

# The Circular Economy and the Water-Energy-Food Nexus

NFG Policy Paper No. 7/2015 Robert Brears



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# The Circular Economy and the Water-Energy-Food Nexus

Robert Brears

*The NFG Policy Papers 7, 8, 9 represent a mini series of papers which constitute a pilot study that aims to bring in an interdisciplinary perspective to the NFG's political science research, by drawing on other disciplines such as geology. These papers look at the EU as a source of models and templates in non-traditional security for the Asia Pacific region, and focus primarily on urban water management and water security. This series will only be published online.*

## Executive Summary

The global economy is based on a take-make-consume model where natural resources are turned into products and the waste disposed of instead of being reused as a resource. In the Asia-Pacific region climate change along with rapid population and economic growth is resulting in resource scarcity potentially leading to economic and political instability. Europe has developed policy and technological innovations that can facilitate the transition towards a circular economy where waste becomes a resource. By using existing instruments Europe can transfer its circular economy knowledge and technology to the Asia-Pacific region. This can help ensure global security, influence climate change negotiations and create jobs in Europe.

## Policy Recommendations

- The EU needs to create a European Green Bank to provide financial assistance to European small and medium-sized enterprises (SME's) developing circular economy technologies, with additional assistance provided for exporting to strategic markets in the Asia-Pacific region. In addition to providing capital, assistance could come in the form of business support, coaching and market intelligence. Increasing exports in circular economy technologies will increase jobs and GDP growth in the EU and enhance Europe's overall economic competitiveness.
- The EU must initiate Green Trade Delegations to key strategic partners in the Asia-Pacific region to showcase EU-wide circular economies, technologies and practices. Delegations to places such as China, Japan, Korea and Singapore could be used to not only increase exports of circular economy technologies. They could also be used to establish public-private partnerships in circular economy research and development, with the possibility of accessing Horizon 2020 funding. This would contribute to the wider goal of fighting global climate change and environmental challenges.
- The EU needs to provide development assistance for achieving a circular economy in the Asia-Pacific region to fight common challenges such as climate change and environmental degradation. Development assistance can come in the form of education of target countries' tertiary students in circular technologies, exchanges of scientists from the Asia-Pacific region to European research institutions and capacity-building of government officials and policy-makers on developing circular economy frameworks.
- The EU needs to provide a dedicated, stand-alone research fund for universities in Europe to develop curriculum as well as conduct research in circular economy technology and practices. In particular, for the circular economy to become mainstream, economic, social and technological barriers need to be overcome. A research fund can support multidisciplinary research for economic analyses, consumer behaviour studies and research on technology that facilitates the transition towards a circular economy.

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## TABLE OF CONTENTS

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Executive Summary	3
1. Introduction	5
2. Water-energy-food nexus pressures in Asia-Pacific	6
3. Why should the EU help reduce nexus pressures?	6
4. Europe's transition towards the circular economy	7
5. Europe, the circular economy and water-energy nexus pressures	9
6. Europe, the circular economy and water-food nexus pressures	10
7. Reducing water-energy food nexus pressures in EU Member States	10
8. Tools to transfer circular economy instruments	12
9. Conclusions	13
Bibliography	15

# The Circular Economy and the Water-Energy-Food Nexus

Robert Brears

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## 1. Introduction

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Since the industrial revolution the total amount of waste has constantly grown as economic growth has been based on a 'take-make-consume and dispose' model. This linear model assumes that resources are abundant, available and cheap to dispose of. In Europe there is a move towards a 'circular economy' where waste materials and products are reused, repaired, refurbished and recycled. In the circular economy what was once regarded as waste can be turned into a resource, which in turn reduces greenhouse gas emissions.

The Asia-Pacific region has seen rapid population and economic growth leading to increased demand for scarce resources. At the same time, climate change has impacted on the availability of water, in turn affecting the production of energy and food resources. A move towards a circular economy is therefore critical for ensuring economic and social stability in a region that is vital to the world. As such, it is only through closer ties and coordination with partners in the Asia-Pacific region that the EU can address major global issues including climate change and resource scarcity. The EU would also gain through job creation and increased economic productivity from producing innovations to further develop the circular economy.

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## 2. Water-energy-food nexus pressures in Asia-Pacific

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Water and energy are linked in two ways. First, water is used in the production of almost every type of energy (coal, geothermal, hydro, oil and gas, nuclear). Second, energy is a dominant cost factor in providing water and wastewater services. In Asia, increasing access to energy is a priority as around 700 million people lack access to electricity and 1.9 billion rely on biomass (e.g. wood) for heating and cooking (UNDP 2013). Despite creating alternative energy sources, over 80 % of the expected increase in energy use to 2035 will come from fossil fuels, particularly coal which in addition to being water-intensive will lead to global warming, further exacerbating water scarcity (ADB 2013). One of the most challenging aspects of the water-energy nexus is that low-carbon growth targets for energy generation place stress on water availability. Among the renewable energy sources available, hydropower is likely to become the dominant source of low-carbon energy. However, not only does hydropower consume water through evaporation from open surfaces of reservoirs, but it also impacts availability of water for downstream users such as agriculture, fisheries, industry and municipalities.

Water for food production accounts for around 70 % of water withdrawals. However, increases in population growth, urbanization and economic growth, along with changes in diet as prosperity increases, mean demand for food will increase significantly. For instance, a change in lifestyle and diets in Asia will increase demand for water-intensive products such as meat and dairy products (FAO 2013). Globally, demand for phosphate as a fertilizer nutrient will rise from 43.8 million tonnes per annum in 2015 to 52.9 million tonnes in 2030 (European Commission 2013). Currently, Asia accounts for almost 60 % of the world's total nutrient use, with China and India consuming around 55 % and 29 % of Asia's total consumption of fertilizer. Over the next five years, Asia's consumption of fertilizer will increase by around 6 % due to changing and interconnected trends including economic and population growth and increased demand for food (PR News Wire 2014).

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## 3. Why should the EU help reduce nexus pressures?

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Addressing environmental degradation, climate change, energy efficiency and water management are key priorities for the EU in the Asia-Pacific region for the following reasons:

### **Global security:**

Increased demand for water, energy and food accompanied by the impact of climate change will affect the supply of natural resources. There is likely to be competition and even conflict over scarce water supplies and resources for energy. This will spur the search for new resources and the use of existing resources sustainably

and efficiently through new technologies. These challenges provide unprecedented opportunities for the EU to offer its policy-making and technological expertise in ways that can underpin global security and prosperity in a sustainable manner.

**Job creation:**

At the aggregate EU-wide level, resource productivity in the EU grew by 20 % between 2000 and 2011. While some of the increase in efficiency was due to the effects of the recession, if this rate was maintained it would lead to a further 30 % increase in efficiency by 2030 and boost GDP by nearly 1 percent, resulting in an additional 2 million jobs (European Commission, 2014). In addition, if European companies implement waste prevention, eco-design, reuse and other similar measures it could bring net savings of EUR 600 billion while reducing annual greenhouse gas emissions by 2-4 % (European Commission 2014). At the same time, the global market for eco-innovation, which is currently worth around EUR 1 trillion per annum is expected to triple by 2030 (European Commission 2015). As such, eco-innovation represents a major opportunity to boost competitiveness and create jobs in European economies (European Commission 2014).

**Influence in climate change negotiations:**

The EU has set itself the aim of negotiating and implementing a global climate change deal in 2015. To deliver on this, the EU will need to develop cooperation between key countries by encouraging them to commit to a sustainable low-carbon development path. This will include helping them manage their rapid urbanization in a low-carbon, climate resilient and sustainable manner. In addition, if greenhouse gas emissions are to be maintained at a low level that avoids catastrophic climate change, the EU will have to forge alliances with major emitters in areas including long-term business cooperation on low-carbon solutions.

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## 4. Europe's transition towards the circular economy

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In 2014 the European Commission adopted the Communication Paper 'Towards a circular economy: A zero waste programme for Europe' in order to establish a common and coherent EU framework for promoting the circular economy. Transitioning towards the circular economy involves: increasing recycling and preventing the loss of valuable materials, showing how new business models, eco-designs and industrial symbiosis can achieve zero-waste, reduce greenhouse gas emissions while also creating jobs and economic growth (European Commission (2014)). To achieve the circular economy the Communication paper proposes:

**Setting up an enabling policy framework:**

The European Commission proposes to establish a common and coherent EU framework to promote the circular economy. In particular, the Commission views markets as an important driving force in achieving a circular economy with materials and energy being the principal costs for many companies. However, there are many market barriers to the efficient management of resources. For example,

waste prevention, eco-design, and reuse could save nearly 8% of annual turnover for European businesses, while reducing significantly greenhouse gas emissions (European Commission 2014). For this to happen, market barriers that prevent these opportunities from being developed need to be removed. Existing infrastructure, business models and technology all become 'locked-in' to the linear model of 'take-make-consume and dispose'. Companies may lack information, confidence, or capacity to implement circular economy solutions. The financial system is also a barrier. Circular economy companies can fail to raise capital for innovative solutions that increase efficiency or innovative business models that promote circular economy solutions, because they are perceived as being more risky, and so deter traditional investors. Finally, consumer habits may lock-in linear models hindering the development of new circular economy products and services. This happens when prices do not reflect the real costs of resource use to society, and policy does not provide a strong enough signal for the transition towards a circular economy. Utilising evidence of successful products, materials and value chains, the European Commission plans to work with stakeholders to develop an enabling framework that uses smart regulations, market-based instruments, research and innovations, incentives, information exchange and support for voluntary approaches. To implement the circular economy and achieve a 'sustainable industrial renaissance' in Europe, the EU will rely on proactive businesses and consumers with a special focus on small and medium-sized enterprises (SMEs) implementing circular economy solutions.

#### **Designing and innovating for a circular economy:**

In circular economy innovations, the goal is to design out waste throughout the value chain, rather than relying on solutions at the end of a product's life. This can be achieved through activities that include: reducing the quantity of materials required to deliver a particular service (also known as lightweighting); reducing the use of energy in production and use phases (efficiency); reducing the use of materials that are hazardous or difficult to recycle in products and production processes (substitution); creating a market for secondary raw materials (also known as recyclates); designing products that are easier to recycle (eco-design); developing the necessary services for consumers (infrastructure); incentivizing and supporting waste reduction and high-quality separation by consumers (incentives); and facilitating the clustering of activities to prevent by-products from becoming waste (industrial symbiosis) (European Commission 2014).

#### **Unlocking investment in circular economy solutions and harnessing the action of businesses by supporting SMEs:**

As businesses are the key actors in a transition towards the circular economy, upstream and downstream decisions need to be better connected, with clear incentives between producers, investors, distributors, consumers and recyclers. In addition to using market mechanisms to ensure the efficient allocation of resources, a functioning secondary materials market needs to be developed. More attention also needs to be paid to enabling entrepreneurs to tap into potential new markets linked to the circular economy. The Commission's Communication Paper itself recommends the EU should encourage investment in circular economy innovations and address barriers to mobilizing more private financing for resource efficiency.

**Modernising waste policy and targets by turning waste into a resource:**

Turning waste into a resource is part of ‘closing the loop’ in the circular economy. Objectives and targets set in European legislation are crucial drivers in improved waste management as they stimulate innovation in recycling and reuse, limit landfilling, reduce losses of resources, and create incentives for behavioural change. The EU has a political commitment to reduce waste generation, to recycle waste into a major, reliable source of raw materials, to recover energy only from non-recyclable materials and eliminate landfilling. The benefit of reducing waste is growth and job creation at relatively no cost, while also enhancing the environment. To boost the economic, social and environmental benefits gained from better management of municipal waste, the Commission proposes to increase reuse and recycling of municipal waste to a minimum of 70% by 2030, ban the landfilling of recyclable waste and biodegradable waste by 2025, and promote the development of markets for high quality secondary raw materials.

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## 5. Europe, the circular economy and water-energy nexus pressures

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Transitioning towards the circular economy is at the core of the resource efficiency agenda established under the Europe 2020 Strategy for smart, sustainable and inclusive growth. As part of Europe 2020, a ‘Flagship Initiative for achieving a resource-efficient Europe’ has been set out that aims to create a framework for policies that support Europe’s transition towards a resource-efficient and low-carbon economy where resource efficiency minimises the amount of waste produced in a circular economy. To achieve these goals, the ‘Flagship Initiative’ calls for a 20-20-20 target to be reached by 2020: a 20% reduction in EU greenhouse gas levels compared to 1990 levels, reducing energy usage by 20%, and a 20% increase in renewable energy (European Commission 2011). To achieve these goals the EU aims to manage waste as a resource in order to: increase recycling rates to reduce pressure on demand for primary raw materials; help reuse valuable materials that would have been wasted; reduce energy consumption and greenhouse gas emissions from extraction and processing which will in turn boost the EU’s competitiveness; ensure security of supply of essential resources; fight climate change; and limit the overall environmental impacts of resource use.

A crucial area for improved resource efficiency is water, it being an essential component of the agriculture, industry and energy sectors. Reduced water availability would impact on economic output and energy production. Despite this, 20-40% of Europe’s water is wasted. Water efficiency could be improved by 40% through technological innovations. This would help ensure water resources are used sustainably and the energy footprint of water-using activities kept low (European Commission 2011).

In the Asia-Pacific region, China, Japan and Korea in particular are starting to implement resource efficiency policies. EU experiences in the ‘Flagship Initiative’ can influence these countries, as well as others in the region transitioning towards

a circular economy, for the purpose of enhancing the world's green economy, reducing global greenhouse gas emissions, and achieving global security of scarce resources, including water.

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## 6. Europe, the circular economy and water-food nexus pressures

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'Towards a circular economy: A zero waste programme for Europe' and the 2011 'Roadmap to a Resource Efficient Europe' identified the sustainable supply of phosphorous as an important factor affecting sustainability and long-term global food security. The mineral is an essential building block of life and is an irreplaceable part of modern agricultural production in its use as an animal feed and fertilizer. Despite phosphorous resources being abundant globally, there are three issues affecting the availability of supply, both in the EU and globally. First, there are only small reserves of phosphate-bearing rocks in the EU, with only Finland being a small producer. It is estimated that 90% of the world's phosphorous reserves are located in just five countries: China, Morocco, South Africa, Jordan and the United States. This has led to the EU importing 92% of its phosphorous. Second, there has been price volatility – in 2008 prices of phosphorous rose by 700% in just over a year resulting in increased fertiliser and food prices. Third, there is little possibility of reducing non-essential use of phosphorous as its essential use in animal feed and fertilizer already consumes around 90% of the total mined resource (European Commission 2013). Improving the use of recycled phosphorous in the EU and globally would therefore help safeguard the supply of this critical raw material.

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## 7. Reducing water-energy food nexus pressures in EU Member States

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In the EU, the Netherlands and the UK are examples of leading countries that have adopted both circular economy principles and implemented showcase circular economy technologies that reduce water-energy and water-food nexus pressures.

In the Netherlands, the existence of a large recycling infrastructure, an active market for repairs, and a popular second-hand market show the country is capable of moving towards a circular economy. Increasingly, businesses in various industrial supply chains are cooperating in order to generate industrial symbiosis, for example re-using waste, energy, water and material streams in an economically responsible way. It is estimated that currently the Netherlands recycles 78% of its waste, incinerates 19% and dumps only 3% (TNO 2013). To increase further the circularity of the Dutch economy, particularly in technical fields, means advocating more maintenance and repair work, intensive re-use, and increased recycling. With regard to value creation

in waste streams, the Netherlands has the advantage of being a densely populated country enabling the symbiosis of industrial processes where waste can be directly reused in the production of other goods and services (TNO 2013).

A good example of reducing water-energy nexus pressures in the circular economy can be seen in Amsterdam's main wastewater treatment plant, which creates energy from sewage sludge, reducing the need for water in electricity production. In particular, the city's main wastewater treatment plant 'Amsterdam West', operated by Waternet, is located beside a waste-to-energy plant operated by the AEB Waste to Energy Company. The close proximity enables an exchange of energy flows between the two plants with large environmental benefits: Amsterdam West produces 25,000 m<sup>3</sup>/day of biogas and 100,000 tonnes of sewage sludge per year for burning at the waste-to-energy plant. The energy produced in the waste-to-energy plant is then used to power the Amsterdam West treatment plant. In total, the integration of the two plants produces 20,000MWh/year of electricity and 50,000 GJ/year of heat, saving 1.8 million m<sup>3</sup>/year of natural gas, resulting in avoided greenhouse gas emission of 3,200 tonnes per year (J.P. van der Hoek, A. Struke and J.E.M. de Danschutter 2013). The important lessons from this example that can be exported to the Asia-Pacific region, is that industrial processes can be connected (industrial symbiosis) to prevent industrial by-products from becoming waste, which in turn reduces the quantity of water and energy required in treating wastewater, reducing water-energy pressures. This technology can be exported to Asia-Pacific through providing technological and engineering assistance that aims to mainstream, particularly in cities, waste reduction and high-quality separation of waste for secondary use.

In the UK, the House of Common's Environmental Audit Committee's 2014 report, 'Growing a circular economy: Ending a throwaway society' stated that in 2012-13 household recycling rates had reached 43 % in England, up from 12 % in 2000-01. It is estimated that in 2010 the UK economy was 22 % 'circular', up from 8 % in 2000. Developments in circular economy technologies could mean that by 2030 the UK economy's circularity increases to 27 %, leading to a reduction in material consumption of 30 million tonnes a year (House of Commons 2014). Waste policy and regulation in England is informed by a 'Waste Hierarchy' where the top priority is waste prevention. This is followed by preparing for re-use, recycling, other types of recovery (including energy recovery) and, last of all, disposal or landfill. The economic benefits of achieving a circular economy to the UK's GDP could be an increase of GBP 3 billion a year, while businesses could save GBP 23 billion from low/no cost improvements (House of Commons 2014). By implementing EU circular economy and waste reduction initiatives, the UK could save GBP 9 billion a year while adding 50,000 more jobs. In the manufacturing sector, re-manufacturing has the potential to create between GBP 5.6-8 billion per annum and support over 310,000 jobs (House of Commons 2014).

A UK example of reducing water-food nexus pressures in the circular economy can be seen in an initiative by Thames Water, the largest water and sewage company in the UK. Thames Water has partnered with Ostra Nutrient Recovery Technologies to launch the UK's first nutrient recover facility at the Slough Sewage Treatment Works. The partnership will produce commercial fertilizer from wastewater. Phosphorous and nitrogen concentrated in the facility's wastewater can form a concrete-like

substance called struvite which coats pipes and valves, reducing the plants efficiency in treating wastewater – an energy-intensive process resulting in costly maintenance. The plant’s nutrient recovery system addresses these issues by converting the struvite into pellets of high-grade fertilizer. The plant is expected to produce 150 tonnes of fertilizer pellets a year for sale to crop-growers as well as gardeners. The plant will also save GBP 200,000 per annum by reducing operation and maintenance costs. The important lessons from this example that can be exported to the Asia-Pacific region are that circular economy technologies can: increase efficiency in operations and reduce maintenance costs; increase security of supply of scarce resources, in this case fertilizer for food production; and finally, reduce energy requirements and water use. However, to close the loop it is important to create a viable market for secondary raw material, thus turning waste into a resource.

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## 8. Tools to transfer circular economy instruments

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The EU can use market access tools and innovation funding to expedite the transfer of circular economy knowledge and innovations from Europe to Asia-Pacific. These can help reduce tensions over scarce resources, reduce carbon emissions and support economic growth in Europe.

### **Market access tools for Green SMEs:**

The EU’s ‘Green Action Plan for Small and Medium-sized Enterprises’ provides a framework for how the EU and Member States should enable SMEs to turn environmental challenges into corporate opportunities as part of the transition towards a circular economy. One aspect of the Green Action Plan is to facilitate market access for Green SMEs. Over the period 2008-2014, the EU provided the ‘EU Gateway’, which was a EU-funded initiative for helping SMEs establish long-lasting business collaborations in difficult markets abroad. In Asia, the programme targeted Japan and Korea. As part of this programme, EU Gateway provided SME participants a one-week in-country business mission along with business support services such as coaching, logistical and financial support. Over the period 2008-2014, 46 business missions were organised to visit Japan and Korea. Of the 1,500 participating companies: 83 % found the business mission highly useful to increasing their market understanding; 64 % established business collaborations; and 30 % saw their revenue grow following the mission (EU Gateway 2014). Building on the success of this programme, the EU has developed the ‘EU Business Avenues to South East Asia’ programme which focuses on the Singapore, Malaysia and Vietnam markets. In 2015, the programme will be conducting business missions to these three countries for European SMEs in the clean technology sector. Particular focus will be given to SMEs focusing on water technology, the environment, renewable energy or energy efficiency, either as a producer of a sub-contractor or as an R&D or engineering company with its own technology.

**Horizon 2020 – funding circular economy innovation:**

Horizon 2020 is the largest EU's largest ever research and innovation programme, with almost EUR 80 billion of funding available from 2014 to 2020. The purpose of this funding is to take breakthroughs, discoveries and world-firsts from the lab to the market. Horizon 2020's funding will reflect the policy priorities of the Europe 2020 strategy and address major societal concerns shared by citizens of Europe and elsewhere. One of the main societal challenges Horizon 2020 addresses is entitled 'Climate Action, Environment, Resource Efficiency and Raw Materials'. Activities in this challenge are intended to help increase European competitiveness, raw material security and improve wellbeing. At the same time the challenge will help assure environmental integrity, resilience and sustainability with the aim of keeping global warming below 2°C and enabling ecosystems and society to adapt to climate change and other environmental changes. The objectives of the challenge are to achieve a resource and water efficient as well as climate change resilient economy and society; protection and sustainable management of natural resources and ecosystems; and a sustainable supply and use of raw materials for meeting the needs of a rapidly growing global population within the sustainable limits of the planet's natural resources and eco-system. Research and innovation in this challenge will cover: adapting to climate change; protecting the environment and sustainably managing natural resources and ecosystems; ensuring the sustainable supply of raw materials; and enabling a transition towards a green economy through eco-innovation. Through Horizon 2020 funding, breakthroughs in circular economy technologies will be taken to the market, including in the Asia-Pacific region.

Horizon 2020 also calls for the strengthening of international cooperation with China and India, something to be achieved through strategic partnerships. These strategic partnerships will allow countries in the Asia-Pacific region to draw on Europe's experiences and lessons on how circular economy technology and eco-designs can reduce greenhouse gas emissions, increase resource efficiency and reduce water-energy-food nexus pressures by turning waste into resources. Overall, by exporting Horizon 2020 lessons to the Asia-Pacific region the EU will enhance its economic competitiveness by increasing jobs through exports of circular technologies, while improving the security of non-energy raw materials, increasing human wellbeing, fighting climate change and limiting environmental degradation.

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## 9. Conclusions

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In Asia-Pacific climate change is having an impact on the availability of water, which in turn is creating water-energy-food nexus pressures. In addition, rapid population and economic growth is increasing demand for scarce resources, leading to potential economic and social instability. In Europe there is a move towards the circular economy where existing resources are reused, repaired, refurbished and recycled. There are several reasons why the EU should use its policy-making and technological expertise on increasing resource efficiency in order to encourage the Asia-Pacific region to transition to a circular economy:

- The EU needs to create a European Green Bank to provide financial assistance to European SMEs developing circular economy technologies with additional assistance provided for exporting to strategic markets in the Asia-Pacific region. In addition to providing capital, assistance could come in the form of business support, coaching and market intelligence. Increasing exports in circular economy technologies will increase jobs and GDP growth in the EU and enhance Europe's overall economic competitiveness.
- The EU must initiate Green Trade Delegations to key strategic partners in the Asia-Pacific region to showcase EU-wide circular economies, technologies and practices. Delegations to places such as China, Japan, Korea and Singapore could be used to not only increase exports of circular economy technologies. They could also be used to establish public-private partnerships in circular economy research and development, with the possibility of accessing Horizon 2020 funding. This would contribute to the wider goal of fighting global climate change and environmental challenges.
- The EU needs to provide development assistance for achieving a circular economy in the Asia-Pacific region to fight common challenges such as climate change and environmental degradation. Development assistance can come in the form of education of target countries' tertiary students in circular technologies, exchanges of scientists from the Asia-Pacific region to European research institutions and capacity-building of government officials and policy-makers on developing circular economy frameworks.
- The EU needs to provide a dedicated, stand-alone research fund for universities in Europe to develop curriculum as well as conduct research in circular economy technology and practices. In particular, for the circular economy to become mainstream, economic, social and technological barriers need to be overcome. A research fund can support multidisciplinary research for economic analyses, consumer behaviour studies and research on technology that facilitates the transition towards a circular economy.

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