



Impacts of circular economy policies on the labour market

Final report



Cambridge Econometrics, Trinomics, and ICF
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Impacts of circular economy policies on the labour market

Final report

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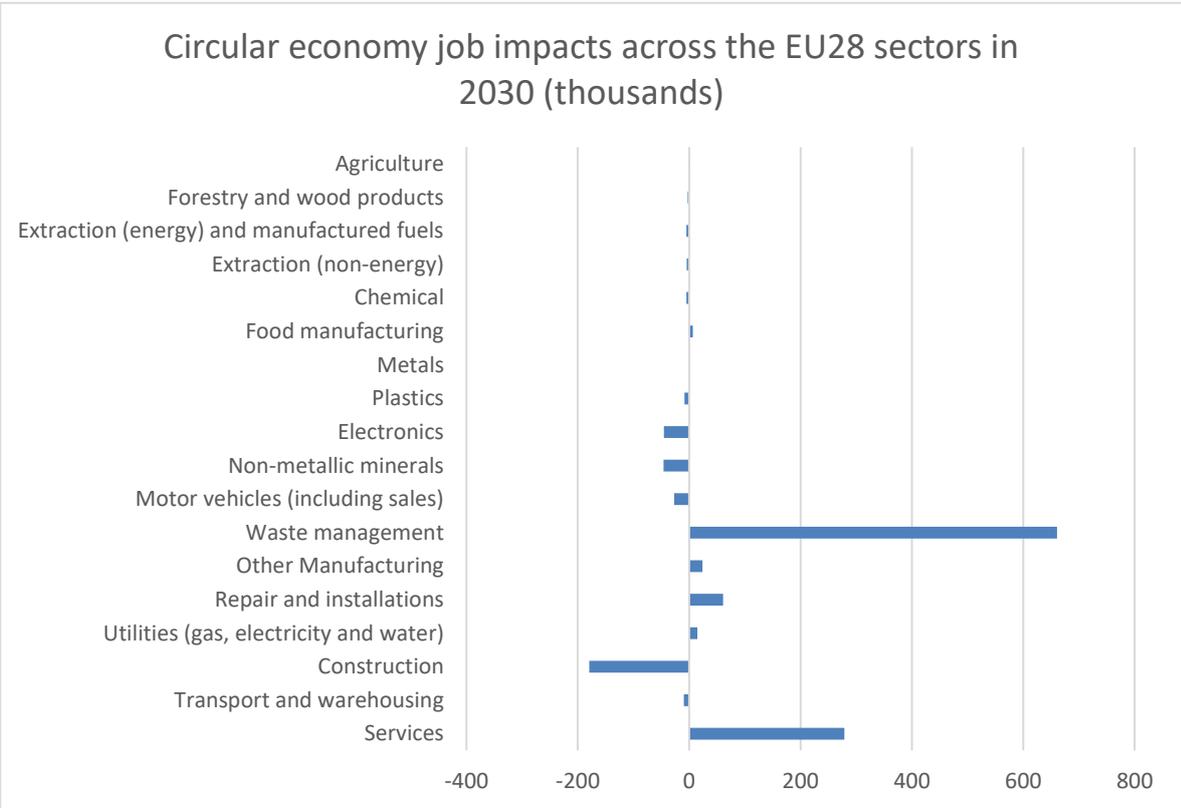
EXECUTIVE SUMMARY

How does a transition to a more circular economy affect jobs and skills demand in Europe?

This report provides detailed answers to this question. The study looked at trends of circular economy activities across different sectors and quantified these activities as modelling inputs to provide employment changes for different sectors. Furthermore, the analysis provide estimates of the occupational shifts and skills requirements that a shift to a more circular economy could entail.

The aim of this report is to develop an understanding of how a transition towards a more circular and resource efficient economy in Europe will affect labour markets across the Member States. Our analysis is the most comprehensive quantification of the EU jobs impacts from the circular economy to date. By using a fully integrated energy-environment-economy model (E3ME), our analysis considers both direct job losses and job creations that result from a shift to a more circular economy. It also captures indirect, induced and rebound impacts from interactions between sectors, Member States, and between economic, environment, material, energy and labour market indicators.

Our findings suggest that the EU is on the right track by making the circular economy a policy priority as circular economy policies will contribute to reducing negative environmental impacts, while simultaneously contributing to higher employment levels. By moving towards a more circular economy, GDP in the EU increases by almost 0.5% by 2030 compared to the baseline case. The net increase in jobs is approximately 700,000 compared to the baseline through additional labour demand from recycling plants, repair services and rebounds in consumer demand from savings generated through collaborative actions. Although the magnitude of job creation is driven by our assumption of the rate of circular economy uptake in the scenarios, our analysis confirms that it is



possible to become more resource efficient and increase employment at the same time.

Source(s): E3ME, Cambridge Econometrics.

While the net impacts on EU employment are positive, the sectoral composition of employment will change. Sectors that produce and process raw materials will decline in size while the recycling and repair sectors will experience additional growth. We have also identified other sectors that will potentially benefit from transition toward a circular economy, including services sectors and electricity. Sectors that could lose out include those that produce durable goods such as

electronics, machinery, cars and accommodation. Construction sector employment is expected to fall from productivity gains as a result of new building techniques. Our scope excludes energy efficiency improvement to existing properties which could well compensate this loss.

Among Member States, the GDP and employment results are positive but are generally higher in the Central and Eastern European countries, primarily due to larger reductions in oil imports in these countries as a result of more circular economy activities in the motor vehicles sector. Countries in western Europe are more affected by a decline in production of electronics and cars. In Eastern Europe, these durable goods are mostly imported and so the reduction in demand improves the trade balance and GDP.

In terms of skills needs across the various sectors and occupations, the additional impacts of circular economy take-up are relatively small-scale in comparison with other drivers of change, such as the impact of technological change on jobs and the shift to high-skilled jobs in some sectors. This finding suggests that take-up of circular economy activities does not in itself have a transformative effect on labour markets with regards to skills needs, even under the ambitious scenario; the jobs and skills implications of the circular economy should be seen in this interconnected context. The general trend is towards increased demand for cross-cutting competences, such as problem solving and communications. Transition to the circular economy therefore provides evidence of the importance of transversal skills, not least because jobs will evolve and workers will need to be adaptable.

There are several ways in which policy tools could address the circular economy transition while promoting jobs and adequate skills – through circular economy policies as well as through education and training policies. Policies should also address employment impacts in affected sectors and areas to support the job transitions.

It should also be mentioned that there are large uncertainties surrounding the future labour intensities in the waste sector due to increased automation, product material enhancement (to ease recycling) and technology. Our employment results for the waste sector could be overestimates if there was a sustained drive to increase mechanisation in the sector. Policies should therefore promote new skills to support the implementation of new technologies in the sector.

Finally, our study highlighted the importance of rebound effects. Rebounds in consumer spending occur as a result of efficiency gains and cost savings from circular economy activities. They can only be captured in a full modelling framework, as was used in this analysis. Although rebound effects are good for the economy, they also mean that there is an increase in material consumption associated with additional consumer spending. Additional policies may therefore be needed if Europe is to meet ambitious targets to reduce overall material use.

1. STUDY INTRODUCTION

1.1. Circular economy activities and impacts on the labour market

The linear economy relies on a “take-make-waste” model of production. Under this model, raw materials for production are used to produce goods and these goods move along the consumption chain from consumers to landfill sites. In contrast, a circular economy emphasises the utilisation of recycled inputs and ensures that the inputs to production can be recycled and reused while preserving or enhancing their economic value (Aldersgate Group, 2012).

In a more circular economy there is lower employment demand in extractive industries (given a decreased demand for raw materials) and it is expected that, as economies become more circular, employment in reuse and recycling industries increases.

According to existing studies, new jobs in the circular economy do not just substitute for declining employment in extractive industries (such as in fossil fuels, or mining and quarrying)¹. According to the Ellen MacArthur Foundation, employment opportunities in the circular economy extend to small and medium-sized enterprises via the development of reverse logistics, increased innovation and entrepreneurship and increased development of the service-based economy (Ellen MacArthur Foundation, SUN and McKinsey, 2015). Another 2015 report by the Green Alliance suggests that employment in the circular economy can generate jobs for a range of skill types and has the potential to boost employment in areas with among the highest unemployment rates (WRAP and Green Alliance, 2015).

Jobs gains due to a transition to a circular economy have the potential to be significant. A study by the European Remanufacturing Network suggests that in Europe remanufacturing alone has the potential to deliver 34,000 to 65,000 new jobs (Circulate News, 2016). WRAP suggests that a transition to a circular economy could create up to 1.2 to 3 million jobs across Europe (WRAP, 2015).

According to a 2015 analysis; “Growth Within: A Circular Economy Vision for a Competitive Europe”, positive employment effects due to a transition to a more circular economy are estimated to be largely driven by the impacts of increased consumer spending. If industries can source a larger share of their inputs from less expensive recycled materials, then prices for consumers would be anticipated to be lower.

Although it is generally agreed that a transition to a circular economy would have positive economic effects, not all sectors would benefit evenly from such a transition. Some industries would likely be negatively impacted (e.g. extractive industries, or the traditional carbon-based power sector). Benefits from a transition to a more circular economy are not expected to be evenly distributed and would likely involve considerable transition costs. However, if well managed, such a transition has the potential to generate considerable economic growth.

1.2. Study objectives

The aim of this report is to develop an understanding of how a transition towards a more circular and resource efficient economy in Europe will affect labour markets across the Member States. More specifically:

- How do changes deriving from EU circular economy policies impact on the economy; how this is reflected in different economic sectors; what effects does this have on the labour force, including changes in sectoral (i.e. reallocation of labour across sectors) and occupational composition?
- Who are winners and losers in the labour market and, in so far as possible, what is the size of the net employment impacts, where possible split by skill group and age?
- What are direct labour markets within circular economy activities; what are the indirect labour market impacts related to the supply of intermediate goods and services from other

¹ Green Alliance (2015), suggests that as the UK is becoming more efficient at utilising resources and transitioning to a circular economy, employment is estimated to grow larger than the estimated decline in extractive industries like oil and gas. WRAP (2015) explored several scenarios for a transition to a circular economy and found potential job creation of between 250,000 and 520,000 jobs and an overall decrease in the unemployment rate. In summary, although employment decreased in some sectors, employment is estimated to increase overall.

sectors; what are the induced labour impacts related to changes in household expenditure patterns?

- Are there differences between the short-term and medium-term perspectives?
- What are the underlying drivers of employment, including ecologically-driven structural change (e.g. of resource productivity increases); technological change and innovation; public green investment, etc.?
- Under what conditions can the circular economy boost employment in the EU?
- How can EU policy support this process, including in skills development, and could how can the EU mitigate possible negative impacts

1.3. Objective outcomes

In order to answer the above questions, it is necessary to both identify key features and sectors within the circular economy and also to understand the wider economic impacts of moving to a circular economy.

By using a large scale macro-econometric model, E3ME (see Annex A), our analysis covers impacts across the whole economy (i.e. both direct, indirect and induced), including for example supply chain effects or developments in wages across different economic sectors and labour crowding out effects. The modelling results are supplemented with additional analysis on occupational levels, while also considering as much as possible impacts on different skills groups.

Finally, this study was carried out in the context of relevant policy – both in the circular economy sphere, resource efficiency and more general labour market policy (e.g. life-long learning, etc.). Where possible, the impacts are linked to potential European policy, covering both the medium-term outcomes but also the transition path to get there (which may show potential social disruption).

Table 1.1 provides a summary of how we answer the project research questions. Specific tasks and their outputs are discussed in the following chapters.

Table 1.1 Answering the key research questions

Research questions	Answers
How do changes deriving from EU circular economy policies impact on the economy? How is this reflected across economic sectors? What effects does a circular economy transition have on the labour force, including changes in sectoral and occupational composition?	5 Impacts on the EU Economy and Jobs 6 Changes in Occupations and Skills Needs
Who are winners and losers in the labour market and, in so far as possible, what is the size of the net employment impacts, split where possible by skill group and age?	5 Impacts on the EU Economy and Jobs 6 Changes in Occupations and Skills Needs 2 Summary of Recent Literature
What are direct, indirect and induced labour market impacts?	5 Impacts on the EU Economy and Jobs
Are there differences between the short-term and medium-term perspectives?	5 Impacts on the EU Economy and Jobs Annex B Literature Review
What are the underlying drivers of employment, including ecologically-driven structural change (for instance of resource productivity increases); technological change and innovation; public green investment, etc.?	2 Summary of Recent Literature 7 Policy Implications
Under what conditions can the circular economy boost employment in the EU?	5 Impacts on the EU Economy and Jobs 7 Policy Implications

How can EU policy support this process, including in skills development, and could how the EU mitigate possible negative impacts?	5 Impacts on the EU Economy and Jobs 7 Policy Implications
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Finally, this study was carried out in the context of relevant policy – both in the circular economy sphere, resource efficiency and more general labour market policy (e.g. life-long learning, etc.). Where possible, the impacts are linked to potential European policy, covering both the medium-term outcomes but also the transition path to get there (which may show potential social disruption).

1.4. Other study deliverables

A separate document contains three annexes is provided with this report: a non-technical description of the model used in this study, E3ME (Annex A), a detailed literature review (Annex B) and a set of sectoral profiles (Annex C). A summary of the literature review is provided in Chapter 2 and Chapter 4 includes a description of the degree of circular economy activity at sectoral level.

2. SUMMARY OF RECENT LITERATURE

We have used the relevant issues from the project's research questions to help structure our summary of the literature. The full literature review is provided in Annex B.

Who are winners and losers in the labour market and what are the size of the net employment impacts, split by skill group and age?

The following sub questions and findings relate to these research questions:

What is the circular economy?

Various definitions and interpretations of the Circular Economy exist, but the definition from the Ellen MacArthur Foundation (2014) is the most commonly cited and is used as the circular economy definition in this study. In essence, the circular economy aims to keep products, components and materials in the economy for as long as possible and thus tries to reduce or eliminate waste. The two main strategies to increase the circularity of the economy are: (1) Regeneration of biotic materials² and (2) maintaining the value of abiotic materials³ for as long as possible through various feedback loops and recovery schemes.

Which sectors are most likely to be affected by the circular economy?

Circular economy activities are often cross-sectoral and also involve new kinds of activities that are not yet captured by traditional classifications of economic sectors. Though some specific sectors can create circular business models largely within their own activities (e.g. the food industry or the construction sector), other (horizontal) circular economy business actions such as design for re-use and recyclability, repair, reuse or waste management, can involve a variety of economic sectors. Such cross-sectoral activity complicates the analysis of circular economy labour impacts.

The literature points to evidence that the sectors that offer virgin materials and those providing durable goods will suffer from lower demand for their products if the degree of circularity in the economy increases. On the contrary, sectors engaging in recycling, maintenance and repair activities will grow rapidly and create new jobs. Companies that offer know-how and technology to enable material-efficiency will also benefit from the transition to a circular economy.

What impacts on employment might the circular economy have?

When analysing the labour market impacts of the circular economy it is important to look at the net job creation or loss and not at the gross impact. The transition to a more circular economy may imply job losses in some sectors and increased employment in others. Therefore, an accurate picture of employment implications can only be obtained when sector-specific impacts are not studied in isolation but put into the context of the changes occurring in the wider economy.

How are the employment impacts of a more circular economy distributed across skill levels?

Several studies have found that increasing the circularity of the economy would have a positive net employment impact and could create jobs across all skill levels. However, most of the studies that we identified and reviewed focused primarily on increasing resource efficiency and increasing recycling rates. The level of ambition envisaged for the circular economy strongly influences the type and extent of labour market impacts that will occur. There is a lack of literature that considers the employment effects of the inner loops of the circular economy (i.e. reuse, remanufacturing, etc.).

Circular economy activities will require both high and low-skilled jobs. For example, there should be more design and technology related jobs, which requires highly-skilled workers, while the increased recovery and reuse of waste would create the need for new lower-skilled jobs. Overall, the

² Biotic material refers to any natural material that originates from living organisms, such as wood.

³ Abiotic material refers to non-biological or non-renewable materials.

transition to a circular economy will entail new and more specialised skills, and reskilling strategies will be needed to enable workers to move from high to low-carbon sectors.

What are the underlying drivers of employment, including ecologically-driven structural change (e.g. resource productivity increases); technological change and innovation; public green investment, etc.?

The following sub questions and findings relate to these research questions:

What can be expected regarding substitution between capital, use of materials and labour?

The transition to a circular economy might change production processes by substitution of some capital inputs with labour inputs. The expected impact on the overall capital-labour ratio in the economy is likely to be driven by two main effects:

- Circulating materials for as long as possible will result in a shift in focus from the primary economic sectors (agriculture, mining & quarrying, etc.) to the secondary and tertiary sectors.
- Within sectors, the share of labour-intensive activities like repairing or refurbishing might increase compared to the manufacture of new products. Even though this could lead to a higher labour-to-capital ratio, it does not automatically increase net employment.

This shows that the impact of the circular economy on the overall capital-labour ratio is very complex. The nature of the employment effects also depends on the indirect and induced effects of the circular economy, which can be net negative for manufacturing sectors (despite servitisation and an increase in refurbishing and repairing activities), but strongly positive overall due to the rebound effect of increased consumption. In addition, the circular economy relies to a large extent on further digitalisation and automation of the economy, and technological development which further affects the labour-to-capital ratio.

How can EU policy support this process, including new skills development, and how could the EU mitigate possible negative impacts?

At the EU and Member State levels, there are a number of policies that are targeted at the transition towards the circular economy, including training programmes that are of relevance to the circular economy. However, at both levels, there are no real skills-related policies specifically designed to foster the transition to a more circular economy.

3. LABOUR MARKET IMPACTS OF CIRCULAR ECONOMY ACTIVITIES – METHODOLOGY

3.1. Overview of our approach

This part of the report describes the approach that we used to estimate the scale of impacts from circular economy activities. Our analytical approach is primarily model based and draws on the macroeconomic framework offered by the E3ME model. However, prior to any modelling being carried out, it was necessary to carry out an in-depth analysis of the key sectors that this study assesses.

The modelling information for each of the sectors chosen is taken directly from our own analysis of sector profiles (see Chapter 4). The E3ME model results provide estimates of the economic and labour market impacts by Member State and sectors, based on the level of circular economy activities we assumed in the scenarios. These results are further disaggregated to provide occupation and skills impacts (see Chapter 6) which allow us to draw policy recommendations (Chapter 7).

3.1.1. *The E3ME model*

The E3ME model includes 43 consumer spending categories, 70 economic sectors, 23 fuel users of 12 fuels and 15 users of 7 raw materials. E3ME also covers each Member State individually (and 31 other world regions). The model captures indirect and rebound effects through its linkages between sectors, labour, energy and materials.

The E3ME model contains a relatively detailed treatment of labour market and is used to feed into the EU's annual skills projections (CEDEFOP, 2018). Its close linkages between physical and economic activities make it suitable for providing labour market impacts of circular economy activities. A full model description is provided in Appendix A.

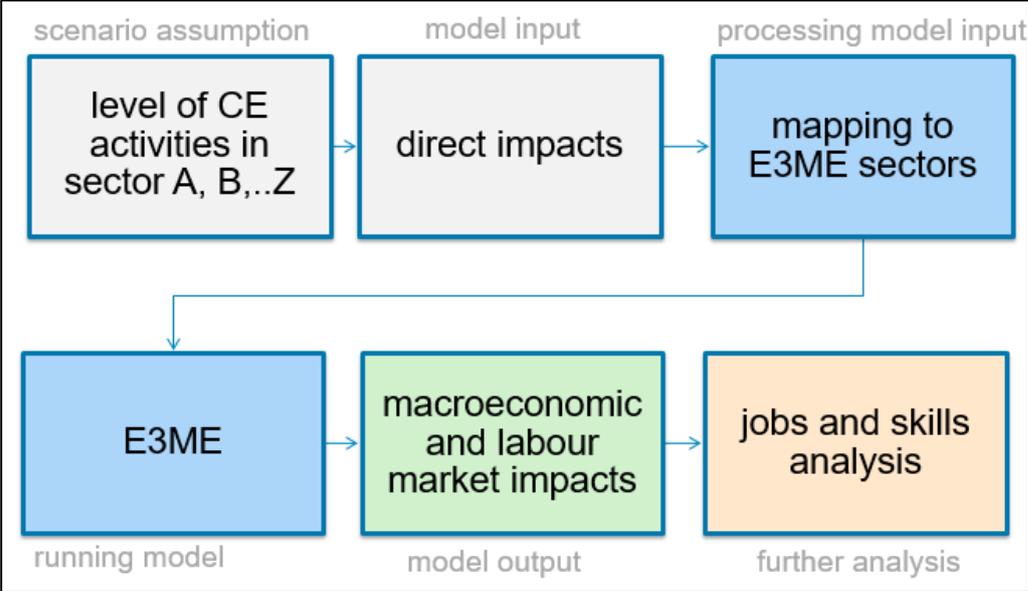
3.1.2. *'Activities' approach*

The scenarios are modelled using an 'activities' approach rather than a 'policies' approach. The scenarios are defined by scaling up or down the level of circular economy activity in each of the five focus sectors. Each sector has different circular economy activities, which are described in detail in the sector profiles in Annex C. No explicit assumptions have been made about whether these changes are driven by policies, behavioural change or new technology. A narrative of these three potential drivers of change and why we have chosen the activities approach has been provided as part of the sector profiles (see Chapter 4).

Flows of work

The diagram below demonstrates the flows of work undertaken. The first task was to identify the circular economy activities within sectors and to estimate direct impacts. After this, the next task was to translate the direct impacts to E3ME modelling inputs by mapping the sectors to E3ME's classifications. E3ME then provided the indirect and wider macroeconomic and labour market impacts of different rates of circular economy activities in the EU. Finally, the modelling results were used to provide further analysis of impacts across occupational groups and skills levels.

Figure 3.1 Flows of work under the circular economy activities approach



3.1.3. *Five key focus sectors*

We have chosen five key focus sectors, which are broad enough to represent the most important circular economy sectors and activities in the EU. These sectors are:

- Food
- Construction
- Motor vehicles
- Waste management
- Electronics and electrical equipment

Chapter 4 provides further details on how the sectors are selected.

3.1.4. *Circular economy activity scenarios*

Two different scenarios were constructed based on different levels of circular economy activities in the focus sectors (moderate and ambitious). These are the scenarios that were modelled to assess labour market impacts.

Table 3.1 provides an overview of the scenarios.

Table 3.1 Overview of the circular economy scenarios

	Food	Construction	Waste Management	Electronics	Motor Vehicles	All
Baseline	Business as usual (continuation of historical trends; legislation adopted by Member States until December 2014 included in forecasts)					
Moderate	Moderate uptake of the circular economy (measures in Circular Economy package & moderate sectoral transformation)					
Ambitious	Ambitious uptake of the circular economy (moderate + extensive sectoral transformation)					

3.1.5. *Circular economy activities in the baseline*

So as to allow comparison with other model-based studies, a baseline was constructed based on official published economic and energy-sector projections. The standard E3ME baseline was used,

which is consistent with the Reference Scenario published by the European Commission (DG ENER, 2016).

The modelling baseline does not explicitly assume a certain level of circular economy activities. The baseline consists of the latest historical data (up to 2016) and projections that include policies that were adopted by December 2014 (plus amendments to three directives in the beginning of 2015). We have not assumed a certain rate of 'greening' activities in the baseline in addition.

According to the documentation that accompanies the projections:

"... the Reference Scenario does not assume implemented the most recent initiatives promoting a circular economy, which would otherwise be expected to have noticeable effects on overall efficiency."

and

"The Reference Scenario includes policies and measures adopted at EU level and in the Member States by December 2014. In addition, amendments to three Directives only agreed in the beginning of 2015 were also considered."

"... the European Commission's Circular Economy Package, adopted on December 2, 2015, and therefore after the cut-off date for the policies to be reflected in the Reference Scenario."

The scenarios that we assess look at additional circular economy activities (moderate and ambitious) on top the level embedded in the baseline.

In order to ensure consistency, the sector profiles (see Chapter 4) assume that there is the same level of circular economy activity as in the baseline (continuation of historical trends; legislation adopted by Member State until December 2014), to which the moderate and ambitious scenarios were compared qualitatively. The modelling inputs were formed as differences from the baseline.

3.2. Estimating the impacts of a more circular economy on jobs

The process of estimating the jobs impacts of different levels of circular economy activities was carried out using the E3ME model. The model determines first the impacts on economic production levels and prices. The demand for labour (which is derived from product demand) follows. The E3ME model is able to capture further indirect, induced and rebound impacts from the initial changes in circular economy activities.

Table 3.2 summarises circular economy activities as types of modelling inputs and how changes are modelled in E3ME.

Table 3.2 E3ME modelling inputs

Type of modelling inputs	Modelling method in E3ME
Increase in alternative materials and energy sources, e.g. recycled materials and biofuels	Changing input-output structure of the relevant sectors
Reduction in the consumption of virgin materials, e.g. metals, plastic and petrol	Changing input-output structure of the relevant sectors
Increase in repairing activities	Changing input-output structure of the relevant sectors (assuming that repairs occur within the same sector)
Collaborative economy	Reduction in demand for traditional business products (less buying), increase in demand within the household sectors (sharing), small increases in demand for collaborative economy platforms
Investment in recycling facilities	Exogenous additional investment by the recycling sector

Changes in the labour intensity of recycling activities compared to traditional waste management	Exogenous increase in employment in the waste management & recycling sector (same sector)
Cost reductions from the more efficient use of resources or production methods (e.g. modular design)	Exogenous reduction to industry costs

3.2.1. *IO coefficients*

The majority of circular economy activities identified in the five focus sectors (see Chapter 4) require adjustment to the existing input-output structure of the model. This reflects the changes to the supply chain of a sector as a result of higher circular economic activities. For example, if the construction sector uses less timber and instead uses recycled wood, this change is entered to E3ME as an adjustment to the input-output coefficients of the construction sector's purchases less from wood manufacturing (lower) and from the recycling sector (higher).

3.2.2. *Investment*

For the waste management sector, we have introduced additional investment to reflect demand for new recycling plants as a result of higher circular economic activities. The additional investment is entered to E3ME exogenously and is assumed to be fully funded through higher recycling sector costs. The model estimates the indirect effects from the investment as well as its induced impacts (from higher employment).

3.2.3. *Collaborative activities*

A big part of the circular economy comes from higher rates of collaborative activities. The fundamental difference between the collaborative economy and the traditional economy is the way that consumers purchase goods and services. In a traditional economy, consumers pay businesses to produce goods and services. This consumer spending generates demand for industry output, resulting in additional demand through a sector's supply chain. This process also generates employment demand.

In a collaborative economy, consumers no longer make these purchases from traditional businesses. Instead, they pay other households to 'borrow' the goods or services that they provide. In the modelling, we do not distinguish between households that are 'buyers' and households that provide the goods and services. Instead the money that would otherwise get spent and transferred to traditional businesses stays within the household sector.

It is assumed that the additional money received by the households that provide goods and services is spent. It is not an unrealistic assumption to assume that households (e.g. an Airbnb host) will spend this money in the same way as his or her income from traditional employment. This assumption generates additional income that gets spent elsewhere in the economy. The additional spending causes a 'rebound effect' from higher consumer demand.

3.2.4. *Productivity and labour intensity*

In some sectors, we have assumed that productivity and labour intensity will change as a result of higher circular economy activities. For example, waste landfill and recycling have different labour intensities. Waste management is a highly mechanized process that requires a small level of labour input. Recycling, on the other hand, can be much more labour-intensive (collecting, sorting, processing, reselling, etc). We therefore introduced a change to the sector's labour intensity to reflect more recycling activities and less waste landfill management.

3.2.5. *Costs*

Reductions in costs arising from modular design in the construction sector are entered exogenously to the E3ME model to provide further impacts. This reduction in cost reflects efficiency gains that are not related to higher labour productivity from modular design.

3.2.6. Main linkages in E3ME

Figure 3.2 summarises the main linkages in E3ME, and shows the importance of the economic input-output system (purchases between different economic sectors) in determining overall impacts⁴. Despite being a highly stylised representation of the complex linkages within the model, it is still possible to determine two loops within the diagram.

Multiplier effect

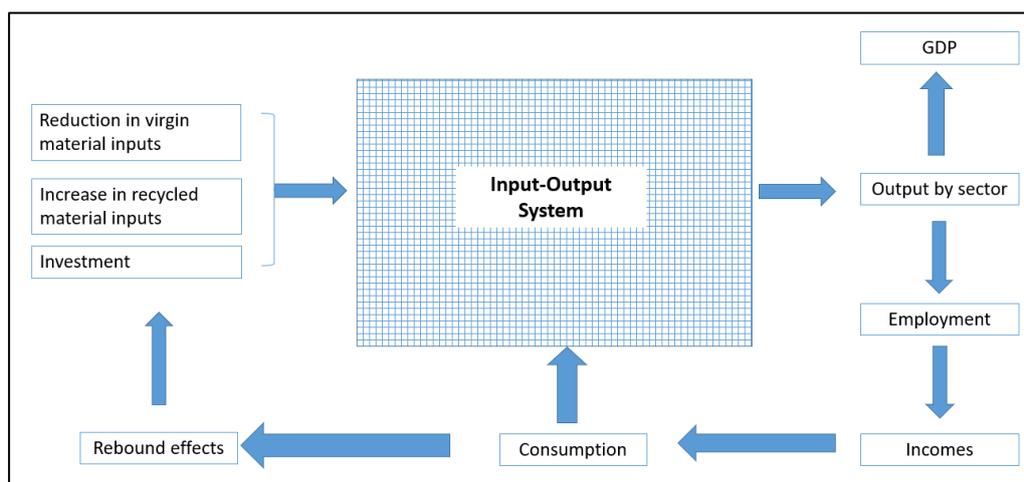
The first of these loops is a standard multiplier effect; if the circular economy measures create additional output and employment then the extra income that goes with that employment may be used to purchase other goods and services. While this can boost economic outcomes further (loop in the bottom right of the diagram) it may also lead to rebound effects in physical consumption (loop round the bottom of the diagram).

Rebound effects

These rebound effects mean that some of the initial reductions in resource consumption are eroded due to additional spending elsewhere in the economy.

Although very little research has been carried out into the potential scale of possible rebound effects in non-energy resource consumption⁵, it is likely that the scale of impacts is smaller than that for energy, at least when talking about the circular economy. The reason is that the benefits of circular economy policies are likely to be economic sectors (e.g. recycling) rather than final consumers, although this could vary according to the particular sectors targeted.

Figure 3.2 Modelling circular economy measures via IO adjustment in E3ME



3.3. Linking jobs to occupations and skills

The task of extending E3ME results to provide impacts by occupation and skill group is very important for identifying skills gaps that could occur if ambitious policies to move to a circular economy are implemented.

3.3.1. Methodology

The E3ME modelling provides estimates of circular economy impacts on total employment levels within each economic sector. The next task is to explore the implications for the shape of jobs and the skills required. By understanding occupational shifts in employment it is possible to assess how the skills required within the economy may evolve, both within sectors and between sectors. This

⁴ Although policies relating to final consumption (e.g. by households) can also be considered with a similar approach.

⁵ Cambridge Econometrics is currently carrying out some internal research on the topic but this is still at a relatively early stage.

analysis is largely qualitative in nature, although it draws on the model data and classifications where relevant.

Using the E3ME output as the starting point, the following two steps have been undertaken:

Step 1 - Occupation

Further disaggregating the employment shifts shown by the model (as necessary) to map potential shifts at a more detailed occupational level:

- The occupational composition of employment at 2-digit level within the priority sectors has been mapped as part of the scoping that underpinned the sector profiles (based on CEDEFOP's 41-industry classification).
- It is possible to apply judgements based on the literature review material and on other sources of labour market data (e.g. some national data; sector studies) to identify which of the most detailed occupational groupings are likely to be impacted by the modelling outputs.
- Key occupations are those within the priority sectors shown either by the modelling or the literature review / sector profile evidence to be substantially impacted by the circular economy.

Step 2 - Skills

Profiling these 'key' occupations in terms of required skills based on the ESCO database at a detailed occupational level (up to four-digit level):

- By mapping the required skills, knowledge and competence associated with detailed occupations in the ESCO classification and combining this with the qualitative evidence about the impact of a more circular economy on jobs (from the literature review), priority skills associated with the shift to the circular economy have been identified.
- By analysing how similar profiles of skills (as captured by occupational groupings) are distributed across the economy, it is possible to form judgements about the potential for cross-sector redeployment; either supporting growth or to mitigate anticipated reductions in workforce size. This analysis can also be supported by looking at occupational distribution across sectors (how the occupational group maps across sectors, i.e. where the jobs are found across sectors and what therefore is the potential for a transition of skills).

4. CIRCULAR ECONOMY ACTIVITIES IN DIFFERENT SECTORS

4.1. Introduction

4.1.1. *The activities approach*

For this study, we have chosen to take an approach based on 'activities' rather than one based on a 'policy' approach. The choice of approach means that the study is not assessing potential impacts of specific policies but is instead looking directly at the links between circular economy activities and the labour market. The scenarios show an increase in the size of the circular economy, without linking the change to particular policies. This approach has also been suggested by the Ellen MacArthur Foundation as the preferable method in 'A Toolkit for Policymakers' (2015). The reason behind it is that the practical implications of a more circular economy will vary between sectors, as sectors differ in the way in which resource flows and relationships with the consumer are organised. Furthermore, for some sectors the major negative resource impacts are related to the production phase, whereas for other products the impacts during the use phase are most significant.

The activities approach implies generating modelling inputs that are bottom-up from a sectoral perspective. The inputs are formed by studying the plausible circular economy activities that will take place in the selected key sectors and their supply chains. This information is derived from the in-depth sector profiles.

4.1.2. *Five key focus sectors*

We have chosen five key focus sectors, which are broad enough to represent the most important circular economy sectors and activities in the EU and their potential impacts on employment and the labour market. Contrary to existing studies, we do not only study the effects of the circular economy on these sectors in isolation, but also account for the indirect impacts on related sectors through their supply chains. The analysis therefore covers goods both before and after production (material sourcing, using the product and its end-of-life phase), meaning that the degree of circularity can be assessed over a product's lifetime.

In order to ensure that the largest part of the impacts of the circular economy are covered by this study, we developed a systematic approach to select the five sectors, further explained in the sections below.

4.2. Sector selection

4.2.1. *Selection criteria*

In order to cover the bulk of the impacts that will be brought about by the circular economy in Europe, sectors have to meet a number of conditions. Ideally, this means that together, the selected sectors:

- Jointly capture a large share of the total potential that the circular economy could deliver to the EU economy by 2030 (the timeframe of this study);
- Represent the sectors and supply chains in the EU economy that are likely to be most significantly transformed by the circular economy towards 2030;
- Represent a variety of potential changes that the circular economy could bring about to the EU economy (in terms of which circular loops and business models are likely to be applied), including both the technological and biological cycles of the circular economy;
- Represent an adequate mix of the different types of labour classes and categories that could be affected by the circular economy in the EU.

In order to arrive at a representative and balanced set of focus sectors that meet the above conditions, we have developed three selection criteria against which all NACE 2-digit sectors of the EU's economy are scored. The five focus sectors that scored highest on these three criteria were selected for the in-depth assessment. The selection criteria were the following:

Table 4.1 Sector selection criteria

Criterion	Description
Circular economy sector potential	The potential that circular economy activities have in the sector (thus representing the extent to which the sector might be transformed by the circular economy from a business perspective)
Circular economy policy importance	Whether the sector is a priority in terms of circular economy policy action and/or whether the sector was identified by previous literature on this topic as a priority sector in terms of its potential for the circular economy
Economic significance	Importance of the sector to the EU economy in terms of value added generation and employment

Selection criterion 1: Potential for the circular economy in the sector

Due to differences in their current linearity and circularity, the extent to which the circular economy will transform a sector varies across different economic activities. In order to select the sectors that will be most significantly affected by the circular economy, we scored the sectors on their circular economy potential, as defined by the Ellen MacArthur Foundation in Growth Within: a circular economy vision for a competitive Europe (2015). This report develops six RESOLVE circular economy levers (different strategies for increasing implementation of circular principles, see box IV-1) and indicates what is the potential for bringing about change in each sector. We assigned a “1” for low potential, “2” for medium potential and “3” for high potential and derived the average score for each sector. In our selection of focus sectors, we have taken into account that the selected focus sectors jointly cover many of the different RESOLVE levers.

Box 4-1 RESOLVE: Activities that can make a product’s lifecycle more circular

REgenerate – Use of renewable energy and materials (biological materials)

Share – Reduce the need for new goods through sharing/renting and the use of second-hand products

Optimise – Reduce resource use, improve durability, reduce wasting of materials during production and optimise operation, e.g. through automation

Loop – Remanufacturing, recycling and recovery of useful materials and components

Virtualise – Replace physical products with virtual services

Exchange – Replace materials and processes by others with less impact on resource use and the environment

Source: Ellen MacArthur Foundation (2015) Growth within: a circular economy vision for a competitive Europe

Selection criterion 2: Policy priority area and other literature

The second selection criterion covers the extent to which a sector is covered by policy action or expected to be covered by future circular economy policy actions, as those sectors are more likely to undergo a circular transition (holding everything else equal). We take the priority actions indicated in the EC Circular Economy Action Plan and its Annex (European Commission, 2015), as indicative for future EU policy action per sector. In addition, previous literature on the topic that reviewed the potential of the circular economy for European sectors – particularly in relation to jobs – has also indicated a number of sectors that are most likely to be impacted by a circular economy in the future (IEEP, 2014). We have also considered those findings and scored sectors on the extent to which they were identified by previous literature or current policy as priority sectors or likely impacted sectors.

Selection criterion 3: Importance of the sector in the economy

In order to select sectors that are likely to experience significant changes in their economic structure and employment effects due to the transition to a circular economy, it is important to select sectors that are currently producing significant value added and employ a significant share of the EU workforce. Merely due to their size, the changes to the sector due to the transition to the circular economy will affect many workers and/or have a significant impact on economic output.

We use data from Eurostat's Structural Business Statistics and National Accounts for the year 2013 on number of people employed in the sector and value added at factor cost at the NACE 2-digit sector aggregation level to score each sector for its role in the EU economy.

As the ultimate aim of the in-depth sector analysis is to develop modelling inputs for the E3ME model, we use the NACE sector classification to define the scope of our sectors as it is consistent with E3ME. For each NACE 2-digit sector, we gathered the data and information for the three selection criteria as described in the previous section.

4.2.2. *Results from applying the selection criteria*

Selection criterion 1: Potential of the circular economy in the sector

The results from scoring all economic sectors on criterion 1 indicate:

- The highest potential for circular actions can be found in the manufacturing sectors (NACE Section C), the construction sector (Section F) and the wholesale and retail sector (Section G).
- The electricity sector (Section D) also shows a high potential for transition on the basis of circular economy principles. This is likely to stem largely from its role in providing renewable energy to circular production processes, however, and therefore plays largely an enabling function to circular initiatives in other sectors.
- Most of the services sectors (Sections J-N, P, Q and R) score low on circular economy transformation potential.

Selection criterion 2: Expected circular policy action and existing literature findings

The findings from applying selection criterion 2 indicate that:

- Agriculture, forestry and fishing, food and beverages, rubber and plastics products and construction activities are mentioned as important sectors in the Circular Economy Action plan, but also in the wider literature.
- The Circular Economy Action Plan also indicates that critical raw materials and bio-based materials are likely to be subject to circular policy action in the future, but these material flows do not correspond to a single NACE sector.
- The WRAP (2015) study states that the waste treatment & recycling sector will be strongly affected by circular economy policies.

Selection criterion 3: Importance of the sector in total EU value added creation and employment

The summary results for selection criterion 3 indicate:

- High employment in the services sectors: NACE sections M-U jointly account for ~37% of employment in the EU. Employment in the primary sector (A) equalled 4% of the total labour force in the EU in 2013. The manufacturing sector, due to its material intensity an important circular economy sector, accounted for 12% of EU employment in 2013. Around 22% of the EU workforce works in the wholesale and retail trade sectors (G-I).
- Significant value added is created in the services sectors (29% of total EU value added in 2013 in sectors M-U). A large share of value added is generated by the real estate sector (including imputed rents; 10% of the total) for which value added measurement errors are common. Contrary to the relatively large share of employment in the agricultural sectors (4%), relatively little value added is created in agricultural activities (1%).

4.2.3. *Final selection of focus sectors*

Based on the results presented, five focus sectors were selected for the modelling exercise:

1. Food products & beverages (NACE A, C10 & 11)
2. Motor vehicles (NACE 29)
3. Construction (NACE F 41&43)

4. Electronics and Electrical equipment (NACE 26 & 27)
5. Waste collection and treatment (NACE 38 & 39)

Even though waste collection and treatment is considered in all sector profiles due to the life-cycle approach to the sector assessments (including the end-of-life stage of products), the waste treatment sector is also chosen as a separate economic sector to be assessed in isolation, due to its important role in closing material loops for all other sectors of the economy. As a result, the assessments of sectors 1-4 mainly focus on the potential of circular actions that prevent the generation of waste, thereby affecting the *volume of waste* going to the waste treatment sector. Sector profile 5 assesses, *how this waste can be treated* in such a way that the circular economy is promoted.

The results from the in-depth sector assessments are included in full in Annex C. The remaining sections of this chapter summarise the outcomes of these analyses based on the following structure:

1. Presenting a short introduction of the sector;
2. Summarising the potential of the circular economy in the sector;
3. Outlining the details of the most important circular activities and transforming these to inputs for the E3ME model.

4.3. Food sector

4.3.1. Overview of the sector

The food production chain is composed of several economic sectors, which together form the extended 'food sector'. At the beginning of the chain are agriculture and fisheries, providing the unprocessed foodstuffs, which are subsequently processed into final products by the food and drinks industry. Finally, those food products are sold via wholesale and retail companies or restaurants and other food services to the final consumer. Within this study, the agriculture & fisheries (NACE A) and the food & drinks industry (NACE C10 & 11) are seen as the core of the food sector. Agriculture and fisheries represents a mere 1.6% of the EU's gross value added (GVA), but the sector provides employment to around 5% of the EU's workforce. The food & drinks industry's employment accounts for approximately 1.8% of the total employment in the EU and creates 1.8% of the EU's GVA. Wholesale and retail is a substantial employer in the EU, as around 4% of the European workforce is employed by these sectors, and they account for 2.2% of the EU's GVA. Lastly, food & drinks services (e.g. catering services, restaurants & bars) provide employment to 1.1% of the EU's workforce and generate 1.2% of the EU's GVA.

4.3.2. Potential of the circular economy in the food sector

Food production and consumption from a biological and nutrient perspective are inherently circular as the nutrients and carbon consumed by animals and humans would normally be cycled back into the food chain as plants. However, intensive agriculture has disrupted the natural balance between nutrient extraction and deposition. As a result, the food value chain is currently very linear as waste is created at several points. For example, agriculture uses almost 17 million tonnes of nutrients (from fertilizers) on an annual basis, of which only one fifth is recycled to the soil after food production and consumption. This enormous amount of nutrient losses leads to depletion of finite resources such as phosphorus, but also to negative environmental impacts such as eutrophication and N₂O and NO_x emissions.

Another inefficient aspect of the current food production system is that around 70% of agricultural land is used to produce meat and dairy products. As the production of animal-derived products requires much more energy and resource inputs than the production of vegetable-based products, the high level of meat and dairy consumption leads to very high requirements for nutrients and arable land. From a circular economy perspective, this is a suboptimal use of the available resources. The increasing demand for agricultural land also promotes the conversion of natural areas to agricultural land, leading to deforestation and biodiversity loss, not only inside Europe but also in countries from which Europe imports animal feed.

The last major issue in the food sector today is that it is still very wasteful during production and consumption. It is estimated that around 20% of all the food that is produced ends up as food

waste. Furthermore, a lot of residues and organic waste are generated throughout the production chain; these resources could be reused more efficiently.

4.3.3. *Circular strategies for the food sector*

The aforementioned linear aspects of the food sector can be addressed through the implementation of three main circular strategies.

Improving nutrient use efficiency and recovery

The first strategy is improving nutrient use efficiency and recovery, which corresponds to the Regenerate lever of the RESOLVE framework. Overall, demand for fertilizers can be decreased by using innovative farming practices. The fertilizers that are used can be preferentially produced through the processing of organic waste and manure. In summary, the following aspects were modelled:

- Reduction in overall fertilizer use;
- Substitution of inorganic fertilizers with organic fertilizers, which will come from 1) better nutrient recovery from manure and 2) increased nutrient recovery from sewage sludge.

Optimal food use

The second strategy is optimal food use, which means first that food waste will be reduced. It also relates to a shift from the consumption of meat and dairy products to vegetable oils, fats and proteins. This strategy aims to achieve a more efficient use of resources and corresponds to the optimise lever of the RESOLVE framework. Optimisation of food use will be modelled as follows:

- Food waste will be reduced throughout the value chain:
 - A reduction in waste generation in the food & drinks industry;
 - A reduced demand for packaging materials by the food & drinks industry;
 - A reduction in demand for food products by food wholesale, retail and food services;
- A reduced demand for food at the level of the final consumer
- A reduction in the demand for animal-derived food products.

Optimise the use of agricultural residues and waste streams

The third strategy is to optimise the use of agricultural residues and waste streams, which is related to the regenerate lever of the RESOLVE framework. Although waste reduction and prevention are always the first priority, the generation of waste or by-products is hard to avoid in some processes. In such cases, it is important to try to loop the materials back into the value chain or at least to recover as much of the embedded energy and resources as possible. For this strategy, two main activities were modelled:

Conversion of organic waste and former foodstuffs to animal feed (Optimised use of residue streams and by-products)

Biogas production from manure in agriculture

4.3.4. *Translating circular economy activities to modelling inputs*

The three aforementioned circular strategies and the corresponding activities have been translated into modelling inputs for E3ME. Table 4.2 summarises how this translation has been done. An elaborate explanation on how we arrived at the assumptions and quantitative model inputs can be found in the food sector's full sector profile in Annex C. Table 4.3 summarises the precise magnitude and directions for each of the modelling parameters defined Table 4.2. The precise modelling inputs can also be found in the full sector profile of the food sector.

One should note that dietary changes were not modelled, despite the fact that such shifts hold significant circular economy potential and can have substantial economic and environmental impacts. However, the current version of the E3ME model does not make a distinction between

different kinds of agricultural and food products and therefore the model is not fit for modelling the effects of such dietary shifts⁶.

Table 4.2 Translation of circular activities in the food sector into E3ME modelling inputs

Circular economy activity	Implications for E3ME modelling
Reduction in overall fertilizer use	<ul style="list-style-type: none"> Reduction in chemical demand (fertilizers) from agriculture through adjusting input-output (IO) coefficients
Substitution of inorganic fertilizers with organic fertilizers	<ul style="list-style-type: none"> As above, plus increased input within agriculture (purchasing organic fertilizer)
Reduction of food waste (assuming less food is bought, avoiding waste, and one unit of input produces more output than in the Baseline)	<ul style="list-style-type: none"> Reduction in household spending on food Reduction in hotel and catering intermediate demand from agriculture and food manufacturing (IO) Reduction in retail intermediate demand from agriculture and food manufacturing (IO) Reduction in food manufacturing intermediate demand from agriculture (IO) Reduction in rubber and plastic products (representing packaging) intermediate demand from food manufacturing sector (IO)
Use of organic waste and former foodstuffs as animal feed	<ul style="list-style-type: none"> Increased demand from agriculture (buying feed directly) of food manufacturing (waste from its production) (IO)
Biogas production from manure in agriculture	<ul style="list-style-type: none"> Utility supply sector purchase (intermediate demand) from agriculture (manure) (IO)

Table 4.3 Scenario inputs for the food sector

E3ME model input	Moderate scenario	Ambitious scenario
Reduction in chemical demand (fertilizers) from agriculture through adjusting IO coefficients	28% reduction in mineral fertilizer input (12 bn EUR cost saving)	46% reduction in mineral fertilizer input (20 bn EUR cost saving)
Increased input within agriculture (purchasing organic fertilizer)	8% of total fertilizer demand (3.2 bn EUR)	13% of total fertilizer demand (4.4bn EUR)
Reduction in household spending on food	12.3 bn EUR of savings	24.5bn EUR of cost savings
Reduction in hotel and catering intermediate demand from agriculture and food manufacturing (IO)	3 bn EUR	6 bn EUR

⁶ The model is currently being expanded to include equations for 17 types of foodstuff, which will be linked to a land allocation module.

Reduction in retail intermediate demand from agriculture and food manufacturing (IO)	1.5 bn EUR	3 bn EUR
Reduction in food manufacturing intermediate demand from agriculture	1.95 bn EUR	3.9 bn EUR
Reduction in rubber and plastic products intermediate demand from food manufacturing sector	2.2% reduction	11.1% reduction
Increased demand from agriculture (buying feed directly) of food manufacturing (waste from production) (IO)	0.4% of the expenditure of agriculture on animal feed is shifted to inputs from food manufacturing	1% of the expenditure of agriculture on animal feed is shifted to inputs from food manufacturing
Utility supply sector purchase (intermediate demand) from agriculture (manure)	145 PJ additional biogas from manure added to baseline	290 PJ additional biogas from manure added to baseline

4.4. Construction sector

4.4.1. Overview of the sector

The construction sector is a key sector for the EU economy and represents a major source of employment. It accounts for 9% of the EU's GDP and provides 18 million direct jobs⁷. In terms of number of companies, the sector is composed 99.9% of SMEs (employing fewer than 250 people) which are responsible for 80% of the construction output. In the EU, the average size of construction enterprises is four workers. Small enterprises (less than 50 employees) are responsible for 60% of production and employ 70% of the sector's working population⁸. The construction sector is the most material-intensive economic sector in the EU. In the EU, of all materials extracted from the earth each year, more than half (by weight) are used in construction (Bio Intelligence Services, 2013). Construction, therefore, has a high potential for increasing the circularity of the economy. In its EU action plan for a Circular Economy, the European Commission singled out construction as a priority sector (European Commission, 2015).

For all these reasons, the construction sector has been selected as a focus sector in this report. In this chapter of the report, we only consider the activities related to the construction of buildings, which accounts for 78% of the sector's value added. Civil engineering activities are excluded. However, the possible circular economy implications for construction-related, high-skilled occupations such as civil engineering are considered in Chapter 6.

4.4.2. Potential of the circular economy in the construction sector

Even though circular economy activities are already happening in the built environment (e.g. the use of digital construction tools for a smart design of buildings, recycling of construction and demolition waste, and the use of more circular construction materials), most work so far has focused on improving the energy efficiency of buildings. However, increasing circularity in the built environment means reducing the amount of resources used, as well as the amount of waste created, during the entire construction life cycle, through reuse, recycling or remanufacturing.

⁷ European Commission website. Accessed at: https://ec.europa.eu/growth/sectors/construction_en

⁸ European Builders Association website. Accessed at: <http://www.ebc-construction.eu/index.php?id=3>

Around 10-15% of building materials are wasted during construction, and around 60% of office buildings in the EU are not used even during working hours)(Ellen MacArthur Foundation, 2015). It is estimated that 20-40% of energy in buildings could be saved and a large amount of demolition waste is landfilled (6-54% depending on the EU country) (Ellen MacArthur Foundation, 2015).

These figures show that a large untapped circular economy potential exists in the sector, in particular for minimising resource use during (1) the production of construction products and (2) the use-phase of buildings, the two lifecycle stages with the biggest environmental impacts. The construction of new buildings requires large quantities of new raw materials. The majority of the materials used in the construction of buildings are new materials, although accurate figures on the use of recycled materials are lacking (European Commission, 2014). Further, many buildings are not yet built in such a way that resource use during the use-phase is minimised. This needs to be addressed if the circular economy potential of the sector is to be realised.

4.4.3. Circular strategies for the construction sector

There are several circular economy strategies that can be applied along the lifecycle of a building, with measures affecting the design phase, the extraction of resources, the actual construction, maintenance of buildings, retrofitting and renovation, and the end-of-life stage. In the design phase, it is important that buildings are made in such a way that they can easily be remodelled, retrofitted, expanded or disassembled. In the construction process it is important to use sustainable materials, preferentially recycled materials and, where suitable, bio-based materials. Prefabrication can prevent wastage of materials at the construction site and modular design will enable easy remodelling of buildings when they need to be renovated, or easier disassembly at a building's end-of-life. Buildings should be designed and constructed in such a way that energy use and the need for maintenance are minimised. At the same time, regular maintenance is often very important to maintain optimal resource efficient operation of buildings. At the end-of-life stage, deconstruction is preferred over demolition as this enables the reuse of materials in the construction of new buildings.

Although all the aforementioned strategies should be employed to make the construction sector more circular, we have focused on the following activities for modelling the circular economy in the sector.

Recycling, reuse and recovery of construction and demolition waste

Recycling, reuse and recovery of construction and demolition waste is an activity with a high potential. Currently around 50% of construction and demolition waste is recycled (own assumption based on Bio Intelligence Service, 2011), although this should increase to 70% by 2020 according to the Waste Framework Directive. We assume this rate will apply in 2030 without further policy action, and that the rate will increase in the moderate and ambitious scenarios. The main impact of this activity would be increased demand for recycled construction materials. This is reflected in the model as a reduction in virgin material purchases, e.g. from the mining and quarrying sector, and as an increase in purchases from the waste treatment sector.

Higher utilisation of buildings

Higher utilisation of buildings through sharing and efficient use of empty buildings has been identified as a high potential measure by the Ellen MacArthur Foundation (2015). European offices occupy 1.4 billion m² of space. Tele-working and office-sharing, enabled by digitalisation, would likely continue to grow but would not fully solve the underutilisation issue (Ellen MacArthur, 2015). Peer-to-peer renting/sharing could increase the utilisation of residential buildings. In the model we assume that demand for traditional accommodation will be reduced, as more people engage in peer-to-peer renting/sharing of homes. This development is reflected in the model as a shift of income from the hotels industry to households. It also slightly increases the revenues for the online platforms that are managing such transactions. The estimates behind these shifts are taken from Trinomics (2017).

Modular design

Modular design involves industrial production, prefabrication and 3D printing. Moving construction towards factory-based industrial processes is already helping companies cut costs as much as 30% and shorten delivery time by 50% or more. Modular design typically reuses and refurbishes some 80% of the components; up to 30% of new buildings could use industrial approaches by 2020 (versus 20% today), 50% by 2030, and 80% by 2050, and these approaches could reduce construction cost by 10-30% per m²(Ellen MacArthur, 2015). The main impacts modelled are

decreased construction costs per unit of output for new buildings and increased labour productivity due to these changes.

4.4.4. *Translating circular economy activities to modelling inputs*

The three aforementioned circular strategies and the corresponding activities have been translated into modelling inputs for E3ME. Table 4.4 summarises how this translation has been done. An elaborate explanation on how we arrived at the assumptions and quantitative model inputs can be found in the full sector profile in Annex C.

Table 4.5 summarises the magnitude and directions for each of the modelling parameters. The precise modelling inputs can also be found in the full sector profile on the construction sector.

Table 4.4 Translation of circular activities in the construction sector into E3ME modelling inputs.

Circular economy activity	Implications for E3ME modelling
Recycling, reuse, waste reduction, and recycling of Construction and Demolition waste (C&D)	<ul style="list-style-type: none"> • Increase in construction demand from recycling (buying more recycled materials) (IO) • Reduction in construction minerals demand (cement, sands, glass, ceramics etc.) from construction (IO)
Sharing, efficient use of empty buildings	<ul style="list-style-type: none"> • Households letting out spare rooms resulting in reduction on demand for traditional accommodation (e.g. hotels) (exogenous reduction in consumer spending on traditional hotels and accommodations) • Small payment to collaborative platforms such as AirBnB (exogenous increase in consumer spending on miscellaneous services) • Assume households spend money from P2P (peer-to-peer) activities on other goods and services (reallocation of consumer spending)
Modular design	<ul style="list-style-type: none"> • Lower construction sector costs per unit of output from non-labour related efficiency gains (exogenous reduction of unit cost in the construction sector) • Increase in labour productivity of new construction per unit of output (exogenous reduction in construction labour demand)

Table 4.5 Scenario inputs for the construction sector

E3ME model input	Moderate scenario	Ambitious scenario
Increase in construction demand from recycling (buying more recycled materials)	5% additional purchases from the waste & recycling sector compared to the baseline	15% additional purchases from the waste & recycling sector compared to the baseline

Reduction in construction minerals demand (cement, sands, glass, ceramics etc.) from construction (IO)	* -5% compared to the baseline	* -15% compared to the baseline
Households letting out spare rooms resulting in reduction on demand for traditional accommodation (exogenous reduction in consumer spending on traditional hotels and accommodations)	Consumer spending on traditional models of accommodation reduced by €6.4bn compared to the baseline	Consumer spending on traditional models of accommodation reduced by €18.4bn compared to the baseline
Small payment to collaborative platform such as AirBnB (exogenous increase in consumer spending on miscellaneous services)	€1.05bn compared to the baseline	€3.03bn compared to the baseline
Lower construction sector costs per unit of output from non-labour related efficiency gains (exogenous reduction of unit cost in the construction sector)	3% lower cost for new buildings in 2030 compared to the baseline	9% lower cost for new buildings in 2030 compared to the baseline
Increase in labour productivity of new construction per unit of output (exogenous reduction in construction labour demand)	*-5% of labour requirement for newbuilds compared to the baseline	*-10% of labour requirement for newbuilds compared to the baseline

Note(s) * own estimation.

4.5. Motor vehicles sector

4.5.1. Overview of the sector

The production of motor vehicles (NACE code 29) includes a range of products including passenger cars, large commercial vehicles (trucks) and motorcycles. The production of passenger cars accounts for the largest share (87%) of the production of motor vehicles in Europe (ACEA, 2015). Passenger cars make up an important part of the life of an average European citizen as many of us depend on cars to provide the mobility we seek for private and professional reasons. Car ownership in the EU is also high. The average European citizen owned 0.49 cars in 2014 (i.e. almost one car for every two citizens). Due to the importance of the passenger cars in the motor vehicles sector (and in society), we have focused on the potential of the circular economy in relation to passenger cars in this sector profile.

As in other sectors, the passenger car sector is analysed from a lifecycle perspective (the car from a cradle to grave perspective) and taking into account supply chain linkages. The production of motor vehicles involves a complex and varied chain of suppliers of various materials and parts, which are assembled together by Original Equipment Manufacturers (OEMs), run by the large automotive brands. Rubber and plastic products, metals and chemicals form the three most important material-based inputs to the motor vehicle sector. The automotive sector in turn is an important client for them: 13% of the total rubber and plastics output in Europe serves as input for the passenger car industry, 11% for the EU metal sector's output and 2% of the chemicals sector's total output. In these three sectors, 3.2% (or 7 million) people were employed in 2014 in the EU.

The production of parts and assembly of cars accounted for 2% of total EU employment (2.4 million people) in 2014. In the retail and distribution stage (the end of the supply chain and the beginning of the life cycle 'use' phase), jobs such as selling (parts and accessories of) cars and the

maintenance and repair of cars represented 2.5% of all EU employment in 2014 (almost 3 million people). Altogether, the motor vehicle supply chain accounted for 8% of total employment in the EU in 2014.

More information on the detailed economic structure of the EU motor vehicles sector can be found in the full sector profile in Annex C.

4.5.2. *Potential of the circular economy in the motor vehicles sector*

According to our analysis of recent literature and data, the potential of the circular economy in the automotive sector differs per life cycle phase. The production of motor vehicles and sourcing of materials has been a competitive market for decades where margins are slim. Under the influence of increasingly stringent regulation, the sector has been innovating strongly to reduce material use and increase efficiency of its production process. In addition, the End of Life (EOL) phase of cars has, under the influence of regulation, developed into more circular outcomes over time: only 9% of the waste generated by passenger cars is disposed of. Overall, 82% of the waste from cars is already recovered (recycled) and 9% is directly reused (without being recycled first). In contrast, the 'use' phase in the car's life cycle is much less optimised and still inherent to significant efficiency losses:

- The EU car is not in use for 92% of the time (parked)
- When in use, on average 1.6 seats in the car are occupied, and
- Engine losses and idling amount to 86% of fuel consumption (Ellen MacArthur Foundation, 2013).

As a result, a large share of the potential of the circular economy in the automotive sector is based on increasing utilisation and efficiency in the 'use' phase of the life cycle of cars. It is also in the use phase that most of the environmental damage is created. Notably, the use phase accounts for 75 to 80% of total GHG emissions in the life cycle of regular diesel/petrol cars.

It is important to consider, however, that even without (additional) circular economy policy efforts, the sector is already undergoing dramatic structural changes by switching to electric drivetrains and autonomous vehicles. In 2016, 1.3% of light duty vehicle sales were of plug-in hybrids (PHEVs). The share of fully electric battery electric vehicles (BEVs) in total EV sales is still relatively small but is growing. There are predictions that within a decade the complete market for new passenger cars will shift to EVs. ING expects that the price for ICEs and BEVs will break even between 2023 and 2028 and that, by 2035, 100% of new car sales will be battery electric vehicles. Other organisations, however, expect that ICEs will remain dominant until 2035 if the international community does not implement ambitious climate policies (McKinsey & Amsterdam Round Table, 2014). Either way, there is an ongoing transition towards electric and autonomous vehicles that is likely to capture a large share of the overall circular potential of the sector, through increased efficiency and a lower environment impact of car driving. However, as argued in the next section, additional policy and industry efforts towards a circular transformation could increase the speed of the transformation.

4.5.3. *Circular strategies for the motor vehicles sector*

A fully circular automotive sector would reduce resource use in the production of cars as much as possible, optimise the utilisation of cars in terms of number of persons in a car and the amount of time the car is driving, and reuse and recycle materials at the end of a life that has been prolonged as much as possible. In the sections below, the three changes to the sector that would contribute most significantly to realising this circular vision for the motor vehicle sector are outlined. These three changes are also introduced as inputs to the E3ME model. In this way the model can be 'shocked' with the changes that resemble a circular transformation of the automotive sector and thus simulate what would happen to employment and other socio-economic parameters. It is important to note that progress on all three actions is to different extents already ongoing in the sector. The scenario design shows that in order to realise the circular vision of the car sector, future actions 'only' have to focus on supporting ongoing transformation rather than initiating new and radical actions.

Car sharing

Car sharing refers to either more individuals using the same car at different occasions or more individuals using the same car at the same time. In both cases, the utilisation rate of cars would increase (up from the current 8%) and productive assets would be used more efficiently so that less resources and assets are needed in total. The transition towards autonomous vehicles could reinforce the effects of car sharing as autonomous vehicles are better suited for car sharing than regular cars (autonomous vehicles are not a circular action on their own). Car sharing is considered a circular action as it reduces the resource use and GHG emissions per person per kilometre while leading to economic efficiency gains along the supply chain. Car sharing would result in the following circular economy implications:

1. The average car would be used more often and/or more seats would be occupied. Thus, all else equal, fewer individuals would need a personal car which would reduce the overall demand per person. In the E3ME model, this is modelled by:
 - Reducing the demand for new cars as less individuals require an individual car
2. Transferring the same amount of people (while using fewer cars) would require less petrol/diesel or electricity. In the E3ME model, this is modelled by:
 - Reducing the demand for petrol/diesel/electricity as less cars will be on the road because more seats are occupied in a single car
3. The demand for products which serve to maintain the car operational would shrink. In the E3ME model, this is modelled by:
 - Reducing the spending on car operations as less individuals will own a car, which will lead to an absolute decline in the demand for additional components and services
4. Online platforms will be used more intensively as most car sharing platforms use online platforms or mobile applications to match car owners and renters. Most of the platforms charge a user fee. Thus, an increase in car sharing would lead to higher expenditures on online platforms that facilitate car sharing. In the E3ME model, this is modelled by:
 - Increasing the spending on online platforms as they are often used for car sharing purposes

Electrification

The electrification of cars is the transition from internal combustion engines (ICEs) towards electric vehicles (EVs). Further electrification of the vehicle fleet would restore the impact on ecosystems as the demand for petrol and diesel would reduce drastically. However, as the new cars require electricity in the use phase, the demand for electricity would increase. Electrification is considered a circular action as it reduces the environmental pressures caused in the use phase of the motor vehicle sector and it leads to economic efficiency gains. The efficiency gains have been proven in practise in the last decade as the business case for EVs has strongly improved. The way in which this action will be modelled using E3ME is:

- Increasing the demand for electricity for the use of cars and reducing demand for fossil fuels (increasing the share of electricity used by cars compared to fossil fuels)

Evolution in materials

The evolution in materials refers to innovations in the materials that are used in the production phase of the car. The evolution of materials is considered a circular action as it reduces the amount of disposed waste, resource use and the GHG emissions per person kilometre. Moreover, as lighter and fewer materials can also achieve cost reductions on the long run, it would also lead to economic efficiency gains. In the motor vehicles sector, there are two effects related to the evolution of materials that would generate substantial changes in the sector. First, the amount of ferrous metals in the production phase of the automotive sector decreases. This would decrease the demand for virgin materials and would make vehicles lighter. The reduced weight would lower GHG emissions per person kilometre. Second, the actions in remanufacturing and the reuse of parts and materials are increased. This would further increase the demand from the recycling sector. In the E3ME model, this is modelled by:

- Decreasing the demand for ferrous metals by car manufacturers as new cars require less and lighter materials and increasingly use recycled materials.

- Increasing the demand for recycled materials as they will substitute the raw materials.

4.5.4. Translating circular economy activities to modelling inputs

The three aforementioned circular strategies and the corresponding activities have been translated into modelling inputs for E3ME. Table 4.6 summarises the identified circular actions and their implications on the sector. An elaborate explanation on how we arrived at the assumptions and quantitative model inputs can be found in the full sector profile in Annex C. Table 4.7 summarises the precise magnitude and directions for each of the modelling parameters defined. The precise modelling inputs can also be found in the full sector profile.

Table 4.6 Circular economy activities in the motor vehicles sector

Circular economy activity	Implications for E3ME modelling
Car sharing & autonomous vehicles	<ul style="list-style-type: none"> • Reduction in demand for cars • Additional reduction in petrol & diesel demand (over and above the reduction in petrol & diesel demand from reduction in demand for cars due to the increased utilization of cars) • Reduction on car operations spending (other than fuels) • Increase in spending to sharing platform (e.g. Zipcars)
Electric vehicles	<ul style="list-style-type: none"> • Increase in electricity demand from cars, shifting away from oil-based products (exogenous change)
Evolution in materials	<ul style="list-style-type: none"> • Reduction in demand for ferrous metals from car manufacturing (IO change) • Increase demand from recycling sector by car manufacturing (IO change)

Table 4.7 Scenario inputs for the motor vehicles sector

E3ME model input	Moderate scenario	Ambitious scenario
Reduction in car demand	-7.5% reduction in household spending on 'purchase of cars' in 2030 compared to baseline	-15% reduction in household spending on 'purchase of cars' in 2030, compared to baseline
Reduction in petrol & diesel demand (exogenous change)	-6.5% change in petrol & diesel demanded by the EU vehicle fleet by 2030, compared to baseline	-8.4% change in petrol & diesel demanded by EU vehicle fleet in 2030, compared to baseline
Reduction on car operations spending (other than fuels)	25% reduction in household spending on 'operation and maintenance of cars' in 2030, compared to baseline	40% reduction in household spending on 'operation and maintenance of cars' in 2030, compared to baseline
Increase in spending to sharing platform	5,370 m euro	16,401 m euro

Increase in electricity demand from cars, shifting away from oil (exogenous change)	3% (half of the reduction of petrol/diesel)	4% (half of the reduction of petrol/diesel)
Reduction in demand for ferrous metals from car manufacturing (IO)	-2.5% change in demand for ferrous metals by production of motor vehicles sector	-5% change in demand for ferrous metals by production of motor vehicles sector
Increased demand from recycling sector by car manufacturing (IO)	5% increase in use of remanufactured/reused materials	10% increase in use of remanufactured/reused materials

4.6. Waste management sector

4.6.1. Overview of the sector

The waste management sector (NACE37-39) differs from the other four sectors that are covered in this report (as well as virtually every other sector), as its 'raw materials' derive from all other sectors. After waste is collected it is sorted and sent to specific facilities according to the treatment type. These treatment types are disposal or incineration, re-use, recovery or recycling, thereby entering into the loop once again as secondary raw materials. This recycling can continue until the material no longer possesses any value for the supply chain. The treatment methods for each waste category vary across the EU. Overall, the majority of waste is landfilled and one third is recycled. The three main sub sectors of the waste sector are collection, treatment and disposal and material recovery/sorting. In 2015, the EU had:

- 20,000 waste collection enterprises, employing 527,000 people.
- 7,000 waste treatment and disposal enterprises employing 203,000 people.
- 20,222 materials recovery enterprises, employing 189,204 people.

The total amount of waste treated in 2014 in the EU was 2.5 billion tonnes. Three quarters of this derives from soils, construction and demolition waste. About 10% consists of 'mixed ordinary waste', which mainly consists of household waste and other similar waste types, while the 'other' category is 15% and includes wastes like metals, animal and vegetable wastes, etc. Although the waste sector fulfils an essential function in the economy it only accounts for 0.4% of the EU's employment and GDP.

4.6.2. Potential for circular activities

Recycling, reuse and recovery are essential parts of the circular economy. Waste management therefore plays a central role in the circular economy and could help prevent future economic losses and depletion of natural capital, as well as offering opportunities for the creation of new jobs. If the waste sector is to become more circular, the principles it needs to follow are generally captured by the well-known waste management hierarchy. The hierarchy runs down through reduction, reuse, recycling, other recovery (e.g. energy recovery) to disposal. The circular approach involves maximising options at the top of the hierarchy and reducing those at the bottom.

There are potentially large gains in terms of circularity to be made by moving up the waste hierarchy. Most of the potential that can be tapped into is outside the waste sector itself. For many products, there is the potential to minimise waste generation throughout the entire value chain, from product design to packaging. This can be done through redesign with waste prevention as a priority. More accurate manufacturing approaches, such as 3-D printing also offer the opportunity to reduce waste. In order to achieve the maximum benefits, there is a need for a joint effort from consumers, producers, policymakers, local authorities and waste treatment facilities.

There is potential to reduce the costs associated with sorting mixed waste to extract valuable materials through the increased use of technology. One example of this potential is the creation of NIR spectroscopy for waste, which is a technology that has been developed to be able to sort waste, such as plastics, more efficiently. There is also a great potential to extract biochemicals or recover energy and nutrients from various waste streams. For example, mixed ordinary waste accounts for 10% of total waste arisings but, due to its varying contents, this waste stream is hard to recycle. However, if the contents were better sorted, mixed ordinary waste would become a smaller waste stream, but would also contribute to waste streams with better recycling rates. For this to happen, consumers need to be willing and able to sort their waste to enable recycling, and the required recycling infrastructure should be in place.

An important issue in enabling waste to be used and seen as a resource is when material stops being legally classified as a waste; this is known as the 'end of waste' criteria. The issue is important because, when a material is classified as a waste, its shipment and use are constrained, making its reuse or recycling more difficult or impossible. Clarifying the definition of waste and waste-related materials is an important step in reducing waste and encouraging circularity; for this reason, an amendment to the Waste Framework Directive as part of the Circular Economy Package in 2015 has been proposed. If the waste market in the EU functioned in a more efficient manner, the waste sector could improve performance.

It is important to note that the largest impacts of the circular economy on the waste sector will originate from circular economy activities in other sectors. Other sectors' activities will lead to changes in demand for the waste management sector. The most significant changes will relate to waste prevention due to the design of more durable products or products with increased reparability. Secondly, product design needs to be changed in such a way that recycling of materials is made easier.

These changes affecting the volume and quality of the waste that is created will not be modelled as changes in the waste sector, but in the sectors upstream that create the waste. The changes in the interlinkages between the waste sector and sectors upstream will lead to endogenous responses for the waste sector in E3ME when we model circular activities in other sectors. The responses include changes in the waste sector's supply-chain, employment and its investment impacts.

4.6.3. Strategies for making the waste sector more circular

Taking the aforementioned considerations into account, there are two main strategies through which the waste sector can contribute to a more circular economy in the EU, namely:

1. Reduce the amount of waste that is landfilled or incinerated without energy recovery. For this subsector a stagnation in activity is expected first, followed by a decline.
2. Increased recycling rates and higher-quality recycling.

These two strategies will have several implications for levels of production and employment in the waste sector. Waste management is a highly mechanised process that requires a small level of labour input. Recycling is much more labour-intensive (due to collecting, sorting, processing, reselling, etc). Therefore, increased recycling is expected to lead to output and employment growth in the waste sector. In the short to medium term it appears that this growth will be labour intensive, but in the medium to long term it may become more mechanised, as automated sorting and dismantling becomes more affordable. In order to model the aforementioned strategies, we introduce a change to the sector's labour intensity to reflect more recycling activities and less waste management. We also expect the non-labour related operational costs of the sector to increase because recycling is a more expensive process than other common waste treatment processes such as landfilling or incineration.

4.6.4. Translating circular economy activities to modelling inputs

A summary of the implications of the two circular economy strategies in the waste sector for E3ME modelling are shown in Table 4.8 and

Table 4.9.

Table 4.8 Circular economy activities in the waste sector

Circular economy activity	Implications for E3ME modelling
Increased recycling rate, leading to:	
- Higher demand for labour	• Increase in labour intensity coefficient
- A need for more recycling stations	• Increase in investments into the waste sector
- Higher operational costs	• Increase in non-labour costs in the waste sector

It is expected that many of the impacts within the total waste sector will be close to zero as waste and recycling fall under the same sector classification in E3ME (NACE 37-39). Positive impacts associated with higher recycling are likely to be offset by reductions in landfill and waste management demand.

Table 4.9 Scenario inputs for the waste sector

E3ME model input	Moderate scenario	Ambitious scenario
Labour intensity per 10,000 tonnes of waste	Around four times higher in recycling compared to landfill(Scottish Government, 2017) - same assumption for both ambitions	
Additional investment	*20% of existing sector investment	*40% of existing sector investment
Additional costs	*20% of existing sector costs	*40% of existing sector costs

Note(s) * own estimation.

4.7. Electronics and electrical equipment sector

4.7.1. Overview of the sector

The electronics (NACE code 26) and electrical equipment (NACE code 27) sectors cover a broad set of products which all consume electricity to use and/or store information, or as a source of power⁹. The sector includes among others, computers, consumer electronics, optical instruments, transformers, electrical lighting equipment and electric household appliances. In order to focus on the sector's most important components in the light of the circular economy, the sector assessment targets types of products and equipment that are part of the EU circular economy debate.

Currently, the regular supply chain in the sector is characterised by a linear process from raw material extraction to use-phase to end-of-life phase(Antea Group, 2016). Concerning economic importance, the sector is responsible for around 10% of the European manufacturing sector's turnover (approximately €0.6 billion out of €6 billion for total manufacturing), value added and number of employees according to Eurostat. This implies that it is of less economic importance than the food, construction and motor vehicles sector. Yet, taking into account the growing importance of electronics, the political priority assigned to this sector, the existing inefficiencies and the substantial environmental impacts, the sector is considered a key sector for the circular economy. The full sector analysis can be found in Annex C.

4.7.2. Potential of the circular economy in the electronics sector

Currently, the trend in the sector is to focus on energy efficiency improvements in the design phase, reverse logistics during use-phase, and the end-of-life phase of products (recycling) as the

⁹ On definition of electrical and electronics goods, see http://www.europe-economics.com/publications/the_economic_impact_of_the_domestic_appliances_industry_in_europe_finaol_report.pdf

main actions to improve circularity. One other rising activity is sharing and leasing business models, where companies experiment with peer-to-peer renting of electronics and electrical products. However, the markets for these are very low scale and immature.

Concerning the use-phase, moderate improvements by circular actions seem feasible. Possible actions include renting/sharing of electronic products and equipment, extending the durability of a product, but much of this depends on consumer behaviour. Currently, this phase accounts for the largest environmental impacts (through GHG emissions). In addition, devices are only used for 50% of their potential lifetime which indicates that the products are underutilised (Ellen McArthur Foundation, Growth Within, 2015). This implies that the potential of reusing electronics which have not yet reached their end-of-life stage, could be improved.

Regarding the end-of-life phase, improvements are possible. According to stakeholders, 38% of end-of-life products are shipped outside Europe illegally (Arcadis & Trinomics, 2016). As there is no control over the recycling process of this waste, valuable materials and components are lost. Moreover, the waste generated by the sector is expected to grow significantly over the coming years (by 12 million tonnes by 2020). On the other hand, the economic value of the materials in waste electrical and electronic equipment is relatively low, which hinders the development of a strong business case.

Improving circularity of the product design is another area of potential that still needs to be further explored and developed. There are several circular economy trends in the sector but some of them have opposing impacts. For example, more complex product design decreases the amount of needed materials and increases functionality, while at the same time decreasing the ability to recycle and repair parts that are glued together and integrated (EEA, 2017). Another trend is modular design. Modularity increases the lifetime of products as parts can be repaired and remanufactured. However, relevant services and parts need to be available (EEA, 2017).

4.7.3. *Circular strategies for the electronics sector*

Despite several challenges, there is the potential to improve the electronic sector's circularity. The following actions are expected to have the largest impacts and are therefore used as model inputs.

Reverse logistics, better use of materials and recycling

Reverse logistics is an overarching term that refers to all actions concerning the reuse and recovery of materials, remanufacturing etc. It is considered a circular action as all actions contribute to closing the loop in the electronics sector. Moreover, due to the size of the current inefficiencies in the processes (e.g. large illegal leakages of end-of-life products outside the European loop), it is the key circular action in this sector and could cause a large reduction in the demand for raw materials and significant economic efficiency gains.

To model reverse logistics in the electronics sector, we estimate the reduction in metal and plastics demand from electronics as key impacts using the WEEE Directive reuse, recovery and recycling targets. Metals and plastics are two of the three main materials arising from the WEEE, besides glass, where ferrous metals account for approximately 50%, non-ferrous metals for 5% and plastics for 20-25% of the WEEE arising (SEC, 2008). Unfortunately, we did not find estimates for the proportion of glass in WEEE. The pressure to extract new metals and plastics would be lower as the recycled materials can substitute new metals and plastics. Thus, the incentive to extract more raw materials as input for the electronics sector will decrease and the demand for recycled products will increase. Moreover, if electronics are increasingly reused, the demand for new products will shrink. This pattern will reinforce the decrease in demand for new metals and plastics.

The demand for repair services will also increase. Due to the reverse logistics, electronics can be more often reused. However, in many cases products need to be repaired or modified before they can be reused. If the lifetime of devices is extended, the probability that products need to be repaired increases as older products require more repair services. Finally, if modular electronics (i.e. phones in which parts can be easily replaced or repaired) became more important, it will become easier and cheaper to replace or repair broken components instead of replacing the entire device. This would also increase the demand for repair services.

Optimising utilisation

Optimising utilisation refers to making better use of existing electronics over their complete lifetime. Moderate increases in the utilisation rate of electronic and electrical products are expected. Increasing the utilisation rate is considered a circular action as it would lower the demand for new products and thus decrease the environmental damage caused by the input of raw materials. There are also several examples that show that actions to increase the utilisation rate can also be profitable to businesses (as economic efficiency gains are still not fully exploited). Existing business models that enhance the utilisation rate of products include peer 2 peer (P2P) platforms. On these online platforms, individuals can rent devices that are generally underutilised (such as a drilling machine). This sort of service can potentially increase the utilisation rate of products substantially. To model the sharing of electronic goods, we base our modelling inputs developed as part of another study for DG Environment on the "Environmental potential of the collaborative economy"(Trinomics, 2017).

4.7.4. Translating circular economy activities to modelling inputs

The aforementioned circular strategies and corresponding activities have been translated into modelling inputs for E3ME. Table 4.10 summarises how this translation has been done. An elaborate explanation on how we arrived at the assumptions and quantitative model inputs can be found in the full sector profile in Annex C. Table 4.11 summarises the magnitude of the modelling parameters. The precise modelling inputs can also be found in the full sector profile.

Table 4.10 Circular economy activities in the electronics sector

Circular economy activity	Implications for E3ME modelling
Reuse, recovery, remanufacture, better use of materials, and recycling	<ul style="list-style-type: none"> reduction in metal demand from electronics (IO) reduction in plastic demand from electronics (IO) increase in demand from recycled materials (IO) increase to the repair sector (IO – within sector)
Optimising use – P2P sharing, extending the lifetime of products	<ul style="list-style-type: none"> reduction in electronics demand from consumers payment to sharing platform e.g. Peerby

Table 4.11 Scenario inputs for the electronics sector

E3ME model input	Moderate scenario	Ambitious scenario
reduction in metal demand from electronics (IO)	Share of ferrous metals in EEE ¹⁰ reduced by 2-4 percentage points compared to the baseline Share of non-ferrous metals in EEE reduced by 0-1 percentage points compared to the baseline	Share of ferrous metals in EEE reduced by 4-6 percentage points compared to the baseline Share of non-ferrous metals in EEE reduced by 0-1 percentage points compared to the baseline
reduction in plastic demand from electronics (IO)	Share of plastic in EEE reduced by 1-2 percentage points compared to the baseline	Share of plastic in EEE reduced by 2-3 percentage points compared to the baseline
increase in demand from recycled materials (IO)	Similar amount to replace raw materials	
increase to the repair sector (IO within sector)	20%*	50%*

¹⁰ EEE Electrical and Electronics Equipment.

reduction in electronics demand from consumers	<p>Numbers are potential savings compared to Baseline.</p> <ul style="list-style-type: none"> • Household appliances 2.5% • Audio-visual, photographic and information processing equipment 1.75% 	<p>Numbers are potential savings compared to Baseline.</p> <ul style="list-style-type: none"> • Household appliances 5% • Audio-visual, photographic and information processing equipment 3.5%
payment to sharing platform e.g. Peerby	25% fee of the above spending	25% fee of the above spending

Note(s) * own estimation.

5. IMPACTS ON THE EU ECONOMY AND JOBS

5.1. Introduction

This part of the report presents the results from the E3ME modelling of the circular economy activities. The next section describes macro impacts for all the scenarios while the subsequent sections present detailed results for the combined scenarios only.

5.2. Impacts on the EU economy and jobs

5.2.1. GDP

The overall impacts of increased circular economy activity on EU GDP are positive (see Figure 5.1). In the Ambitious-Combined circular activities scenario, GDP increases by almost 0.5% by 2030 compared to the baseline. The individual sector scenarios each contribute up to 0.15% of the GDP increases. In the moderate scenario, GDP impacts remain positive but smaller at 0.3% by 2030.

Waste recycling sector

The GDP results suggest that circular economy activities in the waste sectors, due to higher demand from other sectors, produce the most beneficial impacts on GDP. The benefits are due to higher investment required for the recycling plants, as well as additional labour demand to process recycled materials.

Motor vehicles sector

Circular economy activities in the motor vehicles sector produce the second largest boost to GDP. Although there is a reduction in car sales due to collaborative actions in this sector, the benefits of reducing oil and metal imports, as well as rebounds in consumer spending from car-sharing, outweigh any negative economic impacts.

Electronics sector

In case of the electronics sector, the positive impacts are driven by increased demand for repair services, reduction in raw material imports, increase in recycled materials demand and the rebounds in consumer spending from collaborative activities. However, these impacts are slightly dampened by the reduction in sales of new electronics products.

Food sector

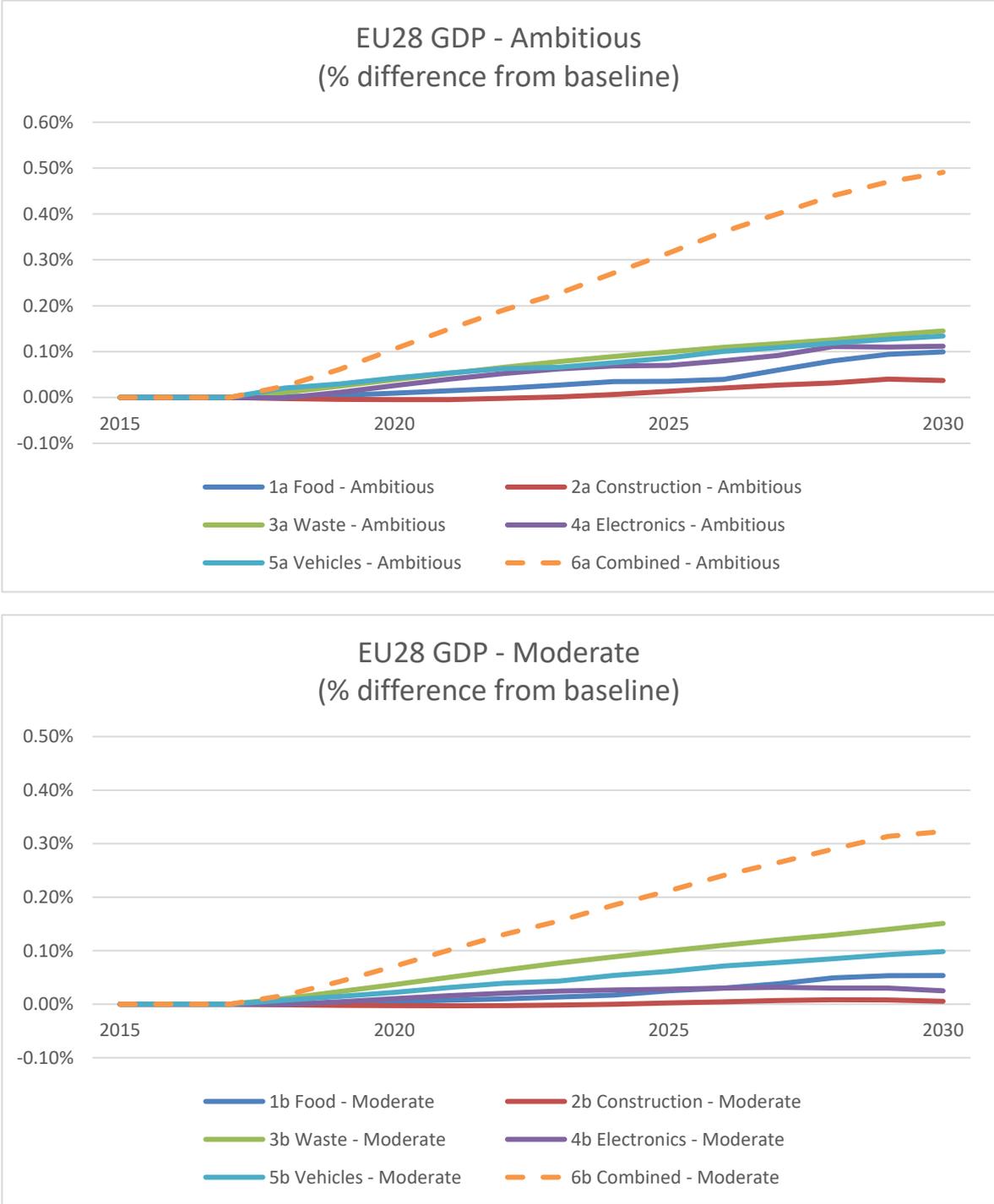
In the food sector, a reduction in food waste reduces domestic demand for agriculture and food manufacturing but the rebounds in consumer spending and trends for organic materials makes the overall impact positive.

Construction sector

Increased circularity in the construction sector produces the smallest impacts on GDP. Although the circular economy activities are similar in this sector, there is a reduction in construction employment demand due to improvements in productivity.

It should be noted, however, that renewable energy (e.g. solar panels) and refurbishment to make buildings more energy efficient do not fall under the scope of the circular economy in this project. The macroeconomic and labour market impacts of improving buildings' energy efficiency in the EU has already been extensively analysed with E3ME for the European Commission. According to the analysis, EU GDP and employment are expected to increase by 0.6% and 0.25%, respectively, by 2030 in a scenario with higher energy efficiency rates in buildings (European Commission, 2016).

Figure 5.1 EU GDP impacts in the circular economy scenarios (% from baseline)



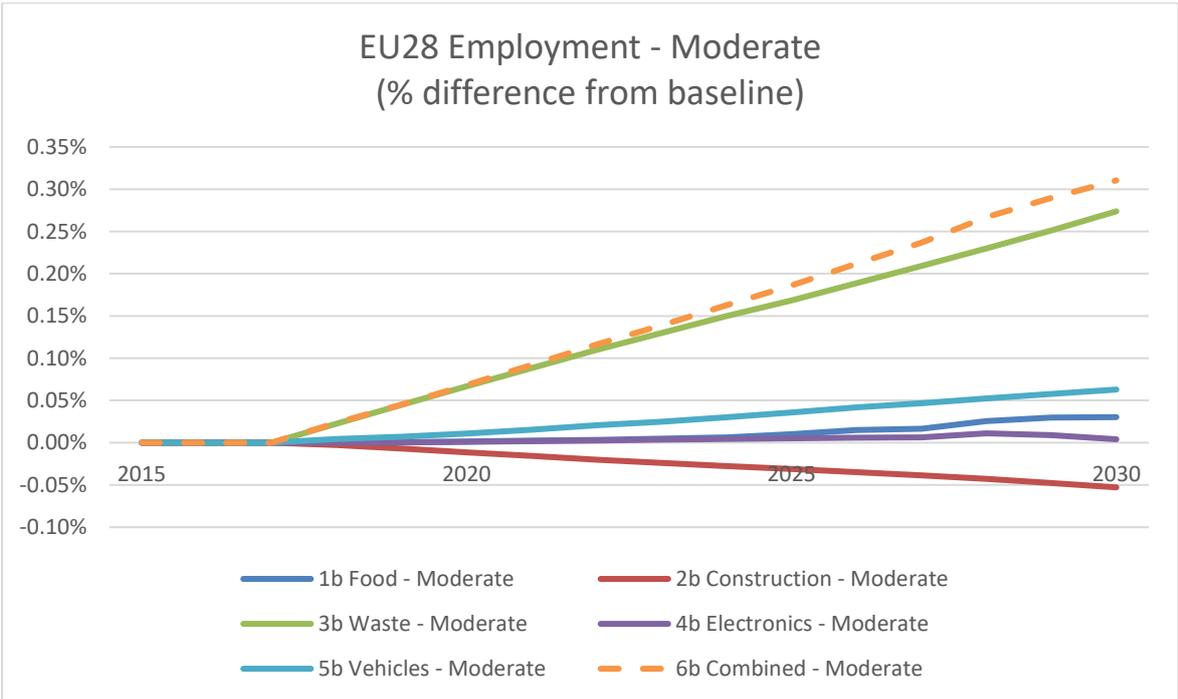
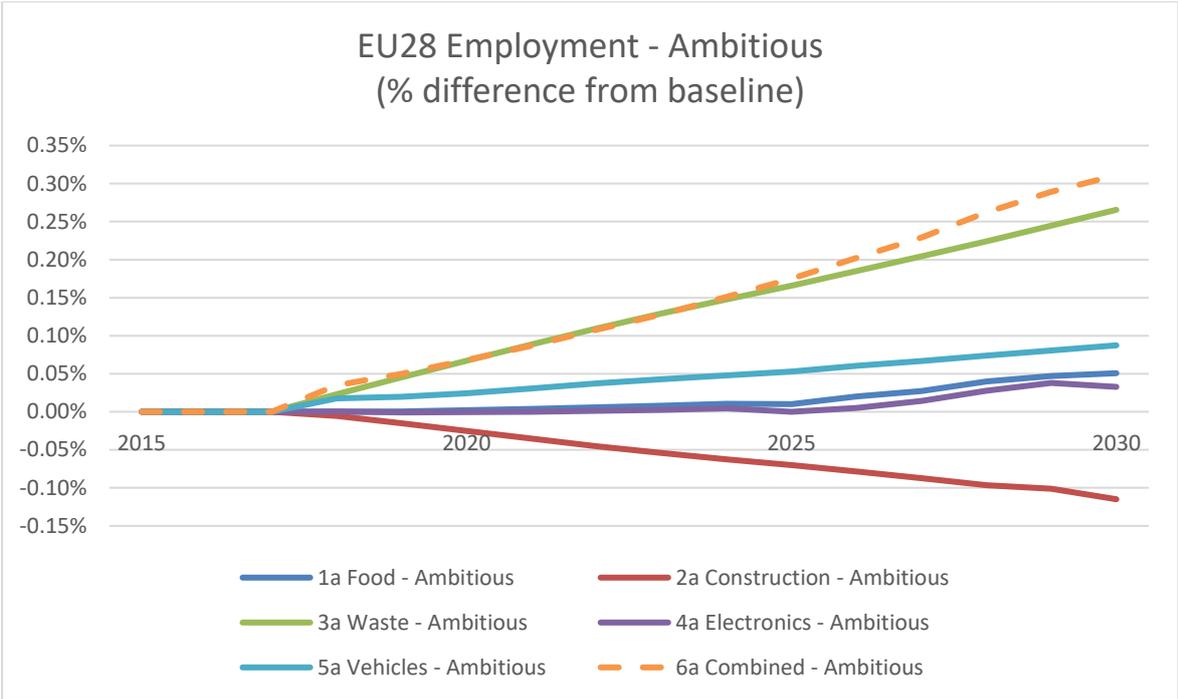
Source(s): E3ME, Cambridge Econometrics.

5.2.2. Employment

The employment results generally follow the same trends as GDP because rates of economic production are a key driver for employment demand. In both of the combined scenarios, employment increases by almost 0.3% (around 650,000 – 700,000 jobs). These results are mainly driven by employment demand in the waste management sectors to cope with higher demand for recycled materials.

The only sector that shows a substantive reduction in employment is construction. In this sector there is a strong improvement in labour productivity from new modular construction techniques (built into the scenario as an assumption), which reduces total labour demand.

Figure 5.2 EU employment impacts in the circular economy scenarios (% from base)



Source(s): E3ME, Cambridge Econometrics.

Although the overall GDP and employment impacts are positive, it is important to consider the complex interactions that underlie the aggregate outcomes. Impacts may not be positive throughout the European economy. The scenarios include a range of different inputs; some result in positive impacts on the economy and jobs (e.g. increased demand for recycling), while others may result in negative impacts (e.g. reduction in raw virgin materials). Table 5.1 provides a summary of the key economic impacts in the scenarios.

Table 5.1 Summary of key economic impacts in the scenarios

Type of modelling inputs	Initial impacts	Indirect and induced impacts
Increase in alternative materials and energy sources, e.g. recycled materials and biofuels	Different supply chains, different costs	Employment, investment, industry prices, trade, income and consumption
Reduction in the consumption of virgin materials, e.g. metals, plastic and petrol	Supply-chain impacts	Employment, investment, income and consumption
Increase in repairing activities	Supply-chain impacts	Employment, investment, income and consumption
Collaborative economy	Supply-chain impacts for traditional businesses, increased income within households	Employment, income and consumptions (knock-on effects from additional incomes from collaborative actions)
Investment in recycling facilities	Boost to economy and sector receiving the investment	Employment and further knock-on effects
Change in labour intensity of recycling activities compared to traditional waste management	Higher income and consumption	Further knock-on effects – mostly related to consumer goods and services
Cost reductions from more efficient use of resources or production methods (e.g. modular design)	Industry prices	Industry demand, trade, employment and further knock-on effects

The overall net impacts from the modelling exercise represent a combination of these positive and negative impacts. The modelling results at sectoral level in the next section give further insights to these complex interactions.

5.2.3. *Other macro- indicators*

Table 5.2 provides a summary of key macroeconomic indicators in 2030 in the two combined scenarios. Consumer spending increases from higher employment levels, rebounds from other savings, and lower inflation. Demand for recycling plants and from higher rates of economic activity drives up demand for investment. In terms of trade, there is a net reduction in imports due to lower levels of fossil fuel and raw material imports. This reduction is larger than the increase in imports that result from higher levels of economic activity. There is very little change in the level of EU exports, indicating limited impacts on competitiveness.

Table 5.2 Summary of Indicators in 2030, EU (% difference from baseline)

	6a Combined - Ambitious	6b Combined - Moderate
GDP	0.5	0.3
Employment	0.3	0.3
Consumer spending	0.4	0.3
Investment	0.4	0.3
Exports	0.0	0.0
Imports	-0.8	-0.3
Consumer prices	-0.1	-0.1
Labour force	0.1	0.1

Source(s): E3ME, Cambridge Econometrics.

5.2.4. Results by Member State

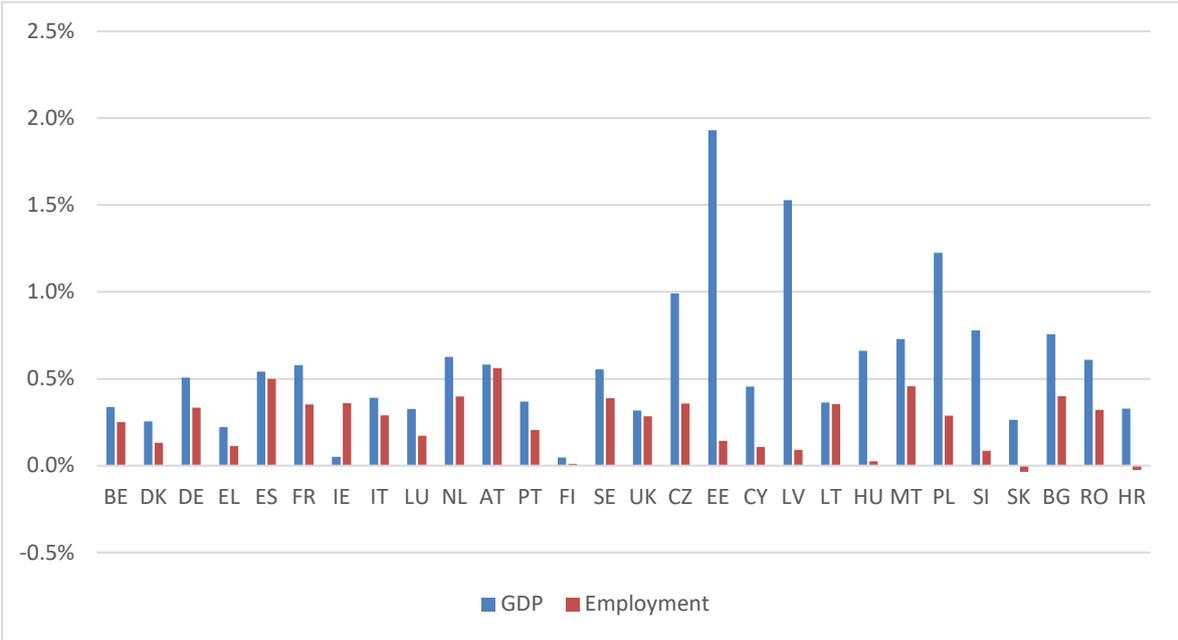
Figure 5.3 presents results for the scenarios disaggregated by Member State. The GDP impacts are positive in all Member States and the employment impacts are positive in most Member States. The variation in the employment results among Member States reflects the different economic structures and labour intensities of the main circular economy activities across the EU.

The GDP results from the modelling are generally higher in the Central and Eastern European countries, primarily due to larger reductions in oil imports in these countries in the scenarios. Despite progress, CEE countries remain relatively more energy-intensive than countries in Western Europe and, as a result, circular economy activities in the motor vehicles sector are more beneficial to them.

Countries in western Europe are more affected by the increase in the share of circular economy activities in the electronics sector. Production of electronics is more concentrated in these countries and so changes to the sector has a proportionally larger impact. In Eastern Europe, electronic devices are mostly imported and so the reduction in demand improves the trade balance and GDP.

Estonia, Latvia, Poland and the Czech Republic see particularly large improvements in GDP from the improved trade balance driven by both the reduction in electronics and oil imports. On the other hand, the GDP impact in Finland is limited. Although the circular economy drives up demand for recycling, there is a reduction in Finland's main exports such as oil, steel, timbers, chemicals and electronics.

Figure 5.3 Results by Member State in the Combined-Ambitious scenario (% from base)



Source(s): E3ME, Cambridge Econometrics.

5.3. Employment impacts at sectoral level

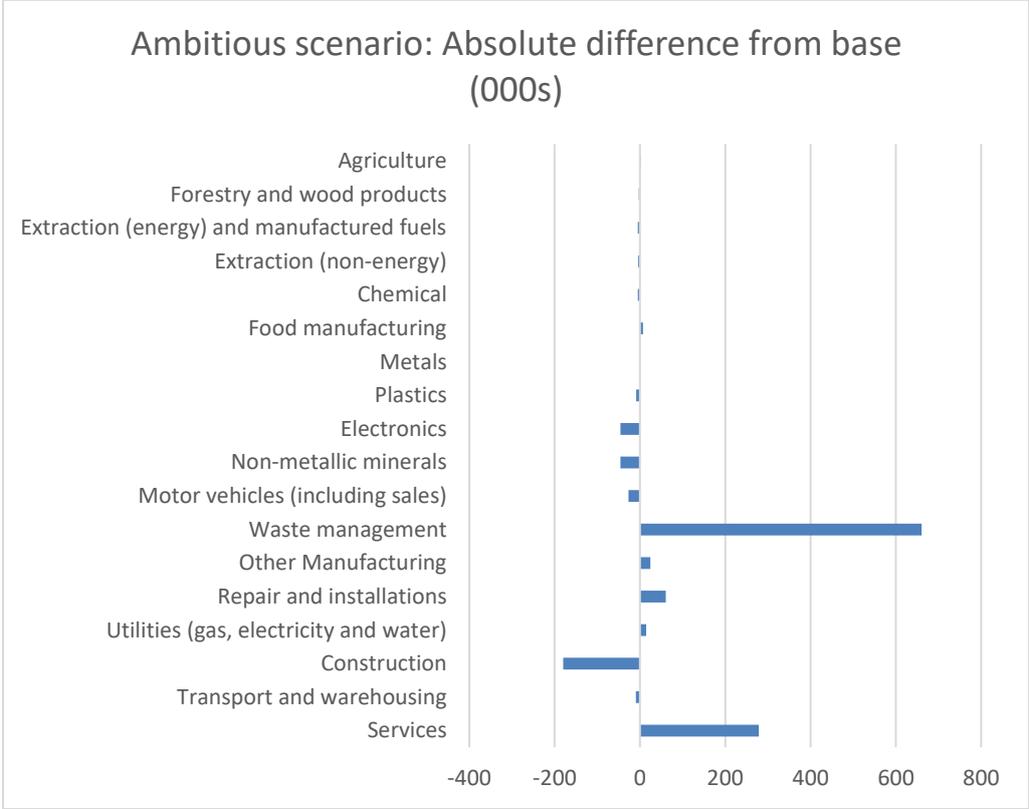
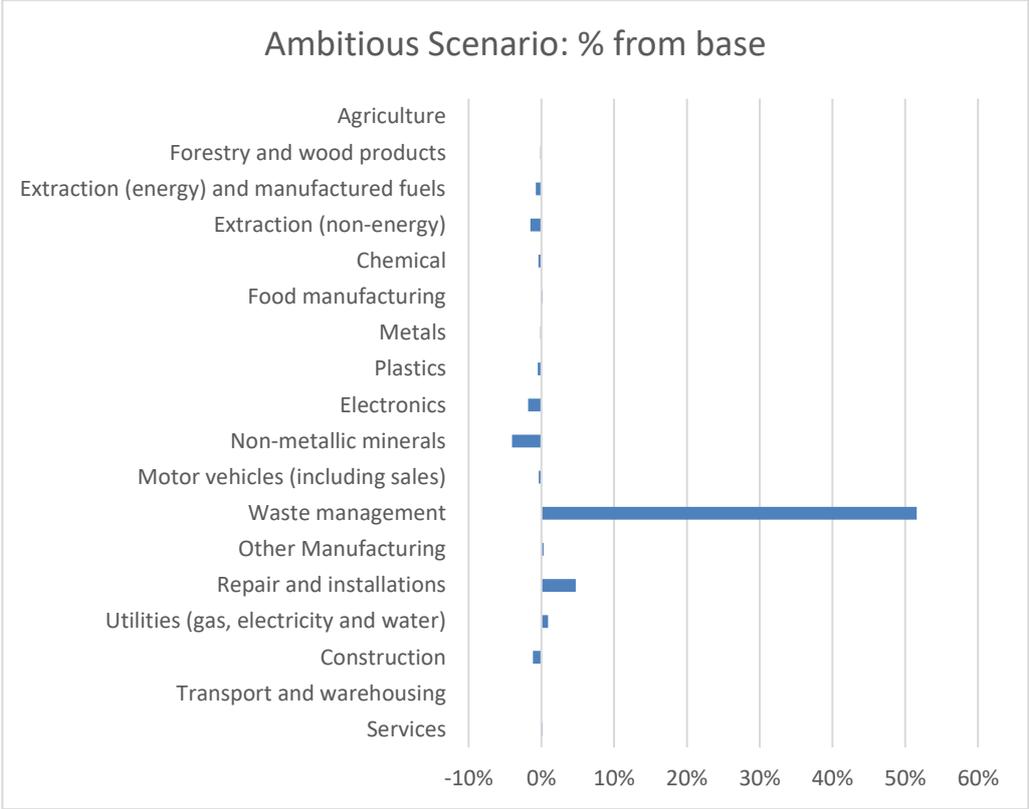
It is estimated that around 700,000 net additional jobs will be created in the Ambitious-Combined circular economy activity scenario. This figure includes both the job losses and gains within and across all sectors of the economy. For example, there is a reduction in agriculture employment demand, as a result of reduction in food waste, but higher demand for organic materials and additional consumer spending compensate the job losses in the sector. Our modelling results show the net impact on agriculture employment to be small but positive.

The most obvious shift in employment patterns is between job losses in sectors that extract and process raw materials, and job increases in sectors that offer recycling and repairing services (see

Figure 5.4). It should be noted that the number of jobs in extracting and processing raw materials in Europe has declined continuously over recent history and now makes up only a small share of total employment (which is only apparent in the lower half of the figure). In 2015, the share of the mining and quarrying sector in total EU employment was less than 0.1%. This trend of declining employment minimises the negative employment impacts from the transition to a more circular economy in the EU.

Other sectors are also affected by a shift to more circular economy. Table 5.3 summarises the likely impacts, based on the modelling exercise and the key relationships between the main sectors of the economy.

Figure 5.4 EU28 employment impacts by sector by 2030



Source(s): E3ME, Cambridge Econometrics.

Table 5.3 Summary of EU employment impacts in the Combined-Ambitious scenario by sector by 2030 (differences compared to the baseline)

Sector	Impacts 000s	Impacts %	Key explanations	Baseline 2015-30 (% change in employ- ment)
Agriculture	1.0	0.0%	Increase in demand for organic materials (feed), fertilizers and bioenergy; compensated by the loss in demand from cutting food waste	-18%
Forestry and wood products	-2.8	-0.1%	Reduction in demand from construction	-6%
Extraction (energy) and manufactured fuels	-4.8	-0.7%	Reduction in demand from transport sector	-26%
Extraction (non-energy)	-4.3	-1.5%	Reduction in demand from construction	-20%
Chemicals	-4.7	-0.4%	Reduction in demand from the agriculture sector	-5%
Food manufacturing	5.2	0.1%	Increase due to rebounds in consumer spending and demand for food waste in production which, compensates the loss in demand from cutting food waste	-17%
Metals	-1.2	-0.1%	Reduction in demand from construction, motor vehicles and electronics, although impacts are small as lower demand reduces import volumes	-12%
Plastics	-8.6	-0.5%	Reduction in demand in single-use plastic and from electronics	5%
Electronics	-50.6	-2.1%	Reduction in demand due to fewer purchases (because of more sharing and longer product lifetimes)	-14%
Non-metallic minerals	-45.8	-4.0%	Reduction in demand from construction	-11%
Motor vehicles (including sales)	-26.7	-0.4%	Reduction in demand due to fewer purchases and more sharing	4%
Waste management	660.4	51.6%	Big increase in demand for recycling activity and recycled materials (more labour intensive activity), which offsets decreases in demand for traditional landfill (less labour intensive)	0%
Other Manufacturing	24.4	0.3%	Increase due to rebounds in spending and from recycling plants' investment; outweighs the reduction in demand from other sectors (through supply chains)	-10%
Repair and installation	60.6	4.7%	Increase due to more repair activities	0%
Utilities (gas, electricity and water)	14.5	0.9%	Increase due to higher electricity demand from electric cars (shifting from oil)	-6%

Sector	Impacts 000s	Impacts %	Key explanations	Baseline 2015-30 (% change in employ- ment)
Construction	-179.4	-1.2%	Reduction in employment due to new construction techniques such as modular design which requires less time to build. Also, reduction in demand from collaborative activities in the accommodation sector	5%
Transport and warehousing	-9.2	-0.1%	Reduction due to collaborative action in the road transport sector and less distribution and storage demand for new products (offsets increased demand for recycled materials)	-2%
Services	267.6	0.2%	Increase due to rebounds in spending and increasing demand for technology platform providers and R&D	7%
Total	695.5	0.3%		3%

Source(s): E3ME, Cambridge Econometrics and CEDEFOP employment projections

5.4. Winners and losers in the scenarios

The objective of this report is to provide a comprehensive quantification of the jobs impacts of circular economy activities. The model-based analysis that was carried out captures both potential job creation due to increased rates of recycling and job losses in extraction and other activities that will see a decline as Europe moves towards a more circular economy. Moreover, the analysis captures employment impacts from indirect and rebound effects on top of the direct changes that we have introduced. We can therefore identify the sectors that are expected to gain and those that are expected to lose out.

Sectors facing reductions in employment

The employment results in the previous section show that the sectors that will see reductions in employment are the mining and extraction sectors. Sectors that process raw materials including wood, non-metallic minerals, chemicals, plastic and metals could also see reductions in employment. By extending product lifetimes and undertaking more collaborative actions (more sharing, less buying), the EU will also see a reduction in demand for sectors that produce durable goods such as cars, accommodation and electronics.

Despite reductions in car purchases, the negative impact on employment in the European car manufacturing sector is limited. There two explanations for this. First, some of the reductions in demand are met through reductions in car imports to the EU. Second, exports of cars remains strong (we do not assume circular economy activities outside the EU in this analysis). The model results show that most of the employment reduction comes from domestic car sales activity rather than production of cars.

Contrary to some of the results from previous studies, construction employment is expected to fall due to the introduction of more efficient building techniques and a reduction in demand for housing from better using existing housing stocks. However, as noted previously, our study excludes energy efficiency in buildings. Construction employment would likely increase if there was a substantial programme of energy efficient investment (European Commission, 2016).

Sectors with increases in employment

The highest levels of job creation will be in the waste management sector. This sector includes both recycling activities and landfill management. The latter will see a decline but a higher demand for recycled materials will drive up demand for the overall sector. The results for job creation also reflect how recycling activities are much more labour-intensive (collecting, sorting, processing,

reselling, etc). Landfill management, in contrast, is a highly mechanised process that requires only a small level of labour input.

Another sector that benefits in terms of job creation is the repair sector. Services and some manufacturing sectors also benefit from rebounds in consumer spending and stimulus from recycling demand. Although the agriculture and food sectors will see a reduction in demand if Europe tackles food waste, demand for organic materials and by-products from food production will compensate this loss, resulting in a net small increase in employment.

We have not included renewable energy technologies in our analysis. A push for renewables could lead to further demand for bio-crops, but at the same time generate demand for raw materials (notably metals) to build wind turbines or glass to build solar panels. An increase in these activities could offset the trend of circular economy activities and requires careful management of materials.

5.5. Linking job impacts to occupation and skills

In the modelling, it is in general assumed that workers can easily transfer existing skills between sectors. However, in reality, a worker who loses a job in extraction may not be able to get a new job in the repair sector. Our analysis in the next chapter provides further insights as to what the transition to circular economy means in terms of occupations and skills needs.

6. CHANGES IN OCCUPATIONS AND SKILLS NEEDS

6.1. Approach to understanding the impact on occupations and skills

The E3ME modelling quantifies shifts in sector employment under the moderate and ambitious scenarios for the Circular Economy. The baseline scenario indicates how the pattern of employment is estimated to evolve to 2030, independent of the take-up of circular economy activities, reflecting wider drivers of change. The moderate and ambitious scenarios highlight the additional impact of circular economy take-up on employment.

Key sources

The modelling results provide an entry point for assessing the implications for jobs and skills. In order to assess what the projected employment shifts related to circular economy take-up means for jobs and skills, it is important to look at the occupational composition of the most affected sectors. Occupations provide the key for understanding how the skills mix may evolve as a consequence of the sectoral shifts in employment. This analysis is based on modelling results for the disaggregated E3ME sectors. These sectors map to the NACE classification and are generally more detailed than the five priority sectors used to inform the modelling, which intended to capture the lifecycle of products and services. There are two important sources of evidence/information that support such an analysis:

CEDEFOP

- Cedefop's skills and employment forecast breaks down the occupational composition of sectoral employment at a detailed level to 2030. Looked at alongside the E3ME modelling results on circular economy impact, this provides intelligence on the current distribution of jobs, and therefore skills, within sectors. It also quantifies the distribution of high-, medium- and low-skilled jobs within each occupational group based on the proxy measure of qualification levels, although skill needs in any particular context are obviously much more nuanced in practice.

ESCO

- The ESCO classification of occupations, skills and competences has been developed by the European Commission over a number of years to set out job/skill/knowledge requirements at a highly-granular level. The first full version of ESCO was published in 2017. Its occupational map provides an overview of the skills, competences and knowledge associated with key occupations (as signalled by the Cedefop forecast occupational profile) for the sectors most impacted by circular economy take-up (as indicated by the E3ME modelling).

Sector impacts

in Chapter 5 summarised the employment impacts of the circular economy on key sectors. It showed that the most substantial net employment impacts from the circular economy are concentrated in a small number of sectors. Looking at the disaggregated E3ME sectors, only four sectors are forecast to have a net employment impact of over +/-50,000 jobs across the EU28 by 2030 under the combined/ambitious scenario:

- The sewerage and waste sector is the key area for employment growth linked to the circular economy.
- The repair and installation of machinery sector also shows employment growth related to the additional impact of the circular economy.
- The construction sector shows a significant decline in employment as a consequence of circular economy take-up.
- The electronics sector also shows a net decline in employment linked to the circular economy.

Below we explore the occupation and skills implications of the circular economy for the four sectors anticipated to have a substantial employment impact. For each sector, the potential occupational implications of the E3ME modelling (combined scenario) are described, before looking at the skills associated with key occupations in each sector. The occupational analysis is also broadened out to

consider how the sectoral distribution of occupations may figure in an overall understanding of the impact of the circular economy on jobs and skills.

Below we explore the occupation and skills implications of the circular economy for these four sectors. For each sector, the potential occupational implications of the E3ME modelling (combined scenario) are described, before looking at the skills associated with key occupations in each sector. The occupational analysis is also broadened out to consider how the sectoral distribution of occupations may figure in an overall understanding of the impact of the circular economy on jobs and skills.

6.2. Sewerage and waste: The key area for employment growth

By far the most significant circular economy-related impact is on employment in the sewerage and waste sector. The sector is forecast to gain 650,000 jobs (+50.77%) under the combined moderate scenario and 660,000 jobs under the combined ambitious scenario (+51.59%). This is notable because the Cedefop forecast (excluding additional circular economy-related impacts on employment) indicates a small decline in employment in this sector in the period to 2030. Take up of circular economy activities could therefore be transformative for employment in the sewerage and waste sector.

The changing occupational profile

Table 6.1 shows the occupational distribution of the sewerage and waste sector, based on the Cedefop forecast. The current occupational profile is somewhat weighted towards elementary and semi-skilled occupations. Overall, though, the sector comprises a wide range of occupations and no single sub-major occupational group dominates the profile.

The Cedefop forecast highlights a long-term (non-circular economy) shift towards more highly-skilled occupations, such as science and engineering professionals and administrative and commercial managers. However, the scale of change implied by the circular economy modelling suggests that new jobs will be distributed across a range of occupations.

Table 6.1 Sewerage and waste – Distribution of highest-volume occupations, EU28

Sub-major occupational group	Employment		Share		Net change 2018 to 2030
	2018	2030	2018	2030	
Refuse workers and other elementary workers (ISCO 96)	198,989	199,210	16.1%	16.3%	220
Drivers and mobile plant operators (83)	171,316	161,865	13.8%	13.3%	-9,451
Science and engineering associate professionals (31)	159,130	156,055	12.9%	12.8%	-3,076
Science and engineering professionals (21)	76,154	79,871	6.2%	6.5%	3,716
Business and administration associate professionals (33)	65,745	64,694	5.3%	5.3%	-1,051
General and keyboard clerks (41)	49,135	36,873	4.0%	3.0%	-12,262
Numerical and material recording clerks (43)	45,138	35,109	3.6%	2.9%	-10,029
Labourers in mining, construction, manufacturing and transport (93)	44,708	45,764	3.6%	3.8%	1,056
Building and related trades workers, excluding electricians (71)	39,822	34,527	3.2%	2.8%	-5,295
Production and specialised services managers (13)	37,981	38,464	3.1%	3.2%	482

Business and administration professionals (24)	37,580	39,587	3.0%	3.2%	2,007
Stationary plant and machine operators (81)	36,412	39,699	2.9%	3.3%	3,287
Administrative and commercial managers (12)	36,255	44,803	2.9%	3.7%	8,548
Customer services clerks (42)	31,922	40,695	2.6%	3.3%	8,772
Metal, machinery and related trades workers (72)	31,311	17,868	2.5%	1.5%	-13,444
<i>Grand total</i>	<i>1,237,797</i>	<i>1,219,455</i>	<i>100%</i>	<i>100%</i>	<i>-18,342</i>

Source: Cedefop (2018)

6.2.1. Priority skills (selected occupations)

Refuse workers and other elementary workers

The refuse workers and other elementary workers sub-major occupation is the largest group of workers in this most heavily-impacted circular economy-related sector and, as such, may superficially be expected to be an area in which the labour market and skills impact of circular economy take-up is clearest. Table 6.2 shows that these workers are widely distributed across sectors. It also shows that they are concentrated in sectors where circular economy take-up is expected to have a positive impact on employment. As such, the refuse workers and other elementary workers group may embody the kind of skills requirements at elementary level where there is increased demand as a consequence of the circular economy.

Table 6.2 Sectoral distribution of refuse workers and other elementary workers, EU28

Sector	Share of occupational employment in the sector	circular economy impact on sector employment to 2030*
1 Public administration and defence	12.3%	→
2 Education	8.4%	↑
3 Security and office administrative	7.7%	↑
4 Sewerage and waste	7.7%	↑
5 Real estate activities	7.1%	→

Source: Occupational employment – Cedefop (2018); circular economy impact – E3ME modelling
Circular economy impact based on combined ambitious scenario (+/- 0.2%)

From a skills perspective, slightly over half of refuse workers and other elementary workers in the sewerage and waste sector have medium-level qualifications (53.8%) according to Cedefop data and most of the rest have lower-level qualifications (39.7%). This profile is expected to remain fairly consistent to 2030, with a small shift towards medium- and high-level qualifications. There is a more pronounced shift towards higher-level qualifications for this occupational group in other sectors. As such, there is, in theory, a high potential availability of new entrants to meet any increased demand, even if the impact of circular economy take-up is to increase the demand for these roles across multiple sectors.

The refuse workers and other elementary workers category can be split into different groups of jobs, only some of which are likely to benefit from the circular economy (distinguishing refuse workers from other elementary workers):

- The most relevant roles in the refuse worker minor occupational group are garbage and recycling collectors and refuse sorters. The other category of jobs in this minor group (sweepers and related labourers) is less relevant from a circular economy skills and jobs perspective. It is logical to think that garbage and recycling collectors and refuse sorters will be the elementary waste-related jobs most substantially impacted by the circular economy.
- The other elementary worker minor occupational group includes a group of jobs that also involve collection/delivery (e.g. odd job persons; water and firewood collectors; messengers/package deliverers), some of which are impacted by drivers of change outside

of the circular economy. They are therefore less relevant from the perspective of the circular economy. However, the group also includes meter readers, a job impacted by wider technological/environmental developments.

Table 6.3 shows the essential skills/competences and knowledge associated with the most relevant occupational unit groups based on the ESCO mapping. There is a relatively high degree of commonality in skills and knowledge requirements across the different job roles.

Table 6.3 Skills, competences and knowledge for refuse and recycling workers

	Refuse collector	Recycling worker	Sorter labourer
Essential skills and competences	<ul style="list-style-type: none"> • assess waste type • collect domestic waste • collect industrial waste • maintain refuse collection equipment • maintain waste collection records • manage waste 	<ul style="list-style-type: none"> • assess waste type • collect broken appliances • dismantle broken appliances • dispose waste • ensure compliance with waste legislative regulations • handle chemical cleaning agents • manage waste • operate recycling processing equipment • troubleshoot • use personal protection equipment 	<ul style="list-style-type: none"> • assess waste type • communicate with waste collectors • dispose waste • handle chemical cleaning agents • operate recycling processing equipment • sort waste • store sorted waste
Essential Knowledge	<ul style="list-style-type: none"> • health, safety and hygiene legislation • waste and scrap products • waste management 	<ul style="list-style-type: none"> • health, safety and hygiene legislation • waste and scrap products • waste management 	<ul style="list-style-type: none"> • health, safety and hygiene legislation • waste and scrap products • waste management

Source: ESCO v1.0.2

The circular economy is likely to bring new knowledge requirements, but these requirements are likely to be in scope of what is currently required by these roles. The impact of circular economy take-up on these elementary roles is therefore likely to be an upskilling requirement rather than anything that is transformative to jobs.

The optional skills and competences associated with these roles encompass more generic elements, such as the waste/recycling process, monitoring/compliance and maintaining records, alongside technical competence in areas such as dealing with contamination and handling hazardous waste. Optional knowledge brings in areas with wider applicability such as electricity, electronics principles and pollution prevention.

This provides reasonable scope for transferability into these roles in the sewerage and waste sector, with lack of knowledge likely to be the main barrier. However, the cross-cutting nature of these requirements perhaps indicates areas of knowledge with wider applicability for supporting the growth of the circular economy (i.e. health, safety and hygiene legislation; waste management; pollution prevention etc).

Drivers and mobile plant operators

The drivers and mobile plant operators sub-major occupation is the second largest group in the sewerage and waste sector, although it is not clear that circular economy take-up will substantially impact on these jobs or associated skill requirements. Table 6.4 highlights that only a very small share of these jobs are in the sewerage and waste sector. They are primarily concentrated in the land transport sector, where circular economy take-up (even under the ambitious scenario) is anticipated to have a neutral effect on employment.

Table 6.4 Sectoral distribution of drivers and mobile plant operators, EU28

Sector	Share of occupational employment in the sector	Circular economy impact on sector employment to 2030
1 Land transport	43.3%	→
2 Construction	7.6%	↓
3 Other retail trade	7.1%	→
4 Warehousing	4.8%	→
5 Other wholesale trade	3.6%	→
6 Agriculture	3.4%	→
7 Food, Drink & Tobacco	2.9%	→
8 Postal and courier activities	2.9%	→
9 Sewerage and waste	1.8%	↑

Source: Occupational employment – Cedefop (2018); circular economy impact – E3ME modelling
Circular economy impact based on combined ambitious scenario (+/- 0.2%)

The occupational group encompasses a set of jobs that share skills in areas such as machine/vehicle operation, but deploy these skills in quite different contexts and in combination with sector-specific skills and knowledge. Excluding minor occupational groups related to maritime, rail and passenger transport (e.g. taxi and motorcycle drivers), as well as agriculture and construction-related mobile plant operation roles, the key jobs within the sewerage and waste sector that may be impacted by the circular economy are within the heavy truck and lorry driver minor group, namely, refuse vehicle drivers (see Table 6.5).

There is no evidence of changing skill requirements that are circular economy-related for this group and the impact of the circular economy in this context may be about the overall number of jobs. However, the Cedefop forecast suggests a small decline in the number of driver and mobile plant operator jobs in the sewerage and waste sector to 2030 before circular economy-related impacts are taken into account. Substantial circular economy growth could create additional demand for drivers that mitigates this forecast decline, but this may just mean that employment levels are steady rather than growing.

Table 6.5 Skills, competences and knowledge for refuse vehicle drivers

	Essential	Optional
Skills and competences	<ul style="list-style-type: none"> • adhere to transportation work schedule • drive waste collection vehicle • maintain waste collection records • park vehicles in depot • use personal protection equipment 	<ul style="list-style-type: none"> • assess waste type • collect domestic waste • collect industrial waste • dispose of hazardous waste • dispose of non-hazardous waste • empty community waste collection bins • establish waste collection routes • maintain refuse collection equipment • maintain septic tanks • operate GPS systems • read maps
Knowledge	<ul style="list-style-type: none"> • types of waste collection vehicles • waste and scrap products • waste management • waste transport legislation 	<ul style="list-style-type: none"> • hazardous materials transportation • hazardous waste storage • road transport legislation

Source: ESCO v1.0.2

Science and engineering associate professionals

Science and engineering associate professional roles are an important component of a number of the sectors impacted by the circular economy:

- They represent the third largest occupational group in both the sewerage and waste sector and the repair and installation sector – which are sectors forecast to see an increase in employment as a consequence of circular economy take-up.

- Yet they are also the second largest group in the construction sector and the third largest group in the electronics sector, both of which will have circular economy-related decline in employment.
- Table 6.6 shows that relatively few science and engineering associate professionals currently work in the sectors anticipated to experience circular economy-related employment growth; while the negatively-impacted construction sector has the highest concentration of these jobs across the entire economy.

Table 6.6 Sectoral distribution of science and engineering associate professionals, EU28

Sector	Share of occupational employment in the sector	Circular economy impact on sector employment to 2030
1 Construction	15.8%	↓
2 Architectural & engineering	9.5%	↑
3 Other machinery & equipment	4.9%	→
4 Public administration and defence	4.5%	→
5 Metal products	4.4%	→
6 Other retail trade	4.3%	→
7 Food, Drink & Tobacco	3.8%	→
8 Motor Vehicles	3.6%	→
15 Sewerage and waste	2.0%	↑
19. Optical & electronic equipment	1.5%	↓
20. Repair/installation of machinery	1.4%	↑

Source: Occupational employment – Cedefop (2018); circular economy impact – E3ME modelling
Circular economy impact based on combined ambitious scenario (+/- 0.2%)

It is not, therefore, straightforward to describe the impact of the circular economy on science and engineering associate professional jobs and skills in linear terms. However, the ESCO occupational map provides a way to understand the extent to which the specific occupations most closely associated with key circular economy sectors share common skills and knowledge:

- The minor occupational group most closely associated with the sewerage and waste sector is process control technicians. Most process control jobs relate to energy and manufacturing sectors (power production plants, chemicals, gas processing and chemical plants), which are not forecast to be substantially impacted overall by circular economy take-up. The most relevant occupational unit group is incinerator and water treatment plant operators, which encompasses a variety of technician and operator process control roles where circular economy take-up may transform processes and knowledge requirements (rather than overall employment levels).
- Looking beyond jobs in the sewerage and waste sector specifically, it is possible that circular economy take-up will impact on the physical and engineering science technician minor occupational group. Even in sectors where circular economy take-up has a marginal employment effect, technological innovations driven by the needs of the circular economy could evolve technician processes and knowledge requirements across some electrical, mechanical and chemical engineering roles (and perhaps even more so for electronics engineering technicians specifically). The group also includes civil engineering technician roles found in the construction sector. However, it is not clear from the literature that any decline in construction employment associated with circular economy take-up would specifically affect these jobs. Indeed, some of these civil engineering roles are specifically associated with circular economy-related matters and could experience increased demand (e.g. energy conservation officers; energy consultants).
- The minor occupational group of mining, manufacturing and construction supervisors is likely to be affected differently by sector. At a micro-level, there may be some offsetting from lower demand for mining supervisors to increased demand for waste-related supervisors, but the overall number of jobs concerned is likely to be incredibly small. The wide range of construction-related supervisory roles could feel the impact on circular economy-related decline in employment, although, given that these roles combine a general supervisory competence

with technical/trades-related skills, this is likely to be inconsequential to the sector meeting future skills-related challenges, which depend on effective supply of specialist skills.

Irrespective of sector, the Cedefop forecast describes a split between medium- and high-level qualifications required for the vast majority of these roles. Across all relevant sectors, there is anticipated to be a shift from medium to high-level jobs up to 2030, suggesting a more general upskilling requirement.

While civil engineering associate roles tend to have a more distinctive skill set within this sub-major occupational group, Table 6.7 shows the degree of alignment in skill/competence requirements across other science and engineering associate professional minor occupational groups. While there is clearly sector-specialist skills and knowledge requirements that are role-related, there is also a requirement for more transversal skills related to design, monitoring, operations and communications activities at the associate professional level.

For this important occupational group, this finding may indicate something about the overarching skills and knowledge that could be associated with circular economy take-up. It also shows that, even for sectors expected to be negatively impacted in terms of employment overall, the picture at the level of specific job roles might be more complex.

Table 6.7 Skills, competences and knowledge for selected science and engineering associate professional workers

	Solid waste operator (Process control technician)	Electronics engineering technician (Physical and engineering science technicians)	Waste management supervisor (Mining, manufacturing and construction supervisors)
Essential skills and competences	<ul style="list-style-type: none"> • assess waste type • communicate with waste collectors • control delivered waste • dispose of non-hazardous waste • ensure compliance with environmental legislation • ensure compliance with waste legislative regulations • ensure equipment availability • maintain recycling records • monitor waste treatment equipment • operate recycling processing equipment • test samples for pollutants • troubleshoot 	<ul style="list-style-type: none"> • adjust engineering designs • align components • apply soldering techniques • assemble electronic units • assist scientific research • conduct performance tests • configure electronic equipment • ensure finished product meet requirements • fasten components • inspect quality of products • interpret electronic design specifications • liaise with engineers • meet deadlines • prepare production prototypes • read assembly drawings • read engineering drawings • record test data • solder electronics • test electronic units • use testing equipment 	<ul style="list-style-type: none"> • design plant waste procedures • ensure compliance with policies • ensure compliance with waste legislative regulations • establish waste collection routes • liaise with managers • manage recycling program budget • manage staff • perform planning • supervise staff • supervise waste disposal • supervise work • supervise worker safety
Essential Knowledge	<ul style="list-style-type: none"> • waste and scrap products • waste management 	<ul style="list-style-type: none"> • circuit diagrams • design drawings • electronic components • electronic equipment standards 	<ul style="list-style-type: none"> • health, safety and hygiene legislation • waste management

		<ul style="list-style-type: none"> • electronic test procedures • electronics • integrated circuits • printed circuit boards • types of electronics 	
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Source: ESCO v1.0.2

Science and engineering professionals

Science and engineering professionals are one of the few relatively large groups in the sewerage and waste sector anticipated to grow based on the Cedefop forecast – i.e. even before the additional impact of take-up of circular economy activities is considered. They are a significant component of most of the sectors anticipated to be impacted by the circular economy. As well as being the fourth largest group in the sewerage and waste sector, they are the second largest group in the electronics sector.

However, as Table 6.8 shows, only a small proportion of science and engineering professionals work in these sectors. While only being the seventh largest group in the construction sector, the number of science and engineering professionals working in construction is more than double the combined number working in the sewerage and waste and electronics sectors.

While circular economy take-up affects the various sectors where science and engineering professionals are concentrated in various ways (as Table 6.8 shows), the number jobs is expected to increase to 2030 in all relevant sectors based on the Cedefop forecasts, irrespective of the overall sectoral employment trends. This indicates that any negative employment impacts directly related to circular economy take-up are less likely to impact on science and engineering professionals specifically. The skills challenge, such that it is, may relate to lack of supply to meet future demand; something that is relevant to, but not driven by, the labour market impact of the circular economy.

Table 6.8 Sectoral distribution of science and engineering professionals, EU28

Sector	Share of occupational employment in the sector	Circular economy impact on sector employment to 2030
1 Architectural & engineering	17.2%	↑
2 Construction	7.5%	↓
3 Public administration and defence	6.0%	→
4 Research & Development	5.8%	↓
5 Education	3.8%	↑
6 Motor Vehicles	3.8%	→
7 Other machinery & equipment	3.5%	→
12. Optical & electronic equipment	2.3%	↓
25 Sewerage and waste	1.2%	↑

Source: Occupational employment – Cedefop (2018); circular economy impact – E3ME modelling
Circular economy impact based on combined ambitious scenario (+/- 0.2%)

Science and engineering professional jobs in the sewerage and waste sector are almost exclusively the preserve of people with higher-level qualifications (94.7% in 2018, compared with 82.0% of science and engineering professionals across all sectors). The qualifications profile of these workers in both the construction and electronics sector is closer to the average position.

Unlike science and engineering associate professional roles, there is little scope for, or expectation of, further substantial shifts towards higher-level qualifications to 2030 based on the Cedefop forecast. This reflects the highly-skilled, technically specialist nature of existing jobs across physical sciences, mathematics, life sciences, engineering, electro-technology and architecture/planning.

The higher-skilled nature of the workforce, combined with the level of technical specificity within sectors, inhibits the potential for skills transfer and creates ongoing skills challenge in terms of the time required to train these professionals. It necessarily limits pools of labour supply that employers can draw on. None of these issues are specific to the circular economy and, indeed, in terms of supply, the anticipated circular economy-related net increase in employment in some sectors is inconsequential in the context of wider factors driving up demand for science and engineering professionals.

While it is possible, based on the literature, to identify jobs that may be boosted by circular economy-related matters, such as industrial designers within the architects, planners, surveyors and designers minor occupational group and environmental protection professionals within the life sciences professionals minor occupational group, the E3ME modelling puts in context that the number of these jobs is relatively small in the context of the overall labour market.

The labour market implications of the circular economy in this context therefore align with challenges faced by policy makers more widely in terms of ensuring future skills supply (the STEM skills agenda) and upskilling to maintain skills and knowledge where technological advances continue to evolve the working environment. The circular economy is extremely pertinent in this context, but its additional effect is marginal.

Business and administration associate professionals

The fifth largest occupational group in the sewerage and waste sector, business and administration associate professionals, is also concentrated in sectors in which the circular economy is expected to increase employment. Only a small share of these jobs is currently found in the sewerage and waste sector (see Table 6.9). This indicates that there is a much larger labour pool to draw on, but it may suggest that the real issue for attracting people into new sewerage and waste jobs is that current routes into the sector are ad hoc and small-scale. There could be a need to support pathways into the sector (careers advice, sector-specific training) to effectively meet future skill needs.

Table 6.9 Sectoral distribution of business and administration associate professionals, EU28

Sector	Share of occupational employment in the sector	Circular economy impact on sector employment to 2030
1 Legal and accounting	15.7%	↑
2 Public administration and defence	14.1%	→
3 Financial services	6.8%	↑
4 Other retail trade	6.5%	→
5 Security and office administrative	5.5%	↑
44 Sewerage and waste	0.4%	↑

Source: Occupational employment – Cedefop (2018); circular economy impact – E3ME modelling
Circular economy impact based on combined ambitious scenario (+/- 0.2%)

6.3. Repair and installation of machinery: Substantial growth

The literature indicates that repair and remanufacture activities are a likely growth area as a result of circular economy take-up. However, the jobs associated with this kind of activity are widely dispersed across the economy. The E3ME model suggests that circular economy-related employment growth is focused on the repair and installation of machinery sector and is driven by the circular economy impact on the electronics lifecycle sector.

The sector is forecast to gain 25,000 jobs across the EU28 (+2.0%) under the moderate scenario and 64,000 jobs (+4.7%) by 2030 under the ambitious scenario as a consequence of circular economy take-up. In terms of scale, this is a much more modest increase than that related to the sewerage and waste sector. As the second largest beneficiary of a circular economy-related employment boost, this highlights that the overall impact on employment levels is relatively small-scale. The Cedefop forecast (before circular economy-related take-up is accounted for) indicates only a marginal increase in employment in the repair and installation of machinery sector up to 2030, albeit with some substantial occupational shifts.

The scope of the sector, based on the NACE definition, includes 'the specialised repair of goods produced in the manufacturing sector with the aim to restore machinery¹¹'. This encompasses routine repair, but does not include the rebuilding or remanufacture of machinery and equipment, which is considered a manufacturing category. The sector classification and the E3ME modelling separates out the repair of computers and personal and household goods, for which the forecast suggests that circular economy-take-up will have a minimal net employment impact (and which includes the repair of: consumer electronics; household appliances; footwear and leather goods; watches, clocks and jewellery; furniture and home furnishings).

The changing occupational profile

The repair and installation of machinery sector includes a diverse occupational profile with a preponderance of associate professional and craft and related trades jobs.

Table 6.10 lists the largest occupational groups in the sector. It shows an anticipated decline in craft and related trades employment based on the Cedefop forecast. The occupational profile also reflects the wide array of equipment in scope of the sector, which ranges from metal products and machinery, through electronic and optical equipment (including medical equipment), to electrical equipment and a range of transport equipment (excluding motor vehicles).

There is no evidence that circular economy take-up will reverse the forecast decline in craft and trades roles in this sector specifically and, if it does, this is likely to protect jobs rather than lead to skills shortages (all other things being equal). The literature indicates potential circular economy-related growth in remanufacture as an activity, which is anticipated to create a mix of high and low skilled jobs. However, this trend tends not be related to equipment and machinery so much as other goods and services (it could be both, of course).

As the E3ME modelling suggests little overall employment impact from circular economy take-up in the repair of computers and personal and household goods sector, this perhaps indicates that the 'remanufacture agenda', while potentially leading to the new development of new services, only creates a small number of jobs overall. The relevant activities are only a small component of the household goods repair sector. In contrast with the crafts-focused repair and installation of machinery sector, the occupational profile of the repair of computers and personal and household goods sector is much more geared towards service workers - with the largest groups being personal service workers (31.2%), cleaners and helpers (17.0%) and personal care workers (6.8%).

Table 6.10 Repair and installation – Distribution of highest-volume occupations, EU28

Sub-major occupational group	Employment		Share		Net change 2018 to 2030
	2018	2030	2018	2030	
Metal, machinery and related trades workers (ISCO 72)	189,402	168,760	14.7%	13.1%	-20,643
Food processing, wood working, garment and other craft and related trades (75)	186,326	143,113	14.5%	11.1%	-43,213
Science and engineering associate professionals (31)	114,146	126,752	8.9%	9.9%	12,606
Labourers in mining, construction, manufacturing and transport (93)	63,287	64,418	4.9%	5.0%	1,131
Health associate professionals (32)	61,529	66,597	4.8%	5.2%	5,068
Electrical and electronic trades workers (74)	61,436	57,225	4.8%	4.5%	-4,211

¹¹ Eurostat (2008), NACE Rev. 2 - Statistical classification of economic activities in the European Community

Business and administration associate professionals (33)	56,796	60,430	4.4%	4.7%	3,634
Handicraft and printing workers (73)	53,378	45,109	4.2%	3.5%	-8,269
Building and related trades workers, excluding electricians (71)	48,482	54,039	3.8%	4.2%	5,557
Science and engineering professionals (21)	48,174	64,405	3.8%	5.0%	16,232
Stationary plant and machine operators (81)	47,884	47,763	3.7%	3.7%	-121
Assemblers (82)	45,447	45,622	3.5%	3.5%	175
Numerical and material recording clerks (43)	43,259	36,770	3.4%	2.9%	-6,489
Production and specialised services managers (13)	37,468	40,683	2.9%	3.2%	3,215
General and keyboard clerks (41)	34,367	29,847	2.7%	2.3%	-4,520
Drivers and mobile plant operators (83)	31,477	36,262	2.5%	2.8%	4,786
<i>Grand total</i>	<i>1,284,521</i>	<i>1,285,575</i>	<i>100%</i>	<i>100%</i>	<i>1,054</i>

Source: Cedefop (2018)

6.3.1. Priority skills (Selected occupations)

Metal, machinery and related trades workers

Although the largest occupational group in the repair and installation sector, the vast majority of metal, machinery and related trades workers operate in other sectors (see Table 6.11). This situation partly reflects the fact that many sub-occupational groups are more closely associated with installation rather than repair (e.g. container equipment assemblers within the sheet metal workers occupational unit group, as well as a range of job roles within the category of structural-metal preparers and erectors).

The most relevant minor occupational group is machinery mechanics and repairers, which covers transport, agricultural and industrial machinery technicians and mechanics. There is little evidence that these roles would see a circular economy-related growth. However, essential skills for these roles include handling and disposal of goods and waste (hazardous and non-hazardous), the requirements for which could evolve as a consequence of the circular economy. These skills are relatively transferable in the context of job requirements that generally centre on the use of tools. The findings suggest that, irrespective of the circular economy impact on these occupations (which is expected to be minor in scale), it is likely that these jobs will evolve through skills updating activities.

Table 6.11 Sectoral distribution of metal, machinery and related trades workers, EU28

Sector	Share of occupational employment in the sector	Circular economy impact on sector employment to 2030
1. Other retail trade	17.7%	→
2. Metal products	17.2%	→
3. Other machinery & equipment	9.2%	→
4. Other wholesale trade	9.1%	→
5. Construction	5.9%	↓
10. Repair/installation of machinery	2.3%	↑

Source: Occupational employment – Cedefop (2018); circular economy impact – E3ME modelling
Circular economy impact based on combined ambitious scenario (+/- 0.2%)

Food processing, wood working, garment and other craft and related trades

The second largest occupational group in the repair and installation sector is food processing, wood working, garment and other craft and related trades workers. The Cedefop forecast anticipates that this occupation will experience the largest absolute decline in sector employment before the impact of circular economy take-up is taken into account.

The specific occupational areas in this diverse group that relate to the repair and installation of machinery are marginal to the group itself. Fewer than 5% of these jobs are in the repair sector (see Table 6.12). This share includes niche workers 'not elsewhere classified' such as optical lens finishers and moulders.

However, it is notable that food processing, wood working, garment and other craft and related trades workers are predominantly found in sectors for which circular economy take-up under the ambitious scenario is expected to be positive or neutral. While the overall impact of circular economy take-up on employment in those sectors is marginal, this may hint at a group of jobs that will be in greater demand across the economy as a result of the circular economy.

One of the challenges is that the literature related to circular economy growth in these areas (e.g. remanufacture) alludes to potential jobs that do not map well to the current occupational landscape. Looking beyond the repair and installation of machinery, the relevant minor occupations that most closely map to circular economy activities are various furniture-related roles. These may provide insight into the types of skills and knowledge that some future remanufacture jobs could require (see Table 6.13).

Table 6.12 Sectoral distribution of Food processing, wood working, garment and other craft and related trades workers, EU28

Sector	Share of occupational employment in the sector	Circular economy impact on sector employment to 2030
1. Food, Drink & Tobacco	23.9%	→
2. Textiles, Clothing & Leather	13.5%	↑
3. Manufacturing nes	8.3%	↑
4. Other retail trade	7.4%	→
5. Construction	6.6%	↓
6. Repair/installation of machinery	4.6%	↑

Source: Occupational employment – Cedefop (2018); circular economy impact – E3ME modelling
Circular economy impact based on combined ambitious scenario (+/- 0.2%)

Table 6.13 Skills, competences and knowledge for selected food processing, wood working, garment and other craft and related trades workers

	Furniture upholsterer (Garment and related trades workers)	Furniture restorer (Wood treaters, cabinet-makers and related trades workers)
Essential skills and competences	<ul style="list-style-type: none"> • clean furniture • create patterns for textile products • cut textiles • decorate furniture • fasten components • install spring suspension • perform upholstery repair • provide customized upholstery • sew pieces of fabric • sew textile-based articles • use manual sewing techniques 	<ul style="list-style-type: none"> • apply a protective layer • apply restoration techniques • assess conservation needs • create smooth wood surface • create wood joints • do historical research • document restoration • estimate restoration costs • evaluate restoration procedures • join wood elements • operate wood sawing equipment • provide conservation advice • sand wood • select restoration activities

Essential Knowledge	<ul style="list-style-type: none"> • furniture industry • furniture trends • textile materials • upholstery fillings • upholstery tools 	<ul style="list-style-type: none"> • art history • conservation techniques • technical drawings • types of wood
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Source: ESCO v1.0.2

6.4. Construction: Decline masking growth opportunities

The E3ME modelling indicates that the largest negative employment effect resulting from circular economy take-up relates to the construction sector. Under the ambitious scenario, the sector is forecast to lose 182,000 jobs by 2030 (or 84,000 jobs under moderate scenario). These are large numbers but, given the overall size of the sector, this only relates to a 0.5-1.2% decline in employment as a consequence of circular economy take-up.

The Cedefop forecast anticipates an increase in employment of over 600,000 across the EU28 in the construction sector from 2018 to 2030. The additional impact of circular economy take-up is therefore relatively marginal, although forecasting construction sector employment levels is particularly challenging given its volatility in relation to the economic cycle.

The changing occupational profile

The Cedefop forecast indicates that future growth in construction employment will be concentrated on managerial, professional and associate professional roles (see Table 6.14). It is likely that the occupational impact of the circular economy will follow this lead, with higher-skilled roles replacing some lower-skilled and trades-related roles.

These trends could translate into circular economy-related growth in science and engineering associate professional roles (and some upskilling of those roles), as described in Section 2 of this chapter. The other high-skilled sub major occupational group expected to grow based on the Cedefop forecast is production and specialised services managers (i.e. construction managers). While it is not clear from the literature that circular economy take-up will create jobs in this area, the overall pattern suggests that the picture is not uniformly negative.

Table 6.14 Construction – Distribution of highest-volume occupations, EU28

Sub major occupational group	Employment		Share		Net change 2018 to 2030
	2018	2030	2018	2030	
Building and related trades workers, excluding electricians (ISCO 71)	6,239,233	6,123,562	42.9%	40.3%	-115,672
Science and engineering associate professionals (31)	1,251,619	1,450,184	8.6%	9.6%	198,565
Electrical and electronic trades workers (74)	1,188,582	1,189,109	8.2%	7.8%	527
Labourers in mining, construction, manufacturing and transport (93)	957,192	954,963	6.6%	6.3%	-2,229
Drivers and mobile plant operators (83)	716,325	670,103	4.9%	4.4%	-46,222
Production and specialised services managers (13)	664,845	804,091	4.6%	5.3%	139,246
Science and engineering professionals (21)	495,025	516,237	3.4%	3.4%	21,213
Metal, machinery and related trades workers (72)	480,243	444,280	3.3%	2.9%	-35,963
Business and administration associate professionals (33)	370,606	428,248	2.5%	2.8%	57,642
General and keyboard clerks (41)	363,716	357,176	2.5%	2.4%	-6,541

Numerical and material recording clerks (43)	272,671	264,261	1.9%	1.7%	-8,410
Food processing, wood working, garment and other craft and related trades (75)	267,662	353,611	1.8%	2.3%	85,949
Business and administration professionals (24)	155,143	213,741	1.1%	1.4%	58,597
Administrative and commercial managers (12)	145,028	213,220	1.0%	1.4%	68,192
<i>Grand total</i>	<i>14,546,909</i>	<i>15,180,308</i>	<i>100%</i>	<i>100%</i>	<i>633,399</i>

Source: Cedefop (2018)

6.4.1. Priority skills (selected occupations)

Building and related trades workers

Building and related trades workers represent more than two in five construction jobs. It is a sub major occupational group that is primarily concentrated in the construction sector (see Table 6.15). The Cedefop forecast estimates that, even though construction sector employment is anticipated to grow by over 600,000 across the EU28 from 2018 to 2030, the number of building and related trades workers is anticipated to fall by over 100,000. This decline is likely to be mirrored in terms of circular economy-related impact.

The occupational group can be segmented into building frame and related trades workers, building finishers and related trades workers and painters, building structure cleaners and related trades workers. There is no evidence that any particular specialist group within these categories is likely to be specifically negatively affected by circular economy take-up. Any circular economy-related decline in employment may be experienced across the full range of specialist building trades, reflecting changes in the volume of building activity and maintenance requirements. However, much more significant from a policy perspective will be the probable upskilling requirement across the board related to new materials and design driven by circular economy needs.

Table 6.15 Sectoral distribution of building and related trades workers, EU28

Sector	Share of occupational employment in the sector	Circular economy impact on sector employment to 2030
1. Construction	71.2%	↓
2. Security and office administrative	2.8%	↑
3. Real estate activities	2.0%	→
4. Other retail trade	1.9%	→
5. Public administration and defence	1.6%	→
6. Rubber and plastic products	1.4%	↓

Source: Occupational employment – Cedefop (2018); circular economy impact – E3ME modelling
Circular economy impact based on combined ambitious scenario (+/- 0.2%)

The cyclical nature of construction sector employment means that meeting skills demand during growth periods is a general challenge faced by the sector. It is not clear that the effects of the circular economy will do anything to change these patterns and the overall effect of the circular economy on employment is dwarfed by other drivers. The evidence suggests a substantial shift in the occupational mix within the sector over the next decade that could in itself create a skills challenge. The impact of circular economy take-up in this context is likely to amplify existing challenges that are primarily driven by other factors (such as the use of new technologies within the construction process).

Labourers in mining, construction, manufacturing and transport

The fourth largest sub major occupational group in the construction sector is labourers. These elementary roles are fairly widely distributed across the economy, ranging from freight handlers, to shelf fillers and factory hands. They are more concentrated in sectors anticipated to be negatively or neutrally affected by circular economy take-up (see Table 6.16).

The relevant occupational unit groups in a construction context are building construction labourers and civil engineering labourers. While new processes associated with increased resource efficiency may reduce demand for labour, this is likely to be connected to other, non-circular economy drivers of change.

Of more significance from a labour market perspective is forecast changes to qualification levels of labourers in construction. The Cedefop forecast anticipates a decline in the share of these workers with low-level qualifications from 43.4% in 2018 to 33.3% in 2030, which suggests that there will be fewer opportunities, even among elementary jobs, for people below the medium-qualified level.

Table 6.16 Sectoral distribution of Labourers in mining, construction, manufacturing and transport, EU28

Sector	Share of occupational employment in the sector	Circular economy impact on sector employment to 2030
1. Other retail trade	16.9%	→
2. Construction	14.3%	↓
3. Other wholesale trade	8.8%	→
4. Food, Drink & Tobacco	5.6%	→
5 Warehousing	4.9%	↓
24. Repair/installation of machinery	0.9%	↑

Source: Occupational employment – Cedefop (2018); circular economy impact – E3ME modelling
Circular economy impact based on combined ambitious scenario (+/- 0.2%)

6.5. Electronics

The electronics sector is forecast to lose fewer jobs as a consequence of circular economy take-up than the construction sector, but to lose a larger share of its current employment base. Employment is anticipated to decline by 25,000 (-1.9%) under the moderate scenario and 64,000 under the ambitious scenario (-4.9%) within the combined scenario by 2030. To put this in context, the Cedefop forecast (excluding additional circular economy impact) indicates a net increase in employment of 74,660 from 2018 to 2030. The negative employment impact of circular economy take-up (under the ambitious scenario) is therefore roughly equivalent to the expected level of employment growth over the next decade.

The changing occupational profile

Table 6.17 sets out the occupational mix of the electronics sector, and highlights forecast growth for both lower- and higher-skilled occupations before the impact of circular economy take-up is taken into account. Given that the circular economy-related decline in employment driver is a function of lower consumer demand as a consequence of increased collaborative use and longer product lifespans, it might be expected that the impact is focused on occupations such as assemblers and electrical and electronic trades workers. The former is expected to grow, while the latter is expected to decline under the non-circular economy forecast.

Table 6.17 Electronics – Distribution of highest-volume occupations, EU28

Sub major occupational group	Employment		Share		Net change 2018 to 2030
	2018	2030	2018	2030	
Assemblers (ISCO 82)	171,970	189,163	13.6%	14.1%	17,193
Science and engineering professionals (21)	152,246	157,327	12.0%	11.7%	5,081
Science and engineering associate professionals (31)	121,562	109,206	9.6%	8.1%	-12,356
Electrical and electronic trades workers (74)	93,708	82,769	7.4%	6.2%	-10,939
Information and communications technology professionals (25)	88,352	104,183	7.0%	7.8%	15,831
Business and administration associate professionals (33)	72,781	76,019	5.7%	5.7%	3,239
Business and administration professionals (24)	61,565	71,202	4.9%	5.3%	9,637
Numerical and material recording clerks (43)	61,367	53,570	4.8%	4.0%	-7,797
Metal, machinery and related trades workers (72)	48,954	40,429	3.9%	3.0%	-8,525
Production and specialised services managers (13)	46,836	52,420	3.7%	3.9%	5,584
Administrative and commercial managers (12)	45,915	58,793	3.6%	4.4%	12,879
Stationary plant and machine operators (81)	41,809	58,003	3.3%	4.3%	16,195
Labourers in mining, construction, manufacturing and transport (93)	41,406	50,402	3.3%	3.8%	8,996
Information and communications technicians (35)	37,217	35,254	2.9%	2.6%	-1,963
<i>Grand total</i>	<i>1,267,867</i>	<i>1,342,527</i>	<i>100%</i>	<i>100%</i>	<i>74,660</i>

Source: Cedefop (2018)

Other workers, especially those in professional roles, may be positively impacted by circular economy-related drivers to the extent that consumer demand drives product design or manufacturing processes. Table 6.18 shows that the small, but growing, ICT professionals sub major group is concentrated in sectors in which circular economy take-up is anticipated to boost employment. While not to a scale that would in itself likely lead to skills shortages, this highlights how difficult-to-measure granular shifts in employment associated with the circular economy could contribute to future skills shortages.

Table 6.18 Sectoral distribution of Information and communications technology professionals, EU28

Sector	Share of occupational employment in the sector	Circular economy impact on sector employment to 2030
1. Computer programming, info serv	43.2%	↑
2. Public administration and defence	4.9%	→
3. Financial services	4.1%	↑
4. Legal and accounting	3.5%	↑
8. Optical & electronic equipment	2.5%	↓

Source: Occupational employment – Cedefop (2018); circular economy impact – E3ME modelling
Circular economy impact based on combined ambitious scenario (+/- 0.2%)

6.5.1. Priority skills (selected occupations)

Assemblers & Electrical and electronic trades workers

Assemblers and electrical and electronic trades workers are two of the largest sub major occupational groups in the electronics sector (alongside the science and engineering professional/associate professional roles discussed in Section 2 of this Chapter). While these roles sit within different major occupational groups, it is useful to consider them in parallel when looking at potential skills implications of circular economy take-up. Table 6.19 shows that these two groups of workers are concentrated in similar sectors (as well as electronics, this includes construction, electrical equipment manufacture and the other machinery and equipment sector) and the employment effect of circular economy take-up is generally neutral.

While the non-circular economy forecast predicts growth in the assembler group and decline in the electrical and electronics trade group, this is one area where the circular economy might indicate the opposite trend occurring. Increased re-use and extension of product lifecycles could create demand for repair technicians at the expense of product manufacturing roles. Table 6.20 compares the essential skills/competence and knowledge requirements of an example assembler role and a trades role working in electronics. While acknowledging that job roles will themselves evolve as a consequence of circular economy take-up and wider drivers of change, it is notable that repair and maintenance roles have simpler knowledge requirements and broader (more cross-cutting) competence requirements than assembler roles.

Table 6.19 Sectoral distribution of assemblers and electrical and electronic trades workers, EU28

Sector	Share of occupational employment in the sector	Circular economy impact on sector employment to 2030
Assemblers		
1. Motor Vehicles	18.6%	→
2. Electrical equipment	13.1%	→
3. Optical & electronic equipment	10.0%	↓
4. Other machinery & equipment	8.3%	→
5. Manufacturing nes	4.3%	↑
6. Construction	3.9%	↓
Electrical and electronic trades workers		
1. Construction	35.0%	↓
2. Other retail trade	5.3%	→
3. Electrical equipment	4.5%	→
4. Other machinery & equipment	3.6%	→
8. Optical & electronic equipment	2.8%	↓

Source: Occupational employment – Cedefop (2018); circular economy impact – E3ME modelling
Circular economy impact based on combined ambitious scenario (+/- 0.2%)

Table 6.20 Skills, competences and knowledge for selected assembler and electrical and electronic trades workers

	Printed circuit board assembler (Electrical and electronic equipment assemblers)	Consumer electronics repair technician (Electronics mechanics and servicers)
Essential skills and competences	<ul style="list-style-type: none"> • apply through-hole technology manually • assemble printed circuit boards • coat printed circuit board • ensure conformity to specifications • ensure public safety and security • meet deadlines • operate insertion mount machine • prepare board for soldering • read assembly drawings • solder components onto electronic board 	<ul style="list-style-type: none"> • apply company policies • create solutions to problems • maintain customer service • maintain equipment • provide customer follow-up services • provide customer information related to repairs • repair equipment on site • replace defect components • set up consumer electronics • troubleshoot • use repair manuals
Essential Knowledge	<ul style="list-style-type: none"> • circuit diagrams • electronics • integrated circuits • printed circuit boards • semiconductors • through-hole technology 	<ul style="list-style-type: none"> • consumer electronics • electronics

Source: ESCO v1.0.2

The Cedefop forecast describes an anticipated decline at the mid-level within the assembler group to 2030. While the share of assembler jobs in electronics with low-level qualifications will remain static at around a quarter of the workforce, there is anticipated to be a shift from medium to high-level qualifications (from 6.0% of the workforce holding high level qualifications in 2018 to 13.1% in 2030). While the share of highly-qualified electrical and electronic trades workers also increases slightly over the same period (from 14.6% to 17.5%), there is not a similar scale of decline in share at medium-level (-1.1% compared with an -8.3% decline for assemblers). If one impact of the circular economy is to shift demand from assembly to repair, this may be consistent with an increased demand for higher skilled levels and more cross-cutting skills.

6.6. Conclusions / Implications for skills demand

Looking across the various sectors and occupations, the additional impacts of the circular economy are relatively small-scale in comparison with other drivers of change. This suggests that take-up of circular economy activities does not in itself have a transformative effect on labour markets, even under the ambitious scenario. However, this does not mean that the jobs and skills implications of the circular economy are negligible, or that there is no value in considering what the long-term impacts might be. It shows instead that change is gradual and that the impact of the circular economy should be viewed in the context of non-circular economy labour market changes (i.e. the additional effects of circular economy uptake do not take place in a vacuum). Drivers such as automation, innovation and the evolution of global markets feed the potential of the circular economy, as well as acting on labour markets more broadly.

From a skills perspective, the literature indicates changing demand for skills linked to the circular economy that generally aligns with other drivers of change, such as the impact of technological change on jobs and the shift towards high-skilled jobs in some sectors. In this context, the circular economy may amplify certain areas of future skills demand, where future demand is already being shaped by global drivers of change.

Even in the small number of sectors where the impact of the circular economy on employment runs counter to the prevailing trend, the net employment impact of the circular economy is marginal. For example, forecast growth in construction sector employment to 2030 may just be slightly mitigated by a negative employment impact associated with the circular economy, meaning that overall employment levels are steady. Furthermore, even where there is a decline in occupational employment, there is likely to be a changing demand for skills associated with those jobs. The

possible decline in the number of specialist building trades jobs, for example, is probably less significant than the general knowledge upskilling requirement for these jobs associated with new materials and design processes.

The gradual nature of change is important for understanding which policy levers are likely to be most effective in meeting the changing demand for skills. It is likely that much of general skills updating as jobs evolve will be led by employers, especially where changing knowledge requirements relate to the introduction of new processes, tools and technologies. This cuts across sectors and many different occupational groups, especially within the technician and associate professional, craft and related trades, and plant and machine operator major occupational groups. The extent to which transition to the circular economy is either facilitated or inhibited by the availability of skills will therefore depend on whether employers in different sectors have the capacity to invest in training for their workforces.

The skills implications for the sewerage and waste sector are slightly distinctive, given that this is where a considerable share of the circular economy employment impact is focused. However, this distinctiveness is arguably much more about skills supply than demand. The picture in terms of changing skills demand is similar to other sectors, but on a larger scale. The evidence suggests that the circular economy creates sewerage and waste jobs across a range of occupational levels. It highlights, in common with other sectors, a reasonable scope for transition because new knowledge requirements are likely to be in scope of current job requirements (i.e. a skills evolution rather than revolution). There is also a cross-cutting nature to some of the skills and competences required for key sewerage and waste occupations, especially at the elementary and intermediate levels (e.g. processing, monitoring/compliance, maintaining records), which indicates scope to meet additional labour demand from the existing potential pool of supply. The main challenge from a skills supply perspective might relate to attracting people to a range of technical and non-technical roles (e.g. business and administration associate professionals) if there is not sufficient awareness of the (growing) job and career opportunities in the sector.

While growth in the sewerage and waste sector indicates increased demand for skills across occupational groups, there are also indications that, in other areas, circular economy take-up may shift the occupational balance within sectors. This is arguably more significant from a skills demand perspective, although it is important to reiterate that the number of jobs concerned is usually small. The prospective shift from assembler to trades roles in electronics illustrates where the circular economy could alter skills demand - but it may do so in a way that increases demand more for cross-cutting competences (problem solving; communications etc), once again broadening the potential labour pool. In the construction sector, the evidence suggests that, even in the context of the circular economy having a negative impact on employment, there will be growth in specialist higher-skills occupations that replaces some lower-skills and trades-related roles.

Across a number of sectors the common theme is increased demand for STEM-related skills at professional and associate professional level. At the professional level, the need for highly-skilled technical specialists may increase as a result of the circular economy, but this type of expertise is already in greater demand. It is not a demand that can be easily met through re-skilling given the extent of education and specialist training required for these roles. At associate professional level, though, it is possible to identify more cross-cutting skill requirements for technicians, operators and supervisors working across a range of sectors, as well as a more general need both for skills updating and upgrading as a consequence of the circular economy.

There are also jobs and skill areas that the literature suggests are integral to circular economy take-up, but which do not map to the most affected sectors in employment terms. Remanufacture, for example, is likely to change rather than create jobs, and these jobs will be dispersed across manufacturing and service industries. The current jobs that equate to these areas tend to be niche and require a mix of knowledge of materials combined with craft skills. Future jobs might be quite different in scope. Furthermore, the impact of the circular economy on areas such as product design is not captured by the E3ME model because it does not have a substantial net employment impact, even though it is a theme that clearly underpins skills and knowledge across a wide range of sectors.

7. POLICY IMPLICATIONS

7.1. Priority issues to be addressed

This report confirms that the circular economy has the potential to contribute to employment. In this respect the EU is on the right track by making the circular economy a policy priority as a more circular economy can contribute to resource efficiency and reduce negative environmental impacts, while simultaneously contributing to employment.

One important caveat of this study is that the magnitude of results is largely driven by the expected market uptake of circular activities in the five sectors examined. The larger the market uptake (ambitious vs moderate scenarios), the larger the impacts. Moreover, our circular economy scenarios are not a one-to-one translation of the policy instruments suggested in the EU Circular Economy package. Rather they are scenarios based on the circular potential existing in five focus sectors.

The analysis carried out in this study suggests that circular economy can have a net positive impact on the European economy across a range of economic indicators, including a 0.5% increase in EU GDP, a 0.3% increase in EU employment, a 0.4% increase in EU consumer spending and investment and a 0.1% decrease in consumer prices (in the ambitious scenario) by 2030.

However, inevitably there will be some 'winners' and 'losers' in such a transition. Some sectors will be positively affected, while others will see more negative impacts. Moreover, some Member States may be disproportionately affected. For example, Member States that produce and export durable goods will see reduction in their product demand from higher circular economy activities.

Based on the results of the analysis, the priority areas that would be affected are the following:

Addressing employment impacts in negatively affected sectors – mitigating any job losses

The transition to a circular economy will negatively affect employment in several sectors, in particular construction (with a knock-on effect on forestry), production of consumer electronics in Western Europe (with a knock-on effect on plastics), motor vehicles, and agriculture and food manufacturing (with a knock-on effect on chemicals). Sectors that extract and process raw materials sector are also likely to be negatively affected. However, these sectors have been in decline for some time now and in most cases are not major employers.

Addressing employment impacts in positively affected sectors – bridging any skills gaps and shortages

There are also sectors that stand to gain from the circular economy transition, namely the recycling and repair services, and utilities (gas, electricity and water; with knock-on effect on alternative materials and energy sources). Due to the rebound effects of increased consumer spending and increased demand for technology platform providers and R&D, the general services sector will also benefit from the transition. In particular, the use of innovative business models, such as collaborative economy platforms, has a high potential in terms of employment generation. However, this positive effect could be counterbalanced by negative impacts in other sectors, such as the so-called traditional economies (Trinomics, et al., 2018).¹²

Special attention to the EU waste markets and repair services – as the biggest winners of the circular economy

A particular attention should be paid to the waste sector and repair services as these are the two main sectors benefiting from the transition to a more circular economy. EU waste markets are extremely complex, and several bottlenecks exist, which make them work inefficiently in the EU. Moreover, EU waste legislation is not clear enough on the applicability of end-of-waste criteria, as a result of which some materials/products become waste in some Member States, while they become products (through reuse) in others (Arcadis & Trinomics, 2016).

¹² A number of studies explores these impacts, e.g. Trinomics et al. (2018), The environmental potential of the collaborative economy, Final report for DG Environment, European Commission

However, there is still a great potential to be tapped for repair services, as consumers tend to often choose buying a new product rather than repairing an old one. Besides the attitudes of consumers towards new and fashionable products, the preference for new products is also due to the fact that information on repair services, the availability of spare parts and their prices is often not easily available to consumers (London Economics et al., 2018).

Reconciling potential opposite effects of promoting circular economy and renewable energy sources

There are also other EU policies whose impacts are not fully coherent with the impacts of the circular economy transition. As noted in previous chapters, renewable energy technologies were not part of the analysis. A push for renewables could lead to further demand for raw materials, such as metals for wind turbines, and glass for solar panels. Such demands might have a counterbalancing effect on the circular economy transition. There might be other policies with similar effects on the circular economy transition, in which case the full employment potential of the circular economy would not materialise.

7.2. Policy implications and recommendations

There are several ways in which the European Commission and Member States can address the main issues and promote the transition to a circular economy, focusing on job creation and the provision of adequate skills. Such policy instruments and supporting measures can be categorised into four groups:

1. Promoting good functioning of the EU waste and repair markets
2. Integrating employment and skills aspects into circular policies and instruments
3. Integrating circular aspects into employment and skills policies.
4. Addressing any skills shortages and mismatches.

The next section presents the key policy recommendations for each of these four categories.

7.2.1. Good functioning of the EU waste and repair markets

Recommendation 1 Ensuring good functioning of EU waste markets

One of the key findings from the study is that the waste sector plays an essential role in achieving a net positive effect on the amount of employment (and GDP) in the EU. This beneficial impact is due to higher demand for such services from other sectors, which results in higher demand and investment in recycling plants and increased labour demand to process recycled materials. This employment impact can only be created if the EU waste markets, as a key sector in the EU generating circular jobs, are functioning properly and ambitious waste targets are set, where landfilling is virtually banned and waste incineration is limited as far as possible, while recycling and high-value loops such reuse and remanufacturing are promoted. The current legislative proposals on waste already contain ambitious targets for the recycling of municipal waste and packaging waste as well as a reduction of landfilling. Such targets will be important in creating a larger market for recycling, resulting in investments in more recycling facilities and demand for more workers in this sector.

Besides ensuring higher recycling, reuse and remanufacturing, waste markets also need to function properly. A study for DG Environment (2016) on 'The efficient functioning of waste markets in the EU' (Arcadis & Trinomics, 2016) identified and assessed a number of bottlenecks in the EU waste markets, and presented a set of policy recommendations, including developing a Schengen area for waste for recycling and recovery, within which waste would move freely. If the EU's waste markets function efficiently, without unjustified restrictions, waste would be routed to better sorting techniques, optimized processes and more effective treatment, recycling and recovery. This would in turn not only protect the environment and health, but also create more jobs and economic growth in the EU's waste management and recycling sectors.

Recommendation 2 Promoting repair services among consumers

The repair services sector has been found as another key sector supporting circular jobs. An ongoing DG JUST/CHAFEA study has been investigating consumers' willingness and engagement with repair services, renting and leasing (London Economics et al., 2018). The study found that consumers often use repair services and frequently look out for repair information on products, but

they often find that this information is difficult to get and would like to receive better information regarding these product characteristics. The study also found that the preference for new and fashionable products is an important barrier to circular economy engagement.

This study presented a set of policy recommendations on how to engage consumers more in repair which includes:

- Information awareness tools, such as campaigns, development of a reparability label, providing information on the availability and price of spare parts and repair services;
- Economic incentives, such as a reduction of the VAT rate on repair services to decrease the costs of repair; and
- Regulatory tools, such as making the essential components in a product replaceable by consumers themselves (via e.g. Ecodesign Directive, or Batteries and accumulators Directive), extending the EU legal guarantee on repair or replacement of a defective product, as having a legal guarantee encourages consumers to engage in repair services.

This would ensure that repair services are more widely used, which would contribute to greater circular economy employment.

7.2.2. Employment and skills aspects in EU circular economy policy

Recommendation 3 Supporting job creation, re-skilling, training and capacity building through EU environment instruments – LIFE and H2020

There are two main EU programmes investing in the circular economy, which could be used to enhance employment and skills in this area. These programmes could also be used to ensure enough skilled workers exist in positively affected sectors, such as waste, repair and utilities, and services, and to mitigate job losses in negatively affected sectors, such as construction and electronics.

LIFE Programme

The LIFE Programme is currently the only EU fund exclusively dedicated to protecting the environment and fighting climate change. The current LIFE Programme has two sub-programmes – Environment and Climate-Action. Circular economy activities are supported through the Environment sub-programme, which receives approximately 75% of the total LIFE budget. Even though the aim of the programme is not to create jobs and develop skills, the programme has played an important role in this (Camarsa et al, 2013). The funded projects offer training courses, capacity building for Member State authorities, support of tertiary education, a specific job creation/training plan and other employment/skills aspects.

To better consider the skills and employment aspects in the LIFE programme, its annual priorities and/or guidelines for project applicants could be adapted. The application package contains a list of priorities that could be amended on a yearly basis given the limits of the LIFE Regulation. There is also a list of indicators that could be used to measure the output and impact of the project, including social indicators such as the number of training courses offered, or the numbers of jobs created.

Currently, the new LIFE Regulation proposal for the programme period 2021-2027 is being prepared.

Horizon 2020 Programme

Horizon 2020 is the financial instrument implementing the EU's Innovation Union strategy¹³, a Europe 2020 flagship initiative aimed at securing Europe's global competitiveness. It is the biggest EU Research and Innovation programme ever, with nearly €80 billion of funding available over 7 years (2014 to 2020), in addition to the private investment that this money will attract. Given Horizon 2020's focus on investing in smart, sustainable growth and jobs in Europe and tackling societal challenges, there is scope for a project within this programme that would aim to support

¹³ http://ec.europa.eu/research/innovation-union/index_en.cfm

capacity building in the circular economy. The former IEE programme has been merged into the H2020 Programme, where for example the BUILD UP Skills programme (currently construction skills under H2020) aimed to address the skills shortages in energy efficiency and renewable energy sources in the construction sector.

A call for proposals addressing employment and skills aspects in circular economy could be launched under this programme. This could be, for example, in terms of developing a knowledge base on skills gaps and shortages, or in terms of provision of training courses and materials for specific sectors (construction and electronics), to re-skill or up-skill workers.

Recommendation 4 Supporting the use of innovative business models through collaborative economy platforms as employment creators

According to the European Commission (as well as recent studies), collaborative economy platforms have the potential to create new employment opportunities, boost flexible working arrangements and create new sources of income (European Commission, 2016). There is an ongoing discussion at EU and Member State level on how to regulate these platforms and the jobs that they create, as the offered services are generally in between the formal and informal economy.

Under certain conditions, collaborative economy platforms have a positive impact on the environment and contribute to an increased circular economy due to increased utilization of goods and assets, such as cars, buildings or other consumer products and machinery. A recently published study for DG Environment on 'The environmental impacts of the collaborative economy' (Trinomics et al., 2018) analysed to what extent and under which conditions the collaborative economy contributes to sustainability in the transport, accommodation and consumer durables sectors. The study also proposes policy actions to contribute to sustainable growth of the EU economy.

By supporting the development of collaborative economy business models, while ensuring that these businesses contribute to sustainable growth and 'fair' jobs, a specific type of circular job could be promoted. Even though currently the size of this market could be considered niche, it is expected to grow considerably in the future.

7.2.3. Circular aspects in EU employment & skills policy

Recommendation 5 Introducing Circular Economy aspects into schools' curricula

Many of the improvements that are possible in a product's lifecycle are dependent on the design of the product. A product's design determines the resource use during production, but also its energy demand and need for maintenance in the use phase, its lifespan as well as the reparability of the product when it gets broken. Lastly, the design of the product and the materials chosen affect how easily the product can be refurbished or recycled or how its components can be remanufactured into a new product, when the product has become obsolete. So to optimise the circular potential of products produced and used in Europe, design with circular principles in mind is key. The EU could contribute to this by providing Member States with guidance on how to mainstream circular economy thinking into industrial engineering and industrial design educational programmes.

Another key requirement for reaching a circular economy is to engage all EU citizens and create awareness on the necessity of a circular economy and a more general awareness on environmental issues. In order to reach the goal of 'living well within the limits of our planet', it is essential that the European youth is taught how to develop sustainable lifestyles. Therefore, it is important that schools pay sufficient attention to teaching children what the environmental impacts are of consumption and to teach them environmentally friendly behaviours and how to make sustainable choices as a consumer.

7.2.4. Addressing skill shortages and skill mismatches

Recommendation 6 Focus on skills updating rather than wholesale employment shifts

The modelling and analysis in this report indicates that the nature of circular economy labour market impacts means that there is no 'silver bullet' policy solution. Policy makers should be somewhat cautious about enacting major change specifically to tackle the labour market impact of the circular economy, because the overall scale of impact in terms of jobs and the occupational mix is smaller than that for other drivers of labour market change.

Any prospective policy intervention from an employment and skills perspective needs to distinguish labour market impacts related to supporting employment growth (new jobs created by the circular economy), mitigating employment decline and changing job and skill requirements as a consequence of circular economy take-up:

- With the exception of the waste sector, net employment growth at sector level driven by the additional impacts of circular economy take-up is of a manageable scale.
- Some of the sectors that are anticipated to see a decline in employment, such as mining and extraction, are small and the circular economy impact can arguably be seen as a continuation of existing trends. The modelling results suggest a larger decline in employment in the construction sector, but it arguably has a distinctive labour market dynamic anyway and the policy implications of circular economy take-up have to be considered in that context.

The most substantial labour market impact is likely to be on changing job and skill requirements as consequence of circular economy take-up. The closest policy focus should therefore be on supporting organisations and individuals to adapt and upskill to meet changing job requirements.

Recommendation 7 A joined-up approach with other structural changes to employment

In the main, the circular economy is not an outlier in terms of the trends that are shaping future jobs and skills. It connects with and provides further resonance to important trends shaping future jobs, such as automation. It is important therefore that policy makers consider the circular economy as part of these wider structural changes to employment and not as a silo in itself.

Furthermore, it is important to recognise that there are ongoing programmes of work at European level that are likely to dovetail with labour market needs associated with the circular economy. The need for 'new' action might therefore be limited and the focus could instead be on ensuring that existing actions explicitly reflect needs associated with the circular economy (although in some areas this is already the case).

The analysis further suggests that policy makers need to consider action at two levels: to meet the needs of specific sectors and to tackle broader or cross-cutting skill needs associated with the circular economy.

A sector-based approach

One of the key questions for policy makers is whether the circular economy evidence indicates a need for a sector-focused programme of support to facilitate transition to the circular economy. In most areas, the case is not clear cut. However, there is a clear opportunity in the form of the Sector Skills Alliances funded under Erasmus+ Key Action 2, which specifically identifies supporting transition to the circular economy, alongside digital skills and the greening of the economy as transversal aspects of the programme. The focus is on qualifications and training curricula, but objectives relating to competitiveness and innovation perhaps provide scope for action that explicitly supports reskilling and upskilling in relevant sectors.

The fundamental consideration for policy makers in this context is the extent to which emerging skills needs and evolving role profiles will be addressed through the normal course of skills updating that is driven by companies undertaking circular economy related activities (e.g. through the introduction of new processes and technologies to the workplace over time). The example of how the motor vehicle manufacturing sector has, partly as a consequence of environmental regulation, adapted to reduce material use and make the production process more efficient signals how sector-driven change can occur.

The potential added value from policy intervention, such as through the Sector Skills Alliances, is that it may enable this transition to take place more quickly/smoothly, and in doing so be a catalyst for realising the potential benefits of the circular economy. The Blueprint for sectoral cooperation on skills provides a further infrastructure for bringing stakeholders together to collaborate on tackling skills issues. Some of the sectors currently covered (e.g. construction, automotive, renewable energy & green technologies) are relevant from a circular economy perspective.

There is a case for policy makers to consider whether additional collaborative action focused on skills is required for the waste sector specifically, following the model set out in the Blueprint for sector collaboration, as it is the area most directly affected by the circular economy. In this

context, however, policy makers should note that the scale of change and the nature of sector employment means that actions just focused on education and training are likely to be necessary but insufficient to meet the needs associated with the circular economy. Jobs are likely to be created across the board. In this context, the most useful tools available to policy makers may relate to communications, promotion of career opportunities and provision of Information, Advice and Guidance to boost the skills pipeline in the long term, by raising the profile of the sector, especially in terms of otherwise high-demand occupations such as business and administration associate professionals.

The circular economy impact on the construction sector is also substantial, but the factors driving change in the sector are well-known. For example, as far back as 2012, the feasibility study exploring the set-up of a European Sector Skills Council in Construction identified a need to look at "how is the development of the construction process (technology, work organisation, labour process) transferred into training, etc." The specific circular economy evidence indicates a potential shift from building trades to science and engineering associate professional roles. It is not clear, however, that this translates into a need for redeployment given the specialist nature of construction trades and the cyclical nature of employment in the sector. The reflection for policy makers may be that training not only needs to keep pace with the evolution of construction processes, but that training investment may need to be increasingly directed towards construction associate professional roles.

Cross-cutting skill needs

A key way to support adaptation to the circular economy and to mitigate employment decline is for policy makers to focus on the cross-cutting applicability of skills. The profile of the likely-affected occupations in many cases combines job-specific skills and knowledge with broader competences that have cross-cutting relevance. Some of the potential shifts associated with the circular economy, such as a transition from assembly jobs to repair and reuse, are likely to be associated with a need for more transversal skills (e.g. customer focused skills, creating solutions etc).

This both provides the potential for a wider pool of labour to fill these jobs and should provide a prompt for policy makers for continued focus on broadly-applicable competences. The Commission adopted a proposal for the new Recommendation on Key Competences for Lifelong Learning in January 2018. While the focus is on basic skills, the original Reference Framework listed a set of transversal themes across all key competences. These transversal elements (such as critical thinking, problem solving and risk assessment) are highly relevant to developing a workforce with sufficient adaptability to meet the needs of the circular economy and should be emphasised by policy makers.

Beyond this, the circular economy evidence further reiterates the importance of science and engineering-related skills. The need to boost skills supply in the context of the STEM agenda is well-known and a priority for policy makers beyond the specific implications of the circular economy. It is clear that, over time, transition to the circular economy will be inhibited if there is insufficient supply of STEM-related skills. This is a skills challenge that percolates through the education and training system.

In terms of how this translates into jobs, however, the analysis of circular economy affected occupations shows that, at professional level, the specialist nature of skills required can inhibit supply. In this context, policy makers should consider ways to support skills transfer and career transition (e.g. through re-skilling programmes for professionals). At associate professional level the potential for job transition is greater and the skill areas, across multiple occupations and sectors, that are likely to require boosting relate to design, monitoring, operations and communications activities. This is in addition to the wider specialist need for education and training on design for reuse.

8. CONCLUSION

Conclusion 1 The EU is on the right track by making the circular economy a policy priority because the circular economy can contribute to resource efficiency and reduce negative environmental impacts, while simultaneously boosting employment.

By moving towards a more circular economy, GDP in the EU increases by almost 0.5% by 2030 compared to the baseline case. The net increase in jobs is approximately 700,000 compared to the baseline. Although the magnitude of the job creation is driven by our assumption of the rate of circular economy uptake in the scenarios, our analysis confirms that it is possible to become more resource efficient and increase employment at the same time. A 'double dividend' is possible.

Our analysis is the most comprehensive quantification of the EU jobs impacts from the circular economy to date. It considers both direct job losses and job creations that result from a shift to a more circular economy. It also captures indirect, induced and rebound impacts from interactions between sectors, Member States, and between economic, environment, material, energy and labour market indicators.

Conclusion 2 The sectoral composition of employment will change in a shift to a more circular economy. Sectors that produce and process raw materials will decline in size while the recycling and repairing sectors will experience additional growth.

It is not surprising that circular economy activities shift demand from the extraction and raw material sectors toward sectors that produce recycled materials and offer repairs. In the waste management sector alone, the net increase in employment could be as high as 660,000 jobs in the ambitious scenario in this report.

Since the level of employment in the extraction and manufacturing of raw materials in Europe has been declining for quite some time, the negative employment impacts from the transition to a more circular economy in the EU are relatively small in magnitude. Our modelling results confirm this finding.

It is important to note that, although the level of job creation in the recycling activity is in line with previous studies, there are also large uncertainties surrounding the future labour intensities in the waste sector due to increased automation, product material enhancement (to ease recycling) and technology. Our employment results for the waste sector could be overestimates if there was a sustained drive to increase mechanisation in the sector.

Other winners from a shift to a more circular economy are likely to include services sectors, agriculture and electricity. Services and some manufacturing sectors benefit from the rebounds in consumer spending and stimulus from higher recycling demand. If consumers spend less on new products then they have additional income to spend on services.

While the agriculture and food sectors will see a reduction in demand as Europe tackles food waste, the demand for organic materials and by-products from food production will compensate this loss, resulting in net small increase in employment.

The electricity sector also benefits from electrification of the transport sector.

Sectors that produce durable goods are expected to lose out overall, due to longer product lifetimes and trends towards a more collaborative economy. These sectors include electronics, machinery, cars and accommodation, as well as sectors that are related to them through supply chain activities.

New construction techniques and better utilising of existing housing stocks would lead to a reduction in construction employment. Our study, however, excludes employment impacts from energy efficiency in buildings which is expected to increase as a result of energy efficient investment (European Commission, 2016).

Conclusion 3 As always, rebound effects are important

The rebounds in consumer spending occur as a result of efficiency gains and cost savings from circular economy activities. They can only be captured in a full modelling framework, as was used in this analysis. Although rebound effects are good for the economy, they also mean that there is a

rebound in material consumption associated with additional consumer spending. Additional policies may therefore be needed if Europe is to meet ambitious targets to reduce overall material use.

Conclusion 4 Addressing employment impacts in negatively and positively affected sectors, with a special attention to the waste and repair sectors, are the priority issues to be addressed by policy.

The sectoral employment shifts due to the transition to a circular economy will inevitably lead to some 'winners' and some 'losers', where policy will need to ease problems of skills constraints and stranded human capital. The waste and the repair sectors are overall the biggest winners of this transition, which requires that these markets function efficiently. Workers that are displaced from extraction sectors and heavy industry may require intensive retraining.

Conclusion 5 There are several ways that policy tools can address the circular economy transition while promoting jobs and adequate skills – through circular economy policies as well as through education and training policies.

One way of ensuring that the circular economy transition addresses the identified employment and skills issues is through introducing employment and skills aspects into circular economy and environmental policy. Such activities are already integrated into LIFE and Horizon 2020, which both aim at promoting a circular economy transition as well as economic growth and jobs. Employment and skills policies also offer a gateway to introduce circular economy aspects into, for example, schools' curricula, as well as education and training. The focus of policies should be on adapting and reskilling to meet changing job requirements, including promoting new skills to support the implementation of new technologies.

Conclusion 6 The circular economy may amplify certain areas of future skills demand, where future demand is already being shaped by global drivers of change.

From a skills perspective, the requirements for a more circular economy are generally aligned with the anticipated impact of other drivers of change on the labour market, such as the impact of technological change on jobs and the shift to high-skilled jobs in some sectors. The jobs and skills implications of the circular economy should be seen in this inter-connected context. Much of the infrastructure is already in place or under development at European level to enable a sector-based response to meet changing skills needs (e.g. under Erasmus+ Key Action 2). The circular economy is already on the agenda, to some extent, as part of these developments. There is a need for additional action to support the waste management sector specifically, but this may be as much about promoting career opportunities as it is about developing new skills.

There are some exceptions, where the impact of the circular economy may shift the occupational balance, such as a shift from assembler to trade and repair roles in the electronics sector. The general trend in this context is towards increased demand for cross-cutting competences, such as problem solving and communications. Transition to the circular economy therefore provides evidence of the importance of transversal skills, not least because jobs will evolve and workers will need to be adaptable.

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