional costs of introducing an energy-efficient process. A financial cost saving to energy users can be obtained when the former more than offsets the latter. To meet such a condition, REP provides manufacturers with some incentives to improve their products' efficiency. REP also induces consumers to purchase more energy-efficient products in the market place.

A more strategic goal of REP is to enhance national security. As resource efficiency is improved, resource imports from foreign countries would decrease. Moreover, depletion of domestic resources would be slowed down.

2.2.2. Implementation

The Ministry of Commerce, Industry and Energy, through the Korea Energy Management Corporation (KEMCO), has operated EEPs. First, the Energy Efficiency Standards & Labelling Program has been in use since 1992. The label on seven target items shows the energy-efficiency grade of the model from one to five.[11] The programme is authorised by the Rational Energy Utilization Act. Next, the Certification of High Efficiency Energy-using Appliance Program has been implemented where energy-using products with relatively high level of

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[8] According to the International Energy Agency, improved energy efficiency in buildings, industrial processes, and transportation could reduce by one third the world's energy needs in 2050, and help control global emissions of greenhouse gases. For more details, see Hebden (2006).

[9] In Korea, various policy instruments have been utilised to improve energy efficiency. For example, tax breaks, loan and subsidy programmes, energy conservation technologies, various pilot projects, energy exhibition and energy service companies, etc. Here, among those programmes, energy efficiency programmes are discussed in detail.

[10] For example, the European Union (EU) currently measures resource productivity by European country and for the EU as a whole through the Eurostat system, and these statistics have shown a satisfying increase in resource productivity for the EU since 2000. For more details, see Resource (2015).

[11] The seven target items are electric refrigerator, electric air-conditioner, incandescent bulb, fluorescent lamp, self-ballasted lamp, ballast for fluorescent lamp, and passenger car. It is to encourage efficiency in the production and use of energy.

energy efficiency are certified. Government organisations should use certified products. The programme is based on the Rational Energy Utilization Act. The Energy-Saving Office Equipment & Home Electronics Program, a voluntary partnership between the government and manufacturers, has also been in use since 1999. Energy-saving products are certified if they meet the energy-efficiency guideline proposed by KEMCO.[12] One of the standards is an automatic switch to power-saving mode when not in use. Warning labels apply to products that fail to meet the standard. The programme is based on announcement No. 1998-136 of the Ministry of Commerce, Industry and Energy. Furthermore, the Average Fuel Economy regulation on cars has been introduced since 2006 where the average fuel economy of all cars sold by a manufacturer over 1 year must meet the standards. The required level varies with engine capacity. It is patterned after the US Corporate Average Fuel Economy system.

2.2.3. Challenges

From a simple engineering perspective, the improvement of energy efficiency (E/G) would reduce energy consumption all the time. However, energy consumption may not be reduced by the amount predicted by the model. It is because of the direct rebound effect. As improved energy efficiency tends to make energy services cheaper, consumption of those services may increase. Increased consumption offsets some potential energy savings. Actually, an extensive historical analysis of technological efficiency improvements has conclusively shown that energy efficiency improvements are almost always outpaced by a net increase in resource use.[13] Considering the limit of REP, ERP catches our attention.

2.3. Energy Recovery Programme (ERP)

ERP has a strong connection with the carbon intensity of the energy mix (C/E). The carbon intensity could be lowered when energy recovers from wastes. The fall of C/E is likely to cause the drop of C/P, with all other factors held constant.

2.3.1. Goals

A goal of ERP is to increase the demand and supply of energy from waste. In Korea, 84 percent of the energy supply comes from fossil-based energy sources. Thus, the deployment of energy recovery is one of the key priorities to achieve a circular economy. Increasing the use of energy from waste is the most effective strategy to move beyond oil.[14] The National Strategy for Green Growth has a target of increasing the share of renewable sources in TPES. In addition, the government plans to increase the use of nuclear power, the least expensive means to generate electricity and produces almost zero GHG.

[12] Manufacturers of selected items can attach energy-saving labels on their products. Examples of selected items are televisions, microwave ovens, computers, and printers.
[13] For more details, see Huesemann and Huesemann (2011).
[14] Reflecting such a perspective, worldwide investment in renewable energy reached US$155 billion in 2008. It was a sevenfold increase from 2002. The United Nations Environment Programme (UNEP) has pointed out that the investment must more than triple until 2020 as global carbon emissions would have peaked by that time. For more details, see UNEP (2009a).

An affiliate goal of ERP is to reduce the generation cost of energy from waste. It would require substantial and continuous investment to foster renewable industries. The public sector should execute a significant amount of research and development (R&D) investment.

2.3.2. Implementation

The most exemplary ERP is the Renewable Portfolio Standard (RPS). RPS, applied to major power generators since 2012, obliges electricity companies to produce a certain portion of electricity from renewable sources. RPS applies to power generators with a capacity of 500 MW or more. Target generators are the Korea Water Resources Corporation and the Korea District Heating Corporation that cover a total of 13 publicly owned and privately owned power generators. Retail suppliers are not directly regulated under the RPS scheme.[15] The renewable portfolio of target generators started from 2 percent of all power generated in 2012. It should amount to 10 percent until 2022. Target generators are permitted to borrow up to 20 percent of the total amount of renewable energy they require for a given year. The borrowing comes from their renewable portfolios for the following years. They should submit the reason for borrowing and quantity to be borrowed.

Renewable energy certificates (REC) are awarded to certified eligible facilities. A renewable energy generator intending to qualify as an eligible facility must apply for the certification. The generator's renewable energy facilities should conform to designated standards for any given renewable resource. Once certified, an eligible facility is automatically registered with the new and renewable energy RPS management system. REC documents 1 MWh of electricity generation from an eligible facility. It is used to demonstrate compliance with RPS requirements.

The Ministry of Trade, Industry and Energy is responsible for announcing the amount of energy subject to RPS and may adjust the amount every 3 years based on a review of technology, performance, and other circumstances. RECs are issued by the Korean New and Renewable Energy Center of the Korean Energy Management Corporation. The issuance, trading, and tracking of RECs are done through the RPS management system.

2.3.3. Challenges

'Not-in-my-back-yard' (NIMBY) concerns may be a significant challenge to overall levels of renewable energy deployment. NIMBY is mainly stirred by visual and other impacts of renewable energy facilities and their constructions are likely to be blocked by local residents.[16] Some projects might be delayed for years just because of aesthetic concerns. So, NIMBY may cause variable or intermittent energy production.

[15] It is because only one power retail distributor exists in the Korean market. Most big power generators are still owned by the public sector.
[16] For more details, see Schirber (2008).

The lack of government support may be another critical challenge. The private market for renewable energy technologies usually does not stand on its own feet. Government support has pulled the growth of the renewable energy industry at least in the initial phase. An exemplary programme is feed-in-tariffs. Under this programme, renewable energy generators are able to earn a premium in accordance with the price table promulgated by the government. Such government supports for ERP are likely to go along with the Recycling Technology Programme (RTP).

2.4. Recycling Technology Programme (RTP)

RTP focuses on developing cutting-edge, converged recycling technology. It goes beyond a linear relation between Kaya's C/P and G/P components. RTP could accelerate the transit into a circular economy by reconciling the rise of G/P with the fall of E/G or C/E.

2.4.1. Goals

A goal of RTP is to lower the share of resource-intensive industry in GDP. Korea's economy heavily relies on resource-intensive industries: steel, petrochemicals, and cement. They accounted for 12 percent of total value-added as of 2008.[17] A way to get away from dependence on resource-intensive industries is to raise the share of the service sector. For example, the service sector's energy intensity is less than one third of the manufacturing sector's energy intensity.

A more ultimate goal of RTP is to build the basis for circular growth. The proper management of electronic waste (or waste electrical and electronic equipment) has become a major concern due to the large volumes of the waste being generated. Also, rare metals found in discarded electronic devices can cause potential environmental impacts associated with toxic chemicals. The potential resource recovery from electronic devices is based on the development of recycling technology.

2.4.2. Implementation

In Korea, recycling technologies are treated as typical green technologies. The Key Green Technology Development and Commercialization Strategies, announced in 2009, was designed as a road map to develop green (including recycling) technologies. In the strategy, core green technologies are categorised into five groups: (i) climate change, (ii) energy source technology, (iii) technologies to improve efficiency, (iv) end-of-pipe technology, and (v) R&D in virtual reality.

More recent recycling efforts in Korea include the recycling target rates, the extended producer responsibility list, the shared responsibility of distributors with producers, and the

[17] The weight is well above the OECD average of 8 percent. Actually, it is the highest in the OECD area.

better collection system by local governments. Along with the development of advanced waste recycling technology, the regulations to encourage its producers to adopt environmentally sustainable technologies are strengthened.

In addition, the certificates programme has been introduced since 2010 where 'green certificates' are awarded to qualified firms, projects, and technologies. A firm for which certified green technology accounts for more than 30 percent of sales is certified as a 'green firm'. Green firms, projects, and technologies have been funded through green financial products. Such products invest at least 60 percent of their capital in green firms and projects. Examples are green bonds, deposits, and investment funds. Also, a green private equity fund has been launched.[18] There are tax incentives for financial instruments. Dividends and interest from green financial products are tax-exempt up to certain ceilings.

2.4.3. Challenges

A challenge is to suppress government failures which may be brought in by RTP. Initially, RTP has been introduced to cope with market failures. As the basic recycling technologies are still too far from commercial viability to attract private investment, policy intervention for recycling technology is needed. But it often brings in government failure. Unless green certificates are well designed along with exit strategies, it would result in another disruptive bubble. Such a risk needs to be managed pre-emptively. To avoid a bubble, RTP should be as neutral as possible. When RTP concentrates on basic recycling technologies, side effects of policy intervention would be minimised.

Another challenge is the reallocation of labour and capital resources across sectors during the shift towards a circular economy. For workers, labour market flexibility to promote the redeployment of workers is essential.[19] Effective training is also critical for the shift to be successful. In particular, it is important to facilitate the entry of new firms in green industries. The new entry would account for a large share of radical innovations. At the same time, the exit of firms in resource-intensive industries needs to be facilitated. Strong global competitiveness of domestic industries is prerequisite for the adoption of new recycling technology.

2.5. Emission Trading System (ETS)

ETS could encompass all components of Kaya's identity. It corresponds to C/P in that it could serve as the market pricing mechanism to meet the midterm reduction target. It could be extended to serve as a trading platform for certificates related to other components: E/G and C/E.

[18] For more details, see UNEP (2009b).
[19] For more details, see OECD (2010c).

2.5.1. Goals

A main goal of ETS is to achieve GHG emissions target in a cost-effective way. ETS is a distinguishable policy instrument based on the market mechanism. If a company needs higher cost for voluntary mitigation, it may buy emissions permits in the market. On the other hand, if a company needs relatively lower cost for mitigation, it may sell extra emissions permits to gain profits. In this way, ETS helps the national GHG mitigation target to be more efficiently achieved.

A derived goal of ETS is to relieve the industry from GHG mitigation burdens.[20] Companies are given strategic options to choose through ETS: direct mitigation, permits trading, external mitigation, and/or permits borrowing. The company may strategically choose the most advantageous way with the lowest cost. In that way, companies under ETS could flexibly respond to the changes in the global carbon market.

A more ultimate goal of ETS is to establish a market-based, cost-effective stepping stone to mutually facilitate GHG reduction and economic growth. ETS could pull a shift to a circular economy by creating a new growth momentum suitable for a circular economy. Under a successfully implemented ETS, emissions reduction is likely to be compatible with sustainable economic growth.

2.5.2. Implementation

Even before the introduction of mandatory ETS, Korea had actively utilised trading mechanisms and since 2005 has participated in Clean Development Mechanism (CDM). CDM allows emissions-reduction projects in developing countries to earn certified emission reduction (CER) credits. Each CER is equivalent to 1 tonne of CO_2. CERs can be credited to projects funded by non-Annex I countries' own money. Korean investment companies have owned CERs and sold them to any Annex-1 country in the market. In addition, the Korea Certified Emissions Reduction (KCER) was introduced in 2005. KCER market is open to firms that have reduced CO_2 emissions by more than 500 tonnes a year. KCERs can also be traded in the market.

In 2012, the Act on the Allocation and Trading of GHG Emission Permits paved the way for the introduction of ETS. The mandatory ETS has been implemented since 2015. The Ministry of Environment supervises the operation of ETS by designating participants, planning emissions permits allocation, conducting monitoring–reporting–verification of emissions estimates, and introducing penalties. The Permit Allocation Committee deliberates and adjusts ETS-related major policies such as allocation plans and market stabilisation measures. GIR supports facility-specific allocations and registries for emissions permits and offsets. Companies whose annual emission volumes exceed a quota have to purchase extra emission rights from other companies. The sum of emission quotas amounts to 1.59 billion tonnes. It is about 21 percent less than the 2.02 billion tonnes suggested by companies. A quota of 15.98 billion Korean

[20] GIR estimates that the mitigation cost under ETS accounts for only 32–57 percent of that under TMS.

allowance units (KAUs) is allocated to each company. One KAU is equivalent to a tonne of CO_2 gas. KAUs are traded at the Korea Exchange. As of 2015, 502 companies were allowed to trade KAUs at the Korea Exchange.[21]

2.5.3. Challenges

A challenge is to operate ETS in a cost-effective way. Too stringent emissions quota would end up compromising the desperate efforts to boost the sagging economy. Governments usually encourage big companies to invest because it is one of the most time-efficient ways to revitalise the economy. Putting a cap on emissions would compromise much of the effect, unless ETS is operated as intended. Industrial sectors are concerned about the possible negative impact on their international competitiveness. Manufacturing firms subject to ETS would be reluctant to make a large-scale investment on their home soil. On the other hand, excessive quota would cause the price of KAU to converge to zero and make ETS malfunction. The supply–demand discrepancy may set off conflicts between controlled entities and controlling departments.

3. Outcomes and Impacts

Up to this point, major policy instruments are identified within Kaya’s identity. The goal, implementation, and challenges of each instrument have been discussed briefly. We now analyse the performance of policy instruments. For that, the logic model is utilised.

The logic model is useful in evaluating the performance of government programmes whose intended result is not to achieve a financial benefit. In such situations, a programme logic model provides indicators in terms of output, outcome, and impact measures of performance. The output of government programmes can be measured in terms of the amount of money spent on a programme (e.g. their budgets), and/or the amount of work done (e.g. number of workers or number of years spent). Often, such as in TMS, REP, ERP, RTP, and ETS, the impact is long-term mission success far into the future. In those cases, the intermediate or shorter-term outcome may indicate progress towards the ultimate long-term impact.

Although it is relatively easy to measure the output, it is a poor indicator of goal achievement.[22] On the other hand, the outcome is a better indicator to show that the programme really meets the intended goals.[23] Government programmes are likely to begin by

[21] Examples of such companies are Samsung Electronics, Hyundai Motor, POSCO, Hyundai Heavy Industries, and Lotte Department Store.

[22] The workers may have just been 'spinning their wheels' without getting very far in terms of ultimate results or outcomes.

[23] Although outcomes are used as the primary indicators of programme success or failure, they are still insufficient. Outcomes may easily be achieved through processes independent of the programme and an evaluation of those outcomes would suggest programme success when in fact external outputs were responsible for the outcomes. For more details, see Rossi et al. (2004).

declaring grand new programmes and causes. But good beginnings do not guarantee the success of such programmes. What matters in the end is outcome and impact. Therefore, this analysis focuses on outcomes to evaluate the performance of government programmes.

It seems still early to verify the short-term outcome or long-term impact of policy interventions (TMS, REP, ERP, RTP, and ETS). It would take a few more years before outcomes of such programmes could be clearly recognisable. The logic model used in this analysis can be regarded as a formative evaluation during implementation to offer the chance to improve the programme. The short-term outcomes and long-term impacts of each policy instrument are investigated here within Kaya's identity.

3.1. Outcomes and Impacts of TMS

Since TMS was established only in 2012, reliable data about the short-term outcome are not available yet. It may take a few years to confirm that TMS is effective in achieving the midterm (2020) mitigation target. Although limited, some insights about the short-term outcome can be identified in terms of per capita CO_2 emissions. Table 10.5 shows that Korea's per capita CO_2 emissions continuously increased between 2008 and 2012. The upward trend is more clearly displayed through its ROC. On the other hand, OECD's per capita CO_2 emissions slightly decreased during the period. The difference can be zoomed in through the comparative indicator, which is calculated as the ratio of Korea's per capita CO_2 emissions over that of OECD. In sum, Korea's TMS has not achieved the expected outcome until now.

Table 10.5. Per Capita CO_2 Emissions

Year	Korea* (A)	OECD* (B)	ROC ($C = A_t / A_{2008}$)	Comparative (D = A / B)
2008	10.3	10.5	1.000	0.982
2009	10.6	9.8	1.025	1.076
2010	11.4	10.1	1.107	1.134
2011	11.8	9.9	1.147	1.198
2012	11.9	9.7	1.149	1.225

OECD = Organisation for Economic Co-operation and Development, ROC = rate of change.
* In tonnes of CO_2 per head.
Source: IEA and authors' calculations.

However, Korea's TMS has earned positive reviews for long-term impact. Its GHG reduction efforts have been internationally recognised. For instance, Korea's climate change policy ranked second best in the 2010 CCPI evaluation. The pre-emptive policy intervention also enables Korea to get well prepared for carbon-related international trade barriers. If mitigation goals are successfully met, Korea could reinforce its international status as one of the leading countries in GHG mitigation.

TMS has laid the groundwork for sustained reduction of GHG emissions. Cost-effective mitigation strategies for buildings, transportation means, and industrial sectors have been set up. It is mandatory for controlled entities to report their GHG emissions. Carbon information is more easily available through the national GHG inventory reporting system. In the end, a long-term national GHG reduction target from 2020 onwards is about to be established.

3.2. Outcomes and Impacts of REP

The short-term outcome of TMS seems to fall short of the mark. The shortfall may be accounted by the economic growth. It manifests the importance of controlling resource use during the economic growth. Most of all, the output of sector-specific energy saving programme to cut the energy intensity has been more or less effective. For example, AFE programme boosted average fuel economy from 10.8 km/litre to 11.5 km/litre between 2006 and 2008, and contributed 7.3 percent CO_2-emissions reduction.

The short-term outcome of REP can be evaluated in terms of energy intensity of the economy. Table 10.6 shows how Korea's energy intensity has dropped since 2008, shown more definitely through its ROC. However, Korea falls behind OECD with respect to the pace of enhancement in energy intensity as the comparative indicator distinctly reveals. Even worse, the gap has been expanded. In sum, the short-term outcome of Korea's REP can be regarded as outstanding even though the pace needs to be accelerated.

Table 10.6. Energy Intensity

Year	Korea* (A)	OECD* (B)	ROC ($C = A_t / A_{2008}$)	Comparative (D = A / B)
2008	8.34	6.90	1.000	1.209
2009	8.41	6.83	1.008	1.231
2010	7.91	5.97	0.948	1.326
2011	7.95	5.75	0.953	1.384
2012	7.88	5.61	0.944	1.406

OECD = Organisation for Economic Co-operation and Development, ROC = rate of change.
* In petajoules per billion 2005 US$ using purchasing power parities.
Source: IEA and authors' calculations.

The long-term impact of REP would be more evident in the future. The Systematic Implementation of the National GHG Emissions Reduction Roadmap was announced in 2014. GHG from the transportation sector will be reduced through expansion of ITS, pay-per-mile car insurance, car-sharing systems, and low-carbon vehicles such as the bus rapid transit. In addition, the efficiency of various facilities and equipment will be improved. For instance, the Building Energy Management System and the Home Energy Management System will be introduced and disseminated. Furthermore, policies will be adopted to reduce GHG in the areas of public sector, agriculture, forestry, fishery industries, and waste.

3.3. Outcomes and Impacts of ERP

The short-term output of ERP can be shown through the contribution of energy recovery to TPES. As of 2007, Korea's share of non-renewable waste in TPES was one of the lowest in the OECD area. Table 10.7 shows the weights of renewable energies and energy from waste in TPES since 2008. The contribution from renewable energies has continuously increased, but falls short of initial expectation. The weight of non-renewable waste remained flat until 2010, but has jumped up since 2011.

Table 10.7. Contribution from Renewable Energies and Energy from Waste

	2008	2009	2010	2011	2012
Renewables*	0.594	0.654	0.712	0.733	0.749
Non-renewable waste*	0.890	0.850	0.874	0.987	1.051

* % contribution to TPES (total primary energy supply).
Source: IEA and authors' calculations.

ERP to increase the demand and supply of non-renewable waste has not shown a tangible outcome. The short-term outcome of ERP can be shown in terms of carbon intensity of energy mix. Table 10.8 shows that Korea's carbon intensity of energy mix presented neither an upward nor downward trend within a 5-year span. The pattern of its ROC was practically the same. However, the comparative indicator between Korea and OECD has fallen into a gentle gradient since 2009, maybe due to the relatively fast uptake of low-carbon technologies in Korea. For instance, Korea's use of nuclear energy has been enlarged to reduce CO_2 emissions from power plants.

Table 10.8. Carbon Intensity of Energy Mix

Year	Korea* (A)	OECD* (B)	ROC ($C = A_t / A_{2008}$)	Comparative (D = A / B)
2008	52.8	55.8	1.000	0.947
2009	53.7	54.9	1.018	0.978
2010	53.9	55.2	1.021	0.976
2011	54.1	55.5	1.025	0.974
2012	53.8	55.3	1.018	0.973

OECD = Organisation for Economic Co-operation and Development, ROC = rate of change.
* In thousand tonnes of CO_2 per petajoules.
Source: IEA and authors' calculations.

3.4. Outcomes and Impacts of RTP

An output of RTP can be assessed by indicators to show the status of green R&D. Table 10.9 shows Korea's total R&D, green technology (GT) R&D, and core GT R&D during the first-year (2009–2013) plan. The GT R&D has increased at the compound annual growth rate (CAGR) of 11.7 percent. It is higher than the total R&D's CAGR of 8.6 percent. It is noteworthy that the CAGR of core GT R&D is even higher. The relatively higher CAGR suggests that more R&D investments have been allocated to green technologies.

Table 10.9. Green R&D (trillion ₩)

Year	Total R&D	Green Technology (GT) R&D	Core GT R&D
2009	12.41	1.95	1.43
2010	13.68	2.24	1.71
2011	14.85	2.55	1.98
2012	15.91	2.71	2.06
CAGR (%)	8.61	11.73	13.00

CAGR = compound annual growth rate, R&D = research and development, ₩ = Korean won.
Source: Green Technology Center Korea.

The short-term outcome can be assessed to determine whether RTP has contributed to the economic growth with GHG emissions controlled. Table 10.10 shows the ROC of each component of Kaya's identity. The declining trend in ROC of E/G shows that the short-term outcome of REP is positive. In contrast, the flat ROC of C/E demonstrates that the short-term outcome of ERP falls short of its goal. Much less, those outcomes are overwhelmed by outstanding pace of economic growth (G/P). Altogether, the short-term outcome of RTP is disputable.

Table 10.10. Rate of Change in Emission Drivers

Year	C/P	G/P	E/G	C/E
2008	1.000	1.000	1.000	1.000
2009	1.025	1.000	1.008	1.018
2010	1.107	1.143	0.948	1.021
2011	1.147	1.175	0.953	1.025
2012	1.149	1.195	0.944	1.018

Source: IEA and authors' calculations.

3.5. Outcomes and Impacts of ETS

The short-term output of CDM was satisfactory. As of 2010, Korea has 35 CDM projects registered with renewable energy projects accounting for a third of them. Another 47 projects are in the process of registration. The United Nations Framework Convention on Climate Change (UNFCCC) predicts that Korea's registered projects would reduce CO_2 equivalent by an average of 15 million tonnes per year, a 4.4-percent reduction of the total. Korea ranks fourth behind China (59 percent), India (12 percent), and Brazil (6 percent).

The short-term output of voluntary carbon market was not satisfactory. In practice, there were few buyers, given the lack of a domestic reduction obligation. Thus, the government bought most KCERs to compensate efforts to reduce GHG emissions. As of 2009, 5.6 million KCERs have been generated from 287 projects. The government purchased 4.7 million of total KCER for ₩23 billion (US$20 million).

The short-term output of ETS since its launch is disappointing. Trading has been minimal so far because corporations are uncertain about the volume of GHG that they would emit in the future. On the first trade, KAU trading volume reached 1,190 tonnes. Additional 190 tonnes were traded in the next 4 days. Since then, there is no trade of KAU because of shortage of sellers in the market.

To ensure a soft landing of ETS, the offset credit trading was commenced on 6 April 2015. The GHG emissions reduced by entities other than corporations subject to TMS are certified for emission allowances. Corporations allotted the emission allowances can request the conversion of the certified offset credit into Korea Credit Unit (KCU). KCUs can be traded in the emissions trading market of Korea Exchange Corporations subject to TMS are able to trade KAUs and KCUs. In the first week, 79,658 tonnes of KCUs were traded. The listing of KCUs is expected to stimulate more brisk trading in the emissions trading market.

The short-term outcome of ETS is not yet certain. It can be assessed to see whether the emissions trading market is vitalised. The successful implementation of ETS would construct the foundation for a market-friendly, cost-effective GHG reduction. The institutional basis for a linkage with an offset mechanism is already formed. Roles of the market and the private sector would be broadened by successfully implementing the linkage. Eventually, enhancing the market function of emissions reductions would spread a circular lifestyle applicable to everyday life.

4. Implications for ASEAN Countries

Hereafter, a set of policy actions for decision makers in ASEAN are recommended. It aims to work collectively and beyond them. Future research directions for scholars are also provided.

4.1. Setting Pre-emptive Target

Korea ratified the Kyoto Protocol to the UN Framework Convention on Climate Change (UNFCCC) as a non-Annex I country. Thus, it has no obligation to set a specific GHG-reduction target. However, it has been pre-emptively involved in the CDM since unilateral projects were allowed. Unilateral CDMs are funded by developing countries' money and not by Annex-1 countries.

Finalising the national midterm target shows that Korea has pursued a pre-emptive strategy to transit towards a circular economy. The business-as-usual scenario (BAU) was a rise of 36.9 percent in GHG emissions between 2005 and 2020. Three initially considered options were to cut emissions by 21 percent, 27 percent, or 30 percent relative to the BAU. Those options implied an 8-percent increase in emissions, no change, or a cut of 4 percent relative to 2005, respectively. Each option was analysed based on Korea's capacity to make reductions and the subsequent macroeconomic impact. Finally, the most ambitious option of a 30-percent reduction was selected as the national midterm target.

The midterm target of Korea is thus positioned between the advanced countries and developing countries. The 2020 targets for Japan, the US, and the EU are approximately 30-percent, 17-percent, and 13-percent reductions relative to 2005, respectively. Those targets still require larger emissions reductions. Mexico has also pledged to reduce emissions by up to 30 percent relative to its BAU baseline by 2020 on the condition of adequate financial and technology transfer mechanisms from developed countries. In contrast, Korea's target is not conditional on international agreements and support. Although not legally binding, the target is guiding Korea's climate change policy framework.

The target under TMS is highly significant as it provides a foothold prior to post-2012 climate change negotiations. In 2015, the Korean government announced it will reduce GHG emissions by 37 percent from the previous projected emission levels for 2030.

4.2. Comprehensive Framework

The shift to a circular economy may require a national strategy that encompasses various policy instruments in a comprehensive framework. Individual policy instruments tend to focus on certain aspects of the transition. The effect of an instrument might be offset by the effect of another. Thus, it is important that policy instruments be orchestrated within a comprehensive framework. The national strategy based on Kaya identity could be used as a cornerstone.

Korea has made intensive efforts to develop a comprehensive strategy at the national level. In 2008, Low Carbon/Green Growth was proclaimed as the nation's vision to guide its development during the next 50 years. In 2009, the first Five-Year (2008–2013) Plan for Green Growth was announced along with the National Strategy for Green Growth to expedite policy implementation at the central government level. Also, the midterm target for national GHG reduction was announced. In 2010, the Framework Act on Low Carbon/ Green Growth was enacted, covering the economy, industry, national territory, environment, and public conduct. In 2011, the Act on the Creation and Facilitation of Use of Smart Grids was enacted as the legal basis for building smart grids. In 2012, the Act on the Allocation and Trading of Greenhouse-Gas Emission Permits was legislated to establish the institutional foundation of the ETS. In 2014, the second Five-Year (2014–2018) Plan for Green Growth was announced to actively use the institutional foundation built during the past 5 years.

Developing countries like those in ASEAN may be willing to begin the shift to a circular economy through various policy instruments. When strategically approached, it would be helpful to derive an optimal policy mix at the national level. For instance, they may use the national strategy and/or the 5-year plan encompassing all major policy interventions: TMS, REP, ERP, RTP, and ETS. The successful transit towards a circular economy may require a socio-economic system. Focused efforts through national initiatives would be essential for the settlement of a sound institutional foundation. An example of such an initiative may be the recycling of resources throughout the entire manufacturing process: factor input, production, use, disposal, and recycling. The governing principle is to firmly establish 3R (reduce–reuse–

recycle). ETS could easily be extended to a more comprehensive certificate trading about resources recycling, and the twin pillars of sustainable energy policy: REP and ERP.

4.3. Taking Practical Actions

The national strategy to pursue circular economy needs to be developed. The impact of the industry sector may be evident in a decomposition of final resource consumption by sector. Compared with developed countries, a developing country would rely more heavily on its industry sector. Nevertheless, the service sector's energy intensity is generally less than that of the manufacturing sector. Thus, a strategy to the share of service sector in total value-added would help a developing country follow the growth path towards a circular economy.

The practical approach to dealing with oppositions from the private sector would be critical. As mentioned, NIMBY (not-in-my-backyard) concerns are likely to be severe obstacles against deployment of renewable energy. A national strategy to particularly develop cooperative structures may be essential as it would help the overwhelming majority of locals believe that renewable energy resources can enhance the neighbourhood.[24] It is obvious that projects are generally more likely to succeed if they have broad public support and the consent of local communities. To do that, a say and a stake need to be given to communities. It is noteworthy that many renewable energy projects are owned by communities in countries such as Germany and Denmark.[25]

Policy instruments relevant to daily living activities are fundamental. Korea uses a system to effectively collect garbage waste and reuse natural resources.[26] Under the system, recycling is mandatory, and garbage must be separated accordingly as common garbage, food waste, recyclable, and large waste objects. Such policies exist throughout the country. Recycled items can be disposed of in any clear plastic bag or divided by items and bound. Containers should be rinsed or washed before disposal. Recyclable waste should be placed in designated areas outside the building. Because some items such as batteries, cell phones, unused medicine, etc. require careful disposal, a separate container for such items should be in place. It is recommended that unused medicines be taken to the nearest drug store for proper disposal. Most large apartment complexes have marked boxes for recyclables. Houses and small apartments/villas should place in position net bags for recyclables.

4.4. Global Cooperation

A key obstacle to the implementation of ETS is concern about its impact on the international competitiveness of domestic industries. A strict ETS may successfully reduce emissions domestically but cause an increase in emissions in neighbouring countries, a phenomenon called carbon leakage. If ETS of a country raises local costs, then another country without ETS

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[24] For more details, see Gourlay (2008).
[25] For more details, see http://www.korea4expats.com/article-waste-disposal-recycling-korea.html
[26] For more details, see http://www.korea4expats.com/article-waste-disposal-recycling-korea.html

may have a trading advantage. If demand for these goods remains the same, production may move offshore to the cheaper country without ETS, the reason companies seem to be overly anxious about the burden of ETS.

Although there is yet no consensus on the magnitude of long-term leakage effects, it manifests the importance of global cooperation. Carbon leakage is a type of spillover effect, which can be positive or negative. For example, ETS might lead to technological developments that aid global reductions. To amplify positive externalities, carbon leakage may be controlled through changes in trading patterns. An exemplary case is to measure the balance of emissions embodied in trade.

Moreover, as more countries take ETS, the positive externalities would get larger. Fortunately, ETS has been successfully introduced in many countries and the market-based environment policy is currently being executed in over 30 countries. In EU, ETS has been implemented since 2005. In New Zealand, a national-level ETS has been implemented since July 2010. In the US, a state-level ETS has been implemented in California. In addition, ETS implementation has been prepared in developing counties such as China, Taiwan, Chile, and Turkey.

Even before ASEAN member states establish ETS domestically, they could participate in CDM projects. CDM constitutes the official international carbon market together with ETS and the Joint Implementation under the Kyoto Protocol. CDM allows emission-reduction projects in developing countries to earn CER credits. Non-Annex I countries owning CERs can sell them to any Annex-1 country in the market. Annex I countries can use CERs to meet a part of their emissions-reduction targets under the Kyoto Protocol. It would be helpful to set up the National GHG Management System. Its role may be to operate ETS, allocating allowance unit across sectors, and verify ETS-related statistics. The role to cooperate with international organisations is also played by the National GHG Management System.

4.5. Maintaining Balance between Penalties and Incentives

The cost-effective implementation of policy instruments would serve as the groundwork for national GHG mitigation efforts. For that purpose, the balance between penalties and incentives needs to be strategically maintained.

As for the penalty, fines under TMS and taxes in energy prices can be managed. The ratio of environmental taxes over total tax revenue may be a key indicator. Tax reforms to raise the ratio may be considered and the share of taxes in energy prices may be another indicator. For example, the government can raise the tax on fossil fuel–based energy sources such as diesel, gasoline, LPG butane, light fuel, and heavy oil. The higher prices would help slow down the consumption growth of such energy sources. Closing the gap between domestic and international fossil fuel prices could cut GHG emissions in ASEAN countries (Burniaux et al., 2009). Generally, feed-in-tariffs could be assessed on each energy source. The renewable energy generators earn a premium in accordance with the price table promulgated by the government. It usually represents the difference between the market price of electricity and the power production cost using renewable resources. Feed-in-tariffs would promote the distribution of renewable energy technology.

As for the incentive, voluntary emissions-reduction targets may work well. The firms may be eligible for low-interest-rate loans on energy-saving facilities, tax benefits, and technical support. Although voluntary approaches are not cost-effective in addressing environmental externalities, they can reveal information about abatement costs and environmental damage at an early stage (de Serres et al., 2010).

Under the mandatory scheme, the government needs to flexibly respond to voices from controlled entities. During the initial stage, companies under TMS and/or ETS would receive carbon allowances for free. Revenues generated from ETS operation (fees, fines, etc.) should be spent to advance circular economy. A couple of options can be used for TMS to operate more smoothly. For instance, voluntary mitigation outside ETS may count towards mitigation targets under ETS. Borrowing from future permits and banking of permits may be allowed. Companies that overachieve mitigating targets can earn rewards by selling or banking extra permits. Overall, public–private partnerships can be invigorated.

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Chapter 11

Low-Carbon Management of POSCO in Circular Economy: Current Status and Limitations

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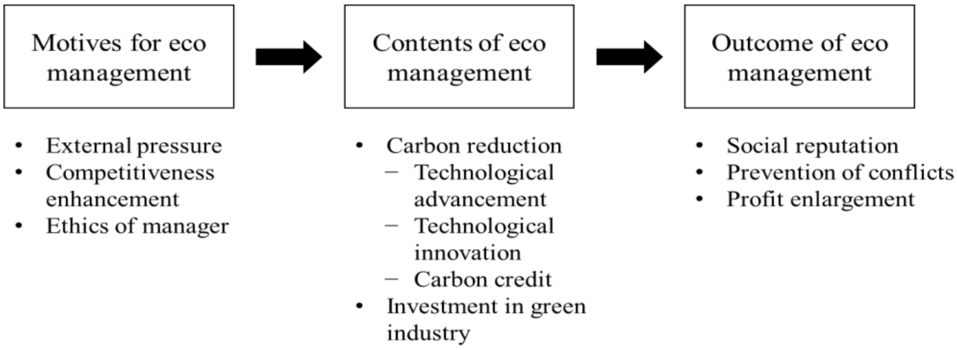
1. Introduction

In this chapter, we present a case analysis of POSCO, a steel-making company in the Republic of Korea (henceforth Korea). In analysing the case, we referred to POSCO's 2014 annual report on carbon management. Since 2009, POSCO has been annually publishing carbon-management reports in Korean and English. Since this 2014 report summarises POSCO's efforts in reducing carbon emissions in a year, it highly fits our case analysis. In addition, we interviewed some POSCO employees to obtain internal information about the company's green management.

Figure 11.1 shows the theoretical model used for our case analysis. This model was developed from the survey of past studies about green management. Thus, three issues framed this case analysis.

- What are POSCO's major motives for circular economy?
- What has POSCO done to reduce greenhouse gas (GHG) emissions? How much investment has POSCO made in green industries?
- What are the positive or negative impacts of POSCO's circular economy?

Figure 11.1. Theoretical Model of Circular and Green Management



Source: Author.

1.1. Overview

Established in 1968, POSCO operates two integrated steelworks in Pohang and Gwangyang in Korea. In 2012, it achieved US$35.7 billion of sales of crude steel and 3.8 million tonnes of steel production, resulting in US$2.8 billion of operating sales. This confirms POSCO's 1st ranking in the steel industry in Korea. Despite the deteriorating business environment caused by various factors in recent times, POSCO has endeavoured to raise its market share in the domestic market and has posted profitability by expanding sales of high-value-added products. POSCO has likewise reinforced its activities related to research and development for new products and steel-processing technology. In addition, the company's global expansion is progressing with the construction of galvanised steel plants in India and China, stainless-steel cold rolling mills in Viet Nam, and operational factories in India, Indonesia, Mexico, and Viet Nam.

POSCO's management performance on sustainability has been recognised early by domestic and international institutions. From 2005 to 2012, POSCO was listed in the Dow Jones Sustainability Index, a global evaluation index for sustainability. From 2010 to 2012, POSCO earned first place in the global steel makers' competitiveness as indexed by the World Steel Dynamics, the leading steel information service firm in the US. In 2012, it occupied the 30th place in the Global Sustainability 100 companies of the World Economic Forum, a meeting for political and business leaders to create the foremost global partnership of business, political, intellectual, and other leaders. It was also named the best company in the Carbon Disclosure Leadership Index by the Carbon Disclosure Project Group Committee.

The opportunities and threats to POSCO's carbon management are summarised in Figure 11.2. Extreme weather conditions cause operational deterioration as a result of difficulty in acquiring raw materials and unreliable water supply which leads to increased production cost. Also, the threat of a decrease in global competitiveness is expected as carbon regulations are introduced to the industry. With the strengthening of regulations on carbon emissions, a decrease in steel production is expected. On the side of opportunities, the dominance of green markets will lead to the development of energy-efficient steel that can provide the early markets with new products. As of now, the demand in the transport sector for high-performance steel is increasing. Other opportunities for the industry are increase in demand for renewable steel, involvement in green industries and renewable energy projects, and reinforcement of stakeholder awareness through external evaluation and transparent disclosure of information.

Figure 11.2. Threats and Opportunities

Threats

- Flood and drought
  - Deterioration of operational condition
  - insecurity of raw materials and water
  - Increase in distribution costs
- Costs for compliance to carbon regulation
  - Decrease in global competitiveness
- Restriction on total carbon emission
  - Decrease in production of steel
- Increase in social responsibility for major emitting firms

Opportunities

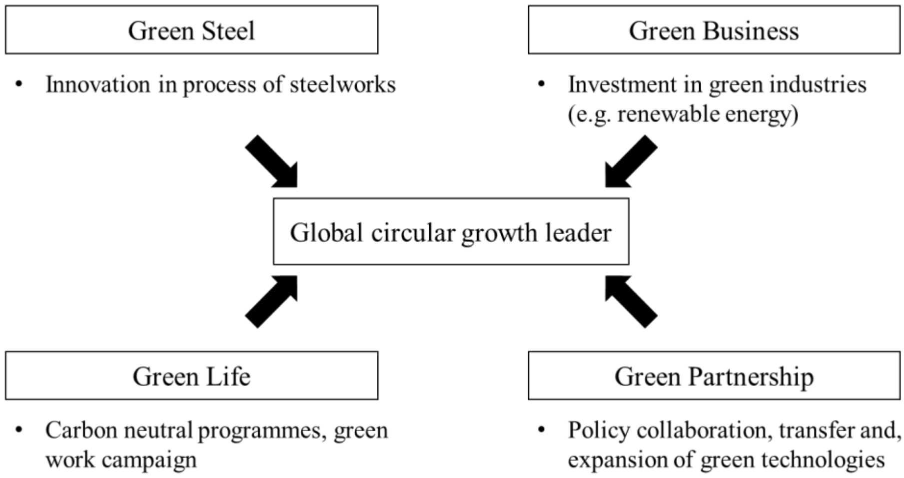
- Domination of green markets
  - Development of energy efficient steel
- Increase in demands for renewable steel
- Participation in green industries
- Innovative technological development
  - Differentiation of competitiveness
- Transparent information on external evaluation
  - Raise in market recognition

Source: POSCO Carbon Report 2014.

As the steel industry pushes forward with new projects, POSCO aims to add 70 million tonnes of steel to the global production system by 2020, develop steel-based materials and eco-friendly materials for the materials sector, and foster renewable energy projects.

Green steel, green business, green life, and green partnership comprise POSCO’s green management envisioned for 2020. Green steel targets carbon reduction in the production process through improvement of energy-saving and efficiency processes. Green business implements renewable energy projects such as wind power, fuel-cell generation, and waste resource recovery, while participating in green industries like smart grids and lithium material. Green life includes green walk campaigns to encourage employees and their families to practice green life and support carbon-reduction projects. Green partnership encourages carbon policies for domestic and foreign cooperation and strengthens corporate activities for a low-carbon society. Figure 11.3 shows the areas of POSCO’s green management.

Figure 11.3. Four Areas of Circular and Green Management



Source: POSCO Carbon Report 2014.

In February 2010, POSCO announced its voluntary GHG target of reducing the amount of CO_2 emissions per tonne of crude steel from 2.1 tonnes to 1.98 tonnes or a 9-percent reduction by 2020. In conjunction with the plan to reduce the use of coal materials, the company plans to invest ₩1.5 trillion by 2018 to improve energy efficiency. Under the Basic Act on Low Carbon Green Growth, the Korean government implements the Energy Target Management and sets 12.5 thousand tonnes of CO_2 emissions as the target goal for firms. From 2012, 458 firms have been designated by the Energy Target Management to carry out this goal. In 2012, POSCO was given the target goal of reducing its carbon emissions to 96.3 thousand tonnes.

POSCO's emissions-reduction efforts have shortened its process of steel production and reduced its CO_2 emissions to 77 million tonnes in 2012 compared to 79.29 million tonnes in 2011. Compared to 2011, POSCO's crude steel production increased by 1.8 percent while CO_2 emissions diminished by 1.5 percent. CO_2 emissions per tonne of produced steel decreased by more than 3 percent, from 2.10 tonnes to 2.03 tonnes, an indication of energy efficiency. To improve its process for producing molten iron, POSCO has reduced its coal consumption and increased the amount of scrap metal used. POSCO has also reduced by 1.02 million tonnes the CO_2 emissions of its transported ingredients, by 5.6 thousand tonnes the transport of employees, and by 1.5 thousand tonnes its domestic and foreign business trips. For example, POSCO employees have passionately participated in commuting by bicycle and cutting down unnecessary foreign business trips. Innovation in steel production is also significant as shown by the 659 thousand tonnes CO_2 reduction as a result of the upgraded car fuel efficiency which came from high-strength automotive steel production, the 2.51 million tonnes of CO_2 emissions reduction through the use of low iron-loss electronic steel which increases a steel's energy efficiency, and the 6.29 million tonnes of CO_2 emissions reduction as a result of a blast furnace slag which generates a substitute ingredient for eco-friendly cement in construction of the steel production process.

Table 11.1 shows the 13 issues POSCO has identified and prioritised in carbon management:

Table 11.1. Issues in POSCO's Circular and Green Management

Rank 2012	Rank 2011	Issues
1	6	Climate-change response strategies
2	1	Corporate policy to reduce carbon emission
3	3	GHG-emissions reduction efforts of POSCO family
4	4	Performance of carbon management
5	7	Activities to reduce GHG emissions at sites
6	5	Carbon disclosure
7	2	New green business
8	12	Carbon management governance
9	8	GHG reduction target
10	11	GHG-emissions reduction through products and by-products
11	10	Management risks related to climate change
12	9	Carbon accounting
13	13	Participation in carbon market

GHG = greenhouse gas.
Source: POSCO Carbon Report 2014.

1.2. Motives

What are the drivers of POSCO's green management? What has made POSCO's management pay attention to green management? In management theory, economic rationality and social rationality form the backgrounds of managerial decision-making (Oliver, 1997). Economic rationality means that the aim of decision-making is to use internal resources optimally and to maximise corporate performance. In contrast, social rationality makes managers decide in the process of adapting to outside pressures; this decision provides the firm with social legitimacy. Which is more important in understanding the motives of POSCO's green management?

An interview with a POSCO executive shows both factors are found. First, the efforts to reduce GHG emissions can reduce costs in the manufacturing process. Success in energy efficiency leads to cost reduction in energy consumption. Second, the attitude of the management toward carbon reduction is not very aggressive. As with most Korean companies, the biggest reason behind managerial concern for green management is government regulations. For example, the Korean Energy Control Enterprise has set GHG emissions targets for large Korean companies and has been pushing them to reach this target.

Academic literature on circular economy stresses the importance of proactive attitude of corporate management to adapt to outside pressure about carbon emissions reduction. Managers should be able to use the pressure for low-carbon economy as a new growth opportunity. In POSCO, the proactive attitude of the management seems to be very weak. Although managers have recently begun to consider the necessity of carbon-emissions reduction, they have yet to imagine the strategic adaptation to low-carbon pressures.

1.3. Greening the Steel Production

This part addresses how POSCO attempts to reduce CO_2 emissions in the steel production process.

1.3.1. Energy efficiency

POSCO's struggles for energy efficiency are divided into three periods. In the first period (1999–2008), POSCO invested ₩1.43 trillion in energy facilities and saved 2.91 tonnes of oil equivalent of energy due to agreement with the government on voluntary energy reduction. In the second period (2009–2015), small and medium-sized investment projects for energy efficiency were conducted. Most large energy-recovery projects were completed. The government's Energy Target Management has been in operation since 2011; ISO 50001 was adopted in 2012. In the third period (2016–2020), POSCO will bring in innovative technologies beyond the limits of current technologies.

Activities to improve energy efficiency are the following:

- Most by-product gases from the steel process are used to recover the energy source.
- To raise self-efficiency in blast furnace by-product gas, combined cycle power plants were established in Gwangyang in 2010 and in Pohang in 2013.
- From 2011, task-force-teams have worked to increase the efficiency of combustion heat-generation in the entire steel factories.
- From 2012, NOx discharge from the combustion plant has been suppressed and steel mill pulse combustion technology has been developed to improve combustion efficiency.
- By utilising advanced information technology, including the smart grid, POSCO tries to accomplish energy efficiency and cost savings.
- By utilising skylights, lighting viscous and automatic control system, and LED lighting, POSCO has improved the working environment and reduced electricity costs.

1.3.2. Process improvement techniques

POSCO will develop and utilise innovative technologies in the future.

- In steelmaking process at Ilgwan steel works, scrap metal issued in the converter to lower CO_2 emissions, and a new type of heat converter has been developed to increase the limit from 15 percent to 50 percent of the conventional scrap usage.
- Using ammonia, technologies have been developed to absorb and separate CO_2 from the blast furnace by-product gas.
- By utilising PSA techniques, the optimal separation processes and adsorbent for the separation of CO and CO_2 have been developed since 2011.
- From 2009, techniques for improving the energy efficiency of steel process to recover the heat held by the high temperature slag have been developed.
- A power-generation system, which simultaneously absorbs the source of heat generated from heating the steel mill and converts it into electric power, is being developed.
- In preparation for the era where massive clean hydrogen manufacturing system is possible, POSCO is developing technologies to replace coals with hydrogens, thereby reducing iron ores.

1.3.3. Carbon management system

POSCO conducts the following for an effective green management at firm level.

- From 2006, POSCO has followed its guidelines for unique carbon estimation based on global standards such as those of the Intergovernmental Panel on Climate Change, the World Business Council for Sustainable Development, the World Resources Institute, the World Steel Association, and the ISO14404. From 2011, POSCO has set up an internal GHG management system in accordance with the action plans of the GHG Energy Target Management of the Korean government.
- The ISO 50001 (energy management system) was finalised in June 2011. POSCO set a task force in January 2012 and acquired the ISO 50001 certification in September 2012.
- An incentive programme has been devised for those in production units who achieve reductions in GHG emissions by their energy efficiency improvement activities.

1.3.4. Circular thinking in business

The necessity for climate change mitigation and carbon-emissions reduction may financially cost heavily for a firm, but new business opportunities can be made by strategic actions.

- By producing and distributing energy-efficient steel products, POSCO is ready for the low-carbon economies. With lightweight and high-strength automotive steel, the weight of a car is lightened by 10 percent and the amount of carbon emissions is reduced by 5 percent. By distributing high-energy efficient electric steels to generators, power-transmission and distribution transformers, and motors, energy efficiency is increased in the final products.

- By utilising the slags generated in the process of steel production, renewable slags are recycled as raw material of cement or as aggregate substitutes. In 2012, 6.29 million tonnes of CO_2-emission reduction was realised by using 8.01 million tonnes of slags as substitute for cement.

- From 2005 to 2011, POSCO participated in GHG-emissions reduction projects conducted by the Korea Energy Management Corporate and earned 3.55 million tonnes of carbon credits by increasing its electric power generation through energy efficiency in steelworks and by reducing GHG through renewable energy. In 2008, POSCO earned 27,000 tonnes of carbon credits per year for 10 years for the United Nations Framework Convention on Climate Change's approval of its Gwanyang Small Hydro Power as a Clean Development Mechanism (CDM) project. Moreover, POSCO gained 21,000 tonnes of carbon credits per year for 30 years by joining in the forest project in Uruguay and taking part in the Future Carbon Fund of the Asian Development Bank and the carbon credit funds of the Ministry of Knowledge Economy.

- In 2012, POSCO completed the construction of a 12-MW solar power plant in Sinan Country, South Jeolla Province. By extension, a 40-MW wind power plant was assembled in Taegi Mountain in Gangwon Province in 2008 and, for the first time in Korea, an offshore wind power plant with total 30-MW scale is being planned to be constructed in Jeju Island in partnership with Doosan Heavy Industries.

- For the waste-energy project, POSCO is pushing its power-generation projects using household wastes and district heating supply project using sewage heat. In 2012, the company installed 100 kW of fuel cells at Seoul Seobuk Hospital and Seoul Children's Grand Park. It has also started to build a fuel-cell power plant at an amusement park in Jakarta, Indonesia, and has contracted with the Fuel Cell Energy in the United States for transferring cell-manufacturing technology.

- In 2012, POSCO invented a direct-extraction technology of non-evaporative lithium, a core ingredient in mobile phones and electronic car batteries, and entered a joint venture for a lithium battery business with Korea Resources Corporation and a Bolivian state-owned company.

1.4. Social Innovations for Circular Economy

1.4.1. Green community

As a GHG-emissions reduction project, POSCO's carbon-neutral programme was launched in 2009 with support from civic organisations, housewives, and students. Participants in this programme are encouraged to propose new ideas to offset carbon emissions. The most doable suggestions can get corporate sponsorship. In 2012, for instance, teams of university students were selected for sponsorship and their projects conducted to propagate carbon-neutral awareness among students.

1.4.2. POSCO family green walk campaign

Launched in 2011, the POSCO Family Green Walk Campaign targets POSCO's employees and their families to acquire green habits through four energy-saving actions: walk, turn-off, reduce, and recycle. They can post ideas and achievements on the Green Walk homepage and ear green coins that can be used to purchase green books or donate them to people vulnerable to climate change.

1.4.3. Green steelworks

Steelworks in Gwanyang and Pohang encourage their employees to commute by bicycles or inner-circle vans. Starting April 2012, Pohang steelworks has designated every Monday as bicycle commuting day and bought 4,000 bicycles for the project. With the help of the city of Pohang, POSCO employees can use three bicycle-only lanes that connect workers' residences to their workplace. A mileage system has also been adopted where workers can get 10 credits of mileage when commuting by bicycle, which can be used for buying company concert tickets and renting sports and recreational facilities.

1.4.4. Energy-saving and power-saving activity

Where electricity supply is unstable, POSCO has prepared various energy-saving plans to raise the awareness of their employees regarding energy saving and response to the government policy on climate change. Pohang steelworks has initiated power-saving taskforce teams to enhance energy efficiency and has succeeded in saving ₩5 billion using cheaper night-time power. At Gwangyang steelworks, shop floor units are taking measures to save energy by adjusting the time to change rolls. POSCO's other energy-saving projects include modifying the grey water facility, installing a boiler waste heat-recovery facility, and setting up an energy patrol team.

1.5. Partnership for Circular Economy

POSCO was the only steel maker in the world to be selected in the Carbon Disclosure Leadership Index for its transparent disclosure of carbon information in governance, risks and opportunities, strategies, GHG emissions, and communication (Han, Sung-Hee from Manager, POSCO Environment & Energy Department). The company continuously fulfils its obligations to build a green economy while cooperating closely with its stakeholders to achieve actual reduction of GHG emissions.

1.5.1. Carbon disclosure

Since 2003, POSCO has been participating in the Dow Jones Sustainability Indexes and Carbon Disclosure Project by disclosing activities related to climate change and CO_2 emissions. By doing so, POSCO earns positive evaluation from the external institutions.

The Dow Jones Sustainability Index annually releases its list of 300 corporations whose sustainability indices belong to the top 10 percent. For 8 consecutive years since 2005, POSCO's good performance has been noted; it topped the environment score in 2012. In 2010, among all steel makers in the world and the 500 corporations listed by the Financial Times Stock Exchange, POSCO was rated as good performer at Carbon Disclosure Leadership Index and Carbon Performance Leadership Index by the Carbon Disclosure Project and, in 2012, took the first place in the Carbon Disclosure Leadership Index. In the Environmental Tracking Carbon Ranking released by the Environmental Investment Organization, POSCO was selected as one of the top 10 among Asian and Pacific firms.

1.5.2. Climate action by the World Steel Association

POSCO has also been involved in the global steel makers' climate change programme by the World Steel Association. To upgrade the steel industry's reduction technology, POSCO has been participating in Worldsteel CO_2 Breakthrough Programme since 2003, the year the programme started. The CO_2 capture method developed by Worldsteel has been raised to global standard through the establishment of ISO methodology.

1.5.3. Global partnership for energy efficiency

In July 2010, the Global Superior Energy Performance Partnership initiated by the Clean Energy Ministerial raised attention to the need for energy security by reducing energy consumption in industrial and commercial buildings. POSCO joined in the steel working group of sectors that comprised the partnership. In Global Superior Energy Performance Partnership, where there are six working groups, POSCO is participating in one of them: steel working group. POSCO attended the workshop held in Tokyo in March 2012 to discuss the working group's activities and plans.

Table 11.2. Goals for the GSEP Steel Working Group

1	Develop and implement energy management system for steelworks.
2	Develop and implement methodology to use, improve, and verify performance index.
3	Identify and disseminate technologies, including technologies that can be commercialised for reducing CO_2 emissions from iron-and steel-making through energy saving and other breakthroughs.
4	Disseminate information on the steelmaking industry's burden on the environment and facilitation of resource recycling.
5	Exchange information on financial support for carbon policy and technology dissemination of the steelmaking industry.

Source: POSCO Carbon Report 2014.

2. Discussion

In this chapter, we investigate and discuss the comparative review of existing research and case studies as summarised above.

Circular economy at the corporate level in extant studies have been organised into (i) carbon reduction in offices and factories by technological change, (ii) introduction of innovative technologies on carbon reduction, (iii) participation in the carbon market, and (iv) investment and participation in the green industry as a new growth industry. Although POSCO's circular economy and management approaches appear in all areas, the efforts on the first and second parts are relatively more strongly represented than the third or fourth. To illustrate, POSCO's crude steel production in 2012 increased by 1.8 percent than that in 2011 whereas its CO_2 emissions were reduced by 1.5 percent. This implies that POSCO has succeeded in reducing CO_2 emissions by improving its energy efficiency and processing technology. In addition, because reducing GHG has been part of the government's management system since 2011, POSCO was motivated to aggressively participate in carbon reduction.

The fourth part of circular thinking and management is awareness for new business opportunities in green industries and creation of new revenue streams. POSCO's carbon report suggests two activities on this: utilisation of slags generated in the steel-making process and supplying energy-efficient steel for generators or motors. Such activities, however, are still at the initial stage. Besides, POSCO fosters the establishment of solar and wind power plants and participates in other energy projects such as those concerning fuel cells and lithium batteries.

The third area is participation in the carbon market. Introduced in 2015, the carbon market in Korea was still at the beginning stage in 2016. In overseas markets, however, a firm can earn carbon credits by joining in CDM projects as POSCO has done by participating in Gwangyang small hydro and Uruguay forest projects.

The POSCO carbon report mostly deals with the content of green management and barely touches on results and motives of green management. Green business motives are usually organised into institutional pressure from the outside, preceding efforts of companies to improve competitiveness, and ethics of managers. Of these, institutional pressure is considered as the first motive for green management. As explained in the case of the government's GHG target management, institutional pressure is the most powerful initiative and is regarded as coercive pressure (DiMaggio and Powel, 1983). Nevertheless, it may not be to the interest of POSCO, one of the major conglomerates in Korea, to cite external regulatory pressures as reason for its green management. Rather, disclosing the second or the third motive may be more advantageous, especially the second motive of improving competitiveness as it suits more POSCO's status as a leading firm in the market.

Previous studies suggest that firms proactively respond to calls for social responsibility and environmental management (Aguinis and Glavas, 2012). Unfortunately, however, the important issues discussed above are not fully explained in POSCO's carbon report. Because of the importance of corporate social responsibility and sustainability, it is necessary for POSCO to show how it plans to contribute to the society while catching business opportunities and reacting to changes with proactive attitude.

In short, POSCO can describe in detail the institutional pressures that push its green management. As a competitive firm, it should recognise the changing environment and counter it with proper strategies and by being responsive to environmental changes. Lastly, it should address its managers' ethical and strategic intentions by presenting in detail the managerial policies of its CEO on green management.

Omitted in this discussion are POSCO's resource and experiences which can be the basis in propelling green management. In theories on corporate strategy, resource-based views are considerable in researching green management (Wenerfelt, 1984; Barney, 1990).

Performance, the last part of circular management, is rarely dealt in POSCO's carbon report. It is important for POSCO's green management to specify the internal and social impacts of its green management as its value may fade away if it does not produce positive impacts on society and on its competitiveness and performance as a firm. Although not easy, it is important to calculate its investment in green management and how it has contributed to the firm's revenues. Thus, estimating the causal relationship between green management and corporate financial performance or social performance is required.

2.1. Implications for Policymakers

Governments should be able to make the private sector participate in creating circular economies. An effective mechanism for public–private partnership should be developed. To realise such mechanism, governments are required to understand why firms want to invest in circular economy. In our research model, outside pressure, competitive improvement, and corporate ethics are pointed out to be reasons why firms participate in green movement.

Exact understanding of the motives of corporate green management can lead to the development of sound government policies.

As green growth is being paid attention to climate change, energy crisis, and economic downturn, circular economy can be an opportunity for a firm's sustainable growth. Although some firms have been interested in circular principles, there are some hindrances for firms to actively invest in such fields.

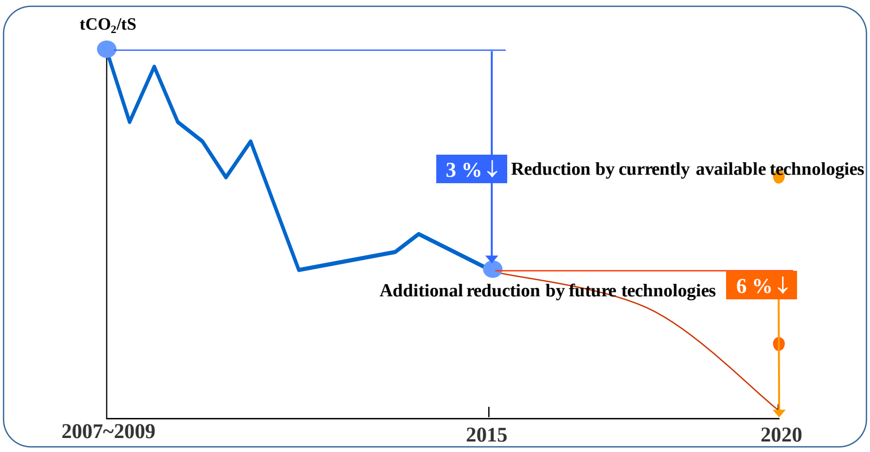
Following are the reasons firms cannot easily invest in the circular economy. Policymakers should consider the following issues to help green management of corporations. First, as the demand for green products or services is not sufficient, firms cannot proactively invest in green industries. Second, products and services in the market are very limited and consumers hardly have enough information about resource-efficient products or services. Third, the global standard for circular economy is immature. If circular economy is certified by internationally recognised institutions, many small and medium-sized firms will participate in the circular economy movement.

2.2. Implications for Corporate Managers

Among the 100 firms listed by the Davos Forum in 2012, POSCO was ranked the 30th most eco-friendly firm. For several years, the motivation for POSCO to reduce GHG is mostly attributed to the need for energy efficiency. The following implications are developed from the experience of POSCO.

First, technological improvement is critical in reducing carbon emissions. By using all available technologies on raw-material reduction and energy efficiency, POSCO, from 2007 to 2009, reduced GHG emissions to 2.09 tonnes of CO_2/tS. POSCO plans to invest about ₩150 billion in CO_2-reduction innovation technology to lower CO_2 emissions by 6 percent by 2020. New technologies on energy efficiency and clean energies are to be developed to create a circular economy.

Figure 11.4. CO_2 Reduction Plan of POSCO (2015–2020)



Source: POSCO Carbon Report 2014.

Second, various programmes to attract voluntary participation from the society may offset the pressure for carbon-emissions reduction from outside stakeholders. A social programme of POSCO is to let all types of members in the society voluntarily take part in carbon neutralisation.

Third, corporate responses to climate change need to be systematically consistent across the firm. The POSCO headquarters in Seoul launches some strategies on climate change, plans CDM projects, and invests in renewable energy businesses. Two major plants in Pohang and Gwangyang perform energy-efficiency projects and measure carbon emissions. The POSCO research institute conducts studies on climate-change policies in the world and suggests effective responses in the new environment. POSTECH, a university famous for science research in Korea, develops energy-efficiency technologies. As affiliated companies of POSCO, they remain consistent in creating synergy in all sorts of circular economic activities.

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Chapter 12

Public–Private Partnerships and Implications for a Circular Economy in Australia

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1. Introduction

Interest in the concept of public–private partnership (PPP) has intensified in recent decades. Essentially, PPP is an arrangement that brings the public and private sectors together in a long-term partnership for mutual benefit (Zen and Regan, 2014). It is seen as a specialised procurement method employed by a government to deliver public goods and infrastructure service (Ibid). The use of PPP is justified through a range of benefits such as improved focus on service; payment being made only when defined assets or services are delivered; better adherence to delivery schedules and budgets; ability to hold the provider financially accountable for performance; access to the best technical and management skills; improved outcomes through the use of competitive forces to stimulate creativity, pricing, and delivery; and access to infrastructure financing without additional borrowing by a government (Infrastructure Partnerships Australia, 2015).

Another concept that has recently attracted considerable attention is circular economy. The aim of a circular economy is to 'eradicate waste, not just from manufacturing processes, as lean management aspires to do, but systematically, throughout the various life-cycles and uses of products and their components' (Nguyen et al, 2014). It is being visualised as a new economic and business strategy that advocates a move from a take–make–dispose approach to a redesigned future where industrial systems are restorative and regenerative and are designed on closed-loop principles. In such a redesigned system, growth does not take place at the cost of environmental health. Furthermore, this new approach offers considerable potential for innovation, job creation, and sustainable economic development.

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This paper is a preliminary attempt to examine whether circular economy principles can be incorporated into PPP frameworks. Given the fact that many PPPs are large in scope and long-term in nature, the incorporation of these principles can yield substantial benefits to society as a whole. However, the paper confines itself to PPPs in Australia. The rest of this paper is presented in five parts. The next section provides a brief overview of PPPs in Australia, followed by a short section providing a justification for PPPs in Australia. Section 4 then examines PPPs and their implications for a circular economy. This is followed by a fairly detailed presentation of a PPP case study in Australia, namely, the Waratah Train PPP Project, where an attempt has been made to examine to what extent circular economy principles were adopted in the design and delivery of this PPP. The last section provides a discussion that examines whether PPPs have the potential to incorporate circular economy principles into the project structure. It should be noted that the conclusions here are only aimed at stimulating further examination and discussion since these are based only on the findings of one case study.

2. Public–Private Partnerships in Australia: An Overview

In recent times, across the world, partnerships between governments and private contractors are being seen as an important feature of what is popularly referred to as 'new public management' (English, 2006). According to Teicher et al. (2006), a PPP, as an element of new public management, is one where 'the government has a business relationship, which is long term, and where private business becomes involved in financing, designing, constructing, owning, or operating public facilities or services.' This implies that PPPs involve private finance and the bundling of design, construction, maintenance, operations, and other services into a single long-term 'whole of life' contract (Clayton Utz, 2013).

Taseka (2008) states that in Australia, the most common types of PPPs are (i) build–own–operate–transfer (BOOT); (ii) build–operate–transfer (BOT); (iii) build–own–operate (BOO); and (iv) design–build–finance–maintain (DBFM). These different types can be subsumed within two types of PPPs: a social infrastructure PPP and an economic infrastructure PPP (Clayton Utz, 2013).

In social infrastructure PPP, the government makes a regular service (or availability payment) which is the primary revenue stream for repaying the private sector for funds used to build a facility such as a school, hospital, prison, and other social (non-income producing) infrastructure. Yet, there have been instances where this model has been used in Australia to deliver economic infrastructure (roads and railways). This model is sometimes called a government-funded PPP (Ibid.). In economic infrastructure PPP, the revenue stream is generated by the users of the facility such as tolls paid by motorists who use a toll road. This is sometimes called a user-funded PPP (Ibid.). However, there are also hybrids and variants of these two models.

An infrastructure PPP formation in Australia generally follows the following sequence (Clayton Utz, 2013).

- The government announces a project.
- Private sector construction contractors, operators, equity investors, debt financiers, and other relevant entities form a consortium to bid for the project.
- The equity investors in the successful consortium establish and take equity interests in a special purpose vehicle (SPV) that enters into the PPP contract with the relevant government agency. The design and construction of the facility is financed from equity and debt finance.
- The PPP contract requires the SPV to design and construct the infrastructure facility, maintain it, and provide others specified services over a specified period that is usually long term.
- If the PPP is government funded, the government pays the SPV a regular payment (monthly, quarterly, etc. as specified in the contract) once the construction is complete. For user-funded PPPs, the SPV can levy charges as agreed.

3. Justification for PPPs in Australia

Initially, a common argument for PPPs was that it would avoid public debt. A more compelling rationale now is that PPPs help achieve what is called 'value for money', defined by the New South Wales (NSW) Treasury as 'getting the best possible outcome at the lowest possible price.' It is argued that bundling of services provides consortiums with an incentive to deliver results more efficiently than what the state can because private money is at risk (English, 2006). Obligations such as providing asset-based services over the life of the contract are additional incentives to minimise life cycle costs (Ibid.).

To demonstrate how a PPP will save money compared to a publicly financed alternative, a public sector comparator is used to the net present cost of a hypothetical public provision of the infrastructure and the services. This value is used to compare bids.

Clayton Utz (2013) points out that a study in 2008 across Australia where 25 PPPs were compared to traditionally procured projects showed the following:

- PPPs had an average construction overrun of 4.3 percent compared to 18 percent for traditionally procured projects.
- Average construction delay for PPPs was 1.4 percent compared to 25.9 percent for traditionally procured projects.

Other advantages include (Clayton Utz, 2013):

- More rigorous due diligence and monitoring applied by debt financiers;
- Improved project scoping and risk assessment by government;
- Greater scope for the private sector to bid innovative solutions which can deliver the required services at a lower whole of life cost;
- Better allowance made for operation and maintenance costs;
- Optimal risk transfer; and
- Financial incentives drive timely completion.

4. PPPs and Implications for a Circular Economy

In PPPs in Australia, the public sector client normally encourages innovative ideas in the design, construction, technical, and commercial elements provided they are within the context of the key performance indicators (KPIs) specified by the contract. Adequate protection is also provided by clients to intellectual property generated by the private sector partners. However, not all innovative ideas will focus explicitly on circular economy principles.

Javed et al. (2013) provide an example of how, in a railway station redevelopment project in Victoria, the private sector partners were able to innovatively design platforms, escalators, and lifts that could clear a full-load metropolitan train in 90 seconds. They also give an example of how, in a South Australian hospital project, automatic guided vehicles were proposed by the contractor to reduce labour cost for handling materials and meals. However, these innovations are not explicitly linked to circular economy principles since the KPIs were linked to time and labour saving, respectively.

Javed et al. (2013) also provide an example from Queensland where a contractor introduced energy- and water-saving measures for an education project. These included a central energy unit rather than chillers in every building, rainwater storage for irrigating in education facilities, and building design relying on natural lighting. Bougrain (2012) gives an example from France (municipality of Tours) where an energy-saving performance contract was awarded as a PPP to modernise and optimise building automation installations and energy systems. This led to substantial energy savings (12 percent) and a reduction of carbon dioxide emissions (15.5 percent) and a win–win situation for all the parties. Similarly, Twigg (2012) gives an example from Assam, India, where the Guwahati Waste Management Company Private Ltd was set up as a PPP to develop a refuse-derived fuel plant to handle mixed municipal solid waste, to build a compost plant for organic and green waste, and to develop a power plant to generate 6 MW of electricity.

It thus appears that at present, unless a PPP project itself is based on circular economy principles, such as the Guwahati waste management example given above, it is not common for a public sector client of a PPP project to explicitly incorporate circular economy principles into the KPI framework.

5. Case Study: The Waratah Train Public–Private Partnership Project in NSW, Australia

To gain insights into the issues and challenges in incorporating circular economy principles in the launching and implementation of a PPP, a case study of a recently completed PPP in Australia – the Waratah Train Public Private Partnership Project in NSW – was undertaken. The PPP was implemented through an SPV called Reliance Rail. The case study focuses on the following:

- Overview of the PPP between Reliance Rail and Sydney Trains;
- An examination of whether circular economy principles were explicitly incorporated in the PPP contract and the KPIs for measuring performance;
- Approaches adopted by Downer EDI and its technical partners as the entity contracted to design, manufacture, and maintain the project assets, to incorporate circular economy principles in the design, manufacture, and maintenance of the Waratah trains;
- Challenges faced by the SPV in incorporating circular economy principles;
- Generic lessons for incorporating circular economy principles in structuring PPPs.

5.1. Origins of the Public–Private Partnership

In late 2004, RailCorp (now known as Sydney Trains)[1] called for expressions of interest for the delivery of new rolling stock that included both single-deck and double-deck car sets. In early 2005, RailCorp issued a request for proposals. Around March 2005, RailCorp decided, after more detailed analysis and consultations, that single-deck car sets could not be adequately justified on economic considerations and decided to only go for double-deck sets. In August 2005, a modified request for proposals specified the supply of 72 sets with eight cars each, another six sets of eight cars each as maintenance spares, and two spare carriages, or a total of 626 train carriages.

Bids were submitted to RailCorp by Reliance Rail and Star Transit in August 2005 and in December 2006. Reliance Rail was awarded the contract as a A$3.6-billion privately financed deal to finance, manufacture, and maintain 626 suburban passenger train carriages for

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[1] From 1 January 2004 until 30 June 2013, RailCorp provided metropolitan passenger rail services via CityRail and long-distance services via CountryLink. RailCorp Rail Corporation New South Wales (RailCorp), as a statutory authority of the State of New South Wales, was responsible for providing metropolitan passenger rail services through its CityRail branded service and long-distance services through its CountryLink service during the period 1 January 2004–30 June 2013. During this period, RailCorp also provided access to freight operators in the metropolitan area. Subsequent to a restructure of RailCorp, SydneyTrains was established on 1 July 2013 to operate services in the Sydney metropolitan area whereas NSW TrainLink was to operate all other passenger services including those operated by CountryLink.

Sydney's rail network. This Rolling Stock Public Private Partnership between RailCorp (now Sydney Trains) and Reliance Rail is also referred to as the Waratah Trains Project. The government of the State of New South Wales (NSW) named the train 'Waratah' after the State of NSW's floral emblem.

In addition to building 78 car sets and two spare carriages, the contract also had two other important components (Reliance Rail 2015):

- Design, build, and commission the Auburn Maintenance Centre to provide maintenance services for the new Waratah fleet for 30 years. This would include the laying of 12 km of track and design and construction of training simulators to provide training to the crew. The total revenue from this was estimated to be A$240 million (fixed lump sum).

- Provide through-life-support (TLS) for all 78 eight-car sets over a period of 30 years. It was mandatory to provide 72 eight-car sets daily to Sydney Trains for its metropolitan services. The estimated total revenue over 30 years for providing TLS was estimated to be A$2.5 billion.

Essentially, Sydney Trains was to pay Reliance Rail based on the availability of the train sets over the life of the contract. Deductions/bonuses for TLS were to be based on performance.

5.2. Delivering the PPP Project

Reliance Rail is an SPV established to deliver the PPP project. It is owned by four entities (Reliance Rail, 2015):

- Downer EDI Limited (49 percent), one of Australasia's largest outsourcing engineering services companies. Downer EDI is an Australian Stock Exchange Top-100 company that operates across the Asia-Pacific region providing comprehensive engineering and infrastructure management services to the public and private transport, energy, communications, and resources sectors. It was founded as Downer & Co. in 1933 in New Zealand and merged with Evan's Deakin Industries in 2011 (Downer, 2015).

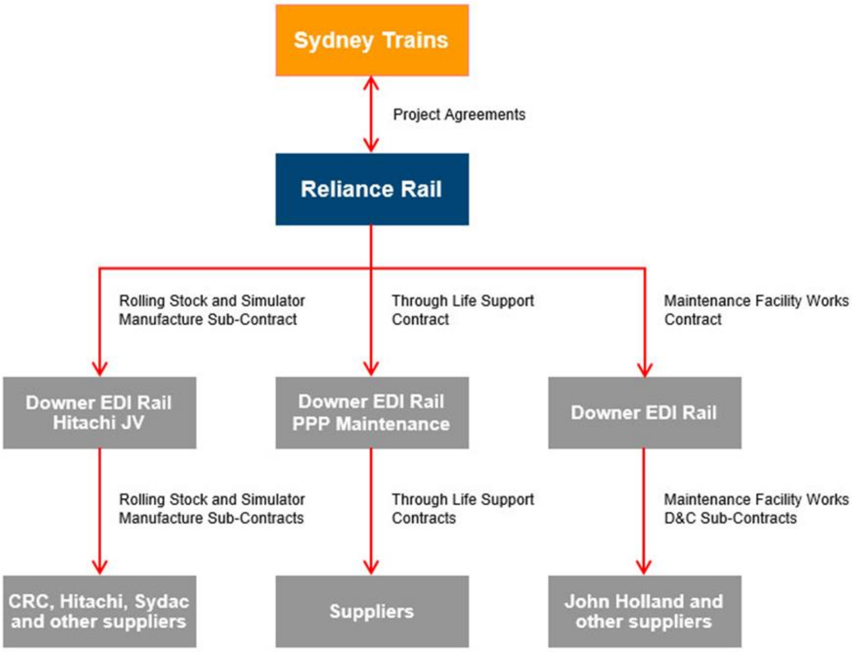
- Interests managed by AMP Capital Investors (25.5 percent), one of the leading specialist investment managers in Australia and New Zealand. It has experience in investing in Australian infrastructure asset class since 1988.

- Royal Bank of Scotland Group plc (12.75 percent), formerly known as ABN-AMRO, a market leader in developing and financing social infrastructure in Australia.

- International Public Partnerships Limited (12.75 percent), formerly known as Babcock & Brown, a United Kingdom–listed PPP/Private Finance Initiative global infrastructure fund and manager of social infrastructure assets. It is managed by Amber Infrastructure Limited which has global experience in the management of social infrastructure assets.

Reliance Rail raised approximately A$2.4 billion in debt and A$137 million in equity financing in December 2006 for the venture. The delivery structure is shown in Figure 12.1.

Figure 12.1. Delivery Structure for the Rolling Stock PPP



PPP = public–private partnership.
Source: http://www.reliancerail.com.au/Page/Home.aspx

Reliance Rail's funding model was the lowest cost financing of any PPP in Australia at the time. The funding structure was acknowledged with the PPP deal winning CFO Magazine's Annual Structured Finance Transaction of the Year Award (Reliance Rail, 2015). The cost of equivalent funding has now substantially increased post the global financial crisis of 2008 (Johnson, 2015).

To deliver the project within the given time frame and budget, Reliance Rail entered into subcontracts with many organisations in the Asia-Pacific region and Europe (Reliance Rail, 2015; Johnson, 2015).

The trains have been designed and manufactured under a contract Reliance Rail has with the joint venture between Downer EDI Rail (DEDIR) and Hitachi. Hitachi was responsible for traction and auxiliary power design and manufacture. DEDIR was responsible for the balance of the project scope including establishing and managing a major subcontract with Changchun Railway Vehicles Co in China for manufacturing the stainless-steel body shells and bogies as well as the partial fit-out of the train carriages using components supplied by other subcontractors separately engaged by DEDIR (Johnson, 2015).

The trains were designed in Australia by DEDIR in conjunction with Hitachi to conform to Australian and international standards. Many of the latest technological advances in rolling stock design were also incorporated. The designs were subject to review by Sydney Trains and many comments were generated, a matter that led to some considerable dispute and delay in the project (Johnson, 2015). Changchun Railway Vehicles Co was selected as the manufacturing subcontractor based on its manufacturing facility capacity and its considerable experience in building stainless steel cars for both domestic and international markets. Its manufacturing facilities incorporate advanced technology from France, Germany, and Japan. Changchun Railway Vehicles Co had built trains under joint venture agreements with Alstom, Hitachi, Bombardier, and Siemens.

To ensure that construction and testing were in conformance with the specified design, DEDIR-Hitachi and Sydney Trains had posted relevant personnel in Changchun to provide on-site quality, safety, and project management oversight in addition to audit and governance support.

Other Tier 2 subcontractors in the PPP supply chain responsible for specialist sub-system design and supply included the following (Reliance Rail, 2015; Johnson, 2015):

- Knorr Bremse (the Czech Republic, Austria, and China) for doors and brakes
- Thales (Australia) for train communication network, communications and surveillance, and systems integration designed in Australia and procured from a variety of international commercial off-the-shelf equipment suppliers
- EKE (Finland) for train information system
- Sigma Coach Air Group for heating, ventilation, and air-conditioning (HVAC), designed in Australia and manufactured in China
- Voith (Germany) for couplers
- Hubner (Germany), for gangways
- Fogtec (Germany) for fire detection system
- LPA Niphan (United Kingdom) for LED lighting and jumper cables
- Flachglas (Germany) for glass windows.

Tier 3 suppliers that manufactured components to DEDIR's designs and/or COTS products and commodities included the following:

- BNG/Miryung (Korea), stainless steel
- Huber and Suhner (Switzerland and China), cable and looms
- Smorgon (NSW, Australia), wheels and axles
- RPC (NSW, Australia), glass-fibre reinforced plastic cab structure
- Castech (China), ferrous castings
- BFG Philippines, GRP interior panels
- Luxembourg, composite floorings from composites.

Under the PPP contract, the NSW government had specified a minimum of 20 percent local industry participation. The project exceeded this by involving local partners (see some of the local partners listed above). Furthermore, the PPP supported training and skills development by taking on a fresh apprentice for every nine technical tradespersons.

The final manufacturing of the train, its assembly, and commissioning were carried out at DEDIR's Cardiff facility in Hunter Valley. This included crew cabs, air-conditioning, some traction equipment, and the train's computer and electrical systems. Prior to the final manufacturing and assembly of the Waratah fleet, Downer EDI Rail spent about A$22 million to upgrade its manufacturing, testing, and commissioning facilities at Cardiff.

The manufacturing and assembly activity at Cardiff led to significant economic and social benefits for the Hunter economy. An estimated A$200-million economic boost was delivered to the Hunter economy (Reliance Rail, 2015). Also, about 300 jobs (that included approximately 190 mechanical and electrical technicians and 30 apprentices) were created. In addition, there were peripheral business flow-on effects for the local economy.

As shown in Figure 12.1, Downer EDI Rail PPP Maintenance Pty Ltd, a wholly owned special-purpose subsidiary of Downer EDI Rail, has been established to provide TLS maintenance services for the Waratah train fleet from the Auburn Maintenance Centre, which was built at a cost of A$240 million and commissioned in 2010. The site area extends over nearly 2 kilometres and has the capacity to accommodate 1,000 cars. The facility has an automatic train-wash plant and a tandem underfloor wheel profiling lathe. TLS services provided at the maintenance centre include the stabling of the trains, washing, graffiti removal, vandalism rectification, carrying out scheduled and corrective maintenance, wheel turning, and presenting readiness certified trains in accordance with Sydney Train operation schedules.

5.3. Technological Aspects of the PPP

The technological aspects of the Waratah fleet may be divided into two parts: design and manufacture and operations related to TLS. Table 12.1 presents some of the key design and manufacturing specifications of the train. Figure 12.2 shows the train set. Figure 12.3 shows the Auburn Maintenance Centre.

Figure 12.2. The Waratah Train Set

Source: http://www.reliancerail.com.au/Page/Home.aspx

Figure 12.3. The Auburn Maintenance Centre

Source: http://www.reliancerail.com.au/Page/Home.aspx

Some of the important design and manufacturing features that enhance the comfort and safety of passengers and the crew include the following (Transport for NSW, 2015; Reliance Rail, 2015):

Technological initiatives for improved comfort

- Smart air-conditioning that can adjust temperatures depending on passenger load and opening and closing of doors at stations.
- Use of durable woollen moquette fabric that provided greater comfort and is also vandal resistant.
- Electronic screens in all carriages to provide information and update passengers on train stopping patterns and arrival at stations.
- Use of LED lighting that saves energy while providing improved lighting.

Table 12.1. Key Technical Specifications

Item	Description
Passenger capacity	896 seats including 16 wheelchair spaces (eight-car set)
Train width	3,035 mm
Ceiling height	2,100 mm end saloons; 1,920 mm upper and lower saloons
Maximum speed (acceleration and deceleration)	130 kph (1 m/sec^2)
Traction system/motor	Two converters per motor car utilising spread spectrum modulation (four AC motors per car supplied by Hitachi, Japan)
Brake system	Regenerative brake with blended electro-pneumatic wheel mounted disc brakes (supplied by Knorr Bremse, Germany)
Heating, ventilation, and air-conditioning (HVAC) system	Two independent cooling units per car 38 kW cooling, 24 kW heat (supplied by Sigma Coach Air Group, Australia)
Body material	Stainless steel

Source: Extracted from Reliance Rail, Transport for NSW.

Layout for improved accessibility

- Provision of additional handrails, more priority seats, and more wheelchair spaces (16 per eight-carriage train) to facilitate greater disability access.
- Facilitating faster boarding and alighting by having wider entrance areas in the train vestibule so that waiting time at stations can be reduced to enable on-time arrivals and departures.

Safety and security

- Provision of additional passenger emergency help points on the train with direct communication access to the guard
- Provision of internal closed-circuit TV monitoring all areas of the train carriage
- Strengthened carriage design and use of fire resistant materials
- Advanced fire-detection technology
- Use of a walk-through carriage configuration to enable passengers to move away to another carriage in case of an adverse incident in their carriage. This walk-through design permits passengers to walk through the entire train if needed so that faster evacuation is possible.

5.4. Circular Economy-Based Innovations in the Reliance Rail Project

As evident from the earlier discussion on the rationale for PPPs, governments enter into a PPP contract based on the tacit assumption that the private sector is capable of providing the service more efficiently than a public sector entity. Innovations in design and operations can lead to greater efficiency. However, based on studies of PPPs, it is pointed out by Rangel and Galende (2010) that innovation is not an intrinsic characteristic of PPP projects although it is an important feature to have. The focus of the public sector client is on KPIs and the private sector partners are free to innovate in the design, construction, technical, and commercial elements provided they are within the context of the performance requirements (KPIs) specified by the contract. However, while KPIs tend to focus heavily on aspects such as time, operations, delivery, safety, and security, they are not explicitly linked to circular economy principles. A review of the contract documents (Transport for NSW, 2015) shows that this is the case for the Waratah Train PPP.

It is of interest that Waratah trains have incorporated several innovations relevant to the promotion of a circular economy. These are described briefly below. The information has been obtained through interviews with Mr Brad Johnson (2015), Mr P. Jaishankar (2015), and information from Reliance Rail (2015) and Transport for NSW (2015).

a) Mass reduction and reusable materials

Reducing the mass (weight) of the train without compromising safety and critical performance parameters can lead to substantial reductions in the use of energy and simplification in the design of other components of the train. The contract included substantial abatement of revenue to Reliance Rail, and ultimately to the DEDIR–Hitachi joint venture, for exceeding the agreed maximum train mass (Johnson, 2015). During the design stage, Reliance Rail explicitly looked for safe and secure opportunities for weight reduction. For instance, while the body of the train was made of stainless steel for reasons of safety and maintenance, the thickness of the exterior stainless steel was optimised to a thinner panel than on equivalent trains. Many of the panels of the interior were also made of aluminium rather than GRP that provides lightness, durability, and ease of maintenance. Furthermore, the axles of the train were of a hollow design to achieve substantial reduction in weight without compromising safety or performance. Thus, the train was engineered to use less material and the key materials used, while intended to last for the life of the train, are all recyclable.

b) Energy consumption

The traction system of a train consumes the greatest amount of energy. The Waratah train fleet uses a regenerative (energy recovery) braking system that has the ability to recover energy even at single-digit slow speeds. These considerations were incorporated explicitly into the design and involved the use of advanced simulation systems to study traction and braking patterns across the train network before finalising the design parameters. The traction system was designed and manufactured by Hitachi of Japan (see Figure 12.1).

The second largest, and almost equivalent to the traction system, area of energy consumption is climate control (heating, ventilation, and air-conditioning) (Johnson, 2015). The Waratah fleet incorporates a three-stage control system that can adjust the load on the HVAC system depending on the number of passengers in the car, opening and closing of doors, and temperature optimisation across zones in the car. The design of the climate control system was done in partnership with Sigma Coach Air Group in Australia.

The third largest area of energy consumption is the lighting system on the train. The Waratah train fleet uses energy-efficient LED lighting (except for headlights) for all internal saloon and cab lights. It is interesting to note that while the initial specifications in the contract did not specify the use of LED lights, Reliance Rail proactively promoted this to save energy and costs of operations as a trade-off against other areas of increased mass and thereby reduce any revenue abatement associated with exceeding the agreed maximum train mass (Johnson, 2015). Thus, the Waratah fleet has the distinction of being the first in the world to use 100-percent LED lighting. All these energy-saving measures while promoting the adoption of circular economy principles also contribute to costs savings especially by reducing power demand and by reducing peak load demand.

c) Improved train allocation and maintenance

The timely arrival of a train and avoidance of breakdowns are all resource saving and lead to conservation of resources (especially energy) and their efficient usage. The Waratah fleet uses a fleet allocation recording system that uses information received from planning, asset management, timetabling, and train tracking systems and delivers information in real time on train movements, allocations, and maintenance alerts thereby enabling better fleet allocation and enabling fleet planning up to a fortnight in advance. This system was designed by Quintiq.

Reliance Rail also explicitly incorporated maintenance aspects at the design stage (design for maintainability) to ensure that the maintenance footprint is as low as possible. Wheels, brakes, and doors are the main areas for regular maintenance while other components and parts are replaced on a predetermined schedule during planned routine and preventive maintenance checks. Maintenance alerts are transmitted to the Auburn Maintenance Centre by the diagnostic software integrated with the various major components of the train such as the traction, braking, HVAC, and doors sub-systems. DEDIR established the specifications for the communications protocols to be used by all sub-systems suppliers in providing fault data in the design stage to enable the integration of the diagnostic software of the major components to be interrogated by the maintenance management information system established at the Auburn Maintenance Centre (Johnson, 2015).

The proprietary intelligent scheduled maintenance system used by EDI Rail PPP Maintenance Pty Ltd was developed by DEDIR during the design phase (Johnson, 2015). This system has the capacity to program and schedule maintenance services to maximise fleet reliability. The performance data generated by the diagnostic software in the trains are analysed to assess any corrective maintenance that may be needed before a train returns to the Auburn Maintenance Centre. The centre also has state-of-the-art equipment such as an advanced wheel conditioning monitoring system that can monitor and assess the wheels of the train from safety and operational performance perspectives as it enters the wash plant for exterior cleaning. To minimise the time for exterior cleaning, the wash plant has been designed to simultaneously wash the sides and ends of the train.

Thales was responsible for designing the train's extensive system of 98 CCTV cameras, digital video recorders, guard video display units, passenger information displays, emergency intercoms, audio servers, and PA systems and hearing loops, all of which are linked together with power over Ethernet. The various sub-system suppliers were responsible for implementing the agreed software communications protocols within their equipment to enable seamless transmission of maintenance data and fault alarms to the Auburn Maintenance Centre. These information technology-based measures to improve allocation and maintenance have long-term implications not just from operational and revenue perspective but also from an environmental perspective. Improved scheduling and maintenance reduce energy usage and thereby contribute towards environmental protection by generating a lower carbon footprint per passenger-km.

d) Use of long-lasting, ease-of-maintenance, and low smoke-toxicity materials

The flooring of the Waratah fleet uses a polymer-based material (Treadmaster TM8) which is durable and resistant to vandalism and graffiti. Woollen moquette fabric is used to cover the seats of the train. This, too, has been chosen for durability and vandal/graffiti-resistant properties. These materials had to go through many tests to ensure that while they are individually highly fire resistant, with low smoke-toxicity output, they have the same attributes when used in conjunction with adhesives used to affix them to the floor and seats. The seats were designed by DEDIR (for which DEDIR owns the intellectual property rights) to ensure safety in case of a crash by incorporating an inertia-locking mechanism into the roll-over seat. The design of the interior, seats, doors, etc. incorporated the safety measures recommended by the Justice McInerney's Report into the Waterfall rail accident[2].

[2] The Waterfall rail accident occurred on 31 January 2003 near Waterfall, NSW, Australia, where the train derailed as a result of travelling at a speed in excess of 117 km/h as it approached a curve where

5.5. Commissioning the Waratah Fleet

The global financial crisis in 2008 slowed down the project's progress. The target dates for the introduction of the first train were set for late 2010. Due to a series of delays, this did not eventuate and the first train was delivered to the operator towards the end of April 2011. RailCorp, as the operator, did not accept the train due to several concerns. Henderson (2011) lists the quality and occupational, health, and safety issues for the rejection of the train as follows:

- Windscreens that turn milky when sunlight strikes them at certain angles
- No padding at the ceiling-mounted guide rope pulleys for the passenger emergency ramp at either end of the train
- Cable shrouding that partly obscures the peripheral vision of the driver
- Train-monitoring computer screen glare and reflection
- Poor quality stainless steel welding seen in the indents of some areas of the carriage exterior
- Gaps in the plastic moulding
- Hand rails not lining up with the stairs
- Software issues.

These issues were traced both to China and Cardiff and after these problems were rectified, the first train set was allowed to commence its run in July 2011 under carefully controlled conditions. In October 2011, this set was allowed to operate during peak hours. More Waratah train sets were then rolled out progressively and in June 2014, the final set was delivered.

On 2 February 2014, the Community of Metros (2014) stated:

> In just over 14 months, 14 eight-car double deck trains (which include 1 spare set) have been introduced into passenger service and accumulated more than a million kilometres in service. Feedback and internal surveys indicate customers rate the Waratah train as the best train for performance and comfort amongst all existing fleet, including other recent fleet acquisitions. Similarly feedback from crew about the Waratah trains has been positive with train performance in line with expectations.

5.6. Challenges Faced in Delivering the PPP Project and the Scope for Incorporating Circular Economy Principles

The Waratah PPP project had its share of difficulties during implementation. Redesign and rework to meet the technical requirements of the public sector partner was one area which caused delays in the implementation. Issues with some suppliers in terms of meeting contract

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the safe speed was 60 km/h. The driver of the train had apparently lost consciousness due to heart attack. Seven people aboard, including the train driver, died. The inquiry identified several shortcomings – systemic, technical, design, staff training, etc. The Waratah PPP has incorporated all the recommended measures to promote safety.

specifications also led to delays. Sending DEDIR experts to the various sub-system suppliers helped to expedite some of the work and expeditiously resolve difficulties. With the benefit of hindsight, it was felt that some of these problems and delays could have been minimised or avoided. However, a major challenge is how to explicitly introduce circular economy principles within a PPP framework. A discussion with Johnson (2015), who was extensively involved in this project, brought out some insights that are not commonly found in the literature.

Firstly, the term 'mutual benefit' itself, in respect of partnerships in PPPs, could be open to debate. What is beneficial for one entity (say the private sector) may not necessarily be seen as beneficial by the other entity (the public sector) and vice-versa. This mismatch could come about due to differences in objectives and the different planning horizons of the two entities. For instance, the private partner may want more time to undertake focused efforts to work with its supply chain partners to explicitly introduce circular economy principles and introduce innovations in design and manufacture. However, this may not be acceptable to the public sector partner who may be under pressure to ensure quick delivery due to political compulsions.

Secondly, the priority for private sector investors in the SPV is return on investment and generating a steady revenue stream as quickly as possible. Johnson (2015) refers to this as 'a hard-dollar approach.' The preference is, therefore, for the use of tested and proven approaches in terms of design, manufacture, and maintenance so that the risk of compromising financial returns is minimised. The adoption of circular economy principles, as of now, is still not widespread and thus their incorporation requires innovation across the supply chain. This is seen as inherently risky. Thus, no overt support is extended by the investors for incorporating circular economy principles unless it can be clearly demonstrated that it can lead to cost reduction and enhanced revenue streams or it is specified at the outset as contract deliverables and any perceived risk profile is appropriately priced by the debt and equity investors in the SPV (Johnson, 2015).

In the case of the Waratah PPP project, the SPV created two main entities to implement the project: the delivery structure and the maintenance structure. The delivery structure team was responsible for the design, manufacture, and final delivery of the 78 sets to RailCorp (Sydney Trains). The maintenance structure team is responsible for providing life-cycle maintenance and support to the fleet through the Auburn Maintenance Centre. While both entities operated as core contractors to the SPV, misalignment of the overall objectives of the two entities led to difficulties. The performance assessment of the delivery structure team was based on timely delivery and on keeping design and manufacturing costs as low as possible. This led to differences of opinion with the maintenance structure team who wanted the design and manufacturing to be such that operating costs would be as low as possible since they would be assessed on how much surplus they generate during the provision of life-time support. For instance, wheels, brakes, and doors are the main areas for regular maintenance and thus the maintenance structure team exerted pressure on the delivery structure team to design and manufacture these sub-systems so that life-time support costs would be low. In some instances, this led to increases in design and manufacturing costs thereby creating anxiety within the delivery structure team with respect to their performance assessment. While the creation of two such entities by the SPV for the implementation of the project would seem rational in terms of meeting project objectives, unless performance assessment of the managers and staff of the staff are based on a life-time and holistic view, such internal conflicts can delay and disrupt project delivery.

Fourthly, a project of this magnitude would inevitably involve many suppliers. While the delivery structure of the project could incorporate circular economy principles in the designs developed by DEDIR, it would be difficult to ensure this when its suppliers are responsible for designing and manufacturing specific modules and systems at which they are regarded as the most capable. It would, of course, be advantageous if these suppliers are already incorporating circular economy principles in their design or that these principles were incorporated into the subcontract requirements. Today, many leading engineering and manufacturing firms in the world have adopted 'green approaches' such as waste reduction (through lean approaches), the 3R (reduce–reuse–recycle), design for manufacturability, design for maintenance, reverse logistics, etc. However, it is not evident whether all of them explicitly incorporate circular economy principles although the adoption of green approaches could be regarded as an early stage of incorporating circular economy principles. Thus, in a PPP project such as the Waratah project, unless compliance with circular economy principles is regarded as an essential criterion for supplier selection, it would be difficult to align it with circular economy principles.

Lastly, while the term 'PPP' is used quite extensively, the term 'partnership' itself is quite ambiguous. One would expect the term to refer to a collaborative and cooperative approach. However, Johnson (2015) refers to it as a master–servant relationship where the public sector partner derives tremendous power due to government backing and uses this to demand and obtain what they see as important and reasonable outcome whether explicitly specified or not. The public sector entity places great emphasis on contract compliance and timely completion and becomes wary if innovative approaches are proposed. While it appreciates the value that can result due to successful innovations, it also sees innovation as inherently risky which can lead to delays in delivery. There is thus a tendency to reject suggestions that it does not regard as tested and proven. Since the use of circular economy principles is of recent origin, the private sector partner may lack the leverage to convince the public sector partner of the need to be given an opportunity to be innovative through the adoption of these principles.

6. Discussion

The paper is based on the premise that an economic system that is regenerative by design and is based on circular economy principles that conserve and restore materials and energy and protects environmental health is a pragmatic way forward in today's complex global setting. There is evidence that individual firms across the world, especially in more advanced economies, have already adopted ‘green approaches’ to accelerate the move towards a circular economy.

Over the past 2 decades, the use of PPPs to implement economic infrastructure and social infrastructure projects has increased quite dramatically across the world and many claims are made as to the inherent benefits of PPPs. Common benefits as discussed earlier include lower project costs, faster delivery, development of innovative solutions by the private sector, and higher quality of the delivered end product. The main objective of this paper was to carry out a preliminary examination of whether PPPs have the potential to incorporate circular economy principles into the project structure.

A preliminary study of the literature suggests that, in Australia, applying circular economy principles seems to be an exception rather than the norm with the focus being on cost, time, and delivery. This emphasis could act as a barrier for developing innovative solutions based on circular economy principles. A further barrier is that if variations to the contract are proposed after financial close, there could be substantial cost and time implications due to renegotiating the myriad of agreements required to support the PPP framework. To explore this issue in more detail, the Waratah Train PPP project in NSW, Australia, was examined as a case study. The case study is described in detail in section 5 of this paper. Some useful insights based on both published literature and the Waratah PPP case study, discussed in section 5, are summarised below.

Contributions towards a circular economy

The Waratah PPP, through the initiatives of the private sector partner in seeking to minimise whole-of-life costs, has taken measures to control the use of materials, reduce energy consumption, and protect the environment. These are explained in more detail in section 5.4. The major contributions are:

- Mass reduction and the use of reusable materials in the design and manufacture of the train sets
- Explicit incorporation of energy-saving designs and innovations to reduce the energy consumed in traction (through the use of a regenerative braking system); heating, ventilation, and air-conditioning (through the use of a three-stage control system); and lighting (through the use of LED lighting)
- Improved train allocation and maintenance through the use of information technology-based interventions (FARS, sub-system diagnostic software, intelligent scheduled maintenance system), an innovative advanced wheel conditioning monitoring system
- Use of long-lasting, easily maintained, and low smoke-toxicity materials.

Challenges faced in explicitly incorporating innovations based on circular economy principles

- A mismatch in the objectives of the public sector client and private sector partners due to differences in objectives and the different planning horizons of the two entities can act as a barrier. Suggestions made by the private sector partner to introduce circular economy principles–based innovations in the design and manufacture may not be acceptable to the public sector partner who may fear that 'uncertain' outcomes due to such innovative work may jeopardise compliance, delivery, and cost targets. The power asymmetry between the public sector client and the private sector partner, with the government-backed public sector partner having more leverage, aggravates the situation unless circular economy principles are incorporated into the initial fabric of the procurement for the project by the public sector.

- The private sector investors in the SPV whose priority is a good return on investment and the generation of a steady revenue stream may adopt a 'hard-dollar approach' and may not extend overt support for design and manufacturing innovations unless it can be clearly demonstrated that it can lead to cost reduction and enhanced revenue streams or is a matter of absolute contract compliance.

- Conflicting objectives and non-alignment within the entities of the SPV can also act a barrier to the introduction of circular economy principle-based innovations. In the case of the Waratah PPP project, the delivery structure and the maintenance structure within the SPV had conflicting objectives due to performance assessment approaches that were based more on short-term measures in case of the delivery structure and on life-time and holistic view perspectives in the case of the maintenance structure.

- The involvement of multiple suppliers of components and systems and the use of manufacturing subcontractors can make it difficult to incorporate circular economy principle-based innovations unless many of them incorporate circular economy principles in their own organisations. Thus, in a PPP project such as the Waratah project, unless the use of circular economy principles is regarded as an essential criterion for supplier selection and compliance, it would be difficult to align it with circular economy principles.

Thus, the question of whether circular economy principles can be incorporated into a PPP needs to be linked with the scope that exists for innovation within a PPP framework. Rangel and Galende (2010) and Leringer (2006) examined this aspect in their study of economic infrastructure PPPs. Two aspects based on their studies are relevant. These are design freedom (Leringer, 2006) and penalties and bonuses (Rangel and Galende, 2010).

Design freedom (Leringer, 2006)

One of the arguments used to justify PPPs is that while the public sector client may specify requirements through outputs specifications and service-level agreements, the private sector partner has the freedom to interpret the technical specifications without being guided and impeded by past practices, standards, and norms, thereby facilitating the development of innovative approaches to deliver the project. If this is the case, then the private sector partner could have the 'design freedom' to incorporate circular economy principles in the design and delivery of the project.

However, Leringer (2006) and Johnson (2015) point out that, in general, confusion arises because the private sector partner may assume a degree of freedom that may not be seen as acceptable by the public sector partner and other regulatory bodies. The major issue here is that the output delivered through a PPP has to match the public sector expectations which may not have been comprehensively specified and also converge with other related existing infrastructure of the public sector client, and has to be approved by national regulating bodies. Thus, even though design freedom is spoken of as an advantage of a PPP, in reality, the uncertainty that can arise as a result of exercising design freedom acts as a deterrent to the private sector partner to engage in innovation.

Penalties and bonuses (Rangel and Galende, 2010)

Penalties and bonuses in a PPP are linked to the private sector partner meeting specified performance and quality requirements. A high level of delivery, in accordance with the established KPIs, leads to improvements which can be transferred to users and some of the benefits can be shared with the private sector partner as a bonus. On the other hand, failure to fulfil specified performance and quality requirements can lead to penalties and even cancellation of the contract.

Rangel and Galende (2010) state that to avoid penalties and take advantage of bonuses, a private sector partner is likely to engage in some research and development (R&D) to ensure that they are able to meet the specified performance and quality requirements. The innovations generated through such R&D are likely to be incremental and not radical (major) since the latter could, in the case of failure, lead to the non-achievement of expected outcomes thereby attracting a penalty.

Johnson (2015) also states that the private sector is often ill-equipped or under-prepared to deal with commercial implications that may arise in these large and complex PPP transactions where relatively small margins are achieved through competitive process but the risks of failure to perform adequately are heavily penalised.

The Waratah case illustrates fairly well the behaviour of the private sector partner in the context of design freedom and penalties and bonuses. The design freedom aspect presented by Leringer (2006) provides a possible explanation as to why the adoption of circular economy principles in the design and manufacture was restrictive. Many of the innovations introduced in the Waratah PPP project were either based on well-understood and known technologies or were incremental in nature. Radical innovations that incorporate circular economy principles were not evident. This is supported by the explanation of Rangel and Galende (2010) in the context of penalties and bonuses.

It may, therefore, not be incorrect to state that at the current stage of practice with respect to PPPs, incorporating circular economy principles into the project framework while desirable will not be easy because of the various challenges that have been elaborated in this paper. Unless circular economy principles are specified at the request-for-bid stage and included explicitly in the KPIs, it may be difficult to get the private sector partners to engage in circular thinking and propose innovative solutions.

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