TECHNICAL REPORT

HOW TO IMPLEMENT A LARGER ENVIRONMENTAL TAX REFORM IN FINLAND?

Potential instruments and impacts

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Abstract

Based on the results of the 2018 IPCC Special Report, all countries and sectors should speed up emission reductions to limit global warming to 1.5 degrees. In addition to regulations, carbon taxes are effective at reducing emissions. Based on research, the best way to introduce them is via a budget-neutral environmental tax reform (ETR). With an ETR, other distortionary taxes such as employment taxes are lowered at the same time as emission and other environmental taxes are increased. Finland has historically implemented a few ETRs but not to scale. This research analyses the potential tax instruments that could be used in Finland to support emission cuts and the circular economy. From the potential pool of instruments, a total of three different types of ETR scenarios are formed and their impacts on the economy and emissions are analysed. The first scenario includes environmental taxes that mainly target firms and that might harm the cost-competitiveness of energy-intensive Finnish industries without compensations. The second scenario includes environmental taxes mainly targeting consumers; we analyse their regressivity, which is one of the main concerns regarding environmental and emission taxes. The third ETR scenario aims to promote circular economy solutions. We analyse and summarise the impacts of the three budget-neutral environmental tax reforms with two dynamic general equilibrium models. We concentrate on the potential impacts on employment, GDP, emission projections and the competitiveness of different industries. Based on the findings, all three scenarios would bring about the "double dividend" effect by significantly reducing emissions and increasing employment and GDP compared to baselines. The packages are found to be progressive and have no adverse impact on income inequality. In addition, the general export competitiveness of the Finnish economy is not compromised by the emission tax increases if they are levied as part of a larger ETR. Based on the findings, a decrease in income taxes is key to obtaining the double dividend effect in the Finnish context. The compensation by solely lowering corporate taxes and employers' social security payments leave the total employment and GDP at a lower level compared to the baseline. To conclude, a large, long-term ETR seems to be a good option to support a reduction in GHG emissions and to boost employment in Finland.

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1 Introduction

The main message of the Intergovernmental Panel on Climate Change special report, Global Warming of 1.5°C (IPCC, 2018), is clear. All countries and sectors should speed up emission reductions to limit the global warming to 1.5 degrees. The risks associated with a warming of two degrees are critically higher than with a warming of 1.5 degrees. To be in line with the Paris Agreement and the 1.5-degree target, Finland should also cut greenhouse gas (GHG) emissions faster than planned. In 2017 Finnish GHG emissions were around 56 million tCO_2eq, or around 21% less than in 1990. According to the Finnish Climate Change Panel, Finland should aim for a 60% reduction compared to the 1990 level by 2030. Without a clear change in the emission reduction path, this target will not be met.

From a policy perspective the most important question now is how to achieve such an increase in the GHG reduction path. Which policy instruments would be most effective and cost-efficient in delivering emission reductions quickly and to scale? This report aims to shed some light on this.

Carbon taxes are considered one of the key economic instruments for addressing global climate change. Based on some 30 years of research on carbon taxes, the literature concludes that the best way to introduce them is via an environmental tax reform (ETR). With an ETR, other distortionary taxes such as labour taxes are lowered at the same time as carbon taxes are increased. Such reform is implemented in a budget-neutral way from the perspective of the governmental budget. Compared with not recycling the new carbon tax revenue back to society, ETR minimises the economic losses and can generate what is known as a "double dividend" effect. (Timilsinas, 2018)

With a double dividend effect, we refer to the simultaneous outcomes of lower emissions and increased employment. Typically, decreasing income taxes in particular can be an effective way to achieve the double dividend effect. Yet, decreases in employers' social security payments and corporate taxes, together with increases in R&D and investment support for low-carbon solutions, can also be considered ways to recycle the new tax revenues back to the economy. (Timilsinas, 2018) Lower income taxes increase labour supply, reduce the need to increase wages (which in turn also benefits firms' cost-competitiveness) and compensate consumers for the increase in consumer prices that results from the higher carbon taxes.

The introduction of carbon taxes has often raised concerns in two main areas: 1) their impact on income inequality, as some carbon taxes can have a greater adverse impact on lower-income households relative to higher-income households; and 2) their impact on the global cost-competitiveness of domestic energy-intensive industries. When the carbon tax revenue is recycled back to the economy as with an ETR, any adverse impacts on equality or competitiveness can be mitigated. The regressive effects can be mitigated by increasing the progressivity of income taxes and by increasing social security payments. The competitiveness effects can be mitigated by lowering income taxes (and as a result total wage costs), and/or by lowering employers' social security payments and corporate taxes. (Pigato, 2019) In other words, with an ETR countries can reduce emissions and at the same time support total employment and firms' cost-competitiveness without major adverse impacts on income inequality.

Pigato (2019) and the World Bank recommend all countries implement an ETR for three main reasons: 1) the increase in carbon taxes associated with an ETR brings societal efficiency gains by ensuring that market prices reflect all costs of goods and services including the environmental externalities; 2) ETRs can minimise the economic cost (or even increase the economic activity) resulting from climate policies; and 3) ETRs can raise tax income at a lower cost than other taxes. In addition to the World Bank, the OECD, the European Commission and the Finnish Ministry of Finance have recommended the use of ETRs.[1] So, the idea is not new and in Finland some smaller-scale ETRs have been implemented already. However, their extent has been somewhat less than is considered in this report. For example, in 2011 an energy tax reform took place in Finland. Simultaneously, employers' social security payments were decreased but the reform was not called an ETR. In addition, there are still various exemptions for large energy users and lower tax rates for specific energy sources, which reduce the effectiveness of environmental taxes in Finland. Between 2008 and 2017 environmental taxes accounted for some 6 to 7% of total public tax revenue and were around 2 to 3% compared to GDP. The share of CO_2 taxation increased from 0.3% compared to GDP in 2008 to 0.6% in 2016. During this period income and corporate taxes accounted for 60 to 70% of total tax revenue and 28% compared to GDP.[2]

In addition to carbon and resource taxes, regulation also plays a role in effective climate policy. In various cases regulations can be more effective for achieving a required emission reduction in time. Because of the urgent need to reduce GHG emissions a mix of different policies is needed. With an ETR the transition towards a low-carbon society can be done in a socially just way, as an ETR also provides public income to mitigate the costs of emission reductions for the most affected households and sectors.

In this study we first analyse which tax instruments could be used to implement an ETR to scale in the Finnish context. We provide a review of some potential instruments for increasing carbon, natural resource-use and waste taxes. The vast base for environmental taxation not only supports emission cuts but also circular economy solutions and a more efficient use of natural resources. Policies related to lowering taxes and increasing public spending are easier to implement than those associated with tax increases. Therefore, this report is less detailed with regard to the recycling of the new environmental tax revenue and provides only a short summary of the main options based on findings in literature.

Second, we develop two example scenarios for an ETR. These scenarios have been developed in such a way that they can be used to analyse the two main concerns associated with carbon taxes: 1) competitiveness and 2) income inequality concerns. In the first scenario we

[1] See e.g. Pigato (2019), OECD (2017), EC (2014) and MoF (2010).
[2] Statistics Finland, Taxes and other payments to public sector by name, 2008-2017.

particularly increase carbon taxes which increase Finnish firms' energy costs. Without the recycling of the carbon tax revenue back to the economy, these tax increases might adversely affect Finnish firms' cost-competitiveness. The second scenario includes carbon tax increases which mostly target consumers. We analyse the distributional impacts of the scenario both without any compensation and with compensating for the tax increases with a reduction in income taxes. The economic impacts of scenarios 1 and 2 were studied using the Finnish general equilibrium model, FINAGE.

Last, we summarise the research results from GBE et al. (2018) on how to support circular economy objectives with an ETR in the Finnish context. The ETR scenario was developed to support the implementation of the circular economy road map and the potential impacts of the scenario were analysed with the global E3ME general equilibrium model. The instruments identified in GBE et al. (2018) together with some global best practice examples, partially overlap with the instruments used in ETR scenarios 1 and 2. We provide our conclusions on the potential for a larger ETR in Finland based on all three different ETR scenarios and their expected impacts. None of the scenarios is a recommendation for the Finnish government to implement as such. The decisions on which tax instruments to increase on the one hand, and which to lower on the other, and by how much, are at the heart of political decision-making. The scenarios included in this report provide examples on the kind of instruments that could be included in an ETR and illustrate the expected impacts of different types of ETRs. We find that all three scenarios reduce CO_2 emissions and have a positive impact on employment (and output). In addition, we find that ETRs can be implemented in such a way that they do not increase inequality or harm the export industry.

Chapter 2 provides a review of the lessons from environmental tax reforms implemented to date and a brief literature review of the potential impacts on income equality and competitiveness associated with carbon taxes and ETRs. Chapter 3 introduces the carbon, resource-use and waste tax increases included in the three ETR scenarios. In addition, Appendix A provides additional options on how to support emission cuts and circular economy objectives using tax instruments. Chapter 4 provides a short review of the potential ways to recycle the tax revenue back to the economy. Chapter 5 provides a summary of the FINAGE model and the way ETR scenarios 1 and 2 are modelled while Chapter 6 outlines the results of scenarios 1 and 2. Chapter 7 provides a short summary of the main findings of the ETR scenario 3 based on GBE et al. (2018) and Chapter 8 offers conclusions.

2 Lessons from environmental tax reforms

ETRs have been implemented to some extent in various (mostly rather developed) countries including Finland. The focus of the research has been on the ex ante (theoretical) work on the potential impacts of ETRs. More recently, ex post analyses, which aim to evaluate what really happened during and after an ETR, have also been completed. Pigato (2019) provides a good review of their main findings.

For example, in Denmark the introduction of a carbon tax significantly decreased emissions and yet at the same time it had a negligible effect on GDP between 2000 and 2005 (IEEP, 2013). In the UK, two studies conclude that a carbon tax had no impact on general output, but it increased energy productivity in the target firms. The same studies found a small positive or zero impact on general employment. (Pigato, 2019) Ekins and Speck (2011) found no impact on employment from an ETR implemented in Germany.

Yamazaki (2017) finds in an ex post study of the British Columbian ETR that the general carbon price increase since 2008 (in British Columbia the tax income is recycled back to the economy by decreasing income and corporate taxes and providing lump-sum repayments to low-income households) had a positive impact on employment. The effect was relatively small though, under 1% annually, but around 4.5% in total during the analysis period 2007-2013. However, the findings also suggest that there were industry-specific differences; employment declined in emission-intensive and trade-exposed industries while employment increased in service industries. In addition, GHG emissions decreased by 10% and fossil-fuel consumption was 19% less compared to the rest of Canada. Two other studies on the British Columbian carbon tax found that the impact on GDP growth was mildly positive or negligible. (Pigato, 2019)

With regards to investments and innovations, there are few ex post findings of an ETR boosting both. In Sweden taxes on nitrogen oxides rapidly decreased emissions by increasing the adoption of abatement technologies. The same study concluded that in the UK the Climate Change Levy on fossil fuels increased patenting in the firms affected by the tax. (OECD, 2010) Similarly, Pigato (2019) finds that in Indonesia and Mexico increased fuel prices incentivised firms to adopt new, more fuel-efficient technologies that also raised labour productivity. As a result, there was no impact on profits.

Evidence also suggests that ETRs do not seem to have a significant impact on competitiveness. For example, Bassi and Duffy (2016) conclude that in the UK carbon taxes and other climate policies have not had a detectable impact on competitiveness. Kozluk and Timiliotis (2016) conclude that between 1990 and 2000 environmental policies across the OECD countries advanced clean industries at the expense of dirty industries but had no significant impact on overall trade in goods.

More theoretical, ex ante assessments of the expected impacts of environmental tax reforms suggest that in general ETRs are expected to reduce emissions and increase employment, but effects on output are more ambiguous. (Bosquet, 2000) Indeed, Honkatukia and Tamminen (2013) concluded that the large energy tax reform of 2011 in Finland was expected to reduce emissions, increase employment and have a small negative impact on the GDP. The energy tax reform was considered an ETR because the additional tax revenue was recycled back to the economy by reducing the social security payments of the employers. For the US, Barron et al. (2018) find, using 11 different general equilibrium and energy-system models, that a general carbon tax is expected to decrease emissions and increase the GDP regardless of the way the new tax revenue is recycled back to the economy. Andersen (2010) concludes with an ex post use of the E3ME model (this model is also used in scenario 3 of this report) that the ETRs in Denmark, the UK, Germany, the Netherlands, Sweden and Finland between 1994 and 2003 decreased emissions and had a positive impact on the respective GDPs despite different methods being used for recycling the emission revenues back to the economy. Ekins et al. (2011) modelled a large-scale ETR in the UK and, again, expected a significant reduction in emissions and a positive impact on employment, but no major impact on the GDP.

To conclude, based on both ex post and ex ante analysis, ETRs are expected to significantly decrease emissions and have a small positive impact on employment. The impact on the GDP is likely to be positive but very small or negligible compared to baseline. The positive impact on employment is associated with the wedge between wage income and the marginal product of labour caused by income taxes and indirect labour costs. Lowering the income taxes also reduces the wedge. It therefore also increases the labour supply because for any given wage the price of leisure has increased compared to employment.

2.1 Impacts on income inequality

In Finland, the average annual emissions of high-income households are significantly higher than in low-income households. In 2016 the average emissions were around 12 $tC0_2$ per consumption unit,[3] but in the lowest income decile the emissions were only around 7 tCO_2 and in the highest decile 19 tCO_2. In particular, emissions from transport use are positively correlated with the household income. Similarly, emissions from housing (especially heating and electricity use) and other consumption are much higher in the highest deciles compared to the lowest.[4]

The distributional impacts of emission tax increases also depend on the share of the different emission-intensive products and services out of total income in different deciles and on the exact way emission taxes are increased. According to the Finnish spending review data the shares of high-emission products and services in relation to total disposable income are higher

[3]Consumption units are defined by the OECD and they adjust the total income to the average spending level. For example, the first adult of each family equals one consumption unit, but the second one only 0.8. This accounts, for example, for the lower housing costs per person in households with more people in them. All consumption and emissions of households also need to be adjusted to the total number of consumption units.

[4]Statistics Finland: `https://bit.ly/2UuGqAU`

for high-income households. For example, total spending on transport fuel and flights represents a higher share of total income in high-income deciles compared to lower-income deciles. Similarly, Sterner (2012) finds that fuel taxes in Sweden have been progressive in nature, not regressive. However, in Finland the share of electricity and heating costs over total income are higher in low-income households.[5] In addition, Sipila et al. (2018) find that households located in the Finnish countryside consume significantly higher amounts of transport fuel than city households. This means that lower-income households living in less densely populated areas might be particularly vulnerable to fuel tax increases unless they are compensated by transfers or other means.

Pigato (2019) concludes from a large literature review that the most significant determinant of the overall impact on income distribution is the way the tax revenues are recycled back to the economy. New emission tax revenue can be used to lower labour taxes of low-income earners more relative to higher-income earners or to provide lump-sum rebates. Various studies show that the redistribution of revenues to the lowest-income households by lump-sum transfers can mitigate against increases in income inequality. In Europe and the US, less than 12% of the tax revenues would be enough to compensate the poorest 20% for any distributional impact of carbon taxes. Chiroleu-Assouline and Fodha (2014) further conclude that no matter how regressive the environmental tax is, it is possible to design a recycling mechanism in a way that does not harm the poorest consumers. The conclusion of the World Bank review of ETRs is that concerns regarding distributional inequality and poverty do not justify low environmental taxes. (Pigato, 2019) Yet, before the implementation of an ETR, it is recommended to analyse the potential distributional impacts (in overall and by geographic area) in detail. For example, microsimulation models (together with computable general equilibrium models) can be used for the analysis.

2.2 Implications for competitiveness

Increases in energy and emissions taxes are often opposed based on the assumption that these would harm the global competitiveness of local firms relative to competitors in countries with lower environmental taxation. However, based on research, there are two opposing hypotheses on the potential impacts of environmental regulation and taxes on firms' competitiveness. The first hypothesis, often called the Pollution Haven hypothesis or carbon leakage hypothesis, assumes that strict environmental regulations and high emissions taxes could indeed lead to the loss of competitiveness and therefore decreased exports, relocation of production activities to less regulated countries and increased imports of energy-intensive products. The other hypothesis, called the Porter hypothesis, assumes that strict environmental regulations and taxes can boost firms' competitiveness. They will increase firms' innovations and investments in low-emission technologies, which are more efficient than before, and boost their productivity.

[5] Statistics Finland, spending review.

These new innovations can also lead to higher exports.

A relatively large bank of literature has analysed both hypothesis (in particular the carbon leakage one). Based on two literature reviews by Dechezlepretre and Sato (2017) and Arlinghaus (2015) on the available ex post studies, there is little evidence of carbon leakage caused by environmental regulations or taxes. In cases where there is some evidence of carbon leakage, the effect has been typically very small in comparison to all the other factors that affect firms' global competitiveness and production location decisions.

On the other hand, Dechezlepretre and Sato (2017) find evidence supporting the Porter hypothesis of stricter environmental regulation leading to improved innovations and productivity. Similarly, Pigato (2019) concludes that increases in fuel prices in Indonesia and Mexico were associated with increases in firms' levels of productivity and profitability. The higher fuel prices incentivised firms to adopt new energy-efficient capital rather than increase output prices. On the other hand, the price of electricity has been found to be negatively associated with productivity growth. Many low-emission technologies are currently electricity intensive and the increase in electricity prices can be harder to mitigate with technology changes if the firm is already close to the technology frontier.

What explains these findings? First, energy costs typically represent a small fraction of total costs even in relatively energy-intensive sectors and firms. For example, in Finland direct fuel, electricity and heating cost have been typically just a few percentage points compared to total revenue even in the most energy-intensive sectors including paper, chemical and metal production (Statistics Finland, input-output data). Further, the total energy taxes paid in the same energy-intensive sectors were only around 0.2 to 0.5% compared to total revenue in the period 2012-2014. The highest energy tax payments were paid by land and water transport service sectors, where these taxes accounted for some 4 to 6% compared to revenue (Statistics Finland, environmental taxes and national accounts).

Further, in addition to costs, there are various other factors that affect the competitiveness and performance of firms. The main factors (many of the these also affect the location decisions of firms) can be divided into three main categories: firm-specific, sector-specific and country-specific factors. The literature suggests that firm-specific factors are the most important (see Goddard et al., 2009; Brakman et al., 2009; and Wagner, 2012). Sector- and country-specific factors, such as general cost level, taxation or regulations, are typically much less important. "Firm appeal", referring to the reputation, brand and quality of the firm, is considered one of the most important firm-specific factors affecting competitiveness (see Hottman et al., 2016 and Crozet et al., 2012). Other important firm-specific factors include organisation and management structures, productivity, export market strategy, age and size.

To conclude, firms' competitiveness is driven by their ability to produce goods and services which are of better quality, cheaper or otherwise more attractive to the buyers. However, the possibility for consumers to even compare the products and services of different producers depends on the heterogeneity of the products. If the products are very heterogenous, they are not considered the same in the eyes of the buyer and are thus hard to compare. For example, most services, chemical products and electronics are typically heterogeneous products. Costs are not the most important drivers of their sales and typically it is considered that firms selling heterogeneous products compete in a monopolistic manner. In other words, each producer is basically a monopolist regarding its own product (see Eckel et al. 2015).

Haaparanta et al. (2017) find that 60 to 70% of Finnish exports' domestic added value is associated with heterogeneous products and services. For homogeneous products that are traded in world markets, such as gold or raw oil, input costs are a more important factor for competitiveness than for heterogeneous products. However, Kugler and Verhoogen (2012) and Manova and Zhang (2012) have found significant price heterogeneity also within the sales of homogenous products within a country. In other words, bigger and more productive firms sell the same products with a higher price in the same market. The conclusion is that quality, both observed and unobserved, also plays a role. In addition, Hottman et al. (2016) find with barcode product-level data (products with the same barcode are considered homogeneous) that costs and final price explain less than 20% of the firm's sales and changes in costs typically do not affect the growth of their sales. At least 80% of the sales and their change is explained by the considered quality and brand of the firms and their total product variety. In other words, it seems that costs are not the only factor even for very homogenous products. For example, contact networks, the reputation of the producers and their capability to provide the required quantities in time might affect the final unit price in the sales of homogenous products. Further, if costs do affect competitiveness, their effect would be mostly shorter-term. In the long run, costs play an even smaller role in firms' global competitiveness. See also Pigato (2019) for a review of environmental policies, carbon leakage and firms' competitiveness.

If we expect the increased emission taxes to significantly affect the global competitiveness of a specific industry, ETRs can be tailored to mitigate against those effects. Until now exemptions have been frequently used for this purpose, such as the energy tax repayment scheme in Finland, but Pigato (2019) concludes that exemptions from energy taxes are the least efficient way to preserve the competitiveness of the energy-intensive trade-exposed (EITE) sectors. Exemptions are the costliest way to support competitiveness because they decrease the effectiveness of emissions taxes to reduce emissions while increasing the abatement costs for other sectors. Better ways to support the short-term cost-competitiveness problems in an ETR include reductions in corporate taxes, output-based rebates and support for resource and energy efficiency. These policy options can protect EITE sectors' short-term competitiveness and encourage innovations without compromising the price on carbon. These mitigating policies should be preferably time-limited and reviewed regularly and their level and true need should be very carefully assessed before implementation.

3 Potential tax instruments for additional tax revenue

In this research a wide selection of potential instruments was identified for raising additional tax revenue. The full list of instruments are presented in Appendix A. It includes 43 potential instruments which can be divided into three main categories:

- energy and emission taxes;
- removal of subsidies and tax reliefs and exemptions;
- waste and resource-use taxes that aim to increase circular economy activities.

These instruments have varying impacts on the economy as they target sectors and households differently. Yet, most of the instruments target non-ETS sectors or consumers, since the EU Emission Trading System (ETS) covers the sectors included in it. The potential of the different instruments to reduce greenhouse gas (GHG) emissions also vary. For example, setting a price floor for the EU ETS would affect only the ETS sectors, whereas a consumption-based carbon tax would mainly concern consumers. The impact of energy and fuel taxes on GHG emissions is, again, significantly higher than, for example, the potential impact of a moderate emission-based aviation tax (see Chapter 3.4).[6]

Furthermore, the potential of the instruments for raising fiscal tax revenue differs significantly. While fossil-fuel taxes and a consumption-based carbon tax can provide significant fiscal revenue based on the assessments, resource and waste taxes, on the other hand, typically have much less potential (see Chapter 6 and GBE et al., 2018). To implement a larger environmental tax reform, these considerations are also important.

The final selection on which taxes to increase is at the core of political decision-making. Therefore, this report provides some examples of different options and their expected impacts. There is no single, optimal way of implementing an ETR.

The selection of instruments for the economic modelling undertaken here is also limited by what the FINAGE and E3ME models can relatively easily model. Appendix A, Table 7, includes the potential list of instruments and an estimate of whether the instruments can be relatively easily modelled with the FINAGE model. For example, road usage payments are a potential way to tax the transport sector instead of increasing fossil-fuel payments, but road payments cannot be modelled with the FINAGE model. Similarly, taxes on packaging are challenging to model with FINAGE.

We generated two scenarios that aim to address the main concerns related to emission taxes: their impact on the competitiveness of the energy intensive industries and on income inequality.

[6]The impact of using value-added taxes (VAT) for lowering consumption-based emissions depends on the extent to which the final price of products and services changes as a result of the change in the VAT. Recent research by Kosonen (2013) and Harju and Kosonen (2013) suggest that lowering the VAT rate doesn't always translate into an equal reduction in the final price. Therefore the potential impact of VAT decrease on emissions should be always researched in further detail.

In addition, the third scenario studies how an ETR could enhance circular economy objectives. It is important to note that the scenarios are not implemented to maximise the cost-effectiveness of the emission reductions. This would require significantly more research on the most cost-effective ways to drive down Finnish emissions. However, the existing knowledge on the cost-effectiveness of different technological changes in the transport, energy and industrial sectors identified in Sitra and McKinsey (2018) have affected the choice of instruments. For example, the combination of wind power and the electrification of the transport sector is considered a rather effective measure for reducing emissions. They both have lower total life-time user costs on average by 2030 compared to the current energy production and vehicle technologies. Therefore, targeting the ETS sector (including energy production) by setting a steadily increasing price floor for EU emission allowances is included in scenarios 1 and 3. Scenarios 1 and 2, again, include measures that could boost the electrification of the transport sector, namely the increase of the CO_2 taxation of motor fuels (cuts in new cars' sales tax for zero-emission vehicles are additionally included in the revenue use to further boost changes in the transport sector).

The three scenarios concentrate on the following.

1. Scenario: **"Production taxes"** – modelled with the FINAGE model. This scenario includes increases in emission taxes targeting industry, which could harm the cost - competitiveness of Finnish industry unless this is offset by some compensation mechanism, such as through a decrease in wage taxes, in general electricity taxes for industry and/or in car taxes.

2. Scenario: **"Consumption taxes"** – modelled with the FINAGE model. This scenario includes increases in emission and consumption taxes for consumers and non-ETS sectors, which might potentially lead to increases in income inequality without compensation, such as through a decrease in wage taxes and in car taxes, and a small increase in social security transfers.

3. Scenario: **"Boosting the circular economy"** – modelled with the E3ME model. This scenario targets especially tax increases in energy and natural resource use, which are compensated for by decreases in wage taxes and employers' social security payments and in increases in R&D and investment support for low-carbon technologies.

The scenarios' potential economic and GHG emission reduction impacts are estimated with two different general equilibrium models. Scenarios 1 and 2 are modelled with the Finnish national FINAGE model that models the Finnish transport and public sectors in detail. See Chapter 5 for a detailed description of the model. Scenario 3 is modelled with global E3ME general equilibrium model that is less detailed for the Finnish taxation system but is better equipped to model the energy sector and GHG emission reductions. See GBE et al. (2018) for further detail or visit www.camecon.com/how/e3me-model/. For more information on the rationale used in the instrument selection for scenario 3, "Boosting the circular economy", please refer also to GBE et al. (2018). The instrument selection and modelling results for scenario 3 are merely summarised in this report to make it easier for the readers to compare the different scenarios and their potential impacts somewhat. However, the differences in the modelling outcomes can be partly explained by the differences between the FINAGE and E3ME models, and not only by the differences in the ETR scenario details.

Table 1 provides a general overview of the specific instruments included in the scenarios. The following sub-sections provide more details about their rationale and about the specific tax levels introduced for the instruments in each scenario.

Table 1: Tax revenue increasing instruments in different ETR scenarios.

Tax instrument	**1. "Production taxes", FINAGE model**	**2. "Consumption taxes", FINAGE model**	**3. "Circular economy scenario", E3ME model (see GBE et al., 2018)**
Price floor for EU ETS allowances	✓		✓
Strengthening CO_2 part of fuel taxes		✓	
Emissions-based flight tax on passengers		✓	✓
Consumption tax based on a product's global GHG emissions		✓	
Tax on air freight		✓	✓
Removal of the tax refund for energy-intensive industry	✓		✓
Removal of the reduced tax level for peat in energy production	✓	✓	✓
Removal of the reduced tax level for coal in CHP plants	✓	✓	
Removal of the reduced tax rate on diesel	✓		✓
Removal of the reduced tax rate for light fuel oil	✓	✓	✓
A tax on fossil raw materials in industry			✓
New resource taxes (e.g. taxes for non-metallic minerals and mining)			✓
Nuclear waste tax			✓
Tax on waste incineration			✓
Tax on pesticides			✓

3.1 ETS price floor

Finland has participated in the EU Emissions Trading System (EU ETS) since 2005. It limits emissions from nearly 11,000 power and manufacturing plants and from flights within the European Economic Area (EEA). Around 50% of Finnish GHG emissions are included in the EU ETS. The beginning of the EU ETS was characterised by a surplus of emission allowances. This was due to the economic crisis and use of international credits, which reduced the demand for emission allowances. The price of the allowance remained low for a long time giving a weak incentive to reduce emissions and invest in low-emission technologies.

The Market Stability Reserve (MSR), which started in 2019, should gradually address the surplus of allowances. The price of the emission allowance has already increased significantly since the start of the MSR. The price increased from approximately 5-6 euros in the years after the 2011-2012 European sovereignty debt crisis to the current price of over 20 euros. Yet, the current prices are still below the minimum estimate for the social cost of carbon (i.e. the damage caused by emitting a tonne of CO_2) of 30 euros specified by the OECD (2018). The average estimate by the OECD is around 60 euros per tonne, similar to the estimates by the CPLC (2017) of 40-80 dollars in 2020. By 2030 the cost of carbon should be around 50-100 dollars per tonne according to the same estimates.

The effectiveness of the EU ETS has been widely discussed and e.g. the MSR was introduced due to the problems with the large surplus of emission allowances. For example Silbye and Sørensen (2019) summarize the discussion. Defenders of the system typically point out that the scheme has brought required emission reductions as emissions have stayed until now below the annual cap even though firms can bank unused allowances from previous years. It is estimated that the emissions from the ETS installations decreased by 14.5% between 2010 and 2017 and the ETS has had a significant effect on the emissions of the firms participating in it. (Muuls et al., 2016) Similarly, Arlinghaus (2015) concludes from a literature review that the emission abatement resulting from the EU ETS has been between 3% and 28% depending on the country and sector.

On the other hand, critics of the ETS have argued that the average level of allowances prices has been much lower than initially expected and the cap-and-trade system has not provided sufficient incentive to replace fossil fuels with low-emission options. Since the allowance price has also been highly volatile, it has created uncertainty around the profitability of new green technology investments. In addition, even with the new MSR, the ETS sector's emissions are not expected to decrease fast enough to be in line with the maximum 1.5-degree global warming target and price fluctuations are expected to continue. (Silbye and Sørensen, 2019)

While the use of overlapping domestic policies in the ETS sectors has been criticised for having been ineffective at lowering actual EU-wide emissions historically, both Silbye and Sørensen (2019) and Perino (2018) conclude that the new MSR punctures this "waterbed effect".[7] These results on the waterbed effect are important. Based on these results, overlapping support for low-cost technologies in the ETS sectors or the introduction of a price floor for EU ETS sectors, even if in just a selection of EU countries, could reduce EU-wide emissions at least until 2023 (Silbye and Sørensen (2019) estimate this to continue much longer).

In line with earlier studies,[8] Silbye and Sørensen (2019) and Flachsland et al. (2018) pro-

[7]The "waterbed effect" refers to the reallocation effect of domestic overlapping climate policies that have previously simply transferred the emissions from one part of the ETS system to another without any overall reduction in the total EU-wide GHG emissions.

[8]For example, Hepburn (2006) provides a review of the literature on how to design a mixed cap-and-trade system with price restrictions.

pose at least the use of a price floor to support the EU ETS (a price cap could also be considered). The price floor could mitigate against low or declining prices in the future, enhance confidence in the system and ensure that the carbon price is high enough to support the emission reductions required to limit global warming to 1.5 degrees.

The United Kingdom has already introduced a carbon price floor (CPF). It is implemented as a carbon price support payment that is added to the ETS allowance price in case it is lower than the CPF. In addition to the UK, Flachsland et al. (2018) conclude that various other EU countries have provided supportive signals to the introduction of national CPF systems, including France, the Netherlands, Sweden, Portugal and Spain. German discussions about a carbon price floor have also intensified during the last few years. Flachsland et al. (2018) point out that if unsold allowances are invalidated (via the new MSR, for example), a price floor would enable achieving more ambitious environmental targets than those envisioned by the baseline cap.

Flachsland et al. (2018) conclude that if an EU-wide ETS price floor does not seem politically feasible, there would still be good reason for just a coalition of EU member states to implement price floors. If it is implemented in a similar way to the UK, this could result in diverging compliance costs among entities. On the other hand, if the coalition were to implement it as an auction reserve price or take equivalent action to the effect that at least some of the auctioned allowances are retired from the market, the overall supply of allowances is reduced and the single EUA price preserved. Then, concerns over diverging marginal prices would not apply.

In the UK the price top-up of £18/tCO_2 on the EU ETS price resulted in the coal power plants reducing their emissions by 58% in 2016. (CPLC, 2017) The price floor in the UK affects only the energy sector.

Policies included in the scenarios:

1. ***Production taxes -scenario**: Introduction of a gradually increasing ETS emission allowance price floor equalling 30 euros per tCO_2 in 2020 and increasing to 60 euros per tCO_2 by 2030. The price is applied as a mark-up to the ETS price so that the total price is equal to the targeted price floor.*

2. ***Consumption taxes -scenario**: Not included.*

3. ***Circular economy -scenario**: A carbon price floor of 10 euros per tonne of CO_2 emitted from biomass (e.g. wood and wood by-products). A carbon price floor of 60 euros per tonne of CO_2 emitted by all other energy resources used across all industries (e.g. coal, peat, fossil fuels and CHP) by 2025. In the ETS sectors, the price is applied as a mark-up to the ETS price (see GBE et al., 2018, for more details).*

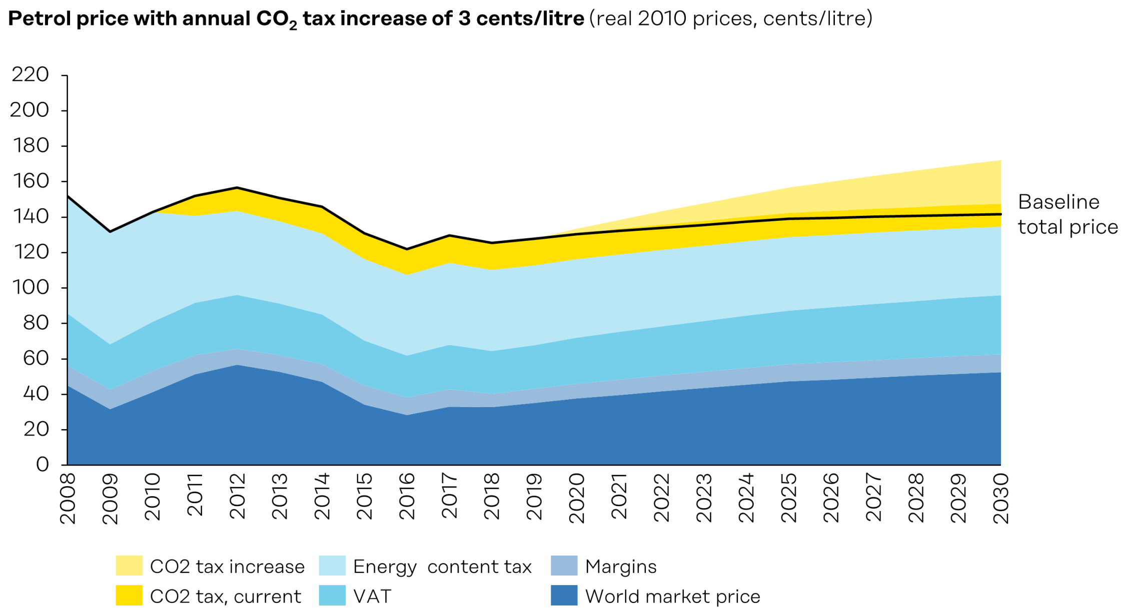
3.2 Increase in the CO_2 component of transport fuel taxes

Finland has a CO_2 emission-based and energy content-based tax component for the main motor fuels as part of its excise taxation system. The current CO_2 tax is 62 euros per tCO_2 and the tax varies according to the estimated CO_2 emissions of the different motor fuel types. However, the energy content part of the tax is in absolute terms higher than that based on CO_2. Tamminen et al. (2018) provide an analysis of the historic and current CO_2 and energy tax levels for different motor fuels. There is no automatic inflation correction for the tax levels, but fuel taxes have often been increased. This has hindered the potential of the economic agents to forecast the future levels of energy taxes.

As part of a report by the Ministry of Transport and Communications' Transport Climate Policy working group (MoTC, 2018), the use of a gradually increasing CO_2 tax component for motor fuels was proposed. The report proposes to increase the tax by three or six cents per litre annually.

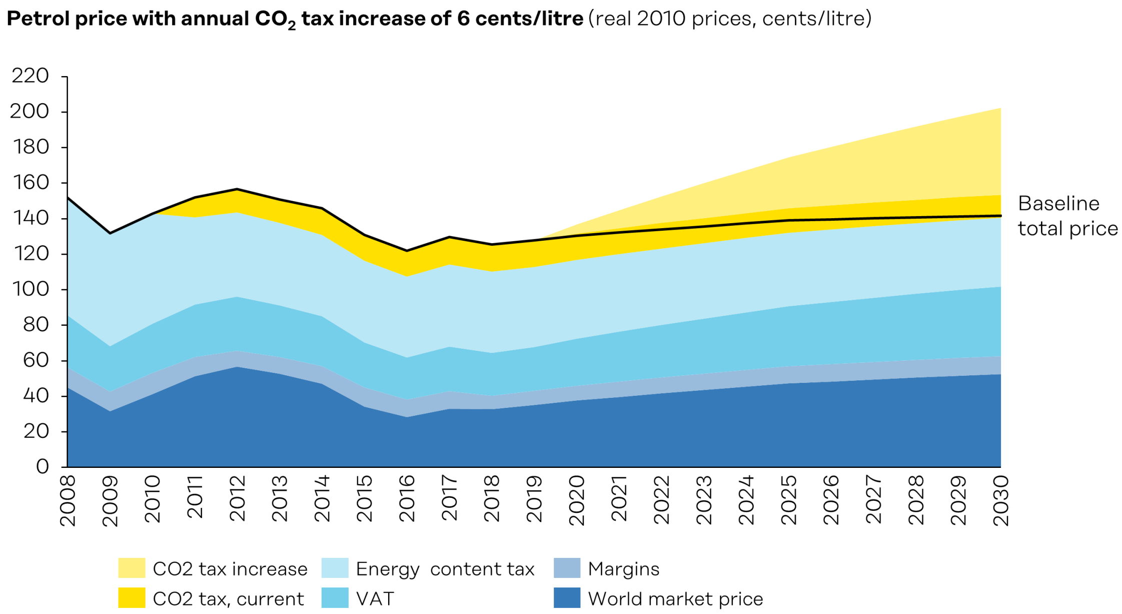
Figures 1 and 2 illustrate what these kinds of increases would mean for the final petrol price (in cents per litre) in real 2010 prices. Compared to the expected increase in wages, annual increases of three cents per litre would increase petrol costs by some 20% in real terms by 2030. By 2030 petrol would cost around 1.7 euros/litre in 2010 prices, while in the baseline (with no additional increases in the fuel taxes) the price would remain at around 1.4 euros/litre. The average annual increase per tank of petrol (around 50 litres) would then be around 1.6 euros annually. At the moment a tank of petrol costs typically around 75 euros. So, for example with the three cent increases, the price would change after the first year to 76.6 euros. In the baseline and in both fuel tax increase scenarios, the real global market price of petrol is also expected to increase. Annual increases of six cents per litre would increase the petrol price to around 2 euros/litre by 2030 in real prices. This equates to around a 40% increase compared to the baseline with no changes to the current taxes or around three euros more every year per average tank of petrol.

Figure 1: Petrol price increases with three cents/litre annual CO_2 tax increases



Source: Statistics Finland, IEA raw oil price forecast, own calculations.

Figure 2: Petrol price increases with 6 cents/litre annual CO_2 tax increases



Source: Statistics Finland, IEA raw oil price forecast, own calculations.

The potential effectiveness of fuel taxes in reducing CO_2 emissions depends on the exact way they are levied. In general, the main effects of taxes come through their impact on prices, which then affects consumption according to price demand elasticities. Therefore, the potential effectiveness of taxes will also depend on the global market prices and their fluctuations. Long-term price elasticities for fuels have typically been estimated to range from -0.25 to a maximum of -0.8 (Brons et al., 2013; Coglianese et al., 2016; and Burke and Nishitateno, 2013). These suggest that a 10% increase in price could lead to a maximum 8% decrease in the demand for fuels. With the better supply of electric cars and (bio)gas motors in the future, the price elasticities can improve compared to what has been found in literature until now.

However, there is some evidence that consumers respond significantly stronger to fuel tax increases than to fuel price increases associated with market fluctuations. Various authors suggest even three- or four-times higher elasticities, which would mean that a 10% increase in taxes could lead to even a 20% decrease in fuel demand. (See e.g. Tamminen et al. (2018) for the literature) For example, Andersson (2017) concludes that this significant difference in the tax elasticity compared to normal price elasticity could be explained by media coverage associated with tax increases and the longevity of the tax changes. In addition, the difference could stem from people's inability to forecast world market prices for fuels. Therefore, they might assume that all tax increases will simply be added to the current average pre-tax price.

As the Finnish proposals to increase fuel taxes are planned to be based on the CO_2 component of energy taxes, they will also increase the competitiveness of the new biofuels compared to fossil fuels. In addition, the proposed annual increases would provide a clear view of the future tax changes for all parties considering vehicle investments and provide incentives for the increasing numbers of plug-in hybrid electric vehicles users to use electricity as the main energy source instead of fossil fuels.

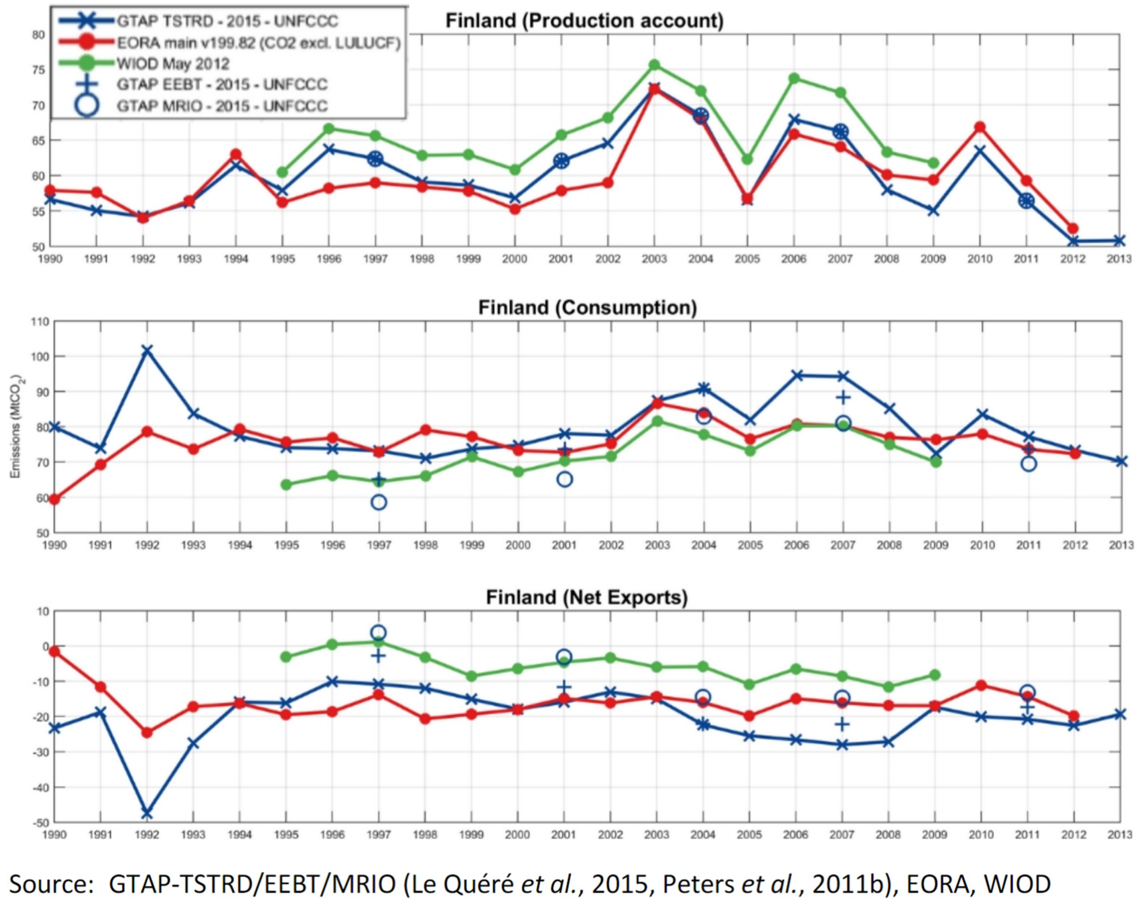
Policies included in the scenarios:

1. ***Production taxes -scenario****: Annual increase of 3 cents/litre for the CO_2 component of motor fuels.*
2. ***Consumption taxes -scenario****: Annual increase of 6 cents/litre for the CO_2 component of motor fuels.*
3. ***Circular economy -scenario****: Not included.*

3.3 Consumption tax based on products' global GHG emissions

According to the guidelines in the United Nations Framework Convention on Climate Change (UNFCCC), national inventories (i.e. reporting on greenhouse gases) should include only the GHG emissions associated with production and energy consumption within national boundaries. In other words, GHG data is "production-based". Most climate policies have therefore targeted GHG emissions originating within national borders. However, during recent decades global production processes have fragmented and different parts of the production processes have been carried out in different locations. Around 70 per cent of the gross trade flows recently have been exports and imports in intermediate products (World Input-Output database), not in final products and services. With regard to GHG emissions accounting and control, this poses a challenge. For example, products consumed in Finland and produced by Finnish firms can still create significant amounts of emissions in other countries because of the use of foreign intermediate inputs. In addition to this, Finland imports many products that are completely manufactured abroad, but Finnish demand affects their production and the emissions associated with it. Peters et al. (2016) estimate that total Finnish consumption has historically generated around 10-30 MtCO2 more in total each year than was emitted within national borders (see Figure 3). Compared to the current total production-based Finnish CO_2 emissions of around 56 MtCO2 in 2017 (Statistics Finland), the difference between the production- and consumption-based estimates are very significant.

Figure 3: Finnish GHG emissions over time, production vs. consumption-based calculations (note different scales)



Source: Peters et al. (2016), p. 42.

For these reasons, the European Parliament has considered the introduction of an additional tax on final consumption for goods and services based on the total, global emissions associated with their production (i.e. a consumption-based carbon tax). The parliament mentions that the complementarity and/or compatibility of such a tax with the EU ETS would have to be ensured to avoid double taxation on EU ETS producers. (Monti et al., 2016) Based on the calculations of Luptacik and Luptacik (2016), such tax could generate significant tax income and basically finance the whole EU budget on its own. While the EU Parliament recommends an EU-wide consumption-based carbon tax, a similar tax could also be imposed at national level, as an additional excise tax, for example. Various researchers have recommended the use of such consumption-based carbon taxes for example in order to protect from supply-side leakage and to finance reductions in other distortionary taxes. (See e.g. Gemechu et al., 2012, and McAusland and Najjar, 2015)

If such a tax were to be implemented at EU level, it could also prevent carbon leakage from the EU area. The EU is a large global market area and the pricing of all emissions at the point of final demand in the EU could create pressure on all firms operating in the EU market to minimise the global emissions they generate. Yet, decision-making on such a tax at the EU level is likely to take a significant amount of time (which we do not have). On the other hand, if such a tax were to be first implemented at the national level in Finland only, with a somewhat potentially faster implementation process, this positive impact on global emissions would not be likely to be that significant. Because consumers currently struggle with the estimation of different products' and services' GHG levels, a national estimation of their emissions and a tax based on them would still 1) provide information guidance for consumers on commodities' GHG contributions; 2) raise the price of products that generate large global emissions in Finland; 3) generate an example for other countries to follow; and 4) create significant fiscal income that could be used to lower other distorting taxes in an ETR. The actual CO_2 impacts of such a tax would need to be estimated carefully as they depend on its impact on both Finnish and global demand for high-polluting products. Lanz et al. (2014) find that both product labels and monetary instruments can increase the market shares of lower-emission commodities, especially if they are close substitutes for the products that emit more.

The carbon footprint of products and services can be estimated with different methodologies. Life-cycle analysis (LCA) and the use of environmentally extended input-output analysis (EIO) are the most used types. While LCA can provide more detailed results at product level, it is typically more time-consuming and does not account for all indirect emissions in all upper supply chains, as EIO does. Gemechu et al. (2012), for example, recommend therefore the use of EIO methodologies. Further, McAusland and Najjar (2015) recommend the use of EIO-based average product-category-level estimates as a starting point for global emission information and consumption-based carbon taxes. In cases where a firm can provide verifiable information about their products' total GHG footprint, the tax can be changed based on them. This would be likely to speed up the process of implementing consumption-based carbon taxes in practice.

For a rough estimation on the potential size and impact of consumption-based carbon taxes in Finland, we developed a somewhat altered method for their calculation compared to previous studies (e.g. Luptacik and Luptacik, 2016) We use data from the WIOD 2011-2014 input-output tables including 43 countries and 56 sectors (see WIOD database website for more information), the OECD 2011-2014 Air Emission Accounts by country and sector, and the EXIOBASE 3.3.15 data on GHG emissions in 2011 for countries not included in the OECD data. We first estimate the direct emission intensities of different sectors i in countries j by function 1:

$$\varepsilon_{ij} = \frac{CO2_{eq,ij}}{R_{ij}} \tag{1}$$

, where $CO2_{eq,ij}$ refers to the CO_2 equivalent of sector i in country j and R_{ij} to be the value of production in the same sector and country. For countries that are not included in the OECD 2011-2014 Air Emission Accounts, we assume that the direct emission intensity in the 2011 data from EXIOBASE is the same for years 2012-2014.

A direct increase in domestic price (with the assumption of a full pass-through) would then equal maximum of:

$$\Delta p^D = \begin{bmatrix} \varepsilon_{ij} * p_{CO2,ij} \\ .. \end{bmatrix} \tag{2}$$

, where $p_{CO2,ij}$ equals CO_2 price per tonne. While in previous studies the CO_2 tax is typically set to be the same for all parts of the global production process, we define this carbon tax to be zero for the sectors that are included in the EU ETS to avoid double taxation for EU producers. In other words, $p_{CO2,ij} = 0$ if country i and sector j belong to the EU ETS. Otherwise the price of CO_2 equals the expected EU ETS price of around 45 dollars per tCO_2 in 2025 and 60 dollars per tCO_2 in 2030. For the following calculation it should be noted that Δp^D is a vector including all sectors in all countries in the data sets.

The final CO_2 tax t on the different products sold in Finland from the different origins ij is then calculated by multiplying the direct domestic price increases with the Leontief inverse $(I - A^{'})^{-1}$ that accounts for the shares of the different sectors in the global production processes and for all indirect impacts from changes in one country.

$$t = (I - A^{'})^{-1} * \Delta p^D \tag{3}$$

These new taxes t are calculated for different CO_2 tax levels with all 2011-2014 input-output structures. The final taxes are then calculated as a simple mean from these four different estimates. This way we can account for the annual changes in the global production structure over time. For the introduction of the new carbon taxes to the modelling of scenario 2 in the FINAGE model, vector t is aggregated to EU and non-EU levels by using the average shares of the different countries in the sector-specific final imports to Finland between 2011 and 2014. For coke and refined petroleum products and for air services the additional tax is set to zero since these in these sectors other tax instruments are increase in the same scenario (namely the fuel taxes and flight related taxes).

The practical implementation of consumption-based carbon taxes is likely to take some time. It would be best to start the process with product-level information requirements on the carbon footprints of different commodities. By starting with labelling requirements, firms would also get more time to develop their own estimates on the detailed carbon footprints of their products and services. Legal considerations when creating the new tax structure could also take time. For these reasons, we assume in the modelling that the new consumption-based carbon taxes would only be introduced in 2025.

Table 2 presents these final consumption-based carbon taxes for different products originating from domestic producers, EU countries and non-EU countries on average for the year 2025 (i.e. with the assumption of a global CO_2 tax of 45 dollars per tCO_2). The table shows that such a carbon footprint tax would be typically significantly higher for non-EU producers since the EU ETS sectors are exempted from the (additional) CO_2 tax and since Finnish and EU producers also have often somewhat smaller carbon intensities in their domestic production (see Table 10 in the Appendix C). There is significant heterogeneity in the results though. For example, a fabricated metal product originating from a non-EU area would need to pay an average carbon tax of 7.1% while a similar product from EU or Finnish producers would be subject to around a 1% consumption-based carbon tax. By contrast, in financial and real-estate services the new tax would be higher for Finnish producers than for non-EU and average EU producers, since these services are more carbon-intensive than in the compared countries on average (see Table 10 in the Appendix C). Tax levels for services are rather low though compared to the various goods in general.

Policies included in the scenarios:

1. ***Production taxes -scenario****: Not included.*
2. ***Consumption taxes -scenario****: Annual increases in product- and service type specific excise taxes from the year 2025 onwards. Taxes introduced in Table 2 for year 2025. Table 11 in the Appendix C present tax levels for year 2030, linear increases in the years between.*
3. ***Circular economy -scenario****: Not included.*

Table 2: Carbon taxes based on global emissions, year 2025, carbon price of 45 \$/tCO_2, taxes reported as % over output value.

	Source of products/service		
Industry description	**Non-EU**	**EU**	**FIN**
Crop and animal production, hunting and related service activities	11.0	6.3	7.9
Forestry and logging	2.6	1.3	0.7
Fishing and aquaculture	1.4	3.6	3.9
Mining and quarrying	7.7	2.5	2.4
Manufacture of food products, beverages and tobacco products	4.3	2.7	3.1
Manufacture of textiles, wearing apparel and leather products	4.4	1.2	1.1
Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials	4.1	1.1	1.0
Manufacture of paper and paper products	5.1	1.0	1.3
Printing and reproduction of recorded media	3.4	0.8	0.8
Manufacture of coke and refined petroleum products	–	–	–
Manufacture of chemicals and chemical products	4.5	1.1	1.8
Manufacture of basic pharmaceutical products and preparations	1.4	0.7	0.4
Manufacture of rubber and plastic products	7.1	1.1	1.4
Manufacture of other non-metallic mineral products	11.5	1.1	1.3
Manufacture of basic metals	16.6	2.0	2.7
Manufacture of fabricated metal products, except machinery and equipment	7.1	1.0	1.2
Manufacture of computer, electronic and optical products	4.1	0.8	0.8
Manufacture of electrical equipment	7.8	1.0	1.1
Manufacture of machinery and equipment n.e.c.	4.7	0.9	1.0
Manufacture of motor vehicles, trailers and semi-trailers	2.6	1.0	1.1
Manufacture of other transport equipment	2.4	0.9	1.1
Manufacture of furniture; other manufacturing	4.1	1.0	1.0
Repair and installation of machinery and equipment	1.4	0.9	0.8
Electricity, gas, steam and air conditioning supply	15.8	1.1	1.4
Water collection, treatment and supply	5.0	1.0	0.7
Sewerage; waste collection, treatment and disposal activities; materials recovery; remediation activities and other waste management services	10.8	4.0	4.5
Construction	2.8	0.9	1.0

Continued on next page

Table 2 – *Continued from previous page*

Industry description	Source of products/service		
	Non-EU	**EU**	**FIN**
Wholesale and retail trade and repair of motor vehicles	1.6	0.5	0.5
Wholesale trade, except of motor vehicles	1.2	0.5	0.7
Retail trade, except of motor vehicles	1.1	0.4	0.6
Land transport and transport via pipelines	3.6	2.0	2.3
Water transport	8.6	5.5	5.8
Air transport	–	–	–
Warehousing and support activities for transportation	3.5	1.0	0.9
Postal and courier activities	9.4	0.7	1.0
Accommodation and food service activities	2.9	0.8	1.1
Publishing activities	0.8	0.7	0.6
Motion picture, video and television programme production, sound recording and music publishing activities; programming and broadcasting activities	0.5	0.3	0.4
Telecommunications	0.8	0.5	0.4
Computer programming, consultancy and related activities; information service activities	0.8	0.3	0.4
Financial service activities, except insurance and pension funding	0.3	0.3	0.6
Insurance, reinsurance and pension funding	0.8	0.3	0.4
Activities auxiliary to financial services and insurance activities	1.5	0.3	0.6
Real estate activities	0.4	0.3	0.5
Legal and accounting activities; activities of head offices; management consultancy activities	3.4	0.3	0.6
Architectural and engineering activities; technical testing and analysis	1.2	0.4	0.5
Scientific research and development	0.9	0.3	0.3
Advertising and market research	0.6	0.4	0.6
Other professional, scientific and technical activities; veterinary activities	1.0	0.4	0.6
Administrative and support service activities	1.1	0.5	0.8
Public administration and defence; compulsory social security	1.2	0.3	0.6
Education	1.1	0.3	0.3
Human health and social work activities	1.4	0.3	0.4
Other service activities	1.4	0.4	0.6

Continued on next page

Table 2 – *Continued from previous page*

	Source of products/service		
Industry description	**Non-EU**	**EU**	**FIN**
Activities of households as employers; undifferentiated goods- and services-producing activities of households for own use	4.3	0.6	0.1
Activities of extraterritorial organizations and bodies	0.0	0.0	0.0

3.4 CO_2 based flight tax for passengers and freight

Aviation causes adverse environmental impacts such as carbon emissions, pollutants, noise and changes in land use. Tickets for international flights are not subject to VAT, following the tradition of international agreements. The Finnish VAT for domestic flight tickets is 10%. (Niemistö et al., 2019)

Air transportation of goods is linked to considerably higher emissions than transport by road or rail (EEA, statistics). Aviation kerosene is not taxed internationally and in the EU there are no air freight taxes in place, offering favourable treatment to air freight compared to other means of transportation.

Helsinki-Vantaa airport is the largest airport in Finland by passenger volume. In 2018, a total of around 17.1 million passengers departed from or arrived at Helsinki-Vantaa. In addition, the airport handled approximately 3.7 million transfer passengers in 2018.[9]

A number of countries have levied a tax on air passengers, for instance France, Germany, Greece, Norway, the United Kingdom and Sweden (Niemistö et al., 2019). In Finland there has been public debate about the possible introduction of an airline passenger tax to reduce emissions, make the "polluters pay", treat different forms of transportation more equally and to collect tax revenue.

In the analysis we introduce a tax of 15 euros for all passengers who either depart from or arrive in Finland, excluding transfers. The tax level is approximately the same as the lowest rate of the UK Air Passenger Duty.[10] If the number of passengers who travel via Helsinki-Vantaa would not decrease after the introduction of the tax, the associated tax revenue would amount to approx. 257 million euros.

Sweden levied an air passenger tax in 2018. Different taxes are used based on the flight destination and distance (six euros for flights within the EU, 25 euros for flights less than 6,000 km and 40 euros for flights over 6,000 km). (Niemistö et al., 2019)

Linnakangas and Juanto (2018) provide estimates for price elasticity of demand for flights in Sweden. For international leisure flights the estimated elasticity is -0,7 meaning that a 10% increase in price would lead to a 7% decrease in demand. For domestic leisure flights the

[9] `www.finavia.fi/sites/default/files/documents/HEL%20matkustajat%201998-2018.pdf`.
[10] `www.gov.uk/guidance/rates-and-allowances-for-air-passenger-duty#rate-bands`

estimated elasticity is -1.0. For business trips the elasticities are much lower for both domestic and international flights.

If the elasticities in Finland are somewhat similar, the price increase due to tax introduction can also be expected to decrease the demand of flight tickets in Finland. However, the Finnish demand for flight tickets may be less elastic than in Sweden because of fewer other connections to EU countries, for instance. Most passengers departing from or arriving in Finland are travelling within the EU. For instance, in 2018 around 12.4 million air passengers out of 17.8 million passengers in total travelled within the EU.[11]

The UK provides an interesting example of an island with an air passenger duty in place since 1994. Because of geographical reasons the UK's airports have not faced strong competition from airports in other countries or other means of transport. (Krenek and Schratzenstaller, 2016)

Based on the experience from the UK, it can be expected that if a Finnish passenger tax were introduced, travellers would perhaps not start using the airports of neighbouring countries. The cost of travelling to neighbouring countries typically exceeds 15 euros, the value of the added tax. In the Netherlands and Denmark, a tax on air travel resulted in increased use of airports in nearby countries. To prevent the passenger flow to other countries the Netherlands and Denmark removed the taxes.[12] (Niemistö et al., 2019)

However, the introduction of a tax in Finland might encourage some domestic passengers to switch to travelling by train or bus, for instance. As the share of domestic passengers of total air passengers is low,[13] the impact on travelled kilometres and emissions can be expected to remain somewhat modest.

It should be noted that the introduction of an air passenger tax is modelled only for passengers leaving or arriving in Finland, i.e. transfer passengers would not have to pay the fee. Therefore, the new tax is not expected to significantly affect the competitiveness of Finnish airlines.

In addition to passengers, air freight has benefited from a lack of kerosene taxation. Other transport means have to pay tax for the fuel based on the fuel's energy content and CO_2 emissions. Based on the recent statistics of the Finnish airport operator Finavia, domestic and international air freight in Finland has totalled between 180,000 to 200,000 tonnes between 2012-2018. The introduction of a 20-euro air freight tax per tonne would result in an increase in tax revenue of approximately 3.8 million euros.

[11] www.finavia.fi/sites/default/files/documents/Kv%20reittiliikenteen%20matkustajat%20maittain%202013-2018%20v2.pdf.

[12] Recently, however, the Dutch government has announced a plan to reintroduce a flight tax. See: nltimes.nl/2018/12/07/dutch-govt-implement-eu7-flight-tax-per-ticket-regardless-destination

[13] www.finavia.fi/sites/default/files/documents/HEL%20matkustajat%201998-2018.pdf

Policies included in the scenarios:

1. ***Production taxes -scenario**: Not included.*
2. ***Consumption taxes -scenario**: A tax on CO_2 of 15 euros per air passenger (excluding transfer passangers) and 20 euros per tonne of air freight.*
3. ***Circular economy -scenario**: A tax on CO_2 of 15 euros per air passenger (excluding transfer passangers) and 20 euros per tonne of air freight.*

3.5 Removal of energy tax refund for energy intensive firms

Finland has provided a repayment system for energy-related excise taxes for energy-intensive firms since at least 1992. From 1992 to 2010 it was relatively limited and included only around 10 or 15 firms because of the strict requirements. In 2012 the system was extended, and the number of firms entitled to repayments increased to over 140. In addition, since 2017, mining companies have been entitled to energy tax refunds. The repayments are categorised officially as state aid to the recipient firms. The system has costed over 200 million euros annually during the past years. The majority of the refunded energy tax payments result from electricity taxes and a smaller part from fossil-fuel energy taxes. (Harju et al., 2016)

The repayment system has undermined the efficiency of the energy tax in reducing energy usage and emissions as it decreases significantly the energy and fuel tax payments of some of the largest emitters in Finland. (PMO, 2000; and Harju et al., 2016) Through the system, the largest energy users have received almost 80% of their energy taxes back, while for smaller firms or energy users the repayment rate has been significantly lower (if they received a repayment at all due to the minimum payment of 50,000 euros of energy taxes). (Harju et al., 2016) Because of this structure, the repayments have also resulted in distortive competition between firms within the same industries and given larger firms a competitive advantage over smaller ones.

In addition to Harju et al. (2016) , representatives of smaller firms and various politicians have criticised the system. If the functioning of the EU ETS is strengthened, the role of national electricity taxes would be mainly fiscal in addition to their impact of energy saving since the electricity taxes are not based on CO_2 emissions. As electrification of industrial processes can also reduce CO_2 emissions in industrial firms (Sitra and McKinsey, 2018), the electricity taxes for energy-intensive sectors in particular should be moderate. Therefore, in the first scenario the energy tax refund system would be abolished, but, as a support, the electricity tax would be lowered to the minimum EU level for all industrial users (in addition, the scenario includes the price floor for EU ETS allowances to make sure that the CO_2 price is high enough). In scenario 3, such a reduction in the electricity tax rate for industrial users would not be included.

Policies included in the scenarios:

1. ***Production taxes -scenario**: Complete removal of the energy tax refund system.*
2. ***Consumption taxes -scenario**: Not included.*
3. ***Circular economy -scenario**: Complete removal of the energy tax refund system.*

3.6 Removal of lower tax level for peat

In Finland peat is used in both electricity and combined heat and power production, CHP.[14] In 2018 around 70% of the taxable peat use was in CHP.[15] In 2017 around 14% of district heating was produced by burning peat.[16]

The taxation of peat does not follow the model applied to other energy fuels such as coal or natural gas, where the tax reflects the related emissions and energy content.[17] The current tax for peat is 3 euros per MWh.[18] No reduction to the energy content tax is applied in CHP use, unlike for coal; see Chapter 3.7

In combined heat and power production the electricity generation is not taxed, but heat is. Therefore, in CHP the tax is levied based on the amount of peat that can be allocated to the production of heat. In addition to being subject to domestic taxation, CHP plants are part of the EU ETS. Plant operators pay for the allowances or receive them free of charge in some cases.

The life-cycle emissions of the most commonly used variety of peat are around 117 CO_2/MJ.[19] If the taxation of peat was based on life-cycle emissions, and the tax were set at 53 euros per tonne of CO_2, similar to other energy fuels, the CO_2 tax on peat would amount to approximately 22 euros per MWh.

Burning one kilogram of peat produces around 9.8 MJ of energy. If peat was taxed according to the taxation model of energy fuels (at the rate of 0.00208 euros per MJ), the energy tax on peat would amount to 7.5 euros per MWh.

Combining these CO_2 and energy taxes, the total tax would amount to approximately 29.50 euros per MWh, i.e. almost ten times the current level. Therefore, currently, there is a significant tax subsidy for peat. In the government budget the calculated tax support for peat equals almost 180 million euros annually.

Applying the same criteria to peat as for other energy fuels would put different fuels in equal positions in terms of how much pollution occurs and would align the tax system more with climate targets.

[14] www.stat.fi/til/salatuo/2017/salatuo_2017_2018-11-01_fi.pdf
[15] www.finlex.fi/fi/esitykset/he/2018/20180191.pdf
[16] www.stat.fi/til/salatuo/2017/salatuo_2017_2018-11-01_tie_001_fi.html
[17] www.finlex.fi/fi/esitykset/he/2018/20180191.pdf
[18] Finnish tax authority.
[19] The most common peat variety is "jyrsinturve": www.koneyrittajat.fi/media/Julkinen/Liitteet/Tapahtumat/Turveristeily2018/Salo_turpeen_tuotanto.pdf

The tax increase would increase the costs of peat use considerably. The change in demand for peat in energy production depends on opportunities to switch to burning other fuels in the existing facilities. A full switch to other fuels is likely to be challenging without additional investments. Therefore, if the production costs of district heating would increase, also the consumer price in district heating might increase. In addition, the costs of industrial peat facilities would increase.

In addition, the areas where peat plays a central role in economic activities would be affected. Thus, public support for investment in cleaner energy and allowing proper transition time might help decrease the impacts on industry and geographical areas.

Policies included in the scenarios:

1. ***Production taxes -scenario****: An increase in CO_2 tax for peat to 53 euros per tCO_2. The reform is phased in gradually over a four-year period.*

2. ***Consumption taxes -scenario****: An increase in CO_2 tax for peat to 53 euros per tCO_2. The reform is phased in gradually over a four-year period.*

3. ***Circular economy -scenario****: An increase in CO_2 tax for peat to 60 euros per tCO_2.*

3.7 Removal of lower tax level for coal

In Finland coal is mostly used in combined heat and power production (CHP). The power plants are part of the EU ETS. They pay for the emission allowances or receive them free of charge. In addition, CHP coal plants are charged a tax based on the amount of coal used in heat production (the production of electricity is not subject to tax).

In 2018, around 3.1 million tonnes of coal was consumed in Finland in power and heat production (including electricity production, CHP and heat only).[20] Coal in CHP is mainly used in the context of district heating. However, there are some industrial CHP plants that use coal.

In district heating around 33,531 TJ of coal was used to produce heat in CHP (i.e. the amount subject to tax) in 2016.[21] In addition, around 3,386 TJ of coal was used in industrial CHP. Therefore around 36,917 TJ of coal was used in CHP in total, which reflects the burning of around 1.48 million tonnes of coal.

Since the beginning of 2019 the CO_2 tax for coal has amounted to 53 euros per tCO_2,[22] resulting in a tax of 147.81 euros per tonne of coal. The taxation is based on life-cycle emissions of coal use, not only the emissions caused by combustion.[23]

[20] www.stat.fi/til/kivih/2018/12/kivih_2018_12_2019-01-31_tie_001_fi.html

[21] https://pxhopea2.stat.fi/sahkoiset_julkaisut/energia2017/html/suom0002.htm

[22] http://finlex.fi/fi/esitykset/he/2018/20180191.

[23] www.vero.fi/yritykset-ja-yhteisot/tietoa-yritysverotuksesta/valmisteverotus/valmisteverolajit/sahko_ja_eraat_polttoaineet/sahkon_ja_eraiden_polttoaineiden_verota/

The energy tax is 0.00208 euros per MJ or 52.77 euros per tonne of coal.[24] However, in CHP the energy tax is not applied to coal or natural gas.[25] The preferential treatment continues in line with the policies from recent years – the Finnish Parliament has put an emphasis on competitiveness of the regulatory environment and reducing the overlapping burden caused by ETS and domestic taxation.[26]

The removal of the lower tax level for coal means applying the energy tax on coal use in CHP. Removing the lower tax level would put different fuels in equal positions in terms of how much pollution occurs and align the taxation system more with climate targets. As the costs of using coal increase as a result of the introduction of taxes, and especially because in the short term switching to alternative fuels is likely to be challenging, the tax introduction might lead to higher energy prices. This, in turn, can reduce energy use and emissions. In the long run, the impact on emissions will depend on the sources of energy that replace coal.

In addition, the tax increase would increase the costs of industrial coal users. Therefore, public support for investment in cleaner energy and allowing time for the transition might help the transition to a low-carbon industry.

If the tax increase from applying the energy tax were not to decrease the quantity of coal used, the tax revenue would increase by around 78 million euros per year ($= 52.77 * 1.48$ million euros).

As power plants are part of the EU ETS, introducing domestic taxation might in theory lead to emission increases in other countries, thus not reducing EU-wide emissions (the "waterbed effect"). However, recent research suggests the waterbed effect is not active due to the Market Stability Reserve, at least until 2023, possibly even longer (see Silbye and Sørensen, 2019, Perino, 2018, and Chapter 3.1).

Policies included in the scenarios:

1. ***Production taxes -scenario****: Increasing the energy tax for coal in CHP to normal rate over 4 years.*

2. ***Consumption taxes -scenario****: Increasing the energy tax for coal in CHP to normal rate over 4 years.*

3. ***Circular economy -scenario****: Not included.*

3.8 Removal of lower tax level for fossil diesel

Most of the diesel consumption in Finland is associated with the haulage and logistics industry. With a lower tax level compared to petrol, Finnish authorities have lowered the costs of logistics, exports and buses. For private diesel cars there is an annual tax sanction in place, called

[24] www.eduskunta.fi/FI/vaski/HallituksenEsitys/Sivut/HE_138+2017.aspx.
[25] www.finlex.fi/fi/laki/alkup/2018/20181226.
[26] www.finlex.fi/fi/esitykset/he/2018/20180191.pdf.

the motive power tax, to treat private diesel car owners on more level terms as those who own petrol cars.

In 2016, the diesel consumption was around 111 TJ in road transport[27] or around 3,081 million litres. [28] Currently the energy tax for diesel is 25.95 cents per litre lower than it would be according to the general tax model for transport fuels.[29]

Removing the reduced energy tax on diesel would put different fuels in equal positions in terms of how much they pollute, align the tax system with climate policy, improve health through disincentivising diesel consumption and encourage energy efficiency.

The removal of the reduced energy tax for diesel will have affect the costs of transport and logistics. Even if the increased cost of fuel for the transport sector can be expected to encourage the development and use of alternative fuels, and the optimisation of routes, public support for investments in haulage vehicles that use clean or low-carbon fuels could help the transition towards a carbon-neutral transport sector.

Please see Chapter 3.2 for a discussion on the price demand elasticities for fuels, consumer responses to tax increases, the income elasticity of fuels and the availability of low-emission vehicles.

Policies included in the scenarios:

1. ***Production taxes -scenario**: The energy tax for fossil diesel is increased to match the level of petrol, to 0.01631 euros per MJ. The reform is phased in gradually over a four-year period, to give time for everyone to adapt.*

2. ***Consumption taxes -scenario**: Not included.*

3. ***Circular economy -scenario**: Removal of the reduced energy tax rate on diesel used in transport minus the motive power tax.*

3.9 Increasing the tax on fossil light fuel oil

Light fuel oil is used in machinery in agriculture and construction, and in households for heating. Light fuel oil is taxed at a lower rate than regular diesel. Light fuel use in private diesel cars is prohibited.[30] Currently the light fuel oil tax is based on the model applied for energy fuels – the energy tax is 0.00208 euros per MJ and the CO_2 tax is 53 euros per tCO_2.[31]

[27] https://pxhopea2.stat.fi/sahkoiset_julkaisut/energia2017/html/suom0004.htm.

[28] By using the heat value for diesel (36 MJ per litre) in the governmental proposal 191/2018, the amount of diesel consumed in road transportation can be estimated to be around 3,081 million litres www.finlex.fi/fi/esitykset/he/2018/20180191.pdf

[29] https://vm.fi/energiaverotus

[30] https://arkisto.trafi.fi/uutisarkisto/1966/kevyella_polttooljylla_ei_saa_ajaa_edes_suljetulla_alueella.

[31] www.finlex.fi/fi/esitykset/he/2018/20180191.pdf.

If light fuel oil was taxed according to the model for transport fuels, both the energy and CO_2 tax would increase. For transport fuels the energy tax is 0.01631 euros per MJ and the CO_2 tax amounts to 62 euros per tCO_2.

Applying the transport fuel tax model for light fuel oil would put different fuels in equal position based on how much pollution occurs, would encourage biofuel use in machinery and would align the tax system with climate targets.

Increasing the light fuel oil tax can be expected to have an impact on agriculture, construction, households and the public sector. Therefore, additional measures to support investment in machinery with alternative fuels and low-carbon heating systems could help the transition to low-carbon machinery and heating.

Policies included in the scenarios:

1. ***Production taxes -scenario**: Tax for light fuel oil is increased to match the level of petrol, i.e. the energy tax increases to 0.01631 euros per MJ and the CO_2 tax to 62 euros per tonne of CO_2. The reform for light fuel oil is phased in gradually over a four-year period, to give time for everyone to adapt.*

2. ***Consumption taxes -scenario**: Tax for light fuel oil is increased to match the level of petrol, i.e. the energy tax increases to 0.01631 euros per MJ and the CO_2 tax to 62 euros per tonne of CO_2. The reform for light fuel oil is phased in gradually over a four-year period, to give time for everyone to adapt.*

3. ***Circular economy -scenario**: Removal of the light fuel oil subsidy.*

3.10 Tax to waste incineration and nuclear waste

Currently there is no tax on waste incineration in Finland (GBE et al., 2018). Around 90 to 125 million tonnes of waste are generated yearly out of which around five million tonnes are incinerated. In 2014 approximately 0.5 million tonnes of waste were incinerated without capturing the energy that occurs during incineration, and 4.5 million tonnes was burned with energy recovery.[32]

Introducing a tax on waste incineration would encourage the reuse of materials that are destined for incineration and would align the tax system more with climate targets.

In Denmark, an incineration tax was introduced together with a landfill tax in 1987. The taxes have not decreased the quantity of waste but have incentivised recycling. As a result, markets for compost products and construction waste have grown. The circular economy scenario introduces a tax of 20 euros per tonne of incinerated waste. The estimated tax revenue is expected to be 100 million euros in 2025.[33]

[32] http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=env_wastrt&lang=en.
[33] www.legco.gov.hk/yr13-14/english/sec/library/1314in09-e.pdf

In 2017, around one third of electricity supply was generated by nuclear reactors (GBE et al., 2018). Currently, nuclear facility operators are obliged to make a payment for the management of nuclear waste. In 2017 the payments to the Nuclear Waste Management Fund totalled 73.1 million euros (ibid.).

In the circular economy scenario, a nuclear waste tax is levied at 4 euros per MWh of energy generated by nuclear power, in addition to the waste-management payment. Introducing the tax would indirectly discourage the extraction of non-renewable resources. The estimated tax revenue would amount to 134 million euros in 2025.

These waste-related tax changes are included only in the circular economy scenario. For further information on them, please see GBE et al. (2018).

Policies included in the scenarios:

1. ***Production taxes -scenario****: Not included.*
2. ***Consumption taxes -scenario****: Not included.*
3. ***Circular economy -scenario****: Introduction of a 20-euro tax per tonne of incinerated waste and a tax on the production of nuclear waste at 4 euros per MWh generated by nuclear power.*

3.11 Increase in resource use taxes for extraction of metal ores and non-metallic minerals

There is currently no tax on the extraction of metal ores or other minerals such as sand, gravel, chemical and fertiliser minerals and stone. However, the mining companies need to pay compensation of 50 euros per hectare to landowners annually.[34]

In addition, there are excavation fees. For metallic minerals the fee is 0.15% of the calculated value of the minerals exploited, based on the average price of the exploited metals. For other mining minerals the mining permit holder is obliged to pay reasonable compensation in accordance with an agreement between the property owner and the permit holder, or confirmation by the mining authority.[35]

In Finland there has been public debate about the excavation of sand and gravel, typically taking place in and impacting the freshwater areas in the southern parts of the country. (GBE et al., 2018)

In the circular economy scenario, the following taxes are introduced: 2 euros per tonne of metal ores and 0.50 euros per tonne of non-metallic minerals extracted. Levying the taxes

[34] https://tukes.fi/en/mining.
[35] Ibid.

would mean a step towards including the environmental externalities in the price of minerals, would encourage the reuse of materials (versus virgin materials) and would protect local environments.

In the circular economy scenario, the combined revenue associated with the taxes on metallic ores and non-metallic minerals would amount to 97 million euros in 2025. These resource-use-related tax changes are included only in the circular economy scenario. For further information on them, please see GBE et al. (2018).

In 2012, the Ministry of Finance estimated that taxing non-metallic minerals could encourage the recycling and reuse of materials, and thus reduce the need to extract virgin materials. However, as the public sector is a significant player in infrastructure and housing, taxing the extraction of non-metallic minerals would increase the costs of the public sector.[36]

Policies included in the scenarios:

1. ***Production taxes -scenario****: Not included.*
2. ***Consumption taxes -scenario****: Not included.*
3. ***Circular economy -scenario****: Introduction of a tax of 2 euros per tonne of metal ores and 0.50 euros per tonne of non-metallic minerals extracted.*

3.12 Increase in taxation of pesticides use and water abstraction

Currently there is no tax on pesticides in Finland. However, pesticide products can be sold and used in Finland only after approval by the Finnish Safety and Chemicals Agency Tukes.[37] To enter the evaluation process conducted by Tukes, a fee must be paid. [38]

In 2017, agricultural and horticultural sales totalled 3,626 tonnes, out of which the active substances contained by the products was 1,327 tonnes. In forestry, the total sales volume of protection products was 8,961 tonnes and the sales of active substances amounted to 3,039 tonnes.[39]

There is currently no tax on water abstraction either. According to Salminen et al. (2018) Finnish industry abstracted around 1,960 million cubic metres of freshwater for purposes other than cooling in 2010. Of this, around 1,643 million cubic metres was abstracted from surface water and around 316 million cubic metres from groundwater.

In addition, 1,891 million cubic metres of surface water and 3.7 million cubic metres of groundwater was used for cooling. Furthermore, around 6,280 million cubic metres of brackish water was abstracted.

[36] www.vm.fi/dms-portlet/document/0/397878

[37] https://tukes.fi/en/chemicals/plant-protection-products

[38] www.tukes.fi/documents/5470659/6373226/Hinnasto/3786e6b0-2eef-4e58-87b8-a360ea3521b1/Hinnasto.pdf

[39] www.tukes.fi/en/chemicals/plant-protection-products/sales-volumes

Introducing taxes on pesticide use and water abstraction would mean taking a step towards including environmental externalities in production costs, encouraging the use of alternative pest-control methods, encouraging the reduction of energy use associated with water abstraction and reducing pressure on waste-water treatment facilities.

In the circular economy scenario, a pesticide tax is levied at 10 euros per kilogram of active ingredients used. In addition, a water abstraction tax is levied at 0.04 euros per cubic metre of water intake for bulk users (excluding seawater). The potential tax revenues would amount to 43 million euros from a pesticide tax in 2025 and 133 million euros in 2025 from water abstraction. These tax changes are included only in the circular economy scenario. For further information on them, please see GBE et al. (2018).

Policies included in the scenarios:

1. ***Production taxes -scenario****: Not included.*
2. ***Consumption taxes -scenario****: Not included.*
3. ***Circular economy -scenario****: A tax of 10 euros per kilogram of active ingredients used and a water abstraction tax of 0.04 euros per cubic metre of water intake for bulk users (excluding seawater).*

4 Recycling the additional revenue back to the economy

The decision on tax increases is typically more challenging than the decision on how to spend the additional revenue. Therefore, the focus of this report is to present options to increase the environmental tax revenues. In this chapter we will briefly outline the key mechanisms available for recycling the revenue back to the economy.

The literature suggests that the lowering of employment taxes for employees and employers is typically an effective way to create the double dividend effect associated with an ETR. In addition, Pigato (2019) recommends using around 12% of the new (emission) tax revenue to compensate the potential regressive effects of emission taxes. This could be done for example by increasing social security payments or increasing the progressiveness of income taxes.

Table 3 presents the mechanisms used in the modelling scenarios to recycle the emission tax revenue back to the economy. In scenarios 1 and 2 we used two different mechanisms to recycle the revenues: 1) by decreasing the income taxation and 2) by decreasing employers' social security payments and corporate taxes. The results suggest (see Chapter 6) that lowering income tax is more efficient at creating economic benefits, such as employment, compared to lowering employers' social security payments and corporate taxes. Therefore, we chose this approach as the main scenario.

Some other options for tax reductions or increases in spending to support emission cuts are listed in Appendix A, Table 8.

Table 3: Tax reductions and increases in spending; instruments included in the different scenarios.

Tax instrument or increase in spending	**1. "Production taxes", FINAGE model**	**2. "Consumption taxes", FINAGE model**	**3. "Circular economy scenario", E3ME model (see GBE et al., 2018)**
Decrease in income taxation	✓	✓	✓
Increase in social security payments		✓	
Decrease in employers' social security payments	(✓)	(✓)	✓
Decrease in corporate taxes	(✓)	(✓)	
Removal of car taxation on low-emission vehicles	✓	✓	
Removal of motive power tax (for diesel, BEV and gas-powered vehicles)	✓	✓	
Decrease in electricity taxation for energy-intensive industries	✓		
Increase in R&D and investment support for low-emission technologies			✓

Decrease in income taxation

Based on extensive literature, a decrease in income taxation is likely to increase labour supply and therefore total employment. A lower income tax level will increase the net salary for a given level of gross salary and therefore increase the willingness of people to work without a need to increase actual gross salaries. This will also help firms to manage employment costs and therefore potentially increase labour demand, too. The modelling results, presented in Chapter 6, suggest that a decrease in income taxation is also critical for obtaining the double dividend effect associated with an ETR in Finland. In other words, the employment and GDP impacts are positive in scenarios 1 and 2 only if the new revenue is recycled back to the economy by lowering income taxation.

Total employment costs represent a significant share of total costs even in various energy-intensive sectors. For example, in the biggest energy-intensive export sectors in Finland, including paper, metal and chemical sectors, labour costs have been around 8-20% compared to revenue during the past years. At the same time energy costs accounted for maximum few percentages of total revenue in the same sectors on average (Statistics Finland). Therefore, measures that alter labour costs can have large economic impacts in energy-intensive sectors as well. In addition, the decrease in income taxes directly compensates all employees for the increasing prices of various products and services resulting from higher environmental taxes.

There are various estimates on the income elasticity of labour supply, i.e. how strong the impact from a lower income tax on labour supply is likely to be. An elasticity of 0.3 means that a 10% increase in the useable income associated with being employed would increase employment by 3%. Studies using microdata suggest that the elasticity is likely to be between 0 and 0.5 (see Jäntti et al. (2015) for estimates using Finnish data). In the FINAGE model the implied elasticity of labour supply is calibrated to about 0.3 at the macro level (the micro level estimate is even lower than this), which is a fairly conservative figure and very close to the elasticity used by Kotamäki (2016) and bit lower than the elasticity recommended for the calibration of macro models by Chetty (2012).

Increase in social security payments

Some environmental tax increases can have a regressive effect, i.e. they hurt the lower-income households more than higher-income households. To make the transition to a low-carbon economy fair from a social perspective, it might be essential to consider using some of the additional tax revenue to increase social security payments and/or to decrease income taxes more for low-income households. Based on Pigato (2019), less than 12% of the new tax revenues should be enough to compensate the poorest 20% for any distributional impact of carbon taxes. Chiroleu-Assouline and Fodha (2014) further conclude that no matter how regressive the environmental tax is, it is possible to design a recycling mechanism in a way that does not harm the poorest consumers. While the initial analyses of the income effects of scenarios 1-3 (see Chapters 6 and 7) show that the ETR packages in question are progressive instead of regressive, we recommend more research on the potential distributional impacts of any ETR model in Finland (e.g. with microsimulation models) and the best ways to mitigate against any adverse impacts.

Decrease in employer's social security payments and in corporate taxes

There are different ways to compensate firms for the increase in energy (and resource) costs. In British Columbia corporate taxes have been lowered as part of an ETR. Similarly, firms' labour costs can be reduced by lowering employers' social security payments. However, in this case it should be carefully analysed how the required social security payments will still be covered. In Finland the employers' social security payments go directly to specific funds, whose income should be guaranteed if social security payments are no longer collected straight from the employers. From this perspective, the lowering of social security payments to compensate firms for the increasing environmental costs also seems less attractive than lowering income taxes. In addition, a decrease in corporate taxes and employers' social security payments does not compensate salary earners/consumers at all for the increases in consumption costs resulting from higher environmental taxes.

Removal of car tax on low-emission vehicles

Various reports have concluded that increased renewal of the vehicle fleet in Finland is essential for the reduction of transport-related CO_2 emissions. On average, Finnish vehicles are significantly older than in other EU countries and the older models use more fuel than similar newer models (MoTC, 2018; Sitra and McKinsey, 2018; FCCP, 2018). To boost the sales of low-emission vehicles, a one-off car tax for new and imported used vehicles could be lowered for low-emission vehicles. Finland imposes a car tax based on the CO_2 emission intensity of the new vehicles in grams per kilometre or based on the weight of the car/van. The tax needs to be paid when one starts using the vehicle for the first time in Finland. It ranges currently from around 3% of final purchase price for zero-emission cars to up to 50% for very heavy/polluting vehicles. (Tamminen et al., 2018) In scenario 1 we have removed the car tax for low-emission vehicles and in addition to this, in scenario 2 we increase somewhat the car tax to high-emission vehicles.

In addition, the taxation of gas-powered vehicles should be also revalued to boost the use of biogas in transportation. Currently, many gas vehicles are still considered to have a relatively high CO_2 emission intensity since the gas used in these cars could be natural gas (with relatively high emissions) instead of the low-emission biogas. In Finland, the use of biogas is promoted with governmental support for the conversion to gas of old diesel and petrol vehicles.

Removal of motive power tax (for diesel, BEV and gas-powered vehicles)

Finland has an additional motive power tax on all other passenger vehicles expect petrol cars. This is to compensate for the fact that the fuel taxation of diesel is lower than the taxation of petrol to keep transport-sector fuel costs low. So, in addition to diesel cars, battery electric vehicles (BEVs) and gas-powered vehicles are liable for this tax. This tax is paid once a year and the rate is somewhat lower for BEVs and gas-powered vehicles compared to diesel cars. The motive power tax increases significantly the annual total vehicle taxes of BEVs and gas-powered cars in comparison to petrol cars. While the annual vehicle taxation should be lower for low-emission vehicles in comparison to higher-emitting vehicles, this is not the case for all BEVs and gas-powered cars at the moment in Finland. Therefore, it has been proposed by several politicians and experts that the motive power tax should be removed at least from non-diesel vehicles. If the lower tax rate for diesel vehicles is also removed or diesel taxation is otherwise increased heavily, it would be natural to remove the motive power tax completely.

Decrease in electricity taxation for energy-intensive industries

Many low-emission technologies involve electrification of current, more emission-intensive, technologies. (Sitra and McKinsey, 2018) From this perspective it could be important to keep the taxation of low-emission electricity low. The current taxation on electricity in Finland is not based on the emissions associated with the generation of electricity. Electricity producers are included in the EU ETS, which controls emissions. Therefore, if the EU ETS is tightened or the allowance price increases with national policies, as is done in scenario 1, it could be reasonable to lower the electricity taxation for the industry to the EU minimum level, or 0.5 euros/MWh. In addition, in scenario 1 the current energy tax repayment system is removed, which increases the energy taxes associated with electricity use by the energy-intensive firms included in the system.

Even for these energy-intensive sectors, such a decrease in the electricity tax would more than compensate for the loss of the energy tax refund. For example, in the paper industry the energy tax refunds have reduced the current energy (including electricity) tax payments by around 75 to 80% on average. As the normal electricity II rate has been 6.9 euros/MWh, this means that the largest energy users in industry have paid around 1.7 euros/MWh in electricity tax. A decrease to the EU minimum level of 0.5 euros/MWh would lower their electricity rate from the current level. If the energy tax repayment system is removed and this is compensated for by lowering electricity II tax (but tightening emission control from the EU ETS), the price of low-emission electricity would remain competitive while the energy taxes for all fossil-fuel use by energy-intensive sectors would increase. These policy changes could accelerate the shift to low-emission (but electricity-intensive) technologies and bring down total emissions.

Increase in R&D and investment support for low-emission technologies

A common way to support a reduction in emissions and the transformation to new low-emission technologies is to support R&D activities. Various studies have found that R&D support for low-emission technologies has boosted firm performance and reduced emissions. (See e.g. Lee and Min, 2015) Therefore, in scenario 3 some 5% of the additional tax revenue is used for supporting the employment costs related to carrying out R&D work into low-emission technologies.

5 Methodology and data for the analysis of ETR scenarios 1 and 2

In this chapter, we estimate the potential for an environmental tax reform using the dynamic AGE model for Finland. We will use FINAGE - an AGE model for Finland - to estimate the dynamic effects of the proposed tax structure changes, as well as their welfare costs. FINAGE is well suited to the analysis of tax structure changes as it includes all major tax types and covers the Finnish economy in great sectoral detail, but here we also tweak the model in two respects. First, to capture the effects of an environmental tax reform - which is essentially aimed at generating relative improvements in the economy by removing existing inefficiencies created by commodity and income taxes by recycling the revenue from environmental taxes – we assume a standard, competitive labour market with endogenous labour-supply decisions made by the households, as in Honkatukia (2011). Second, to capture the dynamic effects of changes in transport fuel taxes, we model the use of passenger cars on the demand for passenger car kilometres provided by different types of passenger cars.

The structure of this chapter is as follows. Subchapter 5.1 gives an outline of the FINAGE model and discusses the role of taxes in agents' decision-making. Subchapter 5.2 presents the modelling of demand and provision of passenger car services and subchapter 5.3 our analyses of the tax reform proposals. Chapter 6 provides the results of the modelling exercises.

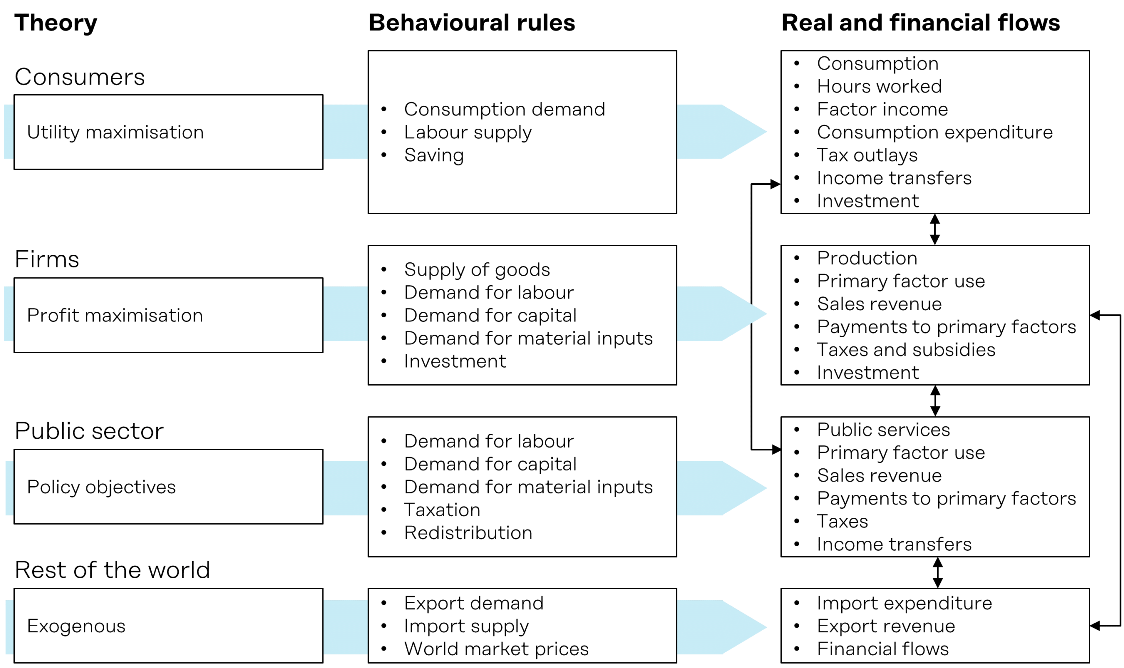
5.1 The basics of FINAGE model

FINAGE is an applied, dynamic general equilibrium model for Finland that covers the whole economy and models all major tax types including labour income taxes, capital taxes and indirect taxes of various forms. The FINAGE database contains detailed information about commodity and income taxes as well as the expenditures and transfers of the public sector, and thus covers most policy instruments available to the government. The model accounts for changes in public deficit and debt and can be used to evaluate the impact of the policy shocks on public-sector sustainability. Further, the government cost structure accounts for the different types of public transfers to households, including age-related benefits and unemployment benefits, and public investments, for example.

FINAGE is based on the MONASH model developed at the Centre of Policy Studies at Monash University. MONASH-style models are used in countries ranging from China and South Africa to the United States and Australia (Dixon and Rimmer, 2002). In Europe, models based on MONASH have been developed for Denmark, Finland and the Netherlands. FINAGE is described in detail in Honkatukia (2019).

The FINAGE database collects information on the structure of the Finnish economy derived from national accounts, arranged in a presentation reflecting the theoretical structure of the model. Here, we use data updated for the long-term industry-level scenarios in Honkatukia et al. (2018), with most industry-level data extending to 2015 or 2016. The database also contains the behavioural parameters that are used to operationalise the behavioural assumptions made in the model. National accounts collect data on the use of goods and services by industry and by product, but it also contains accounts for production and financial positions by institutional sector. The institutional sectors are viewed as independent decision-makers, and it is the behaviour of these decision-makers that the model parameters and coefficients derived from the data describe and control.

Figure 4: The structure of FINAGE



A large part of the database consists of input-output data that captures the structure of demand for intermediate goods and primary factors by industries, the final consumption by consumers, the public sector and the rest of the world. However, input-output data does not contain data on income flows, which must be obtained from other sources in national accounts.

Furthermore, the database also presents the transactions in the economy taking place between the institutional sectors of the economy. In the database, transactions take place between domestic sectors and between domestic and foreign sectors. The domestic sectors are divided into three domestic subcategories – firms, households and the public sector – whereas the foreign sectors represent foreign countries and multinational and international organisations. These institutional sectors are mutually exclusive and their role in the economy can thus be unequivocally presented. For example, export demand is final demand for domestic goods and services by the foreign sectors.

FINAGE models production with conventional, nested production functions. The idea behind industrial classification is to group activities whose production processes or the products they make are similar. However, FINAGE also allows for the multi-production of commodities. The detailed data on commodities and industries allow us to study the production of goods almost at a process level. For example, for the current study, detail on energy carriers and different fuels is especially relevant. Our data covers all fossil fuels and their refined derivatives and their use by industries and households.

In FINAGE, households are assumed to be the recipients of factor incomes, such as wage and capital income. They also possess assets and liabilities abroad and domestically, which implies that a part of domestic income will be channelled abroad. FINAGE allows for different treatments of the labour markets. The labour market equations relate population and population of working age and define unemployment rates in terms of demand and supply of labour.

The concept of an environmental tax reform affects our choice of labour market specification. Environmental tax reforms have been the subject of extensive literature on double dividends in the past. In the Nordic countries, Sweden and Norway studied the potential for an environmental tax reform extensively as long ago as in the 1990s, and Finland has implemented a de facto environmental tax reform several times since the 1998 energy tax reform. The essence of these reforms has been on shifting the tax burden from income taxes - especially taxes on wage income - to energy consumption and on emissions. Thus, the extra tax revenue generated by increased environmental taxes is used to lower income taxes; in an economy with many distorting taxes it is possible that this shift generates welfare gains or at least leads to higher employment. To capture these effects, labour-supply decisions need to be accounted for in the model. Here, we will assume competitive labour markets with flexible wages, since our focus is on the long-term effects of the tax reform on labour supply. This type of labour supply has been extensively studied and it is therefore easy to calibrate to match the empirics of the Finnish labour markets. (Honkatukia, 2011)

To calibrate the labour-supply elasticities implied by the utility maximisation problem in functions 4 to 6, we have used the estimates of Kleven and Kreiner (2006), who find considerably higher elasticities for lower-income deciles than for higher ones. Here, we consider labour supply at an aggregate level, and calibrate the utility function to yield an implied elasticity of supply of about 0.3 with respect to changes in wages (net of the effect of marginal taxes), which is a fairly conservative figure.

Formally, in every period, households maximise the utility from:

$$U_{iC}(C_i) + U_{iL}(L_i), \tag{4}$$

subject to

$$P_{iC} * C_i + P_{iR} * R_i = Z_i + \frac{P_w}{T_{iW}} * N_i, \tag{5}$$

and

$$L_i = H_i - B_i - N_i, \tag{6}$$

where:

C is consumption;

L is leisure;

R is reserved consumption (i.e. saving);

H is total hours available for work;

B is hours in involuntary unemployment;

N is hours of employment;

P_W is the pre-tax wage rate;

T_W is the power of the tax on labour income;

Z is household non-labour income;

P_R is the price of a unit of reserved consumption;

P_C is the price of a unit of consumption;

and where the index i denotes decile.

In function 6, we assume that involuntary unemployment is not leisure and consequently gives no utility.

The price of consumption is given by:

$$P_{iC} = P_Y * T_{iC}, \tag{7}$$

where:

T_{iC} is the power of the tax on consumption (that is, 1 + ad valorem-equivalent rate of commodity taxes) and P_Y equals the producer price of output.

The first order conditions from problem 3 to 4 are:

$$U'_{iC}(C_i) = \lambda_i * P_Y * T_{iC}, \tag{8}$$

$$U'_{iL}(L_i) = \lambda_i * P_W / T_{iW}, \tag{9}$$

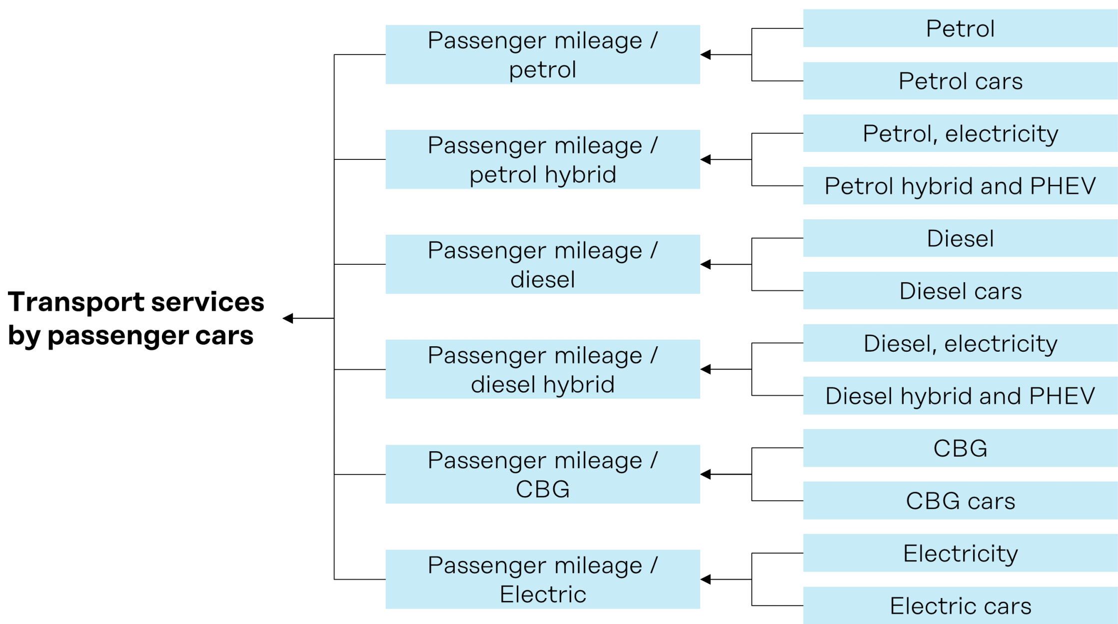
where the superscript prime denotes a derivative; and λ is the Lagrangian multiplier which can be interpreted as the increase in utility that the household would derive from an extra euro of income (a unit increase in Z).

Finally, we assume the households base their intertemporal choices on intertemporal optimisation, with expectations of future incomes affecting the choice between saving and consumption in any given time period.

5.2 Modelling of demand and provision of passenger car services

In the current study, we will consider many policies affecting specific technologies, especially in the transport sector. Data on these technologies stems from Finnish road transport scenarios, and their incorporation into our analyses necessitates some changes to the model. Specifically, while national accounts cover households' demand in detail, the coverage is actually focusing on current purchases of both cars and fuels as much as any consumption goods, and not at all in terms of the transportation services that these vehicles and fuels are generating. Some household goods are modelled as demand for services, however. Here, we follow the example applied in the case of housing, which is treated as a separate industry providing housing services to households and other users using heat, power and fuels as intermediate inputs, and accounting for investment in new housing stock. The analogical treatment of passenger cars is to treat demand for fuels as cars as demand for transport services provided by a passenger–car transport service sector, which uses the fuels as technology-specific intermediate goods, whereas the purchase of new cars is modelled as technology-specific investment by this service sector, as Figure 5 below shows.

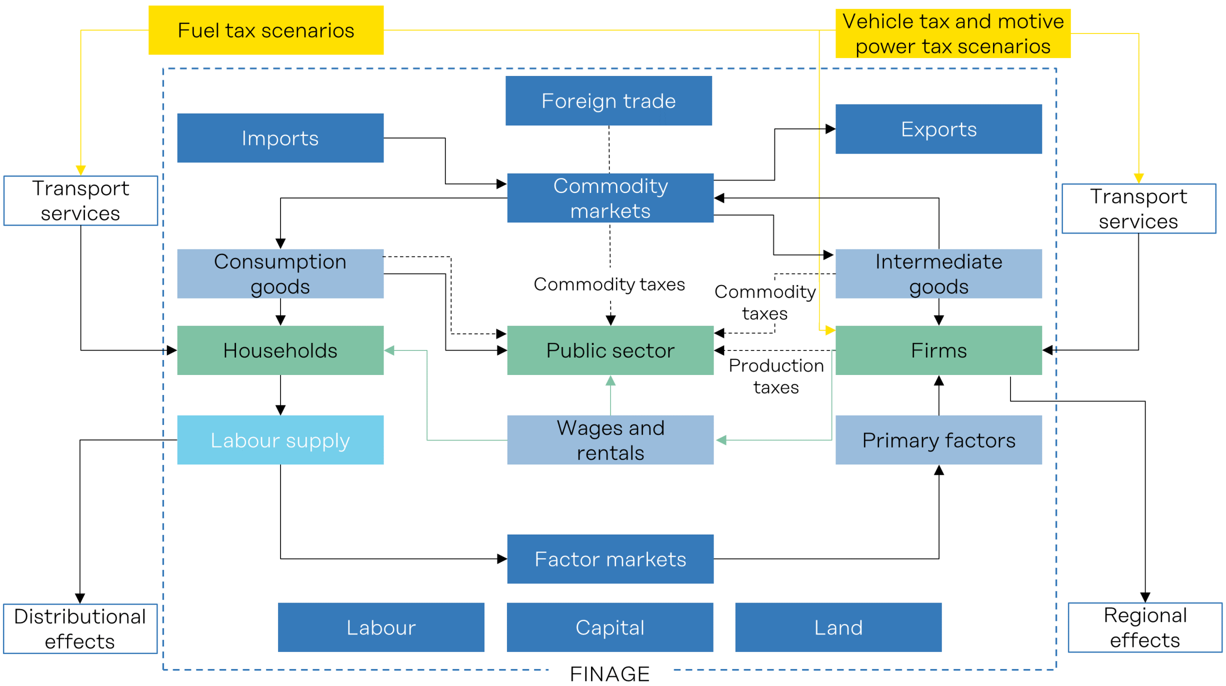
Figure 5: The modelling of passenger car services



The development of the technology-specific passenger stocks is calibrated to match the Ministry of Transport passenger car scenario, which accounts for the development of the car stocks, passenger kilometres and fuel consumption by technology. In this way, our scenarios actually reflect the forecast of demand for passenger mileage and the capital stock and fuels needed for its provision. It would be possible to introduce road tolls to the modelling on the strength of this background, but here we focus on the effects of emission-based purchase taxes on new cars and on the effects of transport fuel taxes on mileage, and also on the investment in new cars – it is notable that our treatment allows for an impact on investment in new cars associated with fuel taxes and taxes on purchases of new cars. This introduces a new element to the Finnish debate on how to promote environmentally friendly cars. However, this type of modelling is already informing policymaking in other countries (such as Dixon's and Rimmer's USAGE Highway in the US, Dixon and Rimmer, 2017).

Finally, we use decile-specific consumption shares from a microsimulation model to provide a top-down estimate of the distributional effects of the reforms. The parameters for the decile-specific consumption functions have been estimated using the large consumption databases of the income-distribution model, and are reported in Honkatukia et al. (2011). The structure of the extended model is depicted in Figure 6.

Figure 6: FINAGE model with road transport extensions



5.3 The baseline scenario to 2030 and modelling of scenario 1 and 2

The baseline scenario conforms to a recent study on industry-level growth (Honkatukia et al., 2018), which reflects the changes in industry structure and demand patterns domestically and abroad of the past two decades. For the immediate future, the baseline follows the autumn 2018 economic forecast of the Ministry of Finance. The baseline imposes the EU 2020 targets for climate policies and as such is close to a WEM scenario for Finland, based on the base scenario in Honkatukia et al. (2018). Since we want to study the effectiveness of alternative policies in helping to achieve larger emission reductions by 2030, we have not imposed all the further measures already included in the Finnish WAM scenario for 2030. EU-wide emission trading is assumed, with Finland being a price taker of exogenous emission permit prices. In the baseline, these are assumed to reach about 30 euros per tonne of CO_2 by 2030, but in the policy scenarios we assume the price to reach 60 euros per tonne by 2030.

Baseline growth is depicted in terms of output growth in Table 4 at the level of major industry clusters. The baseline reflects something akin to export-oriented growth, sustained by the recovery of most export industries from the slump of the early 2010s. The output of most manufacturing industries grows relatively rapidly, helped by a growing employment rate, and trade and other private services are also growing at a brisk pace. Public services, on the other hand, are growing at a considerably slower pace, reflecting our assumption of successful reforms in those sectors. In total, GDP is expected to grow by some 38% by 2030.

Table 4: Baseline output growth by industry.

Industry	**Total output growth from 2018 to 2030, %**
Agriculture and forestry	26
Chemical industries	54
Construction	39
Electronics industry	14
Oil refineries	13
Manufacturing of metals	35
Mining and quarrying	35
Private services	22
Public services	6
Pulp and paper industries	11
Trade	39
Transport services	25
Power, heat and water	16
Other manufacturing	43

The policy scenarios studied here introduce distinct environmental tax packages and consider alternative ways of using the revenue to implement an environmental tax reform. There are three alternatives for the latter.

- Scenario A: no compensation for either consumers or firms (de facto the revenue is used to pay off sovereign debt);
- Scenario B: compensation by lowering taxes on wage income;

- Scenario C: compensation by lowering corporate taxes and employers' indirect labour costs (social security contributions or the like).

To focus on the effects of the taxes, we also assume that nominal grants and transfers to households are unaffected, which in reality they would not be, because even tax-induced changes in consumer price index (CPI) would tend to get passed by CPI-indexed transfers. However, since the CPI is affected in the scenarios, the purchasing power of the transfers may actually increase in our scenarios, as wage inflation especially may fall compared to the baseline.

We model two environmental tax reform scenarios (their components are described in detail in Chapters 3 and 4). Both consist of raising taxes on fossil fuels and other energy carriers to varying degrees, as well as removing exemptions on current energy taxes.

Scenario 1 includes annual 3-cent increases per litre in the CO_2 element of the current transport fuel tax; the removal of tax exemptions on diesel fuel (a de facto lower CO_2 tax compared to petrol) as well as the removal of the yearly motive power tax for non-petrol passenger cars; the removal of exemptions on peat and coal and certain specific uses of transport fuels (such as farming and forestry machinery); the introduction of a price floor for ETS allowances, the removal of the reimbursement of energy taxes on energy-intensive industries in combination with the introduction of lower electricity taxes; and the removal of the purchase tax on low-emission passenger cars (plug-in hybrids, biogas and electric cars).

Scenario 2 includes 6-cent annual increases per litre in the CO_2 element of the current transport fuel tax; the removal of tax exemptions on diesel fuel (a de facto lower CO_2 tax compared to petrol); the removal of exemptions on peat and coal and certain specific uses of transport fuels (such as farming and forestry machinery); and the removal of the purchase tax on low-emission vehicles and an increase in the purchase tax for high-emission vehicles. Scenario 2 also includes the introduction of emission-based consumption taxes on both domestic and imported goods from 2025 on, as well as taxes on air travel and freight.

Together with the three reimbursement options there are thus six scenarios to study. The overall emphasis on the scenarios reflects a focus on more environmentally effective and ambitious use of taxation, achieved in part by removing obstacles to the environmental effectiveness of economic measures already in place, and in part by extending the scope of the measures. Furthermore, while scenario 1 includes elements that compensate for the added cost of more effective environmental taxes on industries, scenario 2 more directly affects consumption.

6 Modelling results, scenarios 1 and 2

Figure 7 below compares the scenarios in terms of effects on GDP by the year 2030, compared to the baseline scenario. The figure depicts the effects of changes in elements of expenditure-side GDP[40] as contributions to GDP growth compared to the baseline scenario. There is a distinct difference between the scenarios associated with the scale of the reforms: in scenario 1 A, the uncompensated increase in commodity tax revenue is about 1.8 billion euros, of which some 400 million stems from taxes on transport fuels. In scenario 2, taxes on transport fuels are raised more, and the extra gain is almost 700 million euros. But the real difference between the scenarios comes from the carbon tax on consumption, which raises some 3.4 billion euros by 2030. Thus, in scenario 2 A, the extra revenue amounts to some 6.2 billion euros. Therefore, while consumption demand falls in both scenarios (i.e. in scenarios 1 A and 2 A), the contribution to a fall in GDP is much more significant in the latter scenario than in the former. The fall in domestic GDP relative to the baseline is about 0.4% in scenario 1 A and 1.4% in scenario 2 A when the new tax income is not recycled back by the lowering other taxes.

Figure 8 also shows that circulating the extra revenue back to the economy makes a big difference. In both scenarios 1 B and 2 B we assume that the extra commodity tax revenue is used to cut marginal taxes on wage incomes. This raises the price of leisure and increases labour supply in both scenarios, which leads to slower wage inflation and thus improved competitiveness of domestic industries. In scenarios 1 C and 2 C, the extra revenue is used to finance a cut in corporate taxes, enhancing investments relative to scenarios 1 A and 2 A, and also increasing the demand for labour as indirect labour costs are cut.

Figure 9 shows the effect on employment, which here matches the effects on labour supply since we assume competitive labour markets. It is apparent that, as long as wages adjust, cutting income taxes has a bigger effect on labour supply and employment than cutting corporate taxes and employers' social security payments. The first option turns into a higher GDP as can be seen from Figure 7.

Figure 10 shows the contributions to 2030 from the income-side of GDP. In the figure, it is clear that circulating the extra revenue has an effect on the results because it encourages employment. This effect is larger when the extra revenue is used to lower taxes on wage income (in the B scenarios) rather than to lower corporate taxes and indirect labour costs (in the C scenarios). Nevertheless, employment and investment are also better off in the C scenarios compared to the A scenarios, where the extra revenues are not recycled back to the economy but used to pay off government debts instead. Thus, the circulation of the environmental tax revenue displays potential to improve the performance of the economy in terms of employment, aggregate consumption and GDP – in other words, double dividends appear plausible.

[40]From expenditure side GDP = consumer demand + investments + government demand + exports - imports.

Figure 7: Contribution of expenditure aggregates on GDP in 2030

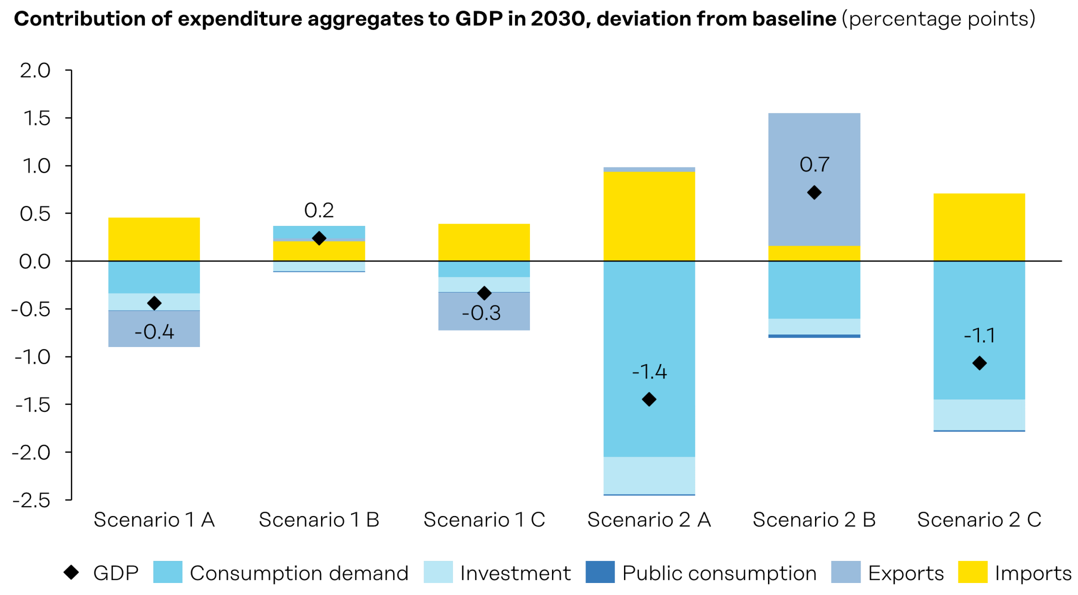


Figure 8: Deviation of GDP from the baseline

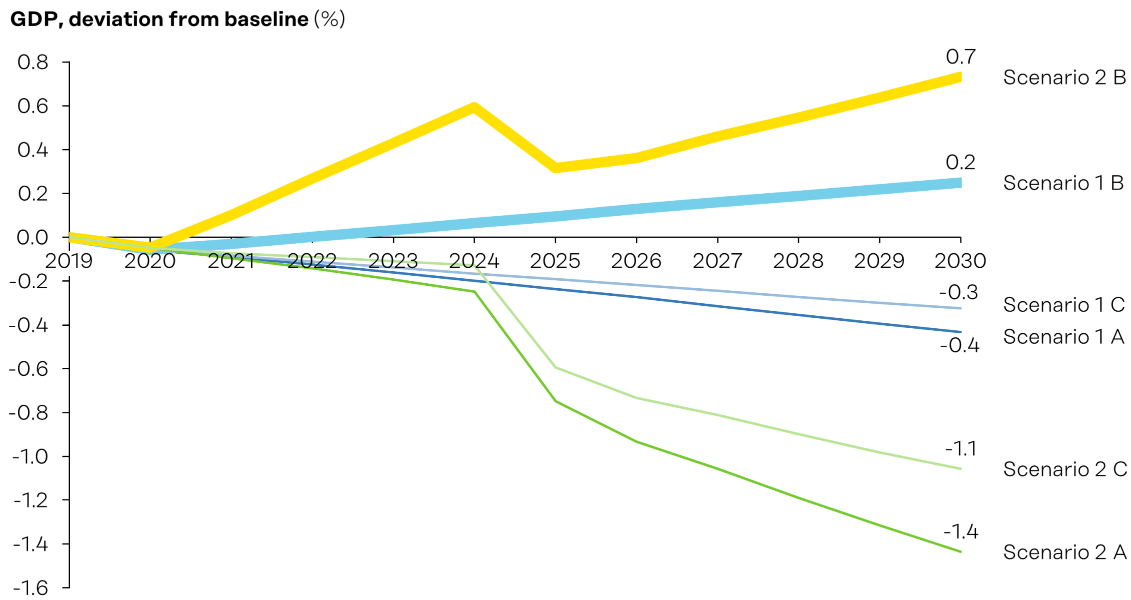


Figure 9: Deviation of employment from the baseline

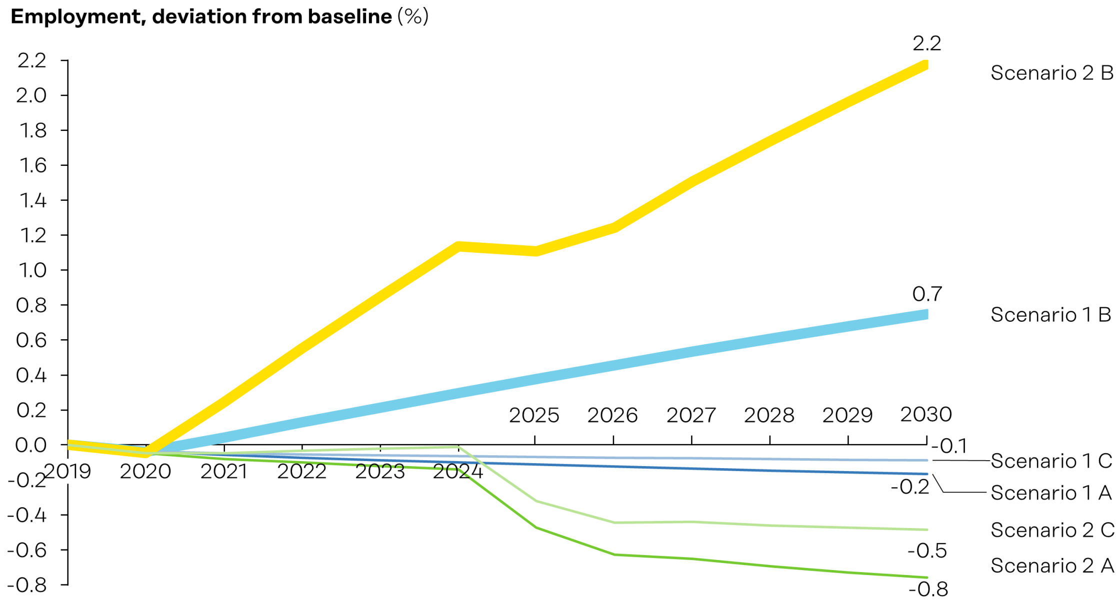
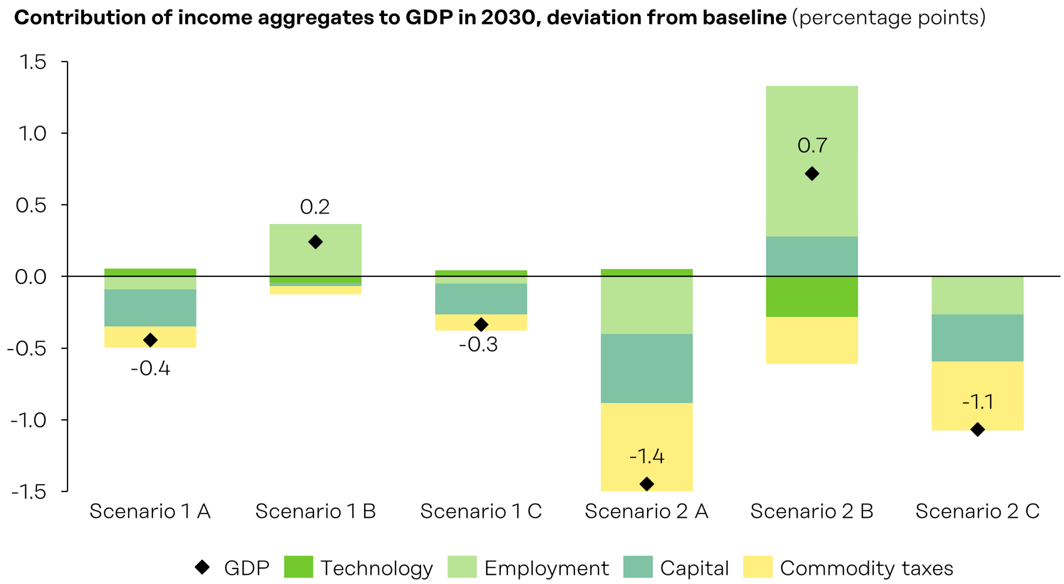


Figure 10: Contribution of income aggregate on GDP in 2030

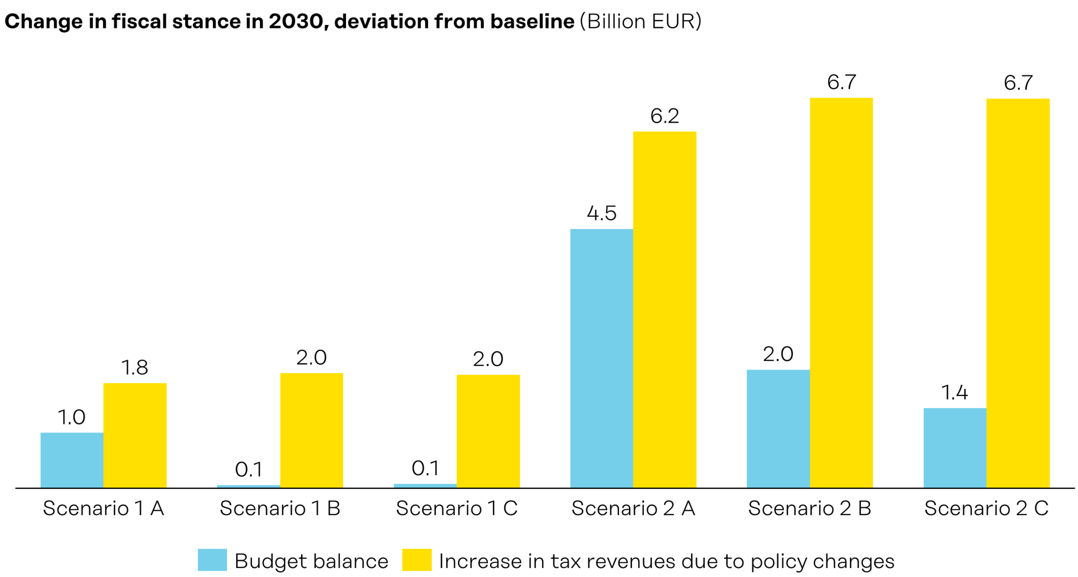


The effects on tax revenue are shown in Figure 11. In scenario 1 A, the uncompensated increase in commodity tax revenue is about 1.8 billion euros, of which some 400 million stem from taxes on transport fuels. In scenarios 1 B and 1 C, this extra revenue is recycled either by lowering marginal taxes on wage income or by cutting corporate taxes and payroll taxes.

We set the recycling target in terms of deviation from baseline revenue, so that for example in scenario 1 B, in marginal income taxes are lowered until they yield 1,8 billion less than in the baseline. In scenario 2 A, taxes on intermediates gain 3.4 billion euros by 2030 (from the consumption-based carbon tax), with transport fuels also raising almost 700 million more than in the baseline. Thus, in scenario 2 A, the extra revenue to be recycled amounts to some 6,2 billion euros. We have chosen to compare the effects of recycling the extra commodity tax revenues collected by with the reform of environmental taxes in scenarios 1 A and 2 A. Budget balance refers to the total tax revenue minus all public spending, including debt payments.

It is clear that recycling affects other tax revenues and also nominal public expenditures (except nominal transfers to households, which we fix to baseline levels). Thus, the effect on overall revenue is not exactly balanced in scenarios 1 and 2 B and C. Scenarios 1 B and 1 C end up increasing the overall budget balance surplus minimally by 2030, whereas scenarios 2 B and 2 C are actually considerably in surplus by 2030, as shown in figure 11. This is due to the effects of the reform not only on wages and commodity prices, but also on the effects on revenues from other taxes, and on the stimulus to the economy from the reform.

Figure 11: Tax revenues compared to baseline, billion euros



The magnitude of the effects on wages is also evident in sectoral results. In Figures 12 and 13 we depict the changes in employment and output by clusters (by clusters we mean aggregated groups of industries) in scenarios 1B and 2B. Figures 22 and 23 in Appendix D include the same results for all scenarios.

The overall result from the scenarios is that employment falls whenever households and firms are not compensated for the rising environmental taxes (scenarios 1 A and 2 A). It also seems that, under competitive labour markets, the effects on employment and output are larger when the revenue is used to lower marginal income tax rates, boosting labour supply (scenarios 1 B and 2 B). The differences are quite large, as many industries benefit from a three to four percentage point increase in employment between these two scenarios. Output benefits relatively less, reflecting both differences in labour share between the industries – relatively more labour-intensive industries benefiting more than those that are less labour-intensive – but also partly because the fall in labour costs tends to increase the labour-intensity of production. It is worth noting that cutting corporate taxes and indirect labour costs (in scenarios 1 C and 2 C) also improves employment and output compared to the no-circulation scenarios, but the effects are smaller than in the marginal tax scenarios.

The effects are much larger in scenarios 2 A to C, both because many taxes are raised more than in scenarios 1 A to C, and because of the introduction of consumption carbon taxes. The latter causes consumption to shift from (especially carbon-intensive) goods towards services, which benefits many service sectors, especially housing. The differences between scenarios 1 and 2 are also evident for energy-intensive industries, where scenarios 1 assume the removal of current energy tax exemptions for energy-intensive industries but compensate for this removal by reducing the general lower electricity tax. Scenario 2 does not include these.

One of the effects an ETR is that it redirects the resources of the economy from energy-intensive to labour-intensive industries. This affects the exports of commodities as well, but as has already been shown, the recycling of the revenues may boost aggregate exports. Figure 14 shows a breakdown of exports by commodity group in scenario 1B and 2B (results for all scenarios are included in Figure 24 in Appendix D). From the figure it is clear that exports of relatively more labour-intensive goods seem to increase whereas commodities with a high fossil-fuel content - mining, oil refining, the chemical industry and manufacturing of metals - are reduced in scenarios 1 A to C; but the recycling of revenues mitigates the effects even for the latter group of commodities and reinforces the shift towards exports of relatively lower fossil-intensive goods. In scenarios 2 A to C, the shift towards less fossil-intensive goods is more marked, and recycling makes an even bigger difference. In scenarios 2 A to C, the carbon tax on consumption causes additional effects that are not present in scenarios 1 A to C by reducing the domestic absorption of things such as agricultural goods, which leaves more domestic production to be exported (although at lower prices).

Figure 12: Employment by cluster compared to the baseline in 2030

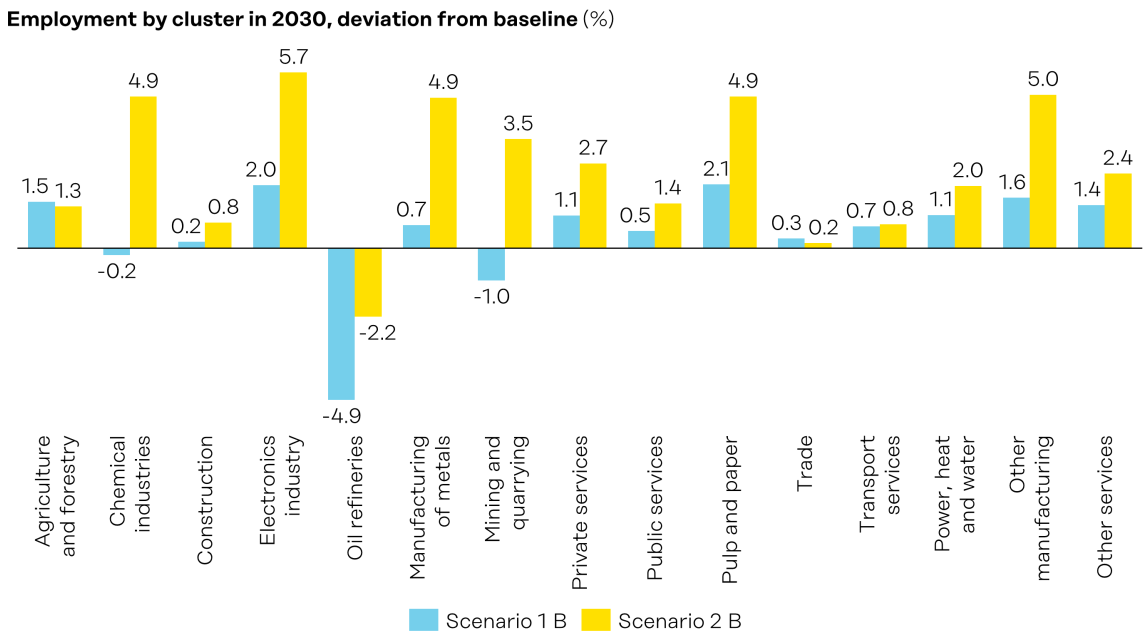


Figure 13: Output by cluster compared to the baseline in 2030

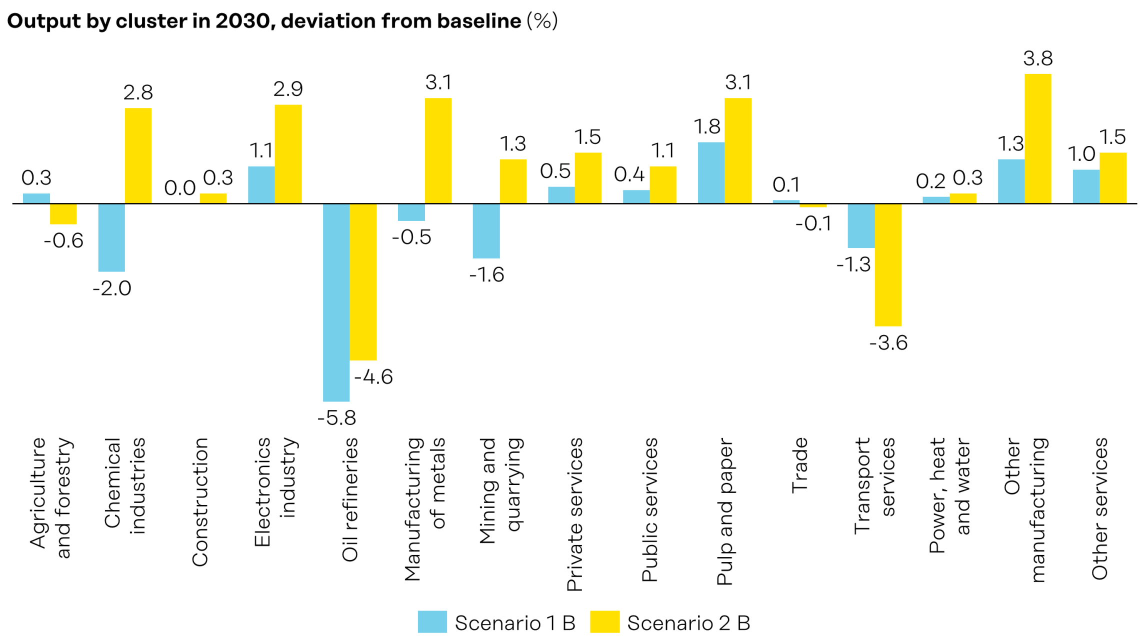
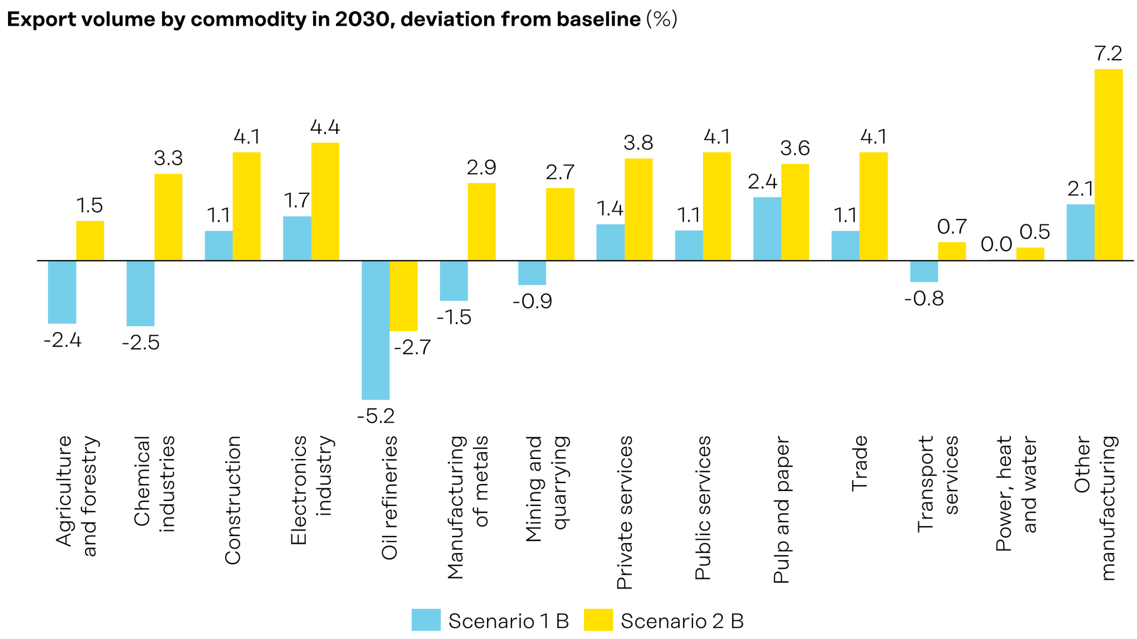


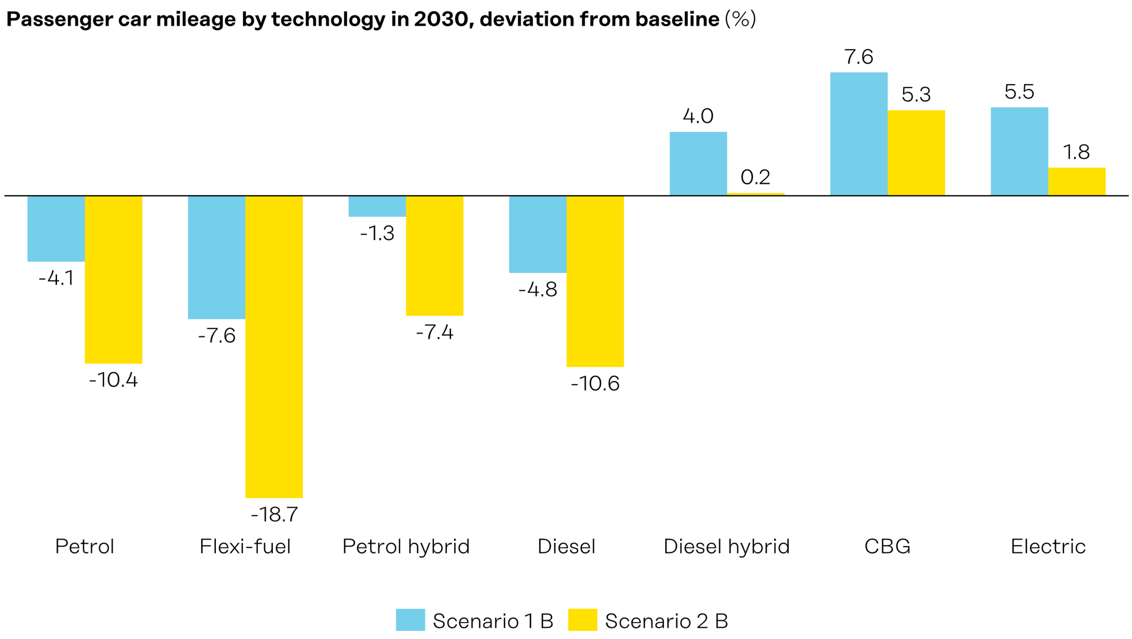
Figure 14: Export volume by commodity



Here, the transport service sector comprises not only the passenger and freight services of the regular transport modes – road, water, air – but also passenger car services. The evidence suggests that even transport services benefit from lower labour costs in scenarios 1 B and 2 B, but the overall effect on these services is still negative. In scenario 1, this is mostly caused by increases in transport fuel taxes, and since these are raised more in scenario 2, the effects are greater. In scenario 2, taxes on air freight and travel are also introduced.

The changes in passenger transport are also partly due to an induced shift towards less emitting vehicles. This is demonstrated in Figure 15, which shows the overall change in passenger car mileage as well as mileage by technology in scenarios 1B and 2B. Results for all scenarios are included in Appendix D, Figure 25. Both main scenarios affect not only the mileage provided by the current passenger car fleet, but also induce a marked shift in investment in new cars towards hybrid and electric cars (with increases in investment/purchases of and away from regular petrol and diesel-driven cars). In scenario 1B, investment in hybrids increases by some 4% compared to the baseline and investment in diesel and petrol falls around 4-5%. In scenario 2B, the investment in petrol and diesel falls by more than a 10% since car taxation to high-emission vehicles is increased, but now also investments to new technologies increase somewhat less than in scenario 1B. The changes are thus quite marked, but because the average age of the Finnish passenger car fleet is around 16 years, it takes time for the fleet to renew itself

Figure 15: Passenger car mileage, deviation from the baseline in 2030



Environmental and energy tax reforms, have often been opposed because there is a widespread belief that they tend to be regressive and hurt the less well-off more than the rich. This is not supported by statistics, which show that households in higher-income deciles tend to consume energy and energy-intensive goods and services relatively (much) more than households in lower-income deciles. This is reflected in simple distributional analyses of our scenarios, where the overall changes in the consumption of all commodities has been allocated to income deciles based on the decile-specific consumption shares. The results of this analysis are presented in Figure 16 for scenarios 1B and 2B (results for all scenarios are presented in Figure 26 in Appendix D). In scenarios 1 A to 1 C, the effects are almost evenly distributed across income deciles - even in scenario 1 B where there is actually an increase in consumption - whereas in scenarios 2 A to C the impact on the lowest deciles is smaller than in most other deciles. Again, this is in line with many studies on consumption patterns.

Figure 17, finally, shows reduction in emissions from fossil fuels compared to the baseline in scenarios 1 B and 2 B. Compared to baseline, emissions are lower because of reduced use of fossil fuels, with increased use of biofuels in the transport sectors accounting for about 40 per cent of the overall reduction.

Our analyses has focused on the effects of economic measures in the economy with less focus on the effects of new technologies in industry and in power generation. The latter have been covered in detail in other recent studies (e.g. PITKO), but as our results show that economic measures offer potential for effective and cost-efficient emission reduction, it is clear the approaches should meet in further research. Therefore, the results presented on the CO_2 effects are also likely to be minimum estimates. In addition to the rough estimation on the power generation and industry CO_2 emissions, for example the potential effects of the consumption-based carbon tax on global emissions is not included in the below estimates. To conclude, the CO_2 impacts of even these scenarios could be estimated further with other models and methods.

Figure 16: Household consumption by income decile, deviation from baseline in 2030

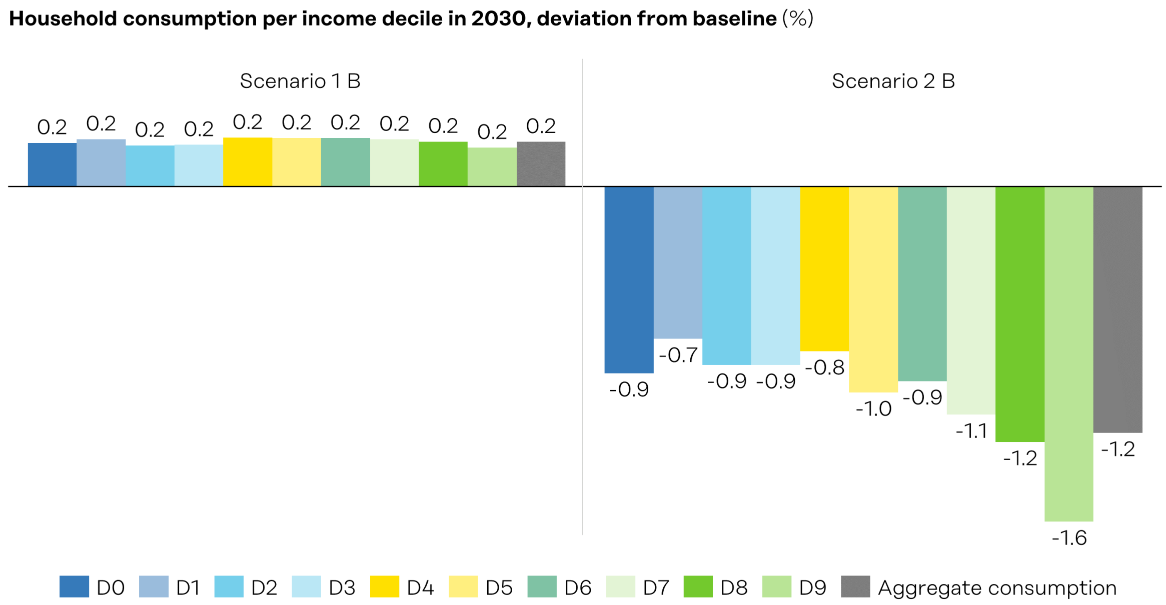
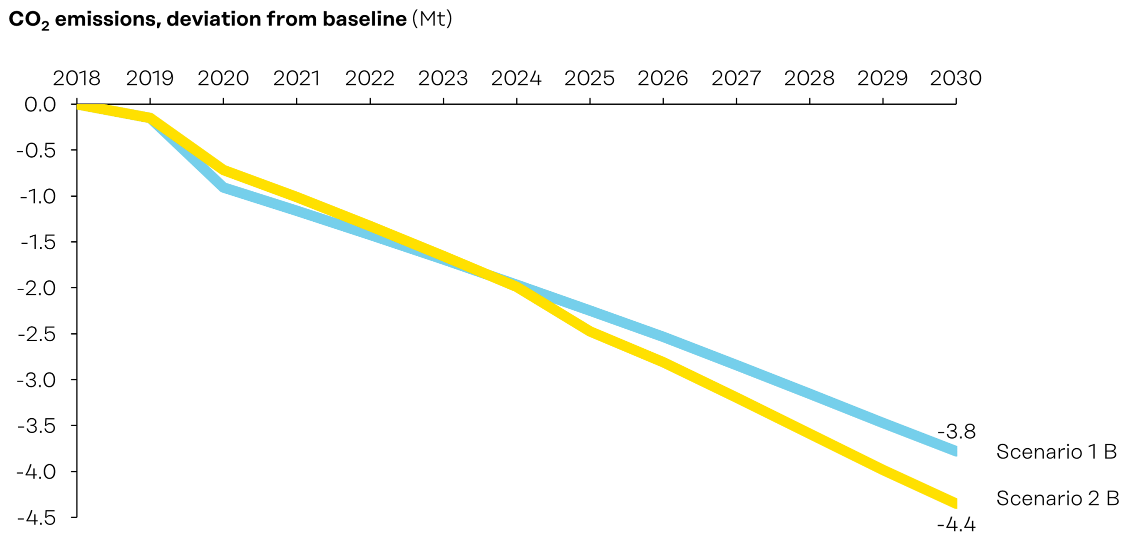


Figure 17: CO_2 reduction, deviation from baseline in 2030



7 Modelling approach and results of scenario 3

Scenario 3 focuses on the promotion of circular economy objectives in addition to climate objectives and is inspired by the Finnish road map to a circular economy 2016-2017. Further information about scenario 3 and the underlying study can be found in GBE et al. (2018). The specific instruments included in scenario 3 are as follows (see Chapter 3 for more details on the instruments).

- Price floor for EU ETS allowances
- Emissions-based flight tax on passengers
- Tax on air freight
- Removal of the tax refund for energy-intensive industry
- Removal of the reduced tax level for peat in energy production
- Removal of the reduced tax rate on diesel
- Removal of the reduced tax rate for light fuel oil
- A tax on fossil raw materials in industry
- New resource taxes (taxes for non-metallic minerals and mining and water abstraction, for example)
- Nuclear waste tax
- Tax on waste incineration
- Tax on pesticides

It is notable that the carbon price floor in scenario 3 also covers the emissions associated with the combustion of biomass. The price floor is equal to 10 euros per tonne of CO_2 emitted from the combustion of biomass and 60 euros per tonne of CO_2 emitted by all other energy sources used across all industries. In scenario 1 the carbon price floor also equals 60 euros per tonne of CO_2, but this excludes biomass.

The revenues are recycled back to the economy using the following mechanisms.

- A decrease in income taxation.
- A decrease in employers' social security payments.
- Income support: 5% of the net increases in government revenues are used to compensate the two lowest income quintiles.

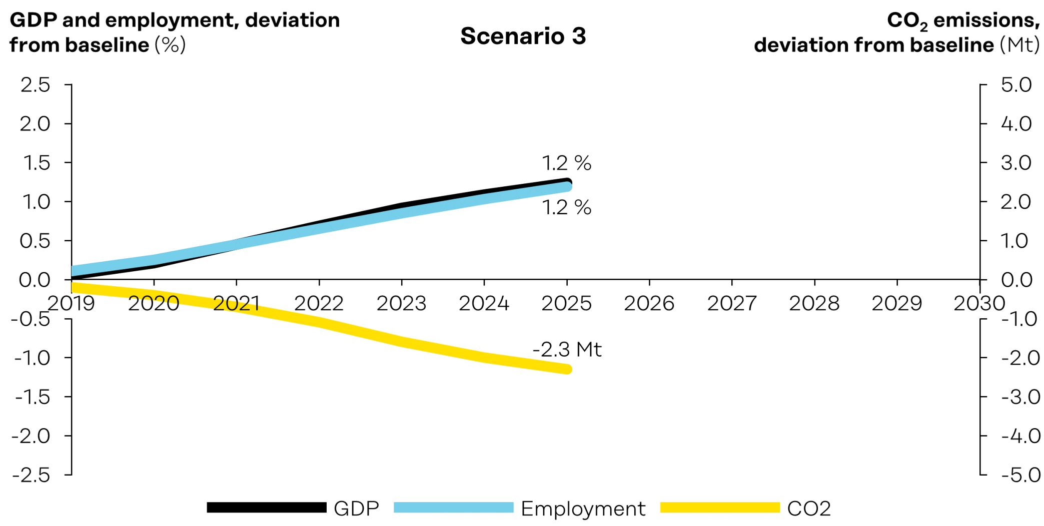
- An increase in R&D and investment support for low-emission technologies.

The tax instruments are introduced gradually so that the additional tax revenues amount to 3.5 billion euros in 2025. Every year the additional tax revenues are recycled back to the economy by lowering labour taxes (personal income tax, social contributions paid by employees and employers and additional income support for the lowest income quintiles) and towards investments in R&D and renewables.

The scenario was modelling using the E3ME macroeconomic model. E3ME is a computer-based model of global economies, used for linkages between the economy, materials, the environment and energy. The model builds on a representation of the national accounting system which incorporates a detailed "input-output" table that outlines the linkages between sectors. E3ME models the energy system in more detail compared to the FINAGE model but is less precise in the modelling of the Finnish economy and public sector. The models also differ with respect to some key assumptions such as the elasticity estimates. Further information about the model and the modelling approach can be found in GBE et al. (2018).

The main results on GDP, employment and emissions are presented in Figure 18 below.

Figure 18: Scenario 3 – impacts on emissions, GDP and total employment



The results suggest that the policy scenario increases GDP and employment by 1.2% in 2025 compared to the baseline scenario. At the same time CO_2 emissions are 6% (approximately 2.3 million tonnes) lower compared to the baseline scenario. In essence, the results suggest an effective decoupling of economic growth from emissions growth. Further results are presented in Table 5 below.

Table 5: Key modelling results in 2025, deviation from the baseline. Source: E3ME, Cambridge Econometrics.

	Deviation from baseline, %	**Deviation from baseline, absolute**
Economic indicators		
GDP	1.2	3.5 billion euros
Employment	1.2	30,600 people in employment
Exports	0.01	
Imports	0.2	
Energy imports	–6.1	
Household expenditure	1.7	
Consumer prices	0.8	
Social indicators		
Change in household income for lowest quintiles	2.0	
Environmental indicators		
CO_2 emissions	–6.0	–2,348,500 tCO_2
Consumption of construction minerals	–0.6	
Non-ferrous ores	–0.8	
Ferrous ores	–0.7	
Final energy consumption	–2.6	23,369,900 toe

In line with the circular economy objectives, material consumption is reduced compared to the business-as-usual scenario. It is likely that the decline in material consumption is driven by, at least to some extent, the introduction of the natural resource taxes. All income quintiles experience an increase in household expenditure, but the relative increase is largest for the poorest quintile (2%) and second largest for the second quintile. The richest quintile experiences the smallest increase (1.4%). Note that even without the specific income support for the lowest two quintiles the results are slightly progressive.

In 2025, the average personal income tax is reduced from the baseline rate of 38.5% to 36.9%. The employers' social contribution rate is reduced from the baseline rate of 20.2% to 20.1%. By lowering personal income tax, households have more disposable income to spend.

The impacts on sectoral outputs are presented in Table 6 below.[41]

[41] E3ME includes 69 industry sectors based on Eurostat classification (see Appendix 2 of GBE et al., 2018).

Table 6: Industry-specific impacts on output. Source: E3ME, Cambridge Econometrics.

Industry	**Output 2025 deviation from baseline, %**	**Output 2025 deviation from baseline, million euros**
Engineering	1.5	978
Other services	1.5	705
Wholesale and retail	1.0	484
Business services	1.0	1,375
Basic manufacturing	0.8	722
Transport and communications	0.8	338
Agriculture	0.4	46
Public services	0.3	203
Construction	0.3	123
Energy and utilities	-1.0	-295

The largest increases in output, both in absolute and relative terms, are in service sectors. These sectors benefit from lower labour costs and are relatively unaffected by the increase in emission and resource taxes. In addition, because of lower income taxes, households have more income to spend. Part of this extra income is spent in the services sector. Only the energy and utilities sector experiences a decline in output compared to the business-as-usual scenario.

8 Conclusions

In this study we have analysed what kinds of tax instruments could be included in the implementation of an environmental tax reform (ETR) in Finland. Based on previous literature on carbon taxes, the most efficient way to increase environmental taxes is to implement an ETR where at the same time other distortionary taxes are lowered. In this report we have in particular paid attention to the opportunities to increase emission, natural resource-use and waste taxes. We identified various different instruments, but naturally many other options could still be feasible as well.

From the pool of different instrument options, we developed two ETR scenarios to specifically view the potential impacts on energy-intensive firms' competitiveness and on income equality. We have modelled the economic impacts of scenarios 1 and 2 with a Finnish general equilibrium model, FINAGE. In addition, we have summarised the findings from GBE et al. (2018) on how to support the circular economy with an ETR in Finland. The economic impacts of scenario 3 were analysed with the global E3ME general equilibrium model.

8.1 The main impacts in the different scenarios

We find that an ETR in Finland could help to reduce the emissions faster than in the baselines with a simultaneous positive impact on total employment and GDP – see Figures 19 to 21. In all of the scenarios, emissions fall by some 2.2 to 2.5 MtCO2 annually in 2025 and by around 3.8 to 4.4 Mt in 2030 in scenarios 1 and 2 (scenario 3 is modelled only until 2025). Such reductions in total emissions would mean around a 10% decrease in 2030 compared to the baseline. At the same time employment increases by some 0.7 to 2.2% compared to the baseline. In practice, such increases in employment would mean tens of thousands of people finding a job. GDP impacts are bit lower than employment impacts in scenarios 1 and 2, but still positive compared to the baseline. As the different scenarios are very different in terms of size of the changes (with scenario 1 shifting only around 2 billion euros by 2030 in tax incomes and scenario 2 around 7 billion) and they are modelled with different models, their direct comparison is difficult. Furthermore, e.g. assumptions on the different elasticities differ between the models. Therefore, the most interesting findings from all of them is the potential to create the double dividend effect of a reduction in emissions but increased employment.

Figure 19: Scenario 1 – impacts on emissions, GDP and total employment

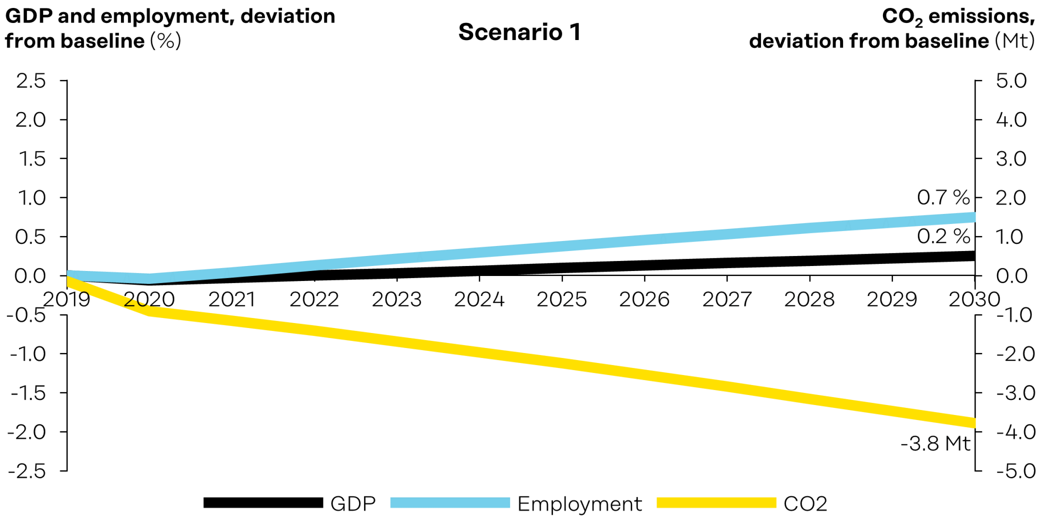


Figure 20: Scenario 2 – impacts on emissions, GDP and total employment

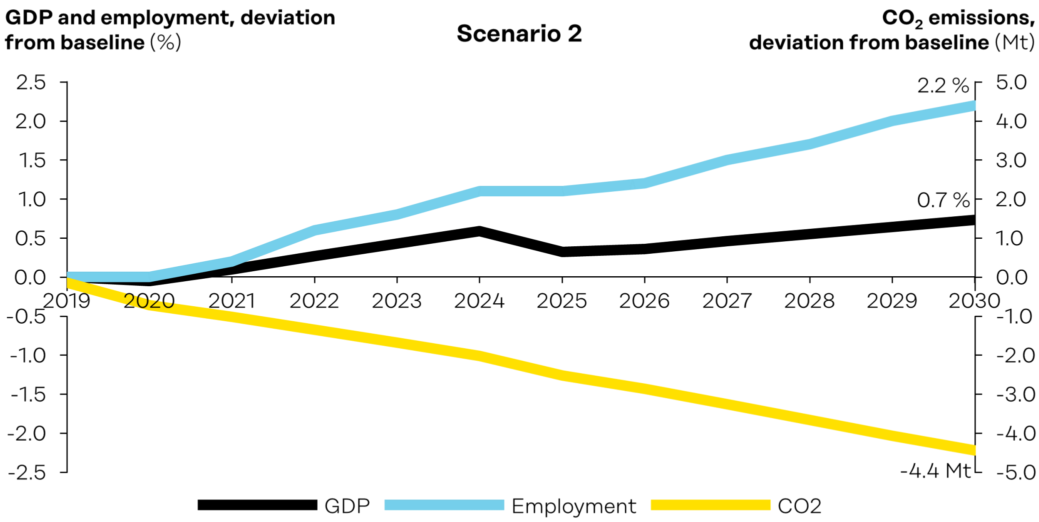
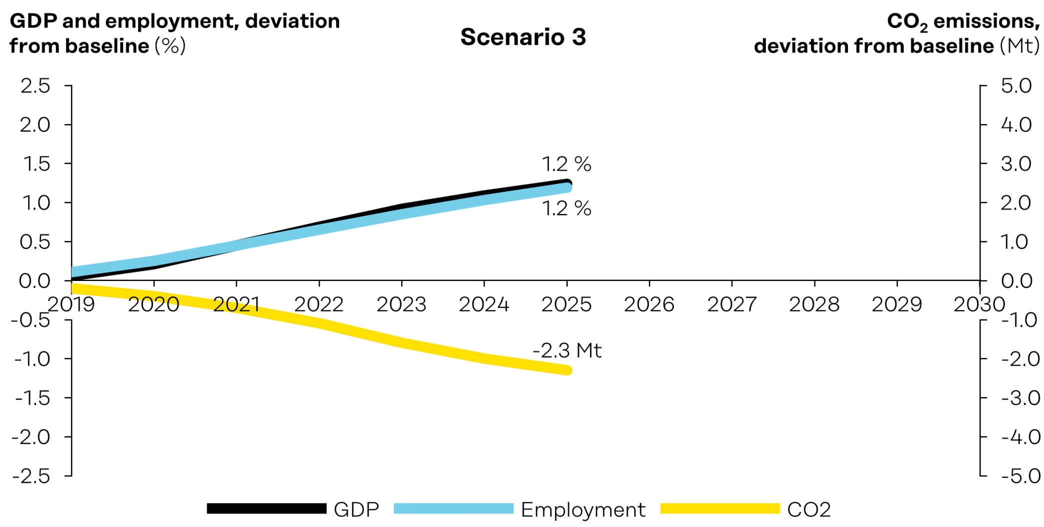


Figure 21: Scenario 3 – impacts on emissions, GDP and total employment



However, based on the analysis of scenarios 1 and 2, the double dividend effect can be achieved only when the new tax revenue from environmental taxes is recycled back to the economy by lowering income taxes. For scenarios 1 and 2 we have considered narrowing the wedge between wage income and the marginal product of labour caused by income taxes and indirect labour costs, as well as the wedge in the price of capital goods and their return. Their relative effectiveness depends on the specifics of the Finnish economy, but also on our focus on longer-term results, whereby it is justifiable to assume that both wages and labour supply adjust. It is clear though that rigidities in price adjustment in any markets would weaken the effectiveness of the compensation policies considered, but even then it would plausibly be possible to achieve gains in employment. In the Finnish case the reduction of corporate taxes and employers' social security taxes would leave the total employment and GDP lower than in the baseline in 2030.

Further, we find that by compensating for the increase in environmental taxes it is possible to alleviate the potential adverse impacts on the economy and sector-level competitiveness. None of the scenarios would lead to an increase in income inequality. They are found to be progressive in nature even before any compensation. In addition, the decrease in income taxation seems effective at compensating for the adverse effects of environmental tax increases in all sectors. In particular, labour-intensive sectors benefit from this. The decrease in the general electricity tax for energy-intensive industries in scenario 1 also compensates very effectively for the other increases in fuel and emission taxes. While in some industries output and employment is left at a lower level than in the baseline, this does not mean that their competitiveness is endangered critically compared to now. These industries merely grow a bit less than they would in the baseline. In scenario 2 all industries, expect for oil manufacturing, grow significantly faster than in the baseline. In scenario 3 only energy and utility production grows less than in the baseline. Total Finnish exports are not affected in scenarios 1 and 3, which affect energy-intensive trade-exposed sectors heavily, and in scenario 2 exports increase significantly by 2030.

8.2 How to go forward?

Before making an actual decision on the implementation of an ETR, it is recommended that detailed evaluations are carried out of whether the selected measures result in targeted reduction in emissions and whether the associated economic and social benefits are acceptable. In practice this implies extensive impact assessments including micro-simulations, regional impact assessments and more detailed energy and emission modelling, among other things. Along with the impact assessment it is also important to continue the public dialogue about which measures best support the rapid transformation to a carbon-neutral Finland.

It is important to note that after the finalisation of the ETR scenario it should not be amended without further assessments. This is because even small adjustments to the scenario may change the expected impacts on the economy. Therefore, careful policy design and planning are vital. A substantial and quick reduction in carbon emissions is only possible by taking advantage of the most efficient instruments. Therefore, we cannot ignore the tax system. The time for the planning of an ETR is now because the implementation of the policy reform should also start fast, meaning during the next Finnish government term from 2019 to 2023.

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A Appendix: Additional tables

Table 7: Potential instruments for raising emission, resource-use and waste taxes.

Potential instruments	**Potential to model impacts with FINAGE**
Energy and emission taxes	
Price floor for ETS allowances (either in Finland alone or as part of a Nordic coalition)	✓
Applying automatic index increases for environmental and energy taxation	✓
Strengthening the emissions dependence of fuel taxes	✓
Strengthening the emissions dependence of vehicle taxes	✓
Road tariffs (in urban areas)	?
A fee per kilometre for heavy transport	?
Connecting electricity tax to market prices to support demand elasticity	✓
Tax on excess heat generated by power plants and industrial sites	?
Creating different levels of property tax according to property energy efficiency	?
Emissions-based flight tax	✓
CO2 excise tax for all products based on life-cycle emissions	✓
Emissions tax on food products (excise tax)	✓
Increasing value added tax VAT on animal-based products	✓
Increasing VAT on food	✓
Applying higher VAT to products and lower VAT to services	✓
Additional tax on air freight	?
Applying emissions-based fairway dues and port fees in shipping	?
Applying emissions-based airport fees	?
Taxation based on personal carbon budget	?
Removal of or decrease in (tax) subsidies	
Tax refund for energy-intensive industry	✓
Reduced tax level for peat in energy production	✓
Reduced tax level for coal in CHP use	✓
Reduced tax rate for diesel	✓
Reduced tax rate for light fuel oil (in machinery)	✓

Continued on next page

Table 7 – *Continued from previous page*

Potential instruments	**Potential to model impacts with FINAGE**
Mileage compensation surpassing actual driving costs	?
Characteristics of deductible business trip expenses favouring private car use	?
Parking benefits at workplaces	?
Fuel tax support for domestic maritime transport	?
Absence of fuel taxes on domestic air travel	?
Energy tax support for domestic agriculture and horticulture	✓
Assistance for transportation	?
Compensation of indirect costs caused by emissions trading	✓
Measures aimed at the promotion of the circular economy	
Expanding the tax on packaging	?
Increasing the waste tax	?
Tax on fossil raw materials used in industry	✓
Fertiliser tax	?
New resource taxes (e.g. taxes for non-metallic minerals and mining)	✓
Tax on disposable products	?
Lowering the VAT on repairs	✓
Nuclear waste tax	?
Tax on waste incineration	?
Water abstraction fee	?
Tax on pesticides	?

Table 8: Potential instruments for decreasing taxes or increasing public spending to support emission cuts.

Potential instruments	**Potential to model impacts with FINAGE**
Income taxation	
Lowering income taxes and decreasing the social security payments paid by employees	✓
Lowering the social security payments paid by employers	✓

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Table 8 – *Continued from previous page*

Potential instruments	**Potential to model impacts with FINAGE**
Income transfers	
Making income taxation more progressive	✓
Fixed transfers for low-income households	✓
Index-linked transfers	✓
Corporation tax	
Lowering the corporation tax	✓
Additional support for low-emission solutions	
Increasing the R&D funding for climate solutions	✓
Funding programme for carbon sequestration pilot projects	?
Lower tax assessment value for company-owned electric cars	?
Removal of the vehicle tax on zero-emission cars	✓
Removal of the motive power tax	✓
Removal of the rail track tax and rail track fees	?
Increasing the support for scraping high-emission cars	?
Support for acquisition and conversion of low-emission vehicles	✓
Support for electric bicycle acquisition	?
Increasing the funding for rail track projects	✓
Increasing the funding for public transport	✓
Increasing funding for projects to support walking and cycling	?
Scaling the airport fees based on emissions	?
Support for the infrastructure for alternative motive powers (especially electric vehicle charging and biogas distribution)	?
Developing tax authority practices to facilitate sharing economy	?
Increasing the tax credit for domestic help for fix ups and energy-related renovations	?
Support for energy renovations in housing associations	?
Expanding the auctioned production support for renewable energy	?
Increasing the support for renewable energy	✓
Net-billing of small-scale renewable energy production	?
Trading of white certificates related to energy efficiency improvements in	

Continued on next page

Table 8 – *Continued from previous page*

Potential instruments	**Potential to model impacts with FINAGE**
industry and commerce	?
Scaling the state subsidy for municipalities based on climate action	?
Allocation of agricultural and silvicultural subsidies for low-emission solutions	?
Increasing support for afforestation of fields and wastelands	✓
Compensation for ecosystem services to increase the carbon storage of fields	?
Support for reconstruction of drained swamps	?
Incentive for forest-owners to increase carbon sinks	✓
Lowering the electricity tax on industry to EU minimum level	✓

B Appendix: Summaries of shocks in modelling packages 1-3

Table 9: Summaries of shocks in modelling packages 1-3.

Tax instrument	**1. "Production taxes", FINAGE model**	**2. "Consumption taxes", FINAGE model**	**3. "Circular economy scenario", E3ME model (see GBE et al., 2018)**
Price floor for EU ETS allowances	Price to 30 eur/tCO_2 in 2020 and to 60 eur/tCO_2 in 2030, linear increase in between 2020 and 2030. The price is applied as a mark-up to the ETS price.	Not included	Price to 10 eur/tCO_2 for biomass by 2025 and to 60 eur/tCO_2 for all other energy resources used across all industries (e.g. coal, peat, fossil fuels and CHP). The price is applied as a mark-up to the ETS price.
Strengthening CO_2 part of fuel taxes	Annual increase of 3 cents/litre for the CO_2 component of motor fuels.	Annual increase of 6 cents/litre for the CO_2 component of motor fuels.	Not included
Emissions-based flight tax on passengers	Not included	A tax on CO_2 of 15 euros per air passenger for non-transit passangers.	A tax on CO_2 of 15 euros per air passenger for non-transit passangers.
Consumption tax based on a product's global GHG emissions	Not included	Annual increases in product- and service type specific excise taxes from the year 2025 onwards. Taxes introduced in Table 2 for year 2025. Table 11 in the Appendix C presents tax levels for year 2030, linear increases in the years between.	Not included
Tax on air freight	Not included	A tax on CO_2 of 20 euros per tonne of air freight.	A tax on CO_2 of 20 euros per tonne of air freight.
Removal of the tax refund for energy-intensive industry	Complete removal of the energy tax refund system.	Not included	Complete removal of the energy tax refund system.
Removal of the reduced tax level for peat in energy production	An increase in CO_2 tax for peat to 53 euros per tCO_2. The reform is phased in gradually over a four-year period.	An increase in CO_2 tax for peat to 53 euros per tCO_2. The reform is phased in gradually over a four-year period.	An increase in CO_2 tax for peat to 60 euros per tCO_2.
Removal of the reduced tax level for coal in CHP plants	Increasing the energy tax for coal in CHP to normal rate over 4 years.	Increasing the energy tax for coal in CHP to normal rate over 4 years.	Not included
Removal of the reduced tax rate on diesel	Energy tax for fossil diesel is increased to 0.01631 euros per MJ (same level as petrol) gradually over 4 years.	Not included	Removal of the reduced energy tax rate on diesel used in transport minus the motive power tax.

Continued on next page

Table 9 – *Continued from previous page*

Tax instrument	1. "Production taxes", FINAGE model	2. "Consumption taxes", FINAGE model	3. "Circular economy scenario", E3ME model (see GBE et al., 2018)
Removal of the reduced tax rate for light fuel oil	Energy tax increased to 0.01631 euros per MJ and he CO_2 tax to 62 euros per tonne of CO_2 gradually over 4 years.	Energy tax increased to 0.01631 euros per MJ and he CO_2 tax to 62 euros per tonne of CO_2 gradually over 4 years.	Removal of the light fuel oil subsidy.
A tax on fossil raw materials in industry	Not included	Not included	A tax of 10 euros per tonnes of oil equivalent (toe) applied to mineral oil and other fossil raw material used in plastics, rubber, painting and other chemical industries.
New resource taxes (e.g. taxes for non-metallic minerals and mining)	Not included	Not included	Introduction of a tax of 2 euros per tonne of metal ores and 0.50 euros per tonne of non-metallic minerals extracted.
Nuclear waste tax	Not included	Not included	A tax on the production of nuclear waste at 4 euros per MWh generated by nuclear power.
Tax on waste incineration	Not included	Not included	Introduction of a 20-euro tax per tonne of incinerated waste
Tax on pesticides	Not included	Not included	A tax of 10 euros per kilogram of active ingredients used and a water abstraction tax of 0.04 euros per cubic metre of water intake for bulk users (excluding seawater).

C Appendix: Consumption based carbon tax - additional tables

Table 10: Carbon content of different product groups in kg of CO_2 per dollar of sales, weighted averages over import countries, 2014.

	Source of products/service		
Industry description	**Non-EU**	**EU**	**FIN**
Crop and animal production, hunting and related service activities	2.5	1.5	1.9
Forestry and logging	0.6	0.3	0.2
Fishing and aquaculture	0.3	0.8	0.9
Mining and quarrying	1.7	0.6	0.6
Manufacture of food products, beverages and tobacco products	1.0	0.7	0.8
Manufacture of textiles, wearing apparel and leather products	1.0	0.4	0.3
Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials	0.9	0.4	0.3
Manufacture of paper and paper products	1.2	0.5	0.7
Printing and reproduction of recorded media	0.8	0.3	0.3
Manufacture of coke and refined petroleum products	1.4	0.9	1.2
Manufacture of chemicals and chemical products	1.0	0.6	0.7
Manufacture of basic pharmaceutical products and pharmaceutical preparations	0.3	0.2	0.1
Manufacture of rubber and plastic products	1.6	0.4	0.4
Manufacture of other non-metallic mineral products	2.6	1.2	0.8
Manufacture of basic metals	3.8	1.0	1.2
Manufacture of fabricated metal products, except machinery and equipment	1.6	0.4	0.4
Manufacture of computer, electronic and optical products	0.9	0.2	0.2
Manufacture of electrical equipment	1.8	0.4	0.4
Manufacture of machinery and equipment n.e.c.	1.1	0.3	0.3
Manufacture of motor vehicles, trailers and semi-trailers	0.6	0.3	0.4
Manufacture of other transport equipment	0.6	0.3	0.4
Manufacture of furniture; other manufacturing	0.9	0.3	0.3
Repair and installation of machinery and equipment	0.3	0.3	0.2

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Table 10 – *Continued from previous page*

Industry description	Source of products/service		
	Non-EU	**EU**	**FIN**
Electricity, gas, steam and air conditioning supply	3.6	2.9	1.8
Water collection, treatment and supply	1.1	0.4	0.3
Sewerage; waste collection, treatment and disposal activities; materials recovery; remediation activities and other waste management services	2.4	0.9	1.0
Construction	0.7	0.3	0.3
Wholesale and retail trade and repair of motor vehicles	0.4	0.2	0.2
Wholesale trade, except of motor vehicles	0.3	0.2	0.2
Retail trade, except of motor vehicles	0.3	0.1	0.2
Land transport and transport via pipelines	0.8	0.5	0.5
Water transport	1.9	1.3	1.2
Air transport	2.1	1.2	1.1
Warehousing and support activities for transportation	0.8	0.3	0.3
Postal and courier activities	2.1	0.2	0.3
Accommodation and food service activities	0.6	0.3	0.3
Publishing activities	0.2	0.2	0.2
Motion picture, video and television programme production, sound recording and music publishing activities; programming and broadcasting activities	0.1	0.1	0.1
Telecommunications	0.2	0.1	0.1
Computer programming, consultancy and related activities;	0.0	0.0	
information service activities	0.2	0.1	0.1
Financial service activities, except insurance and pension funding	0.1	0.1	0.2
Insurance, reinsurance and pension funding	0.2	0.1	0.1
Activities auxiliary to financial services and insurance activities	0.3	0.1	0.2
Real estate activities	0.1	0.1	0.2
Legal and accounting activities; activities of head offices; management consultancy activities	0.8	0.1	0.2
Architectural and engineering activities;	0.0	0.0	0.0
technical testing and analysis	0.3	0.1	0.1
Scientific research and development	0.2	0.1	0.1
Advertising and market research	0.1	0.1	0.2

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Table 10 – *Continued from previous page*

	Source of products/service		
Industry description	**Non-EU**	**EU**	**FIN**
Other professional, scientific and technical activities; veterinary activities	0.2	0.1	0.2
Administrative and support service activities	0.3	0.2	0.2
Public administration and defence; compulsory social security	0.3	0.1	0.2
Education	0.3	0.1	0.1
Human health and social work activities	0.3	0.1	0.1
Other service activities	0.3	0.1	0.2
Activities of households as employers; undifferentiated goods- and services-producing activities of households for own use	1.0	0.1	0.0
Activities of extraterritorial organizations and bodies	0.0	0.0	0.0

Table 11: Carbon taxes based on global emissions, year 2030, carbon price of 60 $/tCO_2$, taxes reported as % over output value.

	Source of products/service		
Industry description	**Non-EU**	**EU**	**FIN**
Crop and animal production, hunting and related service activities	14.6	8.3	10.6
Forestry and logging	3.5	1.7	0.9
Fishing and aquaculture	1.8	4.8	5.2
Mining and quarrying	10.2	3.4	3.2
Manufacture of food products, beverages and tobacco products	5.8	3.6	4.1
Manufacture of textiles, wearing apparel and leather products	5.8	1.6	1.5
Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials	5.5	1.5	1.4
Manufacture of paper and paper products	6.8	1.3	1.7
Printing and reproduction of recorded media	4.5	1.0	1.1
Manufacture of coke and refined petroleum products	–	–	–
Manufacture of chemicals and chemical products	6.0	1.4	2.3
Manufacture of basic pharmaceutical products and pharmaceutical preparations	1.9	0.9	0.5
Manufacture of rubber and plastic products	9.4	1.5	1.9
Manufacture of other non-metallic mineral products	15.4	1.4	1.8

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Table 11 – *Continued from previous page*

Industry description	Source of products/service Non-EU	EU	FIN
Manufacture of basic metals	22.1	2.6	3.6
Manufacture of fabricated metal products, except machinery and equipment	9.5	1.4	1.6
Manufacture of computer, electronic and optical products	5.4	1.1	1.1
Manufacture of electrical equipment	10.4	1.4	1.5
Manufacture of machinery and equipment n.e.c.	6.2	1.2	1.4
Manufacture of motor vehicles, trailers and semi-trailers	3.4	1.3	1.5
Manufacture of other transport equipment	3.3	1.2	1.5
Manufacture of furniture; other manufacturing	5.4	1.3	1.4
Repair and installation of machinery and equipment	1.9	1.1	1.0
Electricity, gas, steam and air conditioning supply	21.1	1.4	1.9
Water collection, treatment and supply	6.7	1.4	0.9
Sewerage; waste collection, treatment and disposal activities; materials recovery; remediation activities and other waste management services	14.4	5.3	6.0
Construction	3.7	1.2	1.4
Wholesale and retail trade and repair of motor vehicles	2.1	0.7	0.7
Wholesale trade, except of motor vehicles	1.6	0.7	0.9
Retail trade, except of motor vehicles	1.5	0.6	0.8
Land transport and transport via pipelines	4.8	2.7	3.1
Water transport	11.5	7.3	7.7
Air transport	–	–	–
Warehousing and support activities for transportation	4.6	1.3	1.3
Postal and courier activities	12.5	1.0	1.3
Accommodation and food service activities	3.8	1.1	1.4
Publishing activities	1.1	1.0	0.8
Motion picture, video and television programme production, sound recording and music publishing activities; programming and broadcasting activities	0.6	0.5	0.6
Telecommunications	1.0	0.6	0.5
Computer programming, consultancy and related activities; information service activities	1.1	0.4	0.6

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Table 11 – *Continued from previous page*

Industry description	Source of products/service Non-EU	EU	FIN
Financial service activities, except insurance and pension funding	0.4	0.4	0.8
Insurance, reinsurance and pension funding	1.1	0.4	0.5
Activities auxiliary to financial services and insurance activities	2.1	0.4	0.8
Real estate activities	0.5	0.4	0.6
Legal and accounting activities; activities of head offices; management consultancy activities	4.5	0.5	0.7
Architectural and engineering activities; technical testing and analysis	1.6	0.5	0.7
Scientific research and development	1.1	0.4	0.4
Advertising and market research	0.8	0.5	0.8
Other professional, scientific and technical activities; veterinary activities	1.3	0.6	0.8
Administrative and support service activities	1.5	0.7	1.1
Public administration and defence; compulsory social security	1.7	0.5	0.8
Education	1.5	0.3	0.4
Human health and social work activities	1.8	0.4	0.5
Other service activities	1.9	0.6	0.8
Activities of households as employers; undifferentiated goods- and services-producing activities of households for own use	5.7	0.8	0.2
Activities of extraterritorial organizations and bodies	0.0	0.0	0.0

D Appendix: Additional figures on modelling results of scenarios 1 and 2

Figure 22: Employment by cluster compared to the baseline in 2030, all scenarios

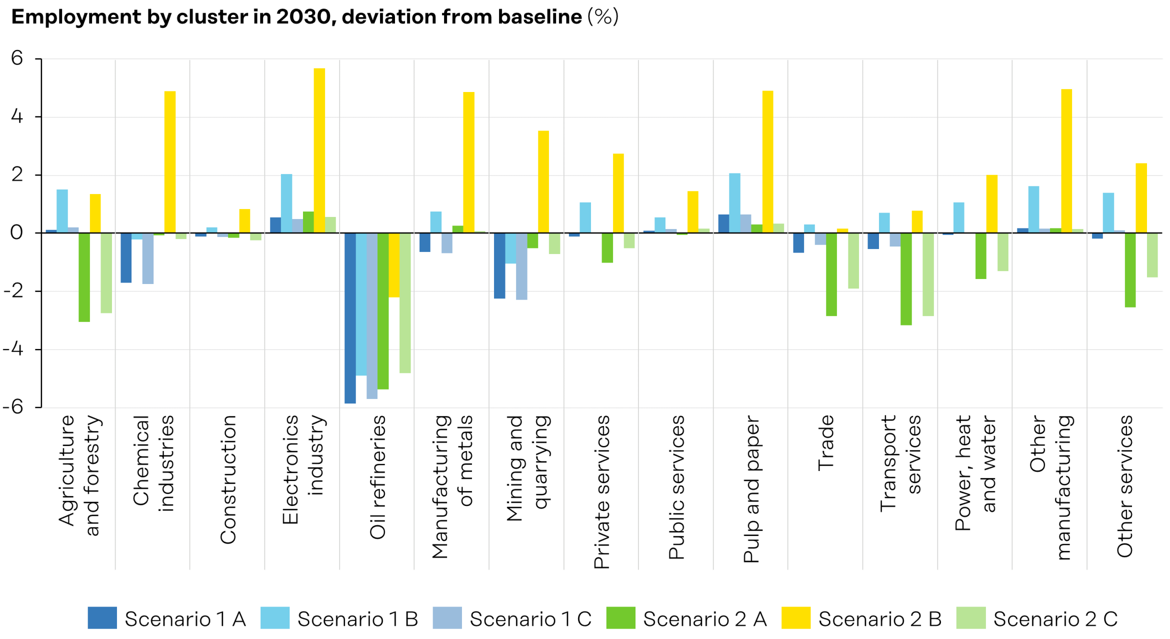

Figure 23: Output by cluster compared to the baseline in 2030, all scenarios

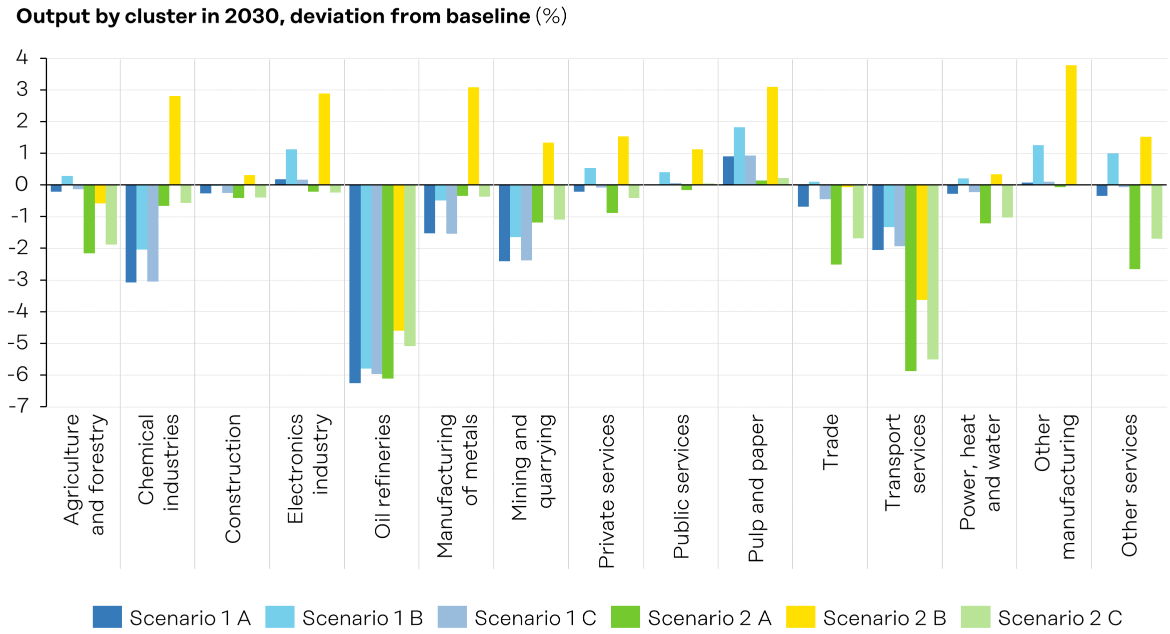

Figure 24: Export volume by commodity, all scenarios

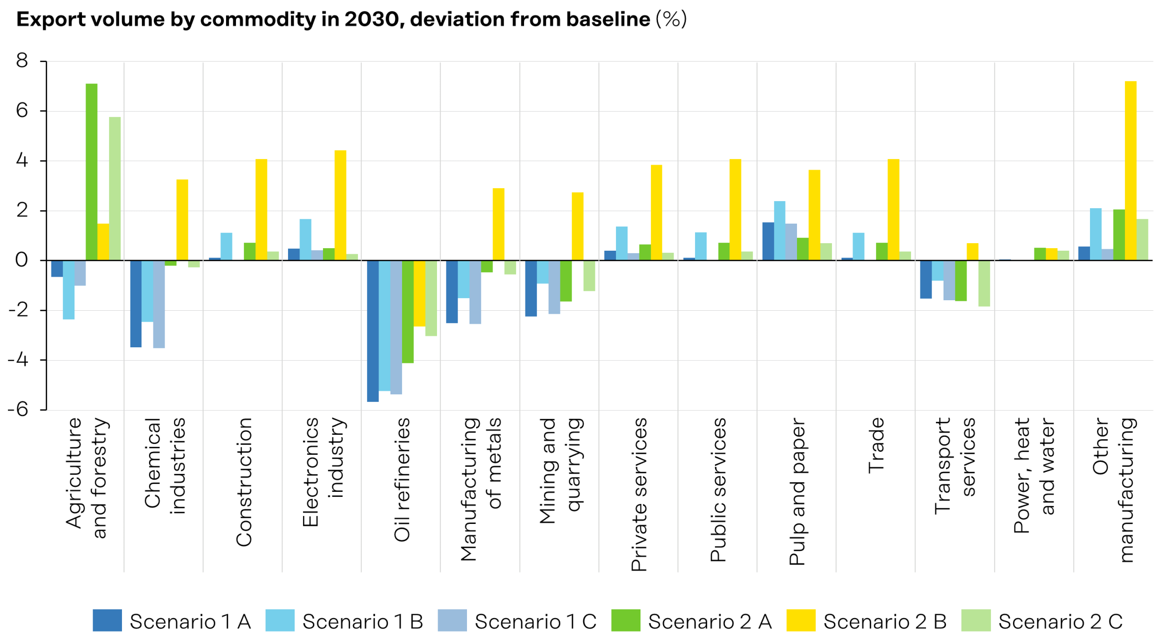

Figure 25: Passenger car mileage, deviation from the baseline in 2030, all scenarios

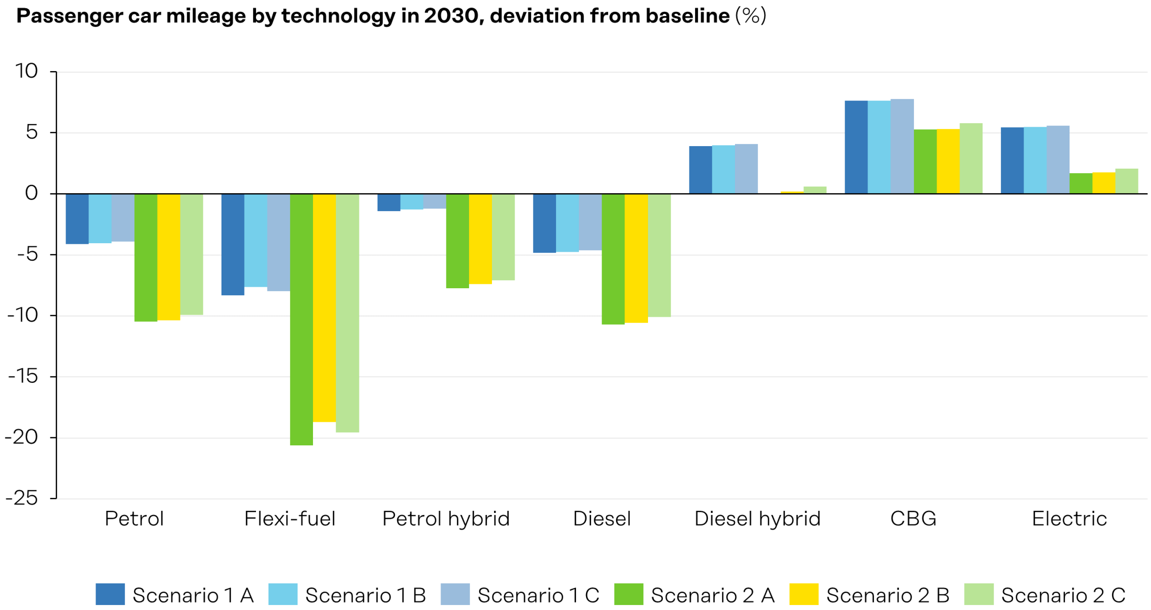

Figure 26: Household consumption by income decile, deviation from baseline in 2030, all scenarios