



The Circular Economy and Benefits for Society

Jobs and Climate Clear Winners in an Economy Based on Renewable Energy and Resource Efficiency

A study pertaining to Finland, France, the Netherlands, Spain and Sweden

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1 Executive Summary

The central theme of this report is how to greatly enhance resource efficiency. The proposition is that a circular economy, where products are designed for ease of recycling, reuse, disassembly and remanufacturing should replace the traditional, linear 'take, make & dispose' model that has dominated the economy so far. This, no doubt, is a major prerequisite to stay within the Planetary Boundaries.

It now takes the Earth almost one and a half year to regenerate what we use in a year (Ecological Footprint). Both governments and businesses are beginning to realize that our linear systems of resource use expose both societies and businesses to a number of serious risks. Resource constraints as well as increasing volumes of waste and pollution are likely to impose increasing threats to welfare and wellbeing and, from a business point of view, to competitiveness, profits and business continuity. Simply put: We are in urgent need of decoupling, or put in other words, a transition to an inclusive and circular economy.

The 'circular economy' is an industrial system that is restorative by intention and design. The idea is that rather than discarding products before the value are fully utilized, we should use and re-use them. Presently only a few percentage points of the original product value is recovered after use.

While relative decoupling of economic growth from resource use has been happening over the past decades, the gains made so far have been rapidly eaten up by a combination of economic growth and the so-called rebound effect, i.e. that the resources freed up by increased efficiency are used up very soon through increased consumption. Here is where the circular economy as a powerful concept comes into play.

Most studies so far on the circular economy have focused primarily on the business case for enhanced resource efficiency. This report rather focuses on the social benefits that a transformation from a linear to a circular economy would entail.

The main purpose of this report is to broadly explore the potential for a significant increase in resource efficiency and to specifically assess what the main benefits for society would be - looking at carbon emissions and employment in particular. We are using the Dutch, Finnish, French, Spanish and Swedish economies as test cases.

It seems from the countries this study has explored – Finland, France, the Netherlands, Spain and Sweden – that the circular economy is a concept which will offer a number of societal benefits for Europe, not least in terms of carbon emissions reductions and new jobs.

The study is relevant not only from an academic but also from a political perspective, particularly in the EU context. The European Commission took several important initiatives in the area of resource efficiency during the years 2011-2014, culminating with the Circular Economy Package.

In November, 2014, the Juncker Commission decided to withdraw the proposal under the pretext of "deregulation". After a lot of critique the Commission has made a commitment to

re-launch its proposal. The objective will be to present a revised proposal in December 2015. According to several statements by the Commission – and implicit in the public consultation on the topic – the aim now is a much broader scope, aiming to “promote the circular economy across the whole value chain”.

We hope that this report can provide valuable input to the discussion on the Commission’s new proposal, as well as national policies, particularly in terms of highlighting the opportunities offered by the Circular Economy for the EU’s competitiveness and jobs agenda.

1.1 Case Study findings

In this study the target date for the changes to be obtained in terms of decoupling is set for 2030. By making use of a traditional Input/Output model – which accounts for the interdependencies of different branches of a national economy - the report assesses first and foremost what the likely effects would be on carbon emissions and job opportunities in Finland, France, the Netherlands, Spain and Sweden – of the following key steps in a circular economy:

- **Enhancing energy efficiency**
The economy in each country would become 25% more energy-efficient.
- **Increasing the percentage of renewable energy in the energy mix,**
by cutting fossil fuel use in half and substituting it with renewable energy sources, as for example wind, solar and biofuels.
- **Organizing manufacturing along the lines of a materially-efficient**
circular/performance-based economy, i.e. by extending wealth, minimizing waste and maximizing the reuse and recycling of materials. A combination of a 25% overall increase in material efficiency + 50% of all virgin materials being replaced by secondary materials + doubling the product life of long-lived consumer products compared to today.

The results are very clear. For each and every one of the three decoupling alternatives – in each of the countries studied - there would be a significant reduction in carbon emissions. In addition, the employment effects would be clearly positive. The results were the following in summary:

The renewable-scenario for all five countries led to an estimated 50% reduction in carbon emissions. That was expected, as halving fossil fuel use should have that effect.

There was no significant net effect on employment unless the respective countries would give priority to using of domestic biomass, rather than other renewables, in substituting fossil fuels. However, when residue materials from the agricultural and forestry-sectors are used in the supply of renewable energy significant number of jobs will be created – not least in the rural regions, where unemployment rates most often are the highest. Up to 15,000 new jobs

could be created in Finland and Sweden, respectively, up to 50,000 jobs in the Netherlands, and up to 100,000 jobs in France and Spain, respectively. In addition, and equally important, there would be a surplus in the balance of trade with a third to two-thirds of a percentage point of GDP in all the countries being explored. As all of the countries examined are net importers of fossil fuels that was also an expected outcome.

The energy efficiency scenario would be likely to cut carbon emissions in all five countries by roughly 30%. Here, the effect on employment would be positive and add new jobs in the range of 15,000 people in Finland, 20,000 people in Sweden, 100,000 people in the Netherlands and 200,000 people in France and Spain, respectively. The trade balance would be improved in most countries, but less so than in the renewable scenario. France and Spain are likely to experience the largest trade surplus gains at 0.4% of GDP. The job increase is partly temporary in nature. However, it would last for many years, probably a couple of decades, during which time the necessary investments in retrofitting of old buildings and other efficiency improvements are undertaken.

The material efficiency scenario is likely to cut carbon emissions in all the countries by between 3 and 10%. The gains in terms of employment would be more significant – representing more than 50,000 people in Finland and Sweden, respectively, more than 100,000 in the Netherlands, more than 200,000 in Spain and more than 300,000 people in France. The same goes for the trade balance – the estimated trade surplus improvement would be in the magnitude of 1-2% of GDP. The new jobs generated are permanent in nature, primarily as a consequence of the changes in the goods-to-services ratio in the economy.

If all the three decoupling strategies would be pursued together the results would be substantial. As the three decoupling scenarios support and enforce each other in virtuous circles – improved resource efficiency having energy efficiency effects, and energy efficiency making it much easier to increase the share of renewable energy and cut the use of fossil fuels – the combined scenario would in reality be the easiest one to achieve:

- **Carbon emissions** are likely to be cut by two thirds or more, almost 70% in Spain, structurally¹.
- **The number of additional jobs** would exceed 75,000 in Finland, 100,000 in Sweden, 200,000 in the Netherlands, 400,000 in Spain and half a million in France. This means that unemployment rates could be cut by a third in Sweden and the Netherlands, and

¹ A circular economy (as it has been modelled in this report) would have less than one-third (up to almost minus 70%) of the carbon emissions compared to a “business-as-usual economy” of the same size; the business-as-usual-economy being the economy we have - a fossil fuel based and resource-inefficient economy. However, as an economy continues to grow due to a growing population and increasing per-capita incomes, the emissions will go up. That will happen as long as the decoupling-efforts do not keep up with the economic growth rate, also in a more circular economy, but in that case from a much lower level. This means that decreasing emissions will have to come from a development where the decoupling efforts always outperform economic growth, continuously.

possibly more - maybe even cutting unemployment in half, provided that some of the likely trade surplus gains would be used for investments domestically, preferably in a way according to the investment-packages presented later on in the report. In Spain the unemployment rate is likely to be reduced from a bit above 20% to somewhere close to 15%, in Finland unemployment could be reduced by a third and in France by almost a third.

- **The improvement in the trade balance** would be around - or even above – 1,5% of GDP in all of the countries studied – representing a few billion euros a year in Finland, more than five billion euros a year in Sweden, around 15 billion euros a year in the Netherlands, 20 billion euros in Spain and 50 billion euros in France. It should be noted, however, that there would be no trade balance gains globally. Some countries, especially fossil fuel and virgin material exporters, tend to lose. Over time – once economies around the world would become more circular, the benefits for the five European countries explored in this study would be reduced.

The result of the simulation is like a snapshot. It describes a hypothetical situation, based on certain assumptions. The simulations were based on a combination of manipulating sector supply chains – in favour of renewables and secondary materials - and anticipating at the same time a significantly higher overall level of resource efficiency in the economy.

1.2 Policy implications

While further case studies are needed to confirm the results of the case study of the Dutch, French, Finnish, Spanish and Swedish economies, it is nonetheless possible to draw some definite conclusions in terms of policy implications, of relevance for each country being part of the study and for the ongoing EU debate on a Circular Economy.

With a growing population, and in the developing countries a much-needed increase of per-capita-income (affluence), technology innovation, in combination with behaviour change - and underpinned by policy reforms - are the only options we have to bring down the environmental impacts. Luckily, there are many types of decoupling that could and should be achieved by improved technology, often complemented by behavioural change.

Unfortunately, policies to promote such actions are rare. While the promotion of labor productivity has been a priority for economic policy-making in the past, resource productivity has been more or less neglected.

To move the economy in the direction of a circular economy, with the potential to deliver considerable social benefits, would require deliberate policy measures - as well as targeted investments - over a period of time; the main objective being to reduce the energy and material throughput in society. Of central importance will be to view a circular economy not as an environmental issue alone, but as an integral part of jobs and competitiveness strategies.

On a related note, a current limitation is that most climate change mitigation strategies are sector-based, with a primary focus on energy use. The general level of resource use in society is seldom taken into account – in spite of the fact that the climate benefits from using products longer and from enhanced rates of recycling and reuse of materials ought to be obvious. The energy saved when recycling metals, for instance, is significant. As a consequence, climate change mitigation strategies need to become more holistic and consider resource efficiency as a key instrument.

In addition to this much needed reframing of the circular economy debate, far-reaching policy reforms are also needed. Some of these measures are already being implemented in some of the countries explored in this study as well as in the EU, albeit not to the extent possible. Such examples are support systems for renewable energy, emissions trading, the eco-design directive, energy efficiency standards, targets for recycling of materials, etc. All these policy measures are in need of being strengthened.

In addition a number of new policy measures should be considered, like *a more proactive use of public procurement, earmarking investments in favour of resource efficiency within EU's different funding schemes, adoption of resource efficiency targets for materials where scarcity is looming or the overall environmental impact of resource extraction and use is significant, and the promotion of new business models geared at functional sales.*

It will also be of crucial importance to *rethink taxation*. This policy area is not an EU competence at present. But the European Commission should be encouraged to take the lead and stimulate a process encouraging Member States to embark on a necessary tax shift.

Taxation in industrialized countries is dominated by taxes on labor. Taxes on the use of natural resources and the resulting undesired waste and emissions, however, are very low. To move society towards sustainability – both socially and ecologically - would require a tax shift, lowering taxes on work and increasing taxes on the consumption of non-renewable resources in the form of materials and fossil fuels. Such a tax shift would accelerate the transition to a circular economy, which is low-carbon and resource-efficient in nature.

An economy favouring reuse and recycling of materials as well as product-life extension is, by definition, more labour-intensive than one based on a *disposal* philosophy, i.e. linear resource flows. The main reason, of course, is that caring for what has already been produced – through repair, maintenance, upgrading and remanufacturing – is more labour intensive than both mining and manufacturing (often in highly automated and robotized facilities).

Parallel to tax reform, *the system of VAT* should be carefully analyzed. Goods produced by secondary materials – where VAT has already been paid once – should be exempted from VAT. Such a reform would promote the use of secondary materials – i.e. reuse and recycling – and help correct a situation where it is often less expensive to use virgin materials than recycled ones.

The investments required – in addition to the *normal* level of investments - for moving towards a circular economy have been calculated to be in the range of 3% of GDP per annum

- currently around six billion euros in Finland, 12 billion euros in Sweden, 20 billion euros in the Netherlands, 30 billion euros in Spain and 60 billion euros in France – every year from now on until 2030. This amount equals about half of the current Swedish balance of payment surplus, less than a third of the Dutch balance of payment surplus. Finland, France and Spain, having run trade and balance of payment deficits in recent years, would have to struggle more to finance these investments. The investments would be needed primarily in the following sectors:

- agriculture, forestry, timber, pulp and paper to promote biofuels and to develop new bio based products
- installation services and construction/renovation to promote energy-efficiency and renewable energy sources
- sustainable infrastructure concerning especially energy and transport, for instance mass-transit transport systems and electric vehicles and ways to charge them
- maintenance and repair, recycling and development to promote material-efficiency
- engineering services and as well in education to be able to meet the increased demand for new competencies in areas like product design, recycling and remanufacturing as well as new business models. The labour force must be ready to take on a set of new tasks required in the emerging “new” economy.

Investments of that magnitude would decrease unemployment with another 2% in all of the countries studied due to the increased domestic production the investments would lead to. As more or less half of the total production value incurred by investments in Finland, France, the Netherlands, Spain or Sweden would take place abroad, i.e. foreign firms exporting components to the investment projects, unemployment would come down in other countries as well. This means that for every member-state deciding to embark on an investment package like the one described, there will be positive employment effects in the EU as a whole. This is a natural consequence in an open-market trading-zone like the EU.

2 The Evolution of Resource Efficiency and the Circular Economy Concept

More than forty years have passed since the launch of “Limits to Growth” by the Club of Rome. Its key message was that a combination of resource depletion and pollution, if untackled, would ultimately – i.e. within the next hundred years - bring the global economy down. The background was the rapidly increasing ecological footprint of humanity, as a consequence of the growth in population, as well as resources used and pollution generated per person. The scenarios of the report showed how population growth and natural resource use trends interacted to impose limits to industrial growth - a novel and, indeed, controversial idea at the time.

It should be emphasized that the main focus of Limits to Growth was the increasing physical impact of economic growth, not growth itself. The message was that the ecological footprint cannot continue to grow indefinitely because Planet Earth is physically limited and, in fact, rather small relative to rapidly increasing human activities.

In 1972, when the report was presented, the world’s population and economy were still probably within the planet’s carrying capacity. The report warned, however, that the human footprint was likely to overshoot the physical limitations of the planet – often expressed today as planetary boundaries – in the near future, mainly because of delays in decision-making at the political level. It stressed at the same time that forward-looking policy ought to be able to solve the problems. The report warned, however, that technological measures alone would not suffice. A truly sustainable solution for the world would require a combination of technological advance and behavioural change.

Few reports have become so controversial and, not least among economists, so heavily criticized. The main criticism centred on the fact that the report was based primarily on higher consumption trends, while not taking sufficiently into account technological development, substitution and price adjustments.

The debate is slowly sobering up. In recent years a stack of international reports have emerged which essentially confirm the majority of the conclusions in the Limits to Growth. The principals behind these reports are various research institutions, the UN Secretary-General, UNEP, the European Commission, OECD, but also organizations tied to the private sector. All of these reports issue strong warnings about the combination of an increasingly unstable climate and the overexploitation of many important ecosystems and natural resources – renewable as well as finite - and pollution taking a heavy toll on vital ecosystems and on human health.

The human ecological footprint has continued to increase. It now takes the Earth almost one and a half year to regenerate what we use in a year. It is important to note, however, that the ecological footprints of developed country citizens are by far much larger than those of developing countries. If all citizens of the world would live by US standards, for instance, we would need more than 4 planet Earths.



IPAT was introduced in the 1970s by a group of pioneers among environmental scientists – individuals like Paul Ehrlich, John Holdren and Barry Commoner. The equation describes the interaction between population (P), affluence (A) and technology (T) and their multiplicative contribution to environmental impact. The IPAT equation states that the Impact (I) = Population (P) x Affluence (A) x Technology (T).

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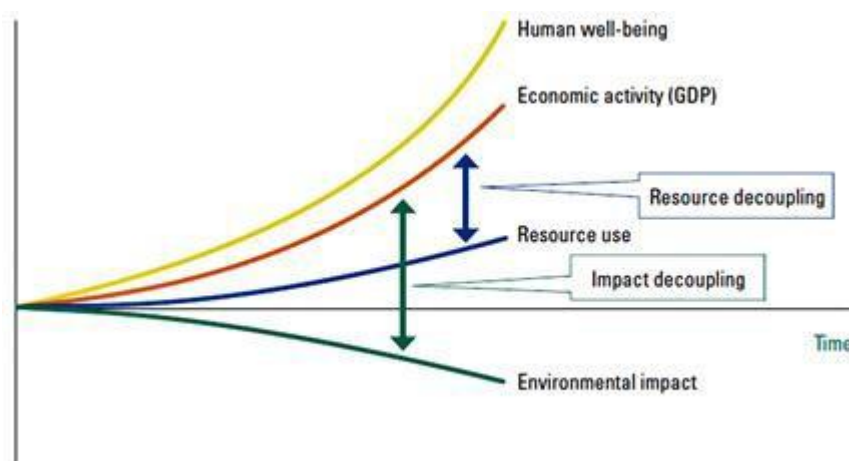
The population factor is often up for discussion. The point is made that the increase in population numbers primarily take place in low-income countries and that the ecological footprint of poor people is low. Right, but the objective ought to be that every human being born on this planet should be able to attain a decent living standard and hence the total size of the population will matter.

The IPAT equation will be revisited towards the end of the report with forecasts for the Dutch, Finnish, French, Spanish and Swedish economies concerning how technology and behavioural change, as modelled in this report, can help to balance – and more than that - an increasing population and rising affluence.

2.2 Decoupling a must

The central theme of this report is the need to use all kinds of natural resources in a much more efficient way than hitherto. Simply put: We are in urgent need of decoupling: a transition to an inclusive and circular economy. Decoupling refers to the ability of an economy to grow without corresponding increases in energy and resource use (source limits) and in environmental pressure (sink limits). A decoupled economy should ideally not negatively affect soil fertility and biodiversity, not diminish resource stocks and not lead to increased toxicity of land, water and air. *Relative decoupling* will buy time, i.e. give the economy some extra time before it runs into resource constraints and/or excess pollution. Once the economy comes close to a boundary, *absolute decoupling* will be a requirement so as to enable the economy to continue to develop sustainably.

Two aspects of decoupling

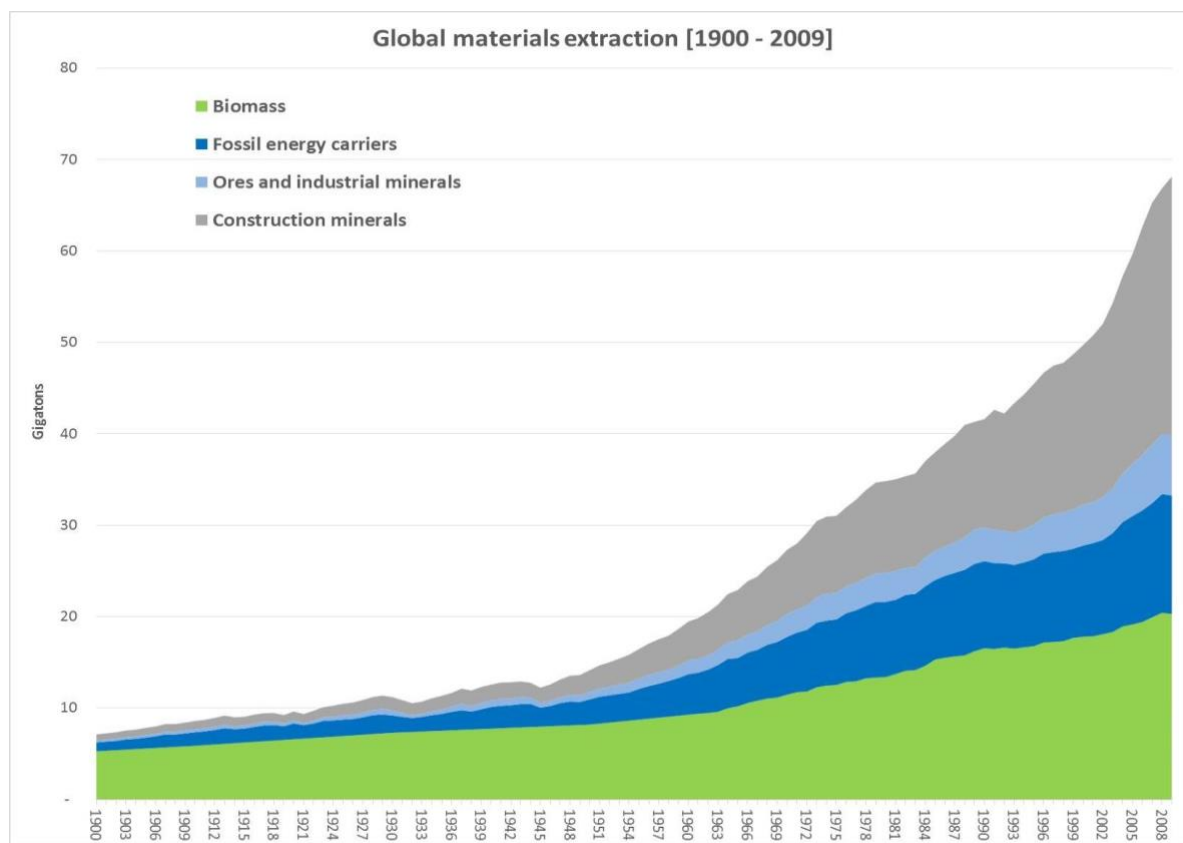


Source: Decoupling Natural Resource Use and Environmental Impacts from Economic Growth 2011 UNEP International Resource Panel Report

Unsustainable growth would unavoidably lead to less development (growth) in the long run since the very preconditions for growth and development – the sources and sinks referred to – are being diminished. The crucial interdependency between the economy and the life-supporting systems provided by planet Earth is well understood by most natural scientists. However, for most social scientists, economists and ordinary people the relationship seems to be less clear.

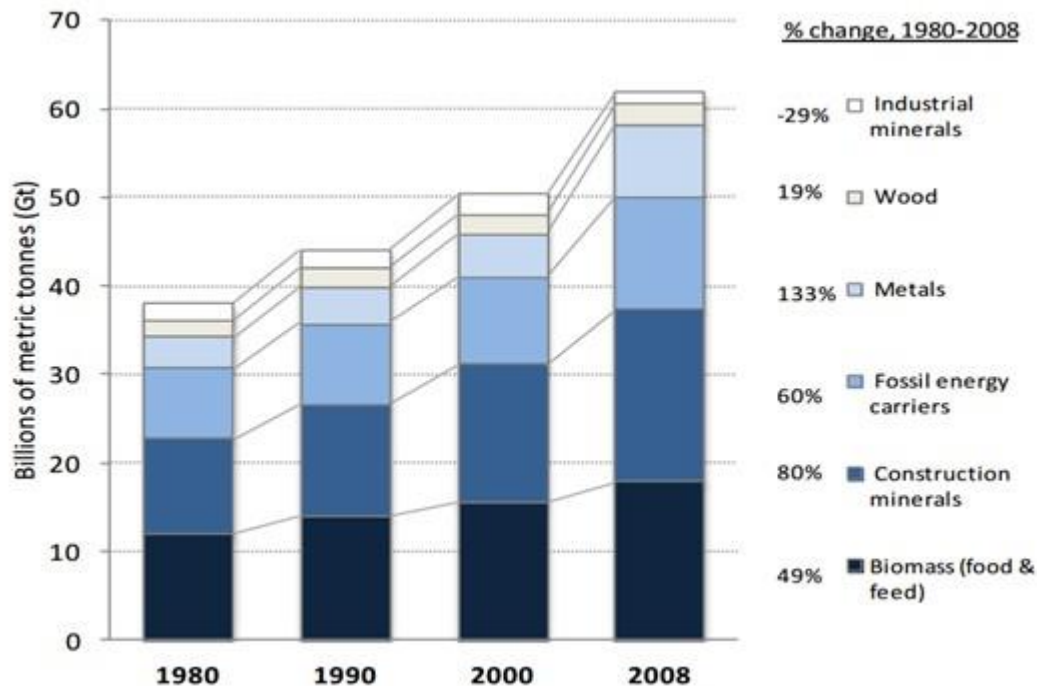
The concept of decoupling economic activity from resource use has been a central theme in the sustainability debate ever since the Limits to Growth Report. While *relative decoupling* has been happening, and is happening; the gains made, so far have been rapidly eaten up by a combination of economic growth and the so-called rebound effect, i.e. that the resources freed up by increased efficiency are used up very soon afterwards through increased consumption. The demand for commodities has continued to increase over time.

The global material extraction over time is increasing continuously. The diagrams below illustrate the situation well:



Source: Krausmann, F., Gingrich, S., Eisenmenger, N., Erb, K.H., Haberl, H., Fischer-Kowalski, M., Growth in global materials use, GDP and population during the 20th century, Ecological Economics 2009, Vol.68(10).

Global materials resource extraction



Source: SERI (Sustainable Europe Resource Institute) material flows database.

According to OECD, growth has been primarily driven by increased global demand for construction minerals, biomass for food and feed, and fossil energy carriers. These three material groups account for 80% of total global material extraction.

By 2050, the world economy is expected to quadruple and the global population to grow from 7.3 billion today to close to 10 billion. A recent UN population report (July 2015) presented a revision upwards of previous population forecasts and predicts that the world population will reach a minimum of 11 Billion people around the turn of the century. Another *OECD* report, *Environmental Outlook to 2050*, shows the additional strain that the increase in population is likely to place on the Earth's material and energy resources and the environment. A growing population with higher average income will require more food, more industrial products, more energy and more water. This creates formidable challenges for sustainable economic and environmental development and, indeed, for a much more efficient use of resources.

With a growing population, and a much-needed increase of per-capita-income in developing countries, technology - in combination with policy reforms - is the only factor left in the IPAT-equation to bring down the environmental impacts. Luckily, there are many types of decoupling that can be achieved by improved technology, often complemented by behaviour change. Unfortunately, policies to promote such actions are rare, and if they are put in place, politicians seem reluctant to really let them influence industrial metabolism or the relative prices of energy and materials to any significant extent. Historically, almost all focus has been on promoting labour productivity, instead of also focusing on material productivity.

2.3 Relative decoupling is happening but...

During the early stages of industrialisation the relationship between GDP growth and resource demand has been more or less linear for most countries. Over time, however, the combination of regulation and technology innovation – and, in some cases, price increases - has led to more efficient resource use and lower emissions per good produced. This means that the link between the growth of GDP and resource use has become less pronounced.

To make use of the IPAT-equation again, technology improvements and/or behavioural choices (e.g. choosing a renewable energy source instead of fossil fuels) has made it possible to break the previous linear relationship between economic growth and resource use and pollution.

Sweden is a case in point. Demand for electric power, for instance, has been more or less stable since the early 1990s. GHG emissions were more than 20 % lower in 2013 as compared to 1990 (territorial emissions only; when embedded carbon in imports is accounted for the picture is different). The Swedish economy has grown significantly during the same period; GDP today is more than 60% higher than in 1990.

In Spain, on the other hand, energy demand grew faster than GDP in the 1980s and 1990s leading to an increase in energy intensity. However, in the more recent past, Spain has moved towards a relative decoupling in its energy use. Together with a modest increase in the share of renewables in the energy mix, energy-related carbon emissions have eventually started to come down. The recent downward turn in carbon emissions was in fact significantly steeper than the downturn in the economy.

In the Netherlands, the economy has become less carbon intensive over the years. But it is only in the more recent past that the rate of carbon emissions reduction was larger than the growth of the economy – meaning that the Netherlands, like Sweden and Spain, now has entered a path of absolute decoupling.

In Finland and France, energy efficiency efforts have been modest in the past. The share of renewable energy in the energy mix has not changed much either. This meant that carbon emissions remained more or less at the same level until recently. However, since 2010, both Finland and France have increased the share of renewable energy. That positive development, but also the fact that both the French and Finnish economies have been subject to sluggish growth ever since the financial crisis in 2008, are the main reasons that carbon emissions have been coming down recently.

Based on recent developments, the assumption for most of the countries examined in this study would be that there is an almost natural movement towards enhanced energy efficiency. This is crucial since increasing energy efficiency is a prerequisite for increasing a country's renewable energy share. For materials in general, however, the trend in all five countries can be described as one of modest decoupling, i.e. resource demand per production output is being gradually reduced. But the efficiency gains made so far have been eaten up over time by growing economies and the rebound effect. To obtain “absolute decoupling” concerning both

energy and materials – something urgently needed in a world where the ecological footprint is increasing rapidly, and where the footprint of industrialised countries are many times higher compared to low-income countries - specific policy measures will be needed though.

Using the IPAT-equation again, the technology factor needs to be pushed significantly, both with regard to efficiency improvements and innovations, and to fuel choices and modes of transportation. This will enable a reduction of the environmental impact so as to meet the targets defined by science (exemplified by the IPCC 5th Assessment Report, the Planetary Boundaries Report, etc).

One thing we know: The world population is likely to increase by two to three billion people in the coming decades. Parallel to that several billion people are expected to experience an increase in their per-capita income, a prerequisite to meet the Sustainable Development Goals agreed in September 2015. All this means increased demand for energy and materials, in a situation where several of the planetary boundaries have already been transgressed, or are close to being transgressed. The only possible factors to push the equation back within the planetary boundaries will be technology and behaviour change.

2.4 Most focus so far on labor productivity

It is, indeed, interesting to compare labor productivity and resource productivity over time. While labor productivity has increased by a factor of twenty or more since the middle of the 19th century, the productivity gains with regard to the use of natural resources have been modest in comparison.

As an example, the world economy extracts an estimated 40% more economic value from each tonne of raw material today compared with thirty years ago. But the world economy has grown by more than 150% during the same period of time, so the result has been a rapid increase in material consumption. (UNIDO, Green Growth 2013).

Both governments and businesses are beginning to realize that the basically linear systems of resource use expose both societies and businesses to a number of serious risks. Resource constraints as well as rising volumes of waste and pollution are likely to impose increasing threats to welfare and wellbeing and, from a business point of view, to competitiveness, profits and business continuity.

The main reasons can be summarized as higher input costs of energy and key raw materials, increased competition for resources in general – leading to possible shortages and disruptions – political instability or resource protectionism among key producing regions and increasing social pressure on companies about resource stewardship and climate change.

2.5 “One issue at a time” versus a systems perspective

Different natural resources and their use are linked to each other in several ways. Energy and water is a case in point. Securing energy supplies and production accounts today for more than 30% of total water withdrawals globally. The current quest for shale oil and gas and exploitation of tar sands are the latest examples, not only using massive amounts of water, but also polluting water and the surrounding areas heavily.

A number of research reports have shown that both resource and environmental strategies have to be systemic in nature and not focus on individual resources alone. Still, there is a strong tendency among most governments today to deal with “one issue at a time”. Climate change is no exception.

Most climate change mitigation strategies are sector-based, with a primary focus on energy use. The general level of material use in society is seldom taken into account – in spite of the fact that the climate benefits from using products longer and from enhanced rates of recycling and reuse of materials ought to be obvious. The energy saved when recycling metals, for instance, is significant.

According to a study by UNEP (2011), less than one-third of some 60 metals studied have an end-of-life recycling rate above 50 per cent and 34 elements are below one per cent recycling. In theory, metals can be used over and over again, minimizing the need to mine and process virgin materials and thus saving substantial amounts of energy and water, while minimizing environmental degradation and CO₂ emissions. In spite of all this, recycling and reuse rates remain very far from optimal for most metals.

Even if attitudes are gradually changing, we should not disregard the fact that both environment protection and climate mitigation most often have been portrayed as costs or burdens for society and, indeed, for business. Many businesses perceive environment taxes and regulation as a threat to competitiveness as well as employment. This is the main reason why progress in terms of environmental policy-making in many areas is slow, often painfully slow.

While competition in an increasingly globalized economy is a challenge, there are overwhelmingly good reasons not to view resource efficiency as a threat – neither to competitiveness, nor to employment. On the contrary, this study demonstrates that there are multiple benefits by moving society and companies in the direction of decoupling, i.e. in the direction of a circular economy.

2.6 Resource efficiency is gaining ground

Decades ago the concept “Cradle to Cradle” was introduced by Walter Stahel, Founder-Director of the Product Life Institute and leading advocate of resource efficiency, and later

advocated by Michael Braungart and William McDonough, in their landmark report, *Cradle to Cradle; Remaking the way we make things*.

The main thrust of the concept is to create industrial systems that are not only efficient, but essentially waste-free. The basis for this thinking is that the linear way in which the world economy currently operates fuels a culture of excessive consumption and creates much more waste than is sustainable in the long term. In contrast, the living world operates in a circular cycle where the by-product of one species easily provides the feedstock of another.

In his seminal book "The Performance Economy" (2010) Walter Stahel presents a convincing case for extending wealth, by replacing material throughput with activities like reuse remanufacturing and recycling. Today's business models are based on maximizing the volume of sales of various products. As an alternative, Stahel advocates a transition to offer services. Sales of products in many areas will be replaced by leasing, coupled with high-quality services.

Since responsibility for the materials used in a product remains with the manufacturing company, strong incentives are created to earn revenue on what has already been produced for as long as possible. The contrast with today's system is significant. According to Stahel the net effects on employment of moving towards a circular/performance-based economy are obvious as service sectors are more labour-intensive than mining and increasingly mechanized assembly lines in factories. To accelerate a shift to a circular economy Stahel suggests a tax reform by shifting taxes from labour and renewable resources to non-renewable resources.

The main principles behind "cradle to cradle" and the performance economy are gradually gaining ground. The European Commission flagship program "For a Resource-Efficient Europe", presented in September in 2011, stressed that:

- Improving the design of products can both decrease the demand for energy and raw materials and make those products more durable and easier to recycle.
- Increasing recycling rates will reduce the pressure on demand for primary raw materials, help to reuse valuable materials which would otherwise be wasted, and reduce energy consumption and greenhouse gas emissions from extraction and processing.

The UNEP Green Economy Report (2011), which makes a compelling case for investing at least 2% of global GDP in greening the central sectors of the economy, is another example. The report convincingly argues in favour of enhanced resource efficiency, postulating that such a direction of manufacturing and construction would both save energy, reduce CO₂ emissions and offer new job opportunities.

The OECD work on green growth is yet another example. As expressed in the report "Resource Productivity in the G8 and the OECD" (2011): "By reducing, reusing and recycling (the 3Rs) materials, we can decrease the need for virgin materials and improve resource efficiency. The challenge before us is to move towards a society where we create

more value with less natural resource input, and where we do not compromise the needs of future generations”.

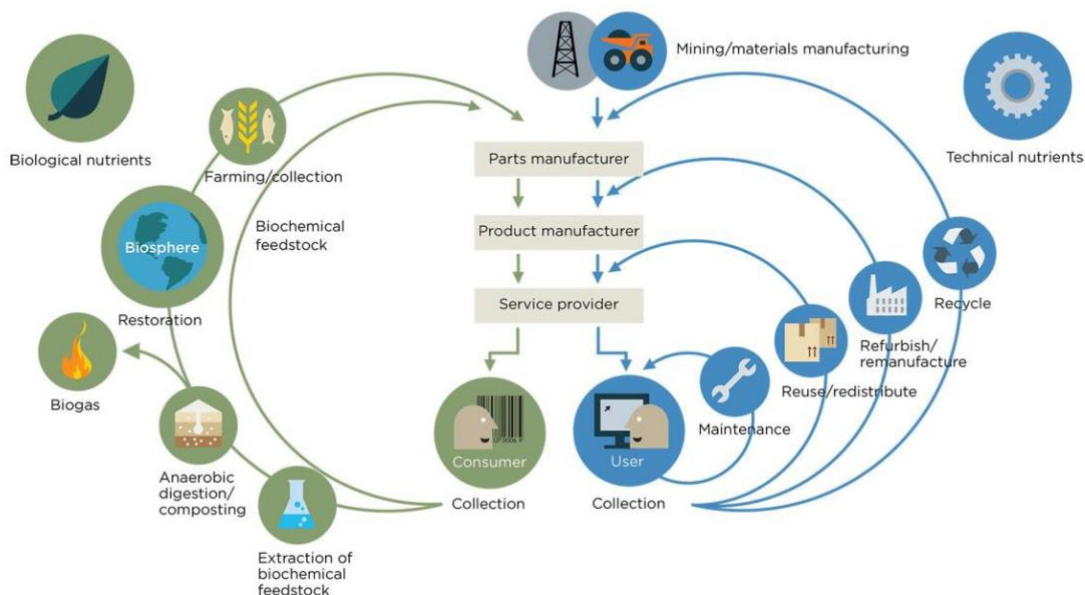
The Ellen MacArthur Foundation and its work on the circular economy represents another major breakthrough, not least because the primary focus is on the business sector. The first report of the foundation – Towards a Circular Economy, I - was presented in early 2012 and backed up by a group of leading multinationals, including B&Q, British Telecom, Cisco, National Grid and Renault. The report makes a strong pitch for a circular economy and defines the objectives as follows:

“A circular economy is an industrial system that is restorative by intention and design. In a circular economy, products are designed for ease of reuse, disassembly and remanufacturing – or recycling – with the understanding that it is the reuse of vast amounts of material reclaimed from end-of-life products, rather than the extraction of new resources, that is the foundation of economic growth.

Moreover, the circular economy shifts towards the use of renewable energy, eliminates the use of toxic chemicals, which impair reuse, and aims for the elimination of waste through the superior and innovative design of materials, products, systems, and, within this, business models.”

Illustration of the circular economy, Ellen MacArthur Foundation

Where does this company sit within the circular economy?



The EMF Report referred to above also estimated that a subset of the EU manufacturing sector could realize net materials cost savings worth up to \$ 630 billion annually towards 2025—stimulating economic activity in the areas of product development, remanufacturing and remanufacturing. That sum only covers “sweet spot” sectors representing a little less than half of the GDP contribution of EU manufacturing.

The calculations in the report were based on the assumption that products and the components involved would only be recycled/reused once. The objective in the future would rather be to add several cycles to a product and its main components. That ought to be made much easier through new technology developments – such as more intelligent design and through the ”Internet of Things”, which, among other things, would help keep track of materials and components and make upgrading much easier.

The dominating business model of today, implying fast turnover of most consumer products, means that a lot of things are discarded even if they are still fully functional. The circular economy as a concept implies recycling and reuse and would be strengthened by extending the use-life of products. Hence the main business case to explore would be to preserve the embedded labour, energy and material value in finished products as long as possible.

In one of its reports, the EMF analysed the potential of applying the circular economy concept to fast-moving consumer goods, which currently account for about 60% of total consumer spending, 35% of material inputs into the economy, and 75% of municipal waste. The EMF-study “Towards the Circular Economy II” (2013) shows that an adoption of the principle of the circular economy could be worth as much as USD 700 billion in consumer material savings alone. The study also highlights the added benefits in terms of land productivity and potential job creation.

In their most recent study “Growth Within”, the EMF and McKinsey suggest that resource productivity is a hugely underexploited source of possible future wealth, competitiveness and business revival. Their calculations show that only about five percent of the remaining value of most material goods is captured and made use of when the products are disposed of.² Businesses in fact spend significant financial resources to get rid of what could potentially be valuable resources.

Due to design flaws, difficulties in dismantling a product or problems separating different fractions of residues, most materials end up in the low-value chain of the recycling business (if they are recycled at all). A lot of money could be saved if different types of materials could be kept separate and re-used – instead of being managed in commingled, or single, streams and thus running the risk of contamination. According to “Growth within”, Europe could have a seven percent higher GDP in the year 2030 – compared to a business as usual-case - if it were to choose a circular economy path, making much better use of materials and putting resource efficiency higher on the agenda. A review of over 60 research reports also showed that a move towards a circular economy would have a clearly positive job effect.

A recently published report by IVA (The Royal Swedish Academy of Engineering) also presents a strong plea for enhanced resource efficiency. The point is made that commodities make up roughly 50% of the cost base for most manufacturing companies in Sweden of today.

² Figure 1 on page 17 in their report.

To enhance resource efficiency is therefore seen as a major prerequisite for competitiveness in the future.

Yet another important report worth mentioning is *Factor 5*, a report to the Club of Rome in 2009 written by Ernst von Weizsäcker, today co-president of the Club of Rome. Weizsäcker gives a broad overview of technology options in different sectors of the economy and concludes that already 2009 (at the time of publication) technology was available in most industrial sectors to radically reduce the energy and materials throughput while maintaining the same quality of wellbeing and service.

The book deals specifically with the issue of the “rebound effect” and how to make sure that resources “saved” will not be put to use in even more environmentally detrimental ways. The best approximation currently proposed to achieve absolute decoupling, without a rebound effect, according to von Weizsäcker, is to politically ensure that energy and resource prices are elevated each year by the percentage of documented efficiency increases of the previous year. This would result in a self-accelerating “ping-pong” between resource productivity and related prices, while the real cost paid for energy and resource *services* remain unchanged (on average) over time.

2.7 Juncker Commission falters

As a follow-up to the flagship program on Resource Efficiency, the EU Commission in 2011 launched the European Resource Efficiency Platform – composed of policymakers, scientists and business leaders within the EU – to help advance the agenda. A legislative proposal “The Circular Economy Package” was launched in July 2014. In November 2014, the Juncker Commission decided to withdraw the proposal under the pretext of “deregulation”. After a lot of critique the Commission has made a commitment to re-launch the proposal. A revised proposal is due to be presented in December 2015.

According to several statements by the Commission – and implicit in the public consultation on the topic – the aim now is a much broader scope, based on the examination how the Commission proposal “can promote the circular economy across the whole value chain”. We hope that this report can provide valuable input upcoming discussions on the Commission’s new proposal and wider EU policies, particularly in terms of highlighting the opportunities offered by the Circular Economy for the EU: s competitiveness and jobs agenda.

2.8 Resource efficiency and societal welfare

Maximizing resource efficiency gains for society as a whole cannot be seen in isolation. It must be linked to and primarily concerned with how well an economy can provide jobs and other forms of societal welfare gains – including the reduction of pollution, not least carbon

emissions. This area has received relatively little attention in academic studies and policy reviews thus far.

Companies facing choices between becoming more capital or labour intensive will analyse carefully the relative financial or market costs between labour and capital (the actual costs and relative prices they face). In both cases these costs are more or less distorted from a societal point of view. The economic costs – i.e. the costs for society - of using natural capital are often undervalued. Furthermore, natural capital is also embedded in the usage of built capital (minerals, water, energy etc.), and that usage of natural resources and ecosystem services is most often underappreciated, often resulting in both misuse and over-use. Lastly but not the least, natural capital is often undervalued through subsidies and the fact that no account is made for its depreciation.

Labour is usually heavily taxed and no account is taken of the positive externalities associated with employment. Under-usage of labour, i.e. unemployment, is actually a cost to society, as unemployment benefits will have to be paid out. Moreover, the person in question would rather work; by not working he or she is losing competence, human capital, making both the person and society worse off. There is also usually a social cost involved as unemployment very often is related to health issues and social problems like exclusion, not only affecting the unemployed person, but his/her family and even the wider community.

2.9 Why tax labour, why subsidize resource use?

In spite of the fact that numerous studies have shown the benefits of a tax shift – moving from taxing labour to resource use – modern tax systems in the EU apply high rates to employment while leaving the use of natural resources tax-free or even subsidized. In such a distorted business environment it is little wonder that most firms find it financially attractive to overuse natural capital and underuse human capital.

In a recent study *New Era. New Plan. Fiscal Reforms for an Inclusive, Circular Economy*, The Ex-Tax Project 2014, the point is made that in 2012, out of euros 5 trillion in tax revenue in the EU member states, over 50% was derived from labour taxes and social contributions, almost 30% in consumption taxes and the remaining 20% was based on capital. Only 6% of tax revenues consisted of environmental taxes, mainly on energy and transport as part of the consumption taxes.

In the figure below the environmental taxes in EU-27 can be seen to increase somewhat over time; the pollution taxes being the smallest portion. However, compared to overall tax revenue, the share of environmental taxes is very low and actually decreasing, despite all the recommendations from think-tanks, international agencies and economists to apply higher tax rates to deal with negative externalities, as that is seen as the most cost-efficient measure to handle pollution problems and the driving forces behind them.



Source: Eurostat database

To redress these obvious distortions will require actions at the level of the firm, the industry and the economy. Companies view their costs and production processes through the lens of financial or market prices, taking into account: the taxes they pay, the accounting rules they follow (especially accounting for depreciation), the sources and terms of finance they secure, the goals and targets that are set by their shareholders, and, for an increasing number of companies, their concerns of corporate responsibility, goodwill and image. However, the financial *bottom line* remains the company's most important metric. Any attempts to alter the basic structural and pricing regimes may be thwarted on grounds of competitive disadvantage. Hence designing policy interventions requires a high level of sophistication and an understanding of the impacts.

Furthermore, attention must be paid to the investment cycles in different parts of the economy and capital destruction avoided. Policy-making should align with the natural turnover of the capital stock and be primarily focused on making sure that fresh capital is no longer invested in *dinosaur technologies*, but rather in the new generation of efficient technologies – many of which already are meeting the demands of a circular economy.

Finally, it should be emphasized that policy interventions at the EU level are to be preferred over individual action by Member States, to ensure that competitiveness is not compromised. Hence the vital importance of the EU Commission re-launch of the Circular Economy Package later on in 2015.

3 The purpose of this study

The calls for a new model of production and consumption are becoming more frequent. The circular/performance-based economy has recently been attracting increasing attention among key business leaders and some policy makers. Companies' and sectors' material savings potential in such a transition have been well documented by the Ellen MacArthur Foundation's reports *Towards the circular economy Vol. 1 & 2 & 3* and *Growth Within*.

However, only scant attention has been paid to the wider societal effects of moving towards a circular economy. The time has no doubt come to explore these issues. The main purpose of this report is to explore the potential for resource efficiency, first and foremost in developed economies, and to assess what the main benefits for society would be - looking at carbon emissions and employment in particular.

We are complementing our former report on the Swedish economy by also performing modelling runs on the Dutch, Finnish, French and Spanish economies in this report. The main reason for studying these five economies is to be able to draw as wide conclusions as possible of the possible effects of a more circular economy. The countries differ significantly from each other in terms of industrial structure, trade patterns, demographics, natural resource endowments and energy use.

The hypothesis in this study is that the circular economy will offer a number of societal benefits for all five European countries – and for Europe as a whole - not least in terms of carbon emissions reductions and job gains.

4 Systematic decoupling: five country studies

4.1 Methodology

As stated above the aim of this report is to primarily study the possible societal benefits of systematic decoupling, with a focus on carbon emissions and employment effects. The main analytical tool used is a model developed from a traditional Input/Output model, which accounts for the interdependencies of different branches of a national economy. The model is extended to make it possible to simulate structural changes within the supply chains of the national economies studied.

Sweden has been examined both through a 60-sector Input/Output-model (the interim report) and a more aggregated 40-sector model (this report). In this report we present results for Finland, France, the Netherlands, Spain and Sweden. The modelling is based on data from the international database WIOD, which could provide data for all the countries examined, albeit limited to the 40-sector-level.

The methodology used is exactly the same as for a 60-sector model, but the fewer numbers of sectors in the 40-sector-model provide fewer details; as for instance, agriculture and forestry are merged instead of treated separately. The energy intensities, labour intensities and import intensities are in that case weighted averages of the sectors merged, which make the results somewhat less exact as compared with the 60-sector model. It is important to note, however, that the results for Sweden differed only slightly in the 60-sector-analysis in comparison with the (former) 40-sector-analysis.

By making use of the Input/Output model the report assesses what the likely effects in countries explored would be on carbon emissions and job opportunities by:

- enhancing energy efficiency
- increasing the percentage of renewable energy in the energy mix
- organizing manufacturing along the lines of a materially efficient circular economy, i.e. by extending wealth (the life-time of durable products), minimizing waste and maximizing the reuse and recycling of materials

At the end of the report a discussion will follow with regard to what changes in policy that would be required to move the economy in the direction of systematic decoupling.

The report will explore the three pathways mentioned above, to try to improve the technology factor in the previously mentioned IPAT-equation. This is done by modifying the traditional Input-Output model slightly. Thereby, we will be able to study employment, energy use and carbon emissions from different sector activities in the economy – and, in particular, to study how these variables would be affected by policies promoting a circular economy, as defined by the three pathways above.

The Input/Output tables in the model show how different sectors buy and sell natural resources and intermediate goods from and to each other, in often complex supply chains during the production process. The end result is the delivery of a product and/or service to the final user, or the product/service being exported.

For each of the 40 sectors there is a description of the various inputs in terms of supplies needed for their production. Parallel to that the deliverables from each and every sector are shown in terms of intermediate demand – produce sold to other businesses – as well as final sales for public and private consumption, public investments and goods/services that are being exported.

Technically, the manipulation of the Input/Output-model to mimic the different kinds of decoupling has been done by "rewiring" the supply chains and then "rebalancing" the sectorial trade in the so called A-matrix in the I/O-model, keeping the overall production value in the economy constant.

The model used is static, using data from 2009 as the entry-point as those are the most recent data that can be accessed through the WIOD-database. Being static, the model cannot take into account technology changes, meaning technological development will have to be modelled explicitly. In the modelling exercises in this report the technology changes will be equal to the proposed changes in the supply chains in the different scenarios. No doubt, many other things will happen in the years to come in the economy pertaining to both changes in technology and employment. The recycling industry, for instance, which is likely to grow significantly as a consequence of the move towards a more circular economy, will probably explore new niches and business models, and develop and make use of a variety of new technologies. It is likely that it will look vastly different from today.

Some key assumptions made in the modelling exercise can be worth mentioning:

To be able to more easily compare the effect from the suggested structural changes in different countries the production value has been kept constant in the modelling exercises. Keeping the production value constant means that the total value of the production using labor, capital and resources in the economy stays the same. Thus, the total production capacity domestically will not change due to the new structure of the economy that the suggested changes in the supply chains lead to.³

To be able to compare the structural effects of the different supply chain changes involved between different countries we had to keep one variable constant. The production value, representing what the production factors in a country are able to produce, was our choice. In reality, the structural changes achieved could both increase or decrease the domestic

³ However, the model allows for several different set ups of what to hold constant, including not restricting the economic activity of the modelling at all, letting the multipliers "play along freely". The differences in the modelling outcomes are usually marginal. Not restricting the outcome in any way in most cases lead to a larger economic production, but not by much.

production (capacity) due to dynamic effects, but allowing for that to happen would make the comparisons between the countries much more difficult.

There is also an assumption that in some areas, subsidies and/or targeted technological procurement might have to be used in the beginning to get things started in the respective decoupling scenarios. Some of the proposed policies would on the other hand possibly raise revenue.

To avoid having to make assumptions about how businesses would spend possible gains from higher efficiency the modelling throughout all scenarios have assumed that the sectors neither gain money nor lose money from the changes made. However, according to certain studies, some of them mentioned in the previous section of this report, many businesses will be able to improve their bottom line by exploiting the opportunities that a more circular economy provides. In spite of this, we have chosen not to assume that sectors would show increased profits from the supply chain rewiring's that we have modelled; see also the last section of the report.

The assumption about a zero-sum game for the proposed changes in the supply chains will not hold in real life. Some sectors/companies will gain a lot, others less and some will even lose. The *Growth within* report assumes that there will be significant gains for the economy at large by enhanced resource efficiency. More conventional macro-analysts tend to be sceptical, arguing that if gains were to be made they would already have happened through market forces. In the study a conservative approach is adopted – for modelling reasons but, as well, to be on the safe side. The realism of the assumptions is specifically discussed in a section at the end of the report.

Another very important precondition in the study is that a significant part of the investments needed for the transition to a more circular economy will depend on public policy and public investments. This is particularly true for infrastructure, i.e. the energy system, the transport infrastructure and the development of more sustainable cities.

Lastly, to simplify the explanation of the simulation runs, the 40 sectors have been divided into different groups:

- Primary sectors which use natural resources as the main (re)source, such as agriculture, forestry, fisheries, mining, water.
- Secondary sectors, in which the main activity is manufacturing, divided into three subgroups:
 - M1 - sectors that mostly upgrade natural resources and sell them to other sectors domestically and abroad, such as wood and basic metals.
 - M2 - sectors that basically produce consumer goods.

M3 - sectors that offer goods that by definition are not long-lived and cannot be upgraded and recycled⁴, such as food or energy carriers.

- Tertiary sectors, which represent all other sectors mainly offering services in a variety of fields, like finance, insurance, logistics, design, marketing, retail etc.

The grouping is made to make it easier for the reader to understand how different sectors are being affected by changes in the supply chains. In the modelling the sectors are treated separately and are never grouped.

The modelling mostly focus on the private sector activities – so any changes in the model runs do not change the public sector employment in any direct ways. It should be noted, however, that the public sector's emissions and resource use are part of the model.

4.2 Targeted policies and investments needed

This study poses the question *What would the overall effects be on the Dutch, Finnish, French, Spanish and Swedish economies, respectively, if decoupling as described above had been pursued systematically?* The result of the simulation is like a snapshot. It describes a hypothetical situation, based on certain assumptions. For the societies to move their economies in this direction would require deliberate policy measures, as well as targeted investments, over a period of time.

These policies and investments would most likely be similar in the five countries studied, but also partly differ. The differences would depend on the different economic structures in the respective countries and to what degree the countries have given priority to renewables and resource efficiency in the past. Of great significance will be the endowments of natural capital and other forms of capital (industrial, human and social).

Sweden and Finland, for instance, are forest countries and the share of biomass in the energy mix is large. Sweden, and to some extent also Finland, are also blessed with significant capacity for hydropower and good potentials for wind energy. France and especially Spain on the other hand offer very favourable conditions for both solar and wind. The Netherlands has good potential for wind energy and energy production from agro residue materials. Also France and Spain have a significant potential for using residue materials from both agriculture and forestry for energy purposes.

In this study the target date for the changes obtained in terms of decoupling is set for 2030. In most developed countries the population will have increased by a few percentage⁵ points by

⁴ If one does not look at it from a nutrient perspective or the possibility to use the excess energy-potential (heat) of the last remains of the energy-carrier (processes).

then and the GDP per capita will - according to different forecasts - have risen by 10-40%⁶ in developed countries and even more in fast-growing developing countries.

A lot of investments will be needed to realise the decoupling ambitions and, hence, a more sustainable economic structure. The different decoupling alternatives require different kinds of investments: rail, mass transit vehicles, new infrastructure for electric vehicles, wind turbines, solar panels, biofuel refineries, smart-grids, retrofitting of buildings, recycling facilities and so on.

With regard to the transport sector major changes will have to occur. The motorcar companies will still be producing vehicles in the tens of millions, but with different engines, fuels, performance, materials, weight and so on. The focus from now on will have to be more on sustainable technology performance than in the recent past. That trend is actually already happening concerning mileage and how to power engines, but to reach the goals in terms of decoupling the transport sector must give more priority to energy and material efficiency as well as to fuel substitution.

A special dimension will be the likely emergence of driverless cars. Such cars will require much less space on the roads, since driverless cars can travel in convoys, inches apart. In such a future transportation scenario, citizens will increasingly refrain from owning vehicles and benefit from car pools and different kinds of on-demand transport services. The companies providing such services will want to have their vehicles both designed and powered differently; the potential for increased material efficiency, mileage and pollution reduction is substantial.

The investments needed to make it possible for the different sectors and subsectors to become increasingly decoupled will temporarily - during the transition phase – increase economic activity, employment and pollution, provided that the investments do not fully crowd out other investments or consumption. There are currently many reasons⁷ to doubt that a full crowding out would occur – not least as long as unemployment rates are rather high and interest rates historically low in the countries explored. In the following section the different assumptions with regard to the three circular economy components, enhanced material and energy efficiency and more rapid phase-out of fossil fuels, will be described.

⁵ Due to migration the population might increase somewhat more than that. In many developing countries the population grow at a rate as well.

⁶ 40% measured from the 2010-level in the developed countries which OECD forecast to grow the fastest, a little less if compared to today (2015). Economically troubled countries might not even achieve a GDP-per-capita-growth of a percent a year on average in the upcoming decade.

⁷ For instance: high unemployment, low interest rates for those who can borrow, a need for an economic injection to get the economy out of the risk of falling (back) into recession and/or deflation, and a need from the financial sector (especially insurance companies and pension funds) for new long-term bonds to invest in.

4.3 Three main decoupling pathways

As has been discussed already, decoupling can be pursued on several fronts. The ones chosen for this study are the ones most discussed in reports from the UN, the OECD, the World Bank, the EU and thus probably the ones most natural to pursue. A detailed description follows below:

The renewable scenario

Scenario 1: Increasing the ratio of renewable energy in the energy mix by halving the use of fossil fuels and substituting it by renewable energy alternatives.



It goes without saying that the five countries in the study will not obtain the same renewable energy mix; the composition will differ according to the respective natural resource endowments and opportunities for developing renewable energy.

The simulation of the halving of fossil energy use is made possible by modifying how the refineries, the utilities and district heating source their feed-stocks – halving their purchases of oil, coal and gas – and substituting those purchases with different kinds of renewable sources.

A country-by-country energy system analysis

In the case of Sweden it would mean going from today's 50% renewable share in the energy-system to close to 70% (excess heat from nuclear power disregarded, the ten Swedish nuclear power reactors, which are neither renewable nor fossil, make the Swedish renewable energy share somewhat tricky to assess). In Sweden fossil fuels would be substituted for by different kinds of biofuels, by electric power and potentially hydrogen, mainly from wind power plants and solar panels.

In the case of Finland it would mean going from today's around 35% renewable share in the energy system to a little above 50% (excess heat from the four – soon to be six - nuclear

power plants is disregarded). In Finland fossil fuels would be substituted for by different kinds of biofuels, the expansion of heat pumps and non-fossil electric power.

In the case of the Netherlands it would mean a huge step from around 5% renewables today up to around 50% in the energy mix. This large leap would require a large expansion of wind power, solar power, heat pumps, and maybe wave and tidal power, and, in addition, a large expansion of biofuels derived from municipal waste and residue materials from the agriculture and forest sectors. The more ambitious the energy efficiency target would be, complementing the renewable energy objective, the easier it would be to cut fossil fuel use in half.

In the case of France it would mean going from today's 15% renewable share in the energy system to close to 40% (excess heat from the almost 60 nuclear power disregarded). In France fossil fuels would be substituted for by different kinds of bio-fuels, heat pumps, electric power (and maybe hydrogen), mainly from wind power and solar panels. In the future tidal and wave power might also become an option.

In the case of Spain it would also mean a major increase in renewable energy - from around 10% renewables in the energy mix to around 50%. This large leap would require an expansion of biofuels from municipal waste and the agricultural, food, forestry, wood and pulp sectors, and a continued expansion of wind power, solar power and maybe in the future also wave and tidal power. Also in Spain an ambitious energy efficiency target would simplify the challenge to cut fossil fuel use in half.

Major renewable energy challenges

Going from a renewable energy share of 5-10% and up to 50% no doubt represents a challenge for both the Netherlands and for Spain. However, to meet the EU targets of GHG emission reductions by 80-95% by 2050 will require even bolder action from 2030 and onwards.

It might actually be more difficult for Sweden – as compared to the targets to be reached by the Netherlands and Spain - to reach a 70% renewable energy share to the year 2030 - from its current 50% level, as that will imply a significant reduction of the use of gasoline and diesel in transport, which thus far has proven to be difficult. This being said, the report in 2013 from Swedish Government Inquiry on transport fuels concluded that the opportunities to cut fossil fuel use in transport by up to 80% in 2030 were reasonably good. So cutting emissions by half in the transport sector cannot be seen as an unrealistic goal.

A good example of fuel substitution – which ought to be an inspiration for the other countries - is the way by which Sweden was able to phase out practically all fossil fuels from district heating since the early 1990s. The objective was primarily met through a combination of carbon taxes – to change the incentives structure - and the use of biomass residues from forestry and agriculture to replace oil and coal.

Generally speaking, the potential for expanding renewable energy in Sweden, Finland, France and Spain must be considered to be very good. In Sweden and Finland the prerequisites for further expansion of biofuels – notably from forestry residues, black liquor in particular – as well as wind energy are excellent. The same goes for CHP, Combined Heat and Power, from biomass. The potential for solar power is good in Sweden as well, in spite of the country's location.

Spain has the potential to become somewhat of a world leader in renewable energy. The conditions in France are almost as favourable. But having had access for many decades to a major nuclear power program, the transition to renewable energy has been slow. The potentials both for solar and wind energy are extremely good in both countries. The same goes for the potential in the future for wave and tidal energy. The potential for biofuels in many parts of Spain and France is good as well. But so far only a fraction of that potential is being utilized. Almost two thirds of Spain's electricity demand today is met through fossil fuels

The Netherlands faces the biggest challenge. One reason for the minimal contribution of renewable energy has been the country's possession of natural gas. The gas option is less and less favourable – both because of earth-quake risks and the fact that the gas supplies have reached their peak and are likely to produce less in the future. Energy security is emerging as a challenge. The Netherlands will eventually have to choose between gas imports from Norway, Russia and/or the Middle East or building up energy supplies based on renewable energy. The renewable options must be considered to be quite good:

Biofuels, starting from a low level, could be tripled in volume already up to 2020, provided the waste streams from agriculture – not least pig farms - could be turned into biogas. A transformation of the mainly fossil fuel-driven transport system to a transport system where public transport takes on a more significant role - and electric power replaces fossil fuels – is another option. Electric vehicles and potentially electric highways to service trucks between the largest cities and ports should be considered. Wind energy could be expanded on shore and off shore. One additional option would be to make use of the sea barriers and dykes. The barriers are optimal places to build wind and solar power. These installations could be complemented by pump systems to make use of excess wind and thus even maybe benefitting from small-scale hydropower. The sea barriers and dykes have to be invested in anyhow, to secure the lowlands from the rising sea levels. Wave and tidal power, once developed to scale, would suit the Dutch coast line well.

In summary, the main priority measures to be considered in all the countries examined to reach the target of halving fossil fuels use no later than 2030 are substituting gasoline in transportation with biofuels and electric vehicles and continuing the expansion of wind and solar energy for electric power.

Changes in this direction are already happening. Electric and/or hybrid cars are increasingly on the market, combining biofuels and electric power; in Norway, for instance, roughly 25% of all new vehicles sold are electric. The biofuels to be considered should primarily be from

2nd generation, in the case of Sweden mainly based on residue materials from the forest industry. Solar and wind – and soon wave power - will play an increasing role over time.

Positive developments in the area of energy storage, notably battery technology, will also help accelerate the transition to both a power system and a transport system less and less dependent on fossil fuels. The policy instruments that can be used are a combination of a strengthened emissions trading system, ETS, and carbon taxes, complemented by specific incentives for the required learning investments to materialise, like green certificates and feed-in tariffs, for solar and wave power.

The energy efficiency scenario

Scenario 2: Obtaining a more energy-efficient economy by becoming overall 25% more efficient as compared with primary energy demand for the year 2010.



This case is explored by reducing energy use across the board. It mostly concerns the demand side of the economy; how we light up things, how we get the temperatures right in the refrigerator, the oven, the bedroom, and the industrial processes, but also how we transport ourselves and all the goods we need. The measures needed are more or less the same in all countries examined and the strategies needed are discussed in national and EU energy efficiency directives.

In the Input/Output-model products and services offered from refineries and energy utilities are simply cut by 25%. The money saved from lower energy bills will be used to purchase energy efficiency equipment and advice. Total costs will stay the same, but a smaller share is spent on energy itself, and a larger share on energy efficiency related goods and services, such as engineering equipment and energy efficiency know-how.

Positive change is already happening in many areas, like more efficient lighting, more fuel-efficient engines, electric vehicles, zero or even plus energy buildings, vastly more efficient household appliances, etc. The sectors providing this know-how and technology, and the sectors installing it will be gaining market shares in this scenario. The digital revolution is underpinning much of the positive change. The Internet of things, IoT, connecting different kinds of products to the world-wide-web through mobile internet, will greatly enhance the potential of using both energy and materials more efficiently.

Furthermore, consumption patterns and habits are already changing. The evolution of the sharing economy, also made possible by the digital revolution, and the emergence of new business models where ownership of products is being replaced by renting and leasing, are significant examples.

The policy measures considered to reach the target – 25% lower energy use - in real life in 2030 could be a combination of taxation and regulation, such as CO₂ limits for new vehicles, stricter standards for insulation – both new and retrofitted buildings – as well as stricter energy efficiency standards for energy-use in all kinds of energy-related products. A special policy measure ought to be considered by introducing so-called *white certificates*, obliging energy companies to assist their customers investing in energy efficiency. Furthermore, research programs to help harness the opportunities for enhanced energy and resource efficiency through the digital revolution should be considered.

The material efficiency scenario

Scenario 3: Obtaining a more material-efficient, circular and performance-based economy by becoming 25% more material-efficient, substituting half of the virgin materials used with recycled materials, and doubling the product-life-time of long-lived consumer products.



This decoupling pathway, would of course take time to achieve; we believe, though, that a target date of 2030 is realistic. The goals would be made possible by incentivising material efficiency through a variety of measures – taxes, stricter recycling targets, limits put on waste

incineration and/or a tax on waste incineration, new business models which could be nudged ahead by for example enhanced producer responsibility obligations, proactive public procurement policies etc.

The main objective is to:

- **Use materials more efficiently**

In this case a doubling of the increase in material efficiency compared to BAU; from 1% historically to 2% per annum seen in the time perspective of 2030.

- **Enhance the use of secondary materials**

In effect substituting half of the virgin materials used today with recycled materials.

This is something many of the companies studied by the Ellen Mac Arthur Foundation have already succeeded to do.

- **Double the product-life of consumer goods**

Including the offering of high-quality services in the form of maintenance and repair.

This is a business strategy that is already being implemented by a number of leading companies, including *Rolls-Royce* selling power by the hour, not engines; *Michelin* offering tyres for trucks to rent, charging truck owners by kilometres used; *Xerox* selling copies made, not copying machines; *Houdini* offering sports equipment for rent, not for sale; *Digital Lumens* offering intelligent lighting systems for rent, not for sale, and *Volkswagen* and *Renault* taking back used engines and engine components, remanufacturing them and selling them as exchange engines.

In total, this means that companies purchase 25% less materials, replace half of their virgin material demand by secondary materials and design their products to be more easily maintained, repaired, upgradable, dismantled, reused and/or remanufactured. The financial resources saved by companies in the process will – in this simulation – be spent on enhancing material efficiency through consultancy work, efficiency-enhancing equipment, design, research and development etc. Similarly, the money saved by consumers not having to buy new products as often as before is spent on upgrading and maintenance services.

The recycling industries will experience an upswing. Their services will be much more in demand and the focus of their activities will broaden – from mainly being concerned about material recycling to the reuse and remanufacturing of products and components. Close partnerships with manufacturing industries will be developed to enhance recycling, reuse and remanufacturing and to help develop new business models, like renting and leasing of products instead of selling.

Over time the concept of a *performance economy* is likely to emerge. In such an economy the main interest of customers will be in high-quality services rather than in owning products. Selling performance will differ depending on the characteristics of the respective products. To offer performance is already part of today's economy; such as selling services by operating public and private networks, like railways, telecoms, motorways, airports, and business-to-business operations.

The challenge will be to step-by-step widen the concept and include an increasing number of consumer products. Incentives ought to be provided for manufacturers to design their products to last longer and to be designed so as to simplify dismantling; by so doing, revenue can be obtained much longer by preserving the quality, performance and value of the existing stock. Revenue will be earned by maximizing the value of the stock (the wealth), rather than by maximizing the flow, i.e. “selling more stuff”.

It is no doubt a simplistic assumption to anticipate that a 25% efficiency improvement in terms of material use – as well as a substitution of secondary materials for virgin materials and a doubling of the service life of products - can be obtained across the board in all sectors of the economy. There are on the other hand numerous examples of areas and products where the efficiency gains and the circularity can be, and already have been, pursued even further.

The same goes for the possibilities to extend the lifetime of different products. They do differ and are dependent, as well, on the intensity of use of a certain product is. But as an approximation the assumptions made for the modelling seems to be reasonable.

4.4 Significant results, both with regard to carbon emissions and jobs

The modelling exercise – based on structural changes as a result of supply chains becoming more renewable and resource-efficient - gave the following overall results, holding the production value constant to simplify comparison:

- The carbon emissions were significantly reduced – albeit to a different degree, depending on the decoupling pathways chosen.
- The effects on employment were also significant, i.e. the number of jobs in the economies studied increased, but also here to a different degree, depending on the decoupling pathways chosen.
- The trade balances were mostly positively affected, more in some scenarios than others, though.

The renewable scenario for all five countries led to an estimated 50% reduction in carbon emissions. That was expected, as halving fossil fuel use should have that effect. Actually the emissions came down with a little more than 50% in all the countries. Hence, renewable energy supply chains generally seem to be less energy- and carbon-intensive than the fossil fuel energy supply chain, otherwise the reductions would have been 50% exactly or less. There was in most cases no significant net effect on employment, unless domestic biomass would increase its market share proportionally more than other renewable energy alternatives to substitute for the fossil fuels.

However, the more the agricultural and forestry sectors would get involved in supplying the renewable energy, the more jobs would be created, and mostly in the rural regions, where unemployment often is higher than in urban areas. Up to 15,000 new jobs could in that case be created in Finland and Sweden, respectively, up to 50,000 jobs in the Netherlands, and up to 100,000 in France and Spain, respectively. Not least important, there would be a surplus in the balance of trade with a third to two-thirds of a percentage point of GDP in all the countries we have explored. As all of these countries are net importers of fossil energy, that was also an expected outcome.

The energy efficiency scenario is likely to cut carbon emissions in all five countries by roughly 30%. Here, the effect on employment would be positive and add new jobs in the range of 15,000 people in Finland, 20,000 people in Sweden, 100,000 people in the Netherlands and 200,000 people in France and Spain, respectively. The trade balance would be improved in most countries, but less so than in the renewable scenario. France and Spain had the largest trade surplus gains in the model runs at 0,4% of GDP. The job increase is partly temporary in nature. However, it would last for many years, probably a couple of decades, during which time the necessary investments in retrofitting of old buildings and other efficiency improvements are undertaken.

The material efficiency scenario is likely to cut carbon emissions in all the countries by between 3 and 10%. The gains in terms of employment would be more significant – representing more than 50,000 people in Finland and Sweden, respectively, more than 100,000 in the Netherlands, more than 200,000 in Spain and more than 300,000 people in France. The same goes for the trade balance – the estimated trade surplus improvement would be in the magnitude of 1-2% of GDP. The new jobs generated are permanent in nature, primarily as a consequence of the changes in the goods-to-services ratio in the economy.

If all the three decoupling strategies would be pursued together the results would be substantial. As the three decoupling scenarios support and enforce each other in virtuous circles – improved resource efficiency having energy efficiency effects, and enhanced energy efficiency making it much easier to increase the share of renewable energy (cut the use of fossil fuels) – the combined scenario will be far easier to pursue than any of the scenarios alone. Carbon emissions are likely to be cut by two thirds, and almost 70% in Spain, structurally⁸.

⁸ A circular economy (as it has been modelled in this report) would have less than one-third (up to almost minus 70%) of the carbon emissions compared to a “business-as-usual economy” of the same size; the business-as-usual-economy being the economy we have - a fossil fuel based and resource-inefficient economy. However, as an economy continues to grow due to a growing population and increasing per-capita incomes, the emissions will go up. That will happen as long as the decoupling-efforts do not keep up with the economic growth rate, also in a more circular economy, but in that case from a much lower level. This means that decreasing emissions will have to come from a development where the decoupling efforts always outperform economic growth, continuously.

The number of additional jobs would exceed 75,000 in Finland, 100,000 in Sweden, 200,000 in the Netherlands, 400,000 in Spain and half a million in France. This means that unemployment rates – compared to today - could be cut by a third in Sweden and the Netherlands, and possibly more, maybe even cutting unemployment in half - provided that some of the likely trade surplus gains would be used for investments domestically.

In Spain the unemployment rate is likely to be reduced from the current over 20% to somewhere close to 15%, in Finland unemployment would be cut by a third, and in France by almost a third, provided that some of the likely trade surplus gains would be used for investments domestically.

The improvement in the trade balance would be around 1,5% of GDP in all of the European countries – representing a few billion euros a year in Finland, more than five billion euros a year in Sweden, about 15 billion euros a year in the Netherlands, around 20 billion euros in Spain and about 50 billion euros in France. It should be noted, however, that there would be no trade balance gains globally. Some countries, especially fossil fuel and virgin material exporters, would tend to lose.

Moving in the direction of enhanced resource efficiency, especially the attempts to enhance reuse and recycling of materials and extending wealth (product-life extension), will result in a change in the *goods-to-services ratio* of any given economy. This, no doubt, is a major reason behind the gains in employment.

An economy favouring reuse and recycling of materials as well as product-life extension, by definition, is more labour intensive than one based on a *disposal* philosophy, i.e. linear resource flows. The main reason is that caring for what has already been produced, through repair, maintenance, upgrading and remanufacturing, is more labour-intensive than both mining and manufacturing.

4.5 Results country by country presented in tables

Results for Sweden in a *what-if*-40*40-sector IO-model-analysis:

	Renewable Case	Energy Efficiency	Material Efficiency	All Three Combined
Emission Reduction	- 50,1%	- 28%	- 5%	- 66%

Additional Jobs	Up to 15,000 ⁹	+ 20,000	+ > 50,000	+ > 100,000
Trade Balance Effects	+ 0,4 of GDP	No change	+ > 1 % of GDP	+ > 1,5 % of GDP

Swedish unemployment is 7-8% today, which represents slightly more than 400,000 people. The current account is running around a 5% surplus since many years.

Results for Finland in a *what-if-40*40*-sector IO-model-analysis:

	Renewable Case	Energy Efficiency	Material Efficiency	All Three Combined
Emission Reduction	- 50,1%	- 32%	- 4%	- 68%
Additional Jobs	Up to 15,000*	+ 15,000	+ > 50,000	+ > 75,000
Trade Balance Effects	+ 0,5 of GDP	No change	+ > 1 % of GDP	+ > 1,5 % of GDP

Finnish unemployment is 8-9% today, which represents slightly more than 300,000 people. The current account is more or less balanced since a few years.

Results for the Netherlands in a *what-if-40*40*-sector IO-model-analysis:

	Renewable Case	Energy Efficiency	Material Efficiency	All Three Combined
Emission Reduction	- 50,2%	- 31%	- 3%	- 67%
Additional Jobs	Up to 50,000*	+ 100,000	+ > 100,000	+ > 200,000
Trade Balance Effects	+ 0,3 of GDP	+ 0,2 of GDP	+ > 2 % of GDP	+ > 2,5 % of GDP

Dutch unemployment is around 7% today, which represents slightly more than 600,000 people. The current account is running a large surplus, sometimes close to 10% of GDP, since a few years.

Results for France in a *what-if-40*40*-sector IO-model-analysis:

	Renewable Case	Energy Efficiency	Materia Efficiency	All Three Combined
Emission Reduction	- 50,1%	- 28%	-5%	- 66%
Additional Jobs	Up to 100,000*	+ 200,000	+ > 300,000	+ > 500,000

⁹ * Concerning all countries the net employment effect in the renewable case was insignificant or low (10,000 in the Netherlands). However, if the agricultural and forestry-sectors increase their market share of supplying renewable energy more jobs would be created. Many of the other ways of supplying electricity and renewable fuels (hydrogen) do not seem to add significant amounts of net jobs compared to supplying fossil fuels (even if the fossil fuels are imported to a large extent). The reason might be that in the construction phase solar and wind provide a lot of installation-jobs, but then in the use-phase, delivering energy, they are rather labor-extensive.

Trade Balance Effects	+ 0,4 of GDP	+ 0,4 of GDP	+ > 2 % of GDP	+ > 2,5 % of GDP
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French unemployment is around 10% today, which represents around 3 ½ million people. The current account is presently balanced after having had a slight deficit the last decade.

Results for Spain in a “what-if”-40*40-sector IO-model-analysis:

	Renewable Case	Energy Efficiency	Material Efficiency	All Three Combined
Emission Reduction	- 50,1%	- 31%	- 10%	- 69%
Additional Jobs	Up to 100,000*	+ 200,000	+ > 200,000	+ > 400,000
Trade Balance Effects	+ 0,7 of GDP	+ 0,4 of GDP	+ > 1 % of GDP	+ > 2 % of GDP

Spanish unemployment is above 20% today, which represents more than four million people. The current account has come back closer to balance after having had deficits for many years, especially during the period after the 2008 crisis.

4.6 Other studies confirm the results

While finalizing this report a study was published in the UK by two British research groups, WRAP and Green Alliance, using a similar Input/Output-methodology to explore the employment effects in the UK of a more ‘circular economy’, i.e. keeping products and resources in use for as long as possible through recovery, reuse, repair, remanufacturing and recycling.

Modelling a modest increase of the already existing tendencies of reuse, repair and recycling in the UK would create over 200,000 gross jobs and reduce unemployment by about 50,000 by the year 2030 in the UK.

A more rapid development towards a circular economy could, according to another modelling scenario in the same study, create around half a million jobs, gross, and reduce unemployment by around 100,000. When analysing the employment opportunities the study identified an extra bonus effect: regional unemployment disparities may be reduced by the fact that a circular economy would offer a broader geographical spread of employment opportunities as compared with an economy based on more linear material flows.

Furthermore, the present occupational mismatch in the economy may be reduced by a higher degree of circularity by creating new opportunities across all skill levels. A more comprehensive development of the circular economy, involving more remanufacturing, services and repair, could also create additional employment near existing manufacturing sites where unemployment – partly as a consequence of automation and robotization - tends to be higher.

In their recently published report *Growth within*, the Ellen Mac Arthur Foundation and McKinsey have reviewed 65 scientific papers and concluded: “*while more research is needed, existing studies point to the positive employment effects occurring in the case that a circular economy is implemented*”. The most cited reason behind this effect is that enhanced resource productivity means lower demand for resources.

This leads to two types of savings: Smaller volumes of materials being purchased save money for the buyer, and the lower demand tends to lower the price per unit of materials used. Less financial resources spent on materials means that resources are freed up to be spent on other things. As resource extractive sectors usually have low labour intensities, employment figures tend to come out higher if the money saved is spent on other things than buying virgin materials.

In a study at the EU-level about the likely effects of a higher resource productivity target, a 2-2½% yearly increase in resource productivity was shown to have the best economic outcome. An estimated two million new jobs would be created according to the “Study on modelling of the economic and environmental impact of raw material consumption” by Cambridge Econometrics (2014).

In a Dutch report “Opportunities for a circular economy in the Netherlands” (TNO, 2013) the potential and possible gains for 17 product categories (mostly metals and electronics) and 34 waste streams (where bio-refineries and biogas extraction were mentioned the most) were explored. Today these product groups and waste streams represent a little more than a percent of the Dutch Economy. The study came to the conclusion that more than 50,000 new jobs were to be created by expanding the circular economy from its current state, by exploiting the opportunities shown for the 17 product categories and the 34 waste streams alone.

4.7 Winners and losers in a more circular economy

The move towards a more circular economy will result in the creation of new jobs in many sectors of the economy. However, economic activity and employment will also shrink in absolute terms in a few sectors. In the renewable energy scenario, sectors/subsectors being able to offer increasing volumes of biofuels – like agriculture and forestry - will gain market share. The same goes for construction and sectors/sub-sectors providing components to the wind power plants and solar panel installations. As electric vehicles will increase in volume, wind power plants, solar panels and other renewable sources will increasingly cater to the energy needs of the transport sector. Mining and quarrying will lose, but those effects on Sweden and Spain are rather limited as they produce no or only rather small volumes of fossil fuels. In the Netherlands, the natural gas sector will lose out. However, as coal and oil are dirtier fuels, the domestic drop in demand might actually be compensated by other countries wanting to substitute their current oil and coal use with Dutch gas.

In the energy efficiency scenarios, fossil fuel providers will also suffer from lower demand. But also providers of renewable energy might be affected. The sectors offering energy efficiency know-how and technology, and installing it, will gain market shares. The construction sector, retrofitting old buildings and helping energy-users to put all kinds of energy efficiency equipment in place, will also benefit. One way for energy companies to compensate for the shrinking business opportunities would be to broaden their business approach and assist customers in making energy use more efficient.

In the material efficiency scenarios, a great number of sectors are impacted. Enhancing material efficiency implies using less materials, as well as increased demand for secondary materials and life time extension services for durable goods. Sectors offering virgin materials will experience lower demand. The same goes for sectors offering durable goods. Winners, on the other hand, will be activities like recycling and remanufacturing, service companies offering know-how and technology making material-efficiency possible. Service companies providing intelligent design, maintenance, repair and upgrading services for durable goods and helping to extend the product lives will be clear winners.

Most probably companies selling fewer but more long-lived products, will in addition provide repair and maintenance services in-house, offering service contracts at the point of sale. Another option would be to lease out the products with the services as part of the deal. Swiss army knives and other quality products already offer such service contracts and leasing a car over several years will have maintenance service included. These kinds of arrangements will probably apply to an increasing number of products and services in the future.

If the three decoupling scenarios are addressed in tandem, some sectors come out really well, while others lose business opportunities on several fronts, even in a growing economy. Altogether activities like recycling, maintenance and repair will grow the fastest and may actually double in size.

The companies providing services and know-how on how to make efficiency gains possible will grow significantly in size, perhaps as much as 50%. The construction sector is likely to increase by around a quarter in size. Many of the structural changes taking place in moving to a more circular economy involve rebuilding and retrofitting existing constructions, as well as building new ones – like solar panel roofs.

All primary sectors engaged in commodity extraction and trading are likely to lose market shares, especially those engaged in fossil fuel-based and mining activities. A circular economy will almost by definition have that effect. Sectors offering durable goods are also likely to see their sales being reduced as the products become even more durable.

For some of these sectors the way to continue earning as much or more revenue will be by developing new business models, offering leasing as well as providing repair, maintenance and upgrading services, as discussed above. Concerning sectors exporting durable goods, they will have to explore cooperation with foreign service companies to be able to offer maintenance, repair and upgrade of their products also outside their domestic markets. This is

already a trend for selected multinational companies selling high-quality expensive goods. One most prominent example is the telecom sector.

As mentioned before, market forces are not likely to move towards a more decoupled structure of the economy by themselves. In real life a move towards a more circular economy would require a set of policy measures – a combination of regulation and economic instruments as well as significant investments in infrastructure, construction and manufacturing aiming at reducing the energy and material throughput in society. In the upcoming sections such investments and policies will be discussed in more depth.

4.8 A transition to a circular economy will require an investment boost

The movement towards decoupling and a circular economy will require a significant boost in terms of investments. The investments required will temporarily increase economic activity and employment. Different types of emissions would initially also increase due to the increased economic activity, but less and less so as the new, much more resource efficient structure of the economy comes into play.

In the longer time perspective, after all the investments are in place and the incentivising policies have had full effect, the economies would be more energy-efficient, more material-efficient, or thrifty, more circular in their material use, more performance-oriented (companies increasingly offering high-quality products as services) and progressively based on renewable energy.

The extra investments required – in addition to the *normal* level of investments - for moving towards a circular economy have in this modelling exercise been estimated to be in the range of 3% of GDP per annum, from now on until 2030. This would mean bringing investments up to a level similar to the level in most European countries during the economic transformation after the Second World War.

For most industrialised countries today, including Finland, Sweden, the Netherlands, France and Spain, the investment share of GDP today is around five percent lower than during that period. Investments have gone from being in the range of 25 % of GDP during the 1950's and 1960s to a level closer to - or even below - 20 % of GDP today.

Spain has been somewhat of an exception, maintaining an investment share above 20 % of GDP in recent decades, primarily due to a later start of the modernisation process than in other parts of Europe and having benefitted from significant EU regional funds as a new member of the EU. The real estate boom preceding the 2008 crisis, after which Spain's investment share fell well below 20%, also played a role.

3 % of GDP equals about half of the present Swedish balance of payment surplus, and actually less than a third of the Dutch balance of payment surplus. In Finland, France and

Spain the situation is a bit different. These countries have recently been able to balance their balance of payment after years of economic downturn and hence deficits. Consequently, these countries would have to look for financing elsewhere than from trade surpluses. EU funding ought to be a possibility – in terms of access to the structural funds as well as the newly established European Fund for Strategic Investments, EFSI.

The investments required will primarily happen in the very sectors that matter most for reaching the decoupling objectives described above: agriculture, forestry, installation services, mobility, construction/renovation, maintenance and repair, recycling and engineering services. Some investments will also have to be directed towards education and employment services in order to make the labor force ready to take on the new tasks required in the *new* economy.

4.9 The investments needed boost for the economy

Running an investment package of the magnitude described above through the Input/Output-model gives the following results:

Out of every million euros invested in open economies like the Netherlands, Sweden, France, Finland and Spain, between a quarter and a third leaves the country immediately in the form of orders to foreign companies (imports). The more open the economy, the higher the ratio. The foreign companies in their turn rely on their contractors, many of them being foreign companies as well.

Furthermore, of the around two-thirds of the investments initially resulting in orders to domestic companies, a significant part also results in production abroad as the domestic firms partly rely on imports in their supply chains. Thus, an investment initiated in one country typically leads to as much business activities abroad as domestically.

As the companies receiving the investment orders have to buy goods and services from others, both from domestic and foreign firms, the total economic activity stemming from the investment will be much higher than the investment itself, *the so-called multiplier effect*.

In the Netherlands, Finland, Sweden and France the multiplier effect of the investments proposed in this study turned out to be slightly higher than two, and in Spain the multiplier turned out to be in the range of two and a half. Hence, for every extra million euros invested, a little more than two million euros - an in the case of Spain, up to two and a half million euros - worth of economic activity would be expected.

In the case of Sweden a suggested circular economy investment package of 12 billion euros per annum (3% of GDP) would normally lead to a total production in Sweden worth close to 14 billion euros due to the initial investment made. The total economic activity in other countries due to orders linked to the initial Swedish investments would be around 13 billion euros.

Summing up, an extra Swedish investment of 12 billion euros is expected to lead to an increase in economic activities of in total 27 billion euros, equalling a multiplier of a little more than 2. In Sweden employment would increase by 80,000 people due to the investment injection. Pollution of different kinds would go up as well during the construction phase.

However, the long-term effect of investing in a more sustainable energy and transport system would lead to radically lower emissions. Consequently, letting the investment package aim towards the development of a more circular economy - instead of the current linear economy - would result in much lower pollution levels over time.

In Finland, which in many respects has an economic structure similar to the one in Sweden, the effects would be similar. As the Finnish economy is only half the size of the Swedish one, an extra circular-economy investment package would be around 6 billion euros. The investment package would lead to around 15 billion euros worth of economic activity, of which approximately half would take place in Finland. Around 40,000 extra people would be employed in Finland as a result of the investments.

In the Netherlands a circular economy investment package of 20 billion euros per annum (3% of GDP) would lead to domestic production worth a little less than 20 billion euros and to imports, i.e. production in other countries, worth almost 25 billion euros. Also in the Netherlands the initial investments made would result in more than twice as much economic activity, but being a trade hub, more than half of that would take place abroad.

In the Netherlands employment would increase with an estimated 100,000 people domestically due to the extra investment package. Over time, employment gains due to the investments made will increase somewhat while emissions would come down significantly and the import fractions would decrease somewhat. Such tendencies are obvious in the modelling results of all the countries studied, but they are most significant in the Netherlands.

In Spain a circular economy investment package of 30 billion euros per annum (3% of GDP) would lead to domestic production worth almost 45 billion euros and to imports, i.e. production elsewhere, worth almost 30 billion euros. Thus, the multiplier effect in Spain is a little higher, the main reason being that the economy is not as open to foreign trade as countries like Sweden, Finland and the Netherlands. That means that the domestic benefits for Spain are even larger than in more open economies. One indicator is that the employment increase in Spain from the investment package is estimated to be in the range of 350,000 new jobs.

In France a circular economy investment package of 60 billion euros per annum would have effects like the ones in the Northern European countries. The French economic structure and the French trade pattern are more like the open Northern European countries as compared to the Mediterranean countries, but being such a large economy in itself, France is not as dependent on trade as small, open economies like Sweden. The total economic activities coming out of an investment package of 60 billion euros would come close to 130 billion

euros, of which around 70 billion euros would take place domestically, employing more than 400,000 people in France.

As the EU countries trade mostly within the EU Single Market – i.e. with other EU member states - a coordinated investment action plan among several EU member states would boost economic activity and employment in all EU countries. EU member states with a surplus trade balance could do economically troubled member states a great favour by not only making investments domestically, but also abroad. Many of the benefits – environmental, economic as well as social - would not only favour the people in the countries where the initial investments were made, but also in the neighbouring countries and other trading partners.

A more circular economy would also result in making some supply chains more regional. Biomass and electricity will not be traded as global goods, like oil for instance.

Furthermore, EU as a whole imports most of its oil and gas. With regard to resources like biomass many member states are more or less self-sufficient. The potential to expand both wind and solar is equally good in most of the member states.

Finally, with regard to secondary materials, member states would be able to rely on their own or neighbouring EU countries's supplies to a large extent. All this means that a move towards a more circular economy will redirect significant parts of the trade patterns in favour of regional trade.

4.10 Necessary investments

The investment level is one important feature. Even more important is of course what kinds of investments being aimed at. An attempt has been made to estimate broadly what types of investments will be required from now on to 2030 to move the economy towards the desired decoupling objectives.

The authors of the study are for obvious reasons more familiar with the Swedish economy and do not possess the same in-depth knowledge of the Dutch, Finnish, French and Spanish economies. This may make the discussion on investments and investment needs a bit biased and give greater detail and specificity to the Swedish situation.

This being said, however, the general requirements in terms of investments to bring about the necessary transformation to a circular economy are very similar in the countries subject to this report and, for that matter, in most industrialised countries.

The report will use Sweden as an entry point and broadly sketch what the required investments are. In relation to the size of the Swedish economy, the Finnish economy is half as large, the Dutch economy is roughly 60 % larger than the Swedish one. The Spanish economy is about two and a half times larger, and the French economy roughly five times bigger than the Swedish one. Here follows a set of proposals of the investments required in Sweden – with some comments on the investment requirements in the other countries as well:

Extension of the *electric power grid, including smart grids, solar power, wind power, charging stations for electric vehicles*, EVs, etc. The cost estimated for Sweden is in the range of 20-30 Billion euros in total up to the year 2030, out of which the private sector is assumed to provide half of the investments.

Increased investments in *railways*: In Sweden it might sum up to an investment need of around 50 Billion euros in total up to the year 2030. The Swedish government has already allocated 15 Billion euros for this purpose. The 50 Billion euros figure does not include high-speed trains.

Greatly extended *public transport and commuter services*. In Sweden this will require an estimated 15 Billion euros in total up to the year 2030 (out of which roughly half of the amount is likely to come from the ordinary budget process).



The electrification of parts of the road network for freight traffic, so-called e-Highways. Several technical options, including overhead contact lines, magnet technology, etc, are being discussed. The investment required in the next fifteen years is estimated to be in the range of 25-50 Billion euros in Sweden, giving priority to the main highways and connections between the largest cities. In the Netherlands the distances are shorter and the benefits of such investments are more profound due to the density of the population.

The *vehicle fleet* has to be renewed, whether we speak of hybrids, EVs or biofuel vehicles. The cost is difficult to estimate, not least because of the significant cost reductions to be expected in renewable energy, in particular solar and battery technology. The vehicle fleet in Sweden comprises some five million vehicles. Most of these vehicles will have to be replaced during the next 15-20 years. The extra cost as a consequence of the need to reduce significantly the dependence on fossil fuels may amount to 1-2000 euros per vehicle, i.e. 10 Billion euros in total. Including heavy vehicles another 10 Billion euros has to be added.

The development of *bio-refineries* – in the range of 25-50 Billion euros in Sweden in total up to the year 2030 - to produce second-generation biofuels. In Sweden and Finland the production of biofuels would primarily be based on residue materials from forest products. In

the Netherlands the biofuels would be derived primarily from farming residues, the food industry and municipal waste.

In France and Spain, strategies to make best possible use of residues both from farming and forest systems could be pursued. The private sector involvement in these kinds of investments will be dependent both on R&D support from the public sector and the incentives provided through the climate policy, especially the level of carbon taxes.

Energy efficiency improvements within industry is another important area. To estimate the costs, however, is difficult. The payback time for most energy efficiency investments tends to be short. The pace of investment is most often slow, however, the main reason being lack of information. Hence the need for well-targeted information programs. Such a state-funded program run by the Swedish Energy Agency was recently successfully implemented within parts of the manufacturing industry in Sweden, not least because of a parallel introduction of tax breaks for companies implementing energy efficiency measures.

The overall costs of energy-efficient improvements tend to be modest. Given the ambition to accelerate the pace of efficiency measures the additional investment for the period 2015 to 2030 can be estimated between 10 and 20 Billion euros. The cost tends to increase towards the end of the period when most *low-hanging fruits* have been harnessed.

There should be a lot of opportunities for inexpensive energy efficiency investments in Spain – a major reason being that the energy efficiency measures in the Spanish economy have been modest in the past. Unlike most other industrialised countries – where energy intensity has been on the decrease ever since the oil crises in the 1970s - energy intensity in Spain in fact *increased* by 1% per annum until recently.

However, since the launch of the EU Lisbon strategy in 2002, the Spanish economy has done considerably better when it comes to incentivising energy efficiency investments. EU policies have contributed to this development through a number of EU directives aiming at enhancing energy efficiency in the Member States. To achieve a 25% increase in energy efficiency no later than 2030 – the assumption in this study - will require a 2% improvement per year. Some EU Member States are already close to achieving the 2% target.

Looking at Finland, France and the Netherlands, none of these countries have been champions of energy efficiency in the past. This means that there ought to be a lot of low-hanging fruit in this area in these countries as well.

Energy efficiency standards and norms for new buildings have been gradually strengthened in the EU in recent years through the Energy Performance of Buildings Directive and the Energy Efficiency Directive. Some provisions in relation to major renovations of old buildings have also been agreed upon. However, much has to happen with regard to the energy performance of old buildings – not least in Member States where fossil fuels still dominate the heating sector. But also in countries like Sweden, where carbon taxation has led to major substitution in terms of energy supply, there is a need to promote energy efficiency vigorously. The biomass saved can and should be used for other purposes.

In Sweden it is estimated that the necessary *retrofitting of old buildings* – for a number of reasons, social as well as environmental – would amount to 150 billion euros over the next decades. Around 50% of those costs would have been incurred at any rate. So the additional cost as part of the decoupling objectives would amount to 75 billion euros. It should be noted, of course, that part of the investment cost would be offset by considerably lower costs for heating and cooling in the years to come.

The necessary retrofittings in commercial buildings are easier to implement – the buildings are younger and easier to retrofit, the commercial motive stronger and rents easier to adjust.

One general comment could be made with regard to the investment challenges: Countries lagging behind on technology adoption in certain areas are not inhibited by entrenched intermediate technology. The opportunities to accelerate economic development through advanced and less costly technologies seem attractive.

4.11 Decouplings up to and beyond 2030

If the countries examined would make all the investments along the lines proposed, they would probably not only reach - but move beyond - the efficiency and renewable energy targets established for this study. This would be a more than satisfactory outcome. However, it should be recalled that the expected 70% reduction in carbon emissions resulting from the decoupling pathways in this study would only be a necessary first step in the overall efforts to avoid dangerous climate change. The emissions reductions in the longer-term perspective must go much further.

The decoupling pathways are not implemented in a vacuum. All of the countries examined will undergo major changes in the years leading up to and beyond 2030. Populations will grow and the same goes for average income. The combined effect is likely to be a significant increase in economic growth. As a result carbon emissions will rise – albeit at a lower pace and from a lower level than before.

The expected population increase in Sweden would raise carbon emissions until the year 2030 by an estimated 15%. Furthermore, the increase in affluence, GDP per capita, partly given a boost by the investment packages described above, is likely to increase Swedish carbon emissions by another 30% or so. Hence, the combined effect from a growing population and increased affluence would be an increase in carbon emissions compared to today by around 50%.¹⁰ This means that policies to stimulate the T factor in the IPAT equation – i.e. technology and behaviour – have to be very strong and consistent. If the goal is to bring about absolute decoupling – and move towards zero emissions – technology and behaviour

¹⁰ Calculation: $1,15 * 1,30 = 1,50$; i.e. a 50% increase. Data on population is derived from the UN; data on economic growth (forecasts) from OECD; data on technology partly derived from the World Bank (concerning historical data), partly from our own modelling (forecasts).

change have to take place twice or even three times as fast as the growth of the economy. Luckily there appears to be quite a number of promising ways to improve on the technology factor.

According to the model-runs in the study, the results in terms of carbon emissions reductions were roughly the same in the five countries being examined:

In Sweden the renewable energy scenario brought about an estimated 50% reduction, the energy efficiency scenario a 28% reduction and the material efficiency scenario a 5% reduction, which in total would bring about a reduction in the carbon emissions of around two-thirds ($0,50 * 0,72 * 0,95 = 0,34$) i.e. a 66% decrease. In France carbon emissions were expected to decrease by in total 66%, in the Netherlands by 67%, in Finland by 68%, and in Spain by 69%.¹¹

As a consequence of growing populations and economies, however, the net effect in terms of emissions reductions would be considerably lower up to the year 2030:

In the case of Sweden the total effect from the combination of the growing population, the increasing average income (affluence) and the technology factors enhanced by the circular economy policies (Population-change * Affluence-change * Technology-change = Emission-change) will be that the emissions in 2030 will be 49% lower – not 66% as a result of the decoupling pathways proposed - than in the year 2010. That is if all decouplings we have modelled come true, and the demographic and economic forecasts from the UN and OECD respectively are reasonably correct. In the other countries, with their forecasted increases in population and GDP-per-capita, the same kind of calculations result in that the emissions in France will decrease by 51%, in the Netherlands and Spain by 54,5% respectively, and in Finland by 55,5% until 2030.¹²

To meet the long term climate policy objectives, which according to the IPCC will require close to zero carbon emissions for EU member states in 2050, the technology factor in the IPAT equation will have to deliver significant results. For instance, to be able to reach a level of per capita carbon emissions of no more than 1 ton per capita in 2050, the emissions reductions after 2030 would in fact have to be significantly higher than the expected results of the decoupling pathways pursued for the period leading up to 2030. The implication is that the contribution from technology and behaviour change would have to lower carbon emissions by 7-9% per year to offset a growing economy and population. Only then would the net emissions reduction be in the range of the required 5% per annum.

¹¹ In France the different technology factors result in ($0,50 * 0,72 * 0,95 = 0,34$) a 66% decrease. In the Netherlands ($0,50 * 0,69 * 0,95 = 0,33$) a 67% decrease. In Finland ($0,50 * 0,68 * 0,95 = 0,32$) a 68% decrease. In Spain ($0,50 * 0,69 * 0,90 = 0,31$) a 69% decrease.

¹² In Sweden the PAT-multiplication gives ($1,15 * 1,30 * 0,34 = 0,51$) a 49% reduction. In France ($1,10 * 1,30 * 0,34 = 0,49$) a 51 % decrease. In the Netherlands ($1,05 * 1,30 * 0,33 = 0,455$) a 54,5 % decrease. In Spain ($1,05 * 1,40 * 0,31 = 0,455$) a 54,5 % decrease. In Finland ($1,05 * 1,30 * 0,32 = 0,445$) a 55,5 % decrease.

In countries anticipating higher population growth and/or a higher rise in affluence (GDP/capita) the demands on technology and behaviour change would be even higher than in the countries discussed in this report.

The main focus in this report has been on carbon emissions. To reduce emissions from other greenhouse gases, like methane and nitrous oxide, might prove even more difficult. Such emissions are primarily associated with land use and food production, and may be even more difficult to curb than carbon emissions as explored in this report.

4.12 The realism behind the proposed decouplings

If the assumptions made in this study – i.e. greatly enhanced energy and material efficiency and the phasing out of fossil fuels - had been made only a decade or two ago they would have been looked upon as both unrealistic and, not least, outrageously expensive. However, since the turn of the century, energy markets have undergone somewhat of a revolution. The learning rates for solar and wind sources are extraordinary – far larger than for different fossil fuel plants, not to speak of nuclear, where learning rates presently seem to be negative from a cost-perspective, partly due to increased security requirements. In many locations solar power is comparable to conventional power and with learning rates still being positive there is no reason why the solar revolution should not continue. The picture is roughly the same for wind energy.

For most materials real prices were falling for most of the 20th century. Around the turn of the century, not least as a consequence of rapid growth in the emerging economies, most commodities underwent major price hikes. However, as a result of the financial crisis, the slowdown of the global economy, and most recently significantly lower economic growth in China, prices are lower again. However, given growing economies and populations over the long term, few analysts predict anything but rising prices in the years to come.

Productive land is becoming increasingly scarce. Water tables are falling. Climate change is making matters worse, leaving dry areas even drier. Deforestation is still a huge problem. Most of the high-grade mines have already been exploited. Oil exploration is happening further off shore, further up north, in deeper locations and further below the bottom of the ocean. As a consequence, it will become increasingly difficult to supply today's mostly linear economies with different kinds of natural resources at affordable prices. Add to that the increasingly negative effects of many forms of material extraction on biodiversity and ecosystem services.

Population factors should not be overlooked. The latest UN forecast tells us that a stabilization of the world population may not be possible below 11 billion people, a significant revision upwards compared to previous estimates. Moreover, OECD estimates there will be 1-3 billion new middle income takers until 2030. Natural capital – both from the point of view of its source and sink functions - will no doubt become increasingly scarce.

Due to all these current trends, material efficiency in all its aspects will no doubt be more attractive to the business community than before. Decision-makers in both politics and business have thus far been slow in responding both to the risks of pollution and resource constraints. This is likely to change, however. COP 21 in Paris is one important meeting where steps towards a more resource-efficient economy are likely to happen. Climate change mitigation strategies so far have been dominated by sector studies. Limited efforts have been made to look at the overall industrial metabolism in society, i.e. the energy and material throughput. This study and several others will hopefully make it abundantly clear that the policy scope must be widened and that the dual approach of both energy and material efficiency would lead to larger reductions in carbon emissions than conventional strategies.

What role may the private sector play in the transition? The business community was the inventor of today's linear systems of production and consumption – “*take, make and dispose*” in the words of Ellen MacArthur. Increasingly, however, many large corporations are developing a different logic - adopting the principles of a circular economy. In the Ellen MacArthur Foundation Circular Economy 100 network, corporations like Phillips, Unilever, Cisco, Renault, H&M and IKEA now work closely together to develop business models geared to the concept of a circular economy. This work is being supported by some of the leading management consultants and auditing firms, like McKinsey, Accenture, KPMG, Deloitte and Boston Consulting Group.

What role may consumers play in the necessary transition? Is increased consumer awareness likely to be of any help in the move towards a more circular economy? Old habits die hard, and the structure of the linear economy is what consumers usually meet when they go shopping. However, a few generations back material efficiency was a necessity - and still is in many rural areas and, indeed, in many parts of the mega-cities in the developing countries.

A positive sign is that many young people in industrialized countries seem to be ready for a major shift in consumer behavior. They seem to be less interested in ownership of various things; rather benefitting from renting and high-quality services. Virtual services are in high demand and a concept like the sharing economy is making strong inroads, witnessed by the emergence of companies like Airbnb, Uber, etc.

Parallel to rethinking business models and product design in industrialized countries vigorous efforts must be made to encourage developing countries not to get stuck in the carbon economy and not to get stuck in *the take, make, dispose economy*. The most natural choice for them ought to be to leapfrog to the circular economy. This, however, has not been the major subject of this report.

To summarize, the accelerating technological development, market forces changing relative prices, and a stronger political determination to curb GHG emissions and ecosystem decline will most probably all contribute to making the decoupling's proposed and tested in this study more likely to come true.

5 Conclusions and Policy Measures

When discussing the various decoupling strategies above, a significant number of policy measures were suggested in order to promote the move towards a circular economy. Some of these policy measures are already being implemented, such as subsidies to promote investments in renewables, emissions trading, ETS, to curb CO₂ emissions from power production and energy-intensive industries, energy efficiency standards etc.

The Barroso Commission in its proposal in June 2014, the Circular Economy Package – which was withdrawn by the Juncker Commission - did include a series of policy measures aiming at enhancing resource efficiency. The main focus was on improving waste management, such as stricter standards for recycling and reuse, ban on landfilling, reducing food waste etc.

All these proposals merit support. But they fall far short of what would be required to pursue decoupling at its full potential and achieve the EU 2050 vision of *living well within the limits of the planet*. As recognized in the EEA report from March 2015 *The European Environment – State and Outlook 2015*, stricter rates for recycling and reuse are important, but unless complemented by more thorough measures they will not be able to fundamentally change direction from linear to circular material flows.

Policy interventions needed to move towards a circular economy include everything from the introduction of principles for product design and changes in the eco-design directive to the greening of public procurement and the introduction of economic incentives to help enhance resource efficiency. The EU Commission would be wise to examine all these policy options in the preparations of the revised Circular Economy Package.

In addition to the policy measures already touched upon, specific resource efficiency targets for materials where scarcity looms or where the overall environmental impact of resource extraction and use is significant ought to be considered.

Furthermore, considerable efforts should be made at the European level to help stimulate the development of new business models – moving from selling products to offering high-quality services. Such business models are by far much more resource-efficient, less polluting and labor-intensive than today's linear economy.

At Member State level taxation systems should be reconsidered. The main rationale for such efforts is a) the fact that labor in most Member States is heavily taxed, which is increasingly problematic, not least in an increasingly digitized economy, and b) natural resources are being used in a very wasteful way and without paying the full costs of their extraction and use. The end result is economic loss, depletion of natural capital, pollution and missed opportunities in terms of employment.

To move society towards sustainability – both socially and ecologically - would require a tax shift, lowering taxes on work and increasing taxes on the consumption of non-renewable resources in the form of materials and fossil fuels. Such a tax shift would accelerate the

transition to a circular economy, which is low-carbon and resource-efficient in nature. As expressed by Walter Stahel:

"A circular economy increases employment because less than a quarter of the labor input to produce a physical good is engaged in the fabrication of basic raw materials such as cement, steel, glass and resins, while more than three quarter are in the manufacturing and service phase. The reverse is true for energy inputs: three times as much energy is being used to extract virgin or primary materials as is being used to manufacture products from these materials. Substituting reused components and goods for primary materials therefore uses less energy but provide more jobs."

While manufacturing in recent years requires less and less manpower, all the services built up around a product in a circular economy - everything from sustainable design, to maintenance, upgrading, repair and reuse - requires more, rather than less labor than today.

Parallel to this necessary tax shift, the system of VAT should be carefully analyzed. Goods produced by secondary materials – where VAT has already been paid once – should be exempted from VAT. Such a reform would promote the use of secondary materials and help correct a situation where it is often less expensive to use virgin materials than recycled ones.

Yet another policy measure to consider would be so-called white certificates for the promotion of investments in energy efficiency. Such certificates could be traded on a market like emission rights or renewable energy certificates.

The European Commission will soon be releasing its new proposal on the Circular Economy. Parallel to that government will conclude their preparations for COP 21 in Paris. The Paris meeting will be of great importance. But just as important will be the follow-up to Paris, as countries move to start implementing recently adopted emission reduction targets. Hopefully, this report will help decision-makers to realize the multiple benefits of serious decoupling – both for climate change mitigation, reduced pressure on the natural systems and job creation.

5.1 The model used is far from perfect

This report has explored the evidence base for the arguments put forward that there are significant benefits for society by increasing energy and material efficiency and, at the same time, substituting fossil energy sources with renewables. The main focus has been on what would be the likely effects on jobs and carbon emissions.

The model used is a traditional Input/Output model. In order to test the assumptions made about a more circular economy, the supply chains of different sectors have been “rewired” to meet the calls from scientific experts for both lower material throughput and lower greenhouse gas emissions. The study uses a “what-if”-analysis approach. As the database we use – World Input Output Database (WIOD) - offers a wide range of data such as employment, energy and materials used, emissions generated, imports and exports etc, it is

relatively straightforward to explore different kinds of energy and material throughput and the consequences for the economy at large.

However, the model used comes with a number of shortcomings, as do all models. It would of course have been preferable to having had access to information like:

- More recent data. However, no easily accessible database that we could find had better data for a variety of countries than the one we chose to use.
- Physical input-output data and not only data expressed in monetary terms as has been the case. There did exist physical input-output-tables in Germany and Denmark in the 1990s, and Statistics Denmark is currently doing an update. A similar model development is presently being considered in the Netherlands as well.
- More subsectors, separating for instance different kinds of energy sources – like coal, oil and gas as well as different kinds of renewables. In the model used, energy is covered by “refineries” and “utilities” and the latter includes water as well. It would, naturally, also have been an advantage to be able to separate activities like recycling, repair and maintenance, not having them in the same sector.
- Being able to differentiate between different categories of waste – distinguishing residue materials that represent a value from those that have to be taken care of at a cost.
- Being able to include natural capital stocks, both as sources and sinks, to be able to grasp more of the natural systems dynamics. All resources are taken from somewhere and end up somewhere (from a thermodynamically point of view), and it would have been preferable to be able to model how the stock dynamics caused by the resource use (depletion) and the pollution (degradation) would play out.
- Being able to include man-made capital stocks of different kinds (machinery, buildings, vehicles), especially if one could separate them according to vintage (how old they are) and performance (how energy- and resource-efficient they are and how much they pollute).
- More economic dynamics, like in a Computable General Equilibrium (CGE) and/or econometric model, to grasp how changes in relative prices are likely to influence both supply and demand.

Some models can handle a few of these things better than others, but no existing model can take care of it all. The pros of the model used for this study is that it is well known, it is transparent, it is readily available for quite a number of countries and, hence, can be easily used for comparisons between countries. The model used is far from perfect. The accurateness of the results could certainly be improved, for example by running Australia or Canada through the model and compare the results with models in these two countries that do include stocks of different types of capital. Such a study might be considered in the near future.

To summarize: The most important *pro* was that we could use the existing WIOD-database to run many countries and rather quickly come up with facts and figures which will help promote a widening of the debate in society about the possible benefits of serious decoupling. The assumptions made for most of the shifts in the economy would most probably be labelled as reasonably realistic in a time perspective of a decade, or close to two decades. As already mentioned, there have in fact been proposals made in the recent past by government task forces in Sweden and the Netherlands related to energy efficiency, the phasing out of fossil fuels, etc, that go beyond the assumptions made in the study.

With the help of the investment programs and policy incentives suggested in the study, our guess is that the economies studied could probably reach a more decoupled state in the year 2030 than the assumptions made in the modelling exercise. However, it should be stressed that the degree of policy incentives needed will to quite some degree depend on how the prices of key commodities will develop in the future, due to looming scarcity, increasing costs of extraction, pollution taxes, etc. Our basic premise is that the likely increase in the future prices for a number of commodities will make decoupling strategies more and more *profitable* over time. Continued technical development – not least the digitization of the economy - will probably also help facilitate the decoupling scenarios anticipated in our modelling.

To conclude: We think that the circular economy will attract both increased political interest and research efforts in all of the areas described above. Eventually there will be more and more data available, coupled to better models, merging some, perhaps all, of the wished for modeling improvements described above. The journey for improved knowledge and understanding about a more circular economy and what it will imply both for businesses and society at large will continue.

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