MEMORANDUM

Saara Tamminen, Outi Haanperä
and Tuuli Hietaniemi

HARNESSING ECONOMIC INSTRUMENTS TO TACKLE THE CLIMATE CRISIS

Finland's experiences with economic instruments applied in climate policy

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1 Introduction

Finland was the first country in the world to adopt a carbon tax in 1990 and since then has used a variety of different types of economic instruments to control GHG emissions and to protect the environment. This brief report summarises the main national economic instruments used in Finland that aim to control GHG emissions (i.e. economic climate policy instruments) and what we know of their (potential) impacts on emissions, fiscal balances and innovations. The list of instruments is not comprehensive but includes the most important national instruments. In addition, some 50% of Finnish GHG emissions are included in the European Union's Emissions Trading System (EU ETS).

The list of national, economic climate policy instruments can be divided into two main parts: 1) tax instruments; and 2) subsidy programmes and other instruments. Tax instruments are primarily managed by the Ministry of Finance, while the numerous subsidy programmes and other instruments fall under the jurisdiction of different ministries.[1] In addition to the economic instruments, various regulations and voluntary programmes are used to cut emissions and improve energy efficiency. These are outside the scope of this report.

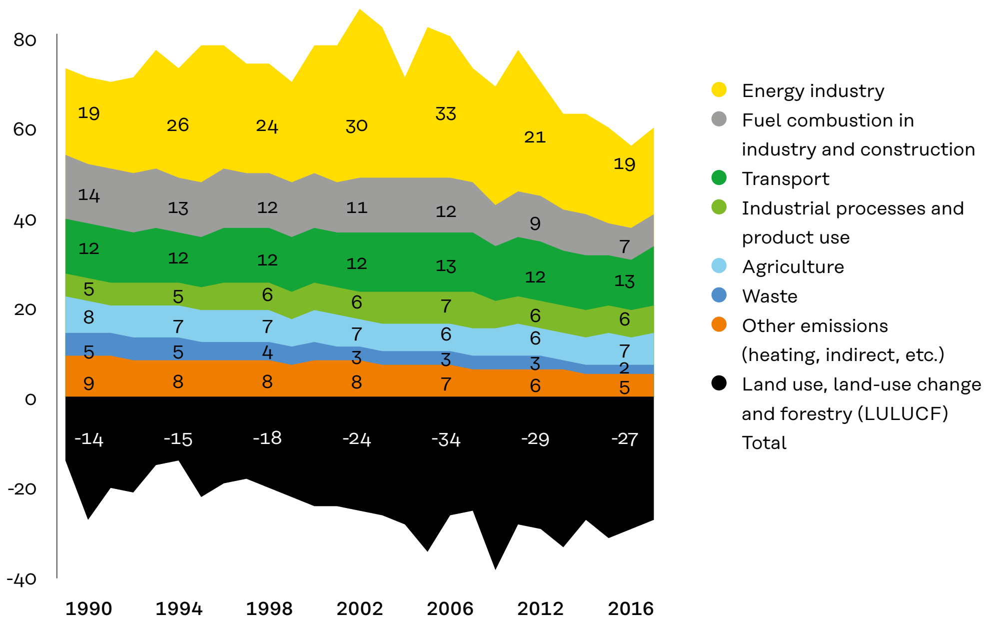
In general, Finnish GHG emissions have fallen over recent years. Since 1990, Finnish emissions have reduced by one fifth (21%). Finland's greenhouse gas emissions in 2017 are estimated to total 56.1 million tonnes CO_2e, excluding land use, land-use change and forestry (LULUCF). The energy sector (including the energy industry, fuel combustion in manufacturing industries and construction, transport, and heating in Figure 1) is the largest producer of greenhouse gas emissions in Finland, accounting for approximately three quarters (74%) of Finnish emissions in 2016. Consequently, the sector is also responsible for the largest share of emissions reductions since 1990. Overall, the energy sector's emissions fell by 22% (12Mt CO_2e) between 1990 and 2017. The main reasons for the decrease in energy sector emissions are the increased shares of forest-based fuels, decreased use of oil in space heating and more recently the net imports of electricity, which lower the condensing power production (Statistics Finland, 2018a, p. 63; see Figure 1). More moderate reductions have been achieved for instance in agriculture, which accounts for 12% of Finnish emissions. Emissions from the agriculture sector reduced particularly in the early 1990s as the use of fertilisers decreased. In waste management emissions are less than half compared to 1990 as a result of increased energy usage of waste instead of landfill dumping. Yet, in the transport sector and in industrial processes and product use emissions relative to the 1990 level have been

1. Primarily under the Ministry of Economic Affairs and Employment, the Ministry of Agriculture and Forestry, and the Ministry of Environment.

relatively stable or increasing. However, compared to the historic predicted baselines of increasing emission trends without any actions (see Figure 2), the reductions are significantly larger. For example, better fuel efficiency in transport has offset the emissions increase that would have resulted from rising vehicle-kilometrage (Prime Minister's Office, 2000; and Statistics Finland, 2018a).

In addition to the national economic climate policy instruments targeting emission cuts, Finland has participated in the EU Emissions Trading System since 2005. It limits emissions from nearly 11,000 power and manufacturing plants as well as from European (within the European Economic Area, EEA) flights. 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 giving a weak incentive to reduce emissions. The Market Stability Reserve, which will start in 2019, is being established to address the surplus of allowances. The price of the emission allowance has increased significantly this year, from approximately 8 euros in January to 21 euros in August. It is estimated that the emissions from the ETS installations decreased by 14.5% between 2010 and 2017[2] 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 as a result of the EU ETS has been between 3% and 28% depending on the country and sector.

FIGURE 1: FINNISH GHG EMISSIONS (IN CO_2 EQUIVALENTS), 1990–2016



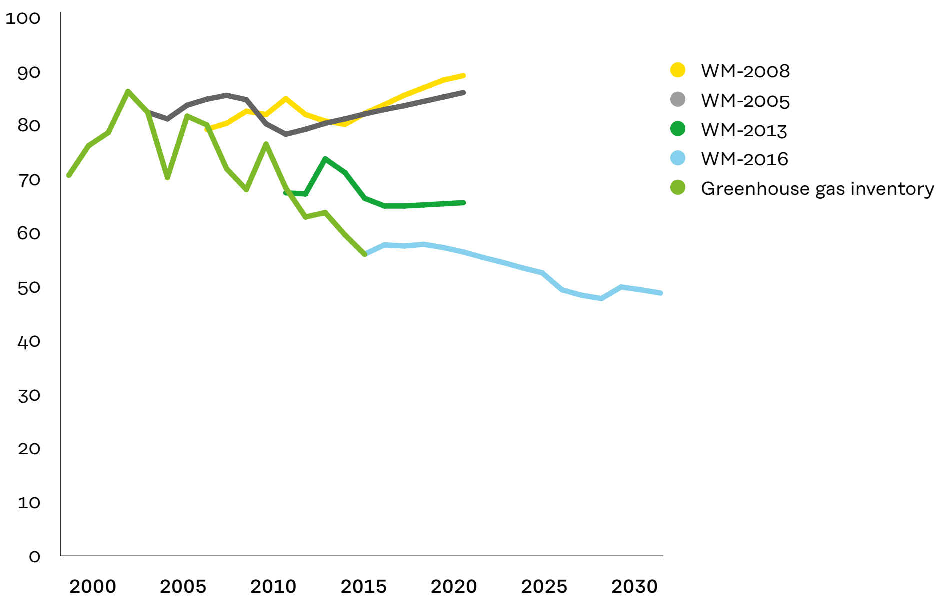
Source: Statistics Finland

2. www.eea.europa.eu/data-and-maps/dashboards/emissions-trading-viewer-1.

In Finland, the emissions in the EU ETS sectors decreased by 24% between 2005 and 2017.[3] However, the role of the EU ETS in reducing the emissions is uncertain. In particular, the feed-in-tariff scheme has also affected the ETS sectors' emissions (see section 3).

In this report we summarise the current findings of how effective the different Finnish economic climate policy instruments have been in 1) stimulating innovations and investments in new technology and 2) creating CO_2 emission reductions, as well as looking at 3) what their fiscal impact and possible other economic impacts were. Section 2 reviews the various national, environmental tax instruments, and section 3 the Finnish subsidy systems for renewable energy and energy efficiency and blending requirement for biofuels. Section 4 concludes the discussion on the national instruments and section 5 provides a more general discussion on the main lessons learned.

FIGURE 2: HISTORIC ESTIMATIONS OF FINNISH GHG EMISSION TRENDS WITH THE POLICY MEASURES (WITH MEASURES, WM) IN FORCE AT DIFFERENT YEARS



Source: Statistics Finland

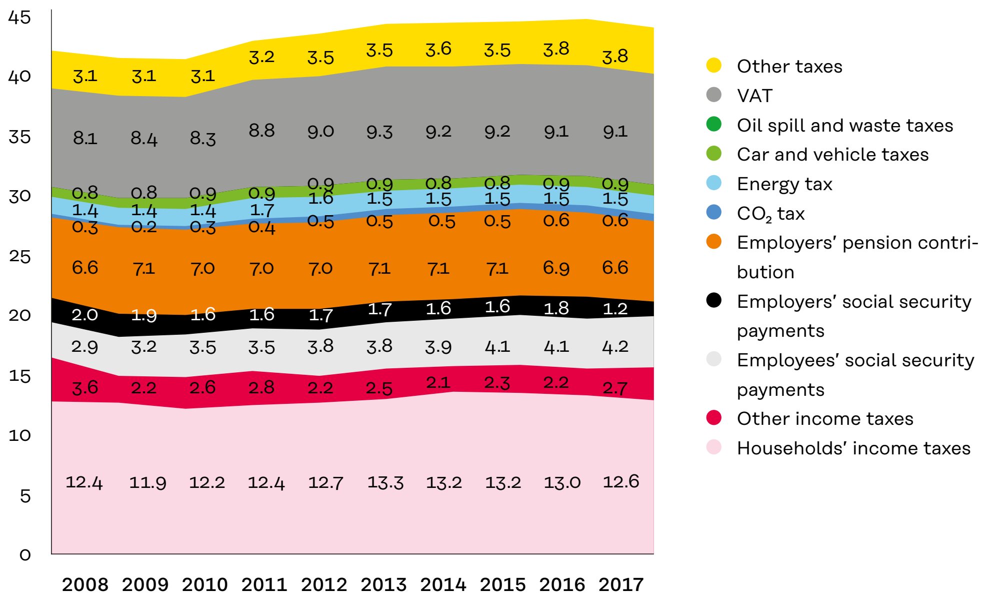
3. www.energiavirasto.fi/paastotiedot.

2 Tax instruments

In Finland the total excise taxes on different primary energy sources have increased gradually over time (see the Appendix) and some researchers have concluded that Finland has started a movement towards an Environmental Tax Reform. Yet, environmentally related total tax income is still limited in comparison to various other tax sources.

Figure 3 presents the tax income by source relative to GDP from 2008 to 2017. The CO_2-based taxes in motor fuels increased from around 0.3% to 0.6% relative to GDP from 2008 to 2017 and at the same time employer's social security payments decreased from 2% to 1.2% relative to GDP. Yet, in total, nearly 70% of the total tax income originated from income, capital and social security-related taxes, while environmental taxes accounted for 6.2% of the total in 2008 and 7.1% in 2017 (or around 3% of GDP). Out of the environmental taxes, energy (content) taxes accounted for the largest share followed by the car and vehicle taxes and CO_2 tax on motor fuels. Oil spill and waste payments were rather minimal in comparison to these; see Table 1.

FIGURE 3: FINNISH TAX INCOME BY SOURCE COMPARED TO GDP, %



Source: Statistics Finland

TABLE 1: ENVIRONMENT-RELATED TAXES AND PAYMENTS, TAX INCOME, IN MILLIONS OF EUROS, CURRENT PRICES

Year	CO_2 and energy taxes	Waste, water and oil protection payment	Car and vehicle taxes	Natural resource usage taxes	Environmental taxes total
2008	3,220	80	1,445	23	4,768
2009	3,101	69	1,336	23	4,529
2010	3,220	79	1,622	23	4,944
2011	3,921	108	1,838	24	5,891
2012	4,009	99	1,765	24	5,897
2013	3,975	102	1,840	23	5,940
2014	3,955	86	1,836	23	5,899
2015	4,120	75	1,849	23	6,066

Source: Statistics Finland

CO_2-based tax on motor fuels and energy tax

Finland was the first country to introduce a CO_2-based tax in 1990, which started at around 1 euro per tCO_2, but varied significantly by fuel type. Until 1997 the energy taxation covered almost all primary energy forms, but in 1997 the system was changed to consumption-based taxation on electricity. This was due to concerns over the competitiveness of the Finnish electricity producers in the new common Nordic electricity market (Hiltunen, 2004). Currently Finland has a CO_2 emission-based tax component for motor fuels as part of their excise taxation and an energy content-based tax on fuels and electricity consumption. The current CO_2 tax is 62 euros per tCO_2[4] and the tax varies according to the estimated CO_2 emissions of the different motor fuel types.

Energy tax is also imposed on electricity unlike the CO_2 tax and it is the same regardless of the primary energy form used in electricity generation. Energy-intensive industries pay a lower electricity tax than consumers and service industries. The energy tax on electricity and energy content tax on motor fuels are based on the volumetric energy content.

Table 4.12 in Statistics Finland, 2018, (see the Appendix to this report) provides a view on the historic and current CO_2 tax and energy tax levels for different energy forms. As early as between 1990 and 2003 the relative levels of CO_2 taxes and energy taxes increased almost twentyfold for motor fuels and sevenfold for electricity (Vehmas, 2005). After that the relative growth rates have been lower, but the absolute changes in tax levels higher. In 2015

4. There are a few exceptions.

the Finnish energy tax levels for different energy products (in euro/quantity) were higher than the EU28 average for all other products except for gas oil in commercial use and in heating (European Commission, 2016, p. 271).

While all electricity users in Finland pay energy taxes, industrial use of fuels as an intermediate input in production, for example, is exempted from all energy taxes.[5] As Finland has participated in the EU ETS since 2005, fuel taxes for heating fuels also constitute partially overlapping regulation.[6] Unless the reforms to the EU ETS increase the auction's allowance price on CO_2 significantly and the free allocation of emission rights drops substantially,[7] the CO_2 emissions of Finnish firms would be better controlled by the EU ETS. In that case the national energy taxation would serve mainly a fiscal and energy efficiency-improving role. However, historically the auction prices in ETS have been relatively low (around 5–10 EUR/tCO_2). This needs to be also taken into consideration while analysing the historic effects of Finnish energy taxes.

For energy-intensive industry, Finland has provided a repayment system on energy-related excise taxes at least since 1992. From 1992 to 2010 is was relatively limited (covering around 10–15 firms) due to the restrictive requirements. In 2012 the system was extended, and the number of firms entitled to repayments increased to over 140. 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 (Prime Minister's Office, 2000; and Harju et al, 2016). Through the system, the largest energy users have had almost 80% of their energy taxes repaid, while for smaller firms/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).

The potential effectiveness of fuel and energy taxes in reducing CO_2 emissions depends also on the exact way they are levied. In Finland they are excise taxes set annually to fixed cents/quantity rates. There is no automatic inflation correction on the tax levels. Therefore, the tax rates have been frequently reviewed. This has hindered the potential of the economic agents to forecast the future levels of energy taxes. In general, the main effects of taxes come through their impact on prices, which then affect consumption

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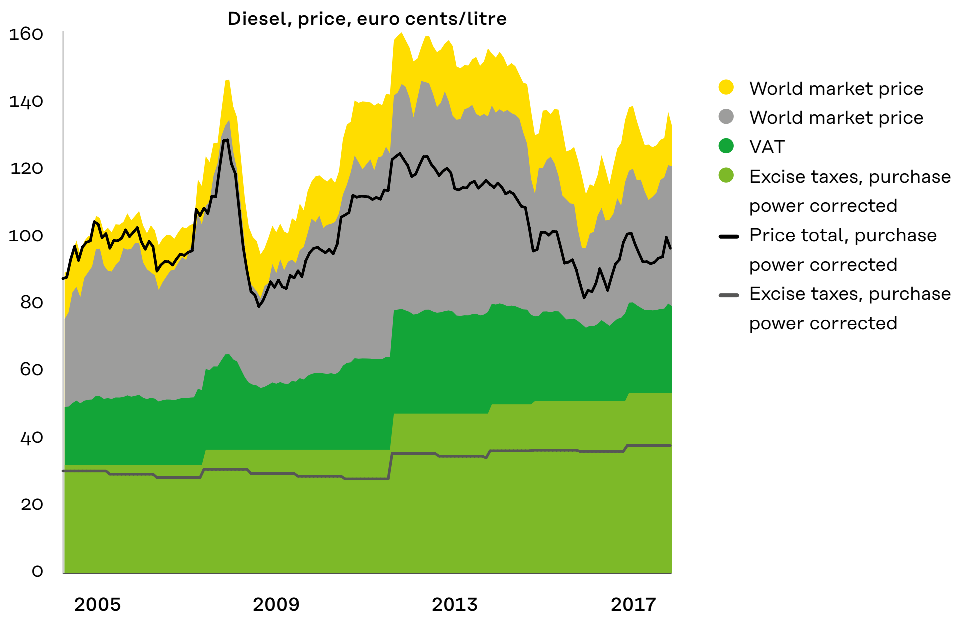
5. Those fuels exempt from tax and strategic stockpile fees are: fuels contained in the reserve stock of the state; fuels used as an energy source in an oil refining process; fuels used as raw materials or that are auxiliary to industrial production, or in direct first use in the production of goods; fuels used in maritime vessel traffic other than private leisure boating; fuels used to generate electricity; and fuels used in aviation other than private leisure flights (www.vero.fi/en/detailed-guidance/guidance/56206/energy_taxation/).
6. Electricity generation is under the EU Emissions Trading System, and electricity generation does not pay any energy or carbon tax on their fuel use. In combined heat and power (CHP) production energy and carbon taxes are paid only on fuels used in heat production. Carbon tax on fuels used in CHP plants (heat production) is only 50% of the normal rate.
7. The auction price of the EU ETS has been relatively low historically and in Finland most of the largest emitters have obtained their emission allowances for free due to competitiveness concerns. In addition, the Finnish Government decided in 2017 on a compensation system for energy-intensive firms based on the possible indirect cost increases in electricity price caused by the EU ETS. All these measures have decreased the effectiveness of energy taxes in reducing energy use and emission: https://vatt.fi/documents/2956369/3204078/115_07_01_2016_lausunto.pdf .

according to price demand elasticities. With regard to the taxed energy products this means that the potential effectiveness of taxes will also depend on the global market prices and their fluctuations, while there is some evidence that consumers react stronger to petrol tax increases than to the general petrol price increases (see the section on the CO_2 effects of these taxes in p. 9).

Figure 4 shows that the Finnish fuel excise taxes and VAT (24% for fuels) have accounted for some 60 to 70% of the final diesel price (a similar picture could be drawn for petrol). However, for example, while in 2012 excise tax on diesel increased, in the following years the world market price of crude oil decreased substantially. The increase in the tax was low in comparison to the world market price decrease and subsequent fossil diesel production price. Therefore, the final price changes have still mostly reflected world market price changes with a counter-cyclical balancing from the fixed cents/litre excise taxes. In addition, in real terms excise taxes and the price of diesel have increased minimally in the long run. See the black lines in Figure 4, which represent the total price of diesel (straight line) and total excise taxes on diesel (dotted line) with constant 2005 purchasing power.[8]

FIGURE 4: DIESEL PRICE (CURRENT, EURO CENTS/L) IN FINLAND DIVIDED ACCORDING TO ITS COMPONENTS

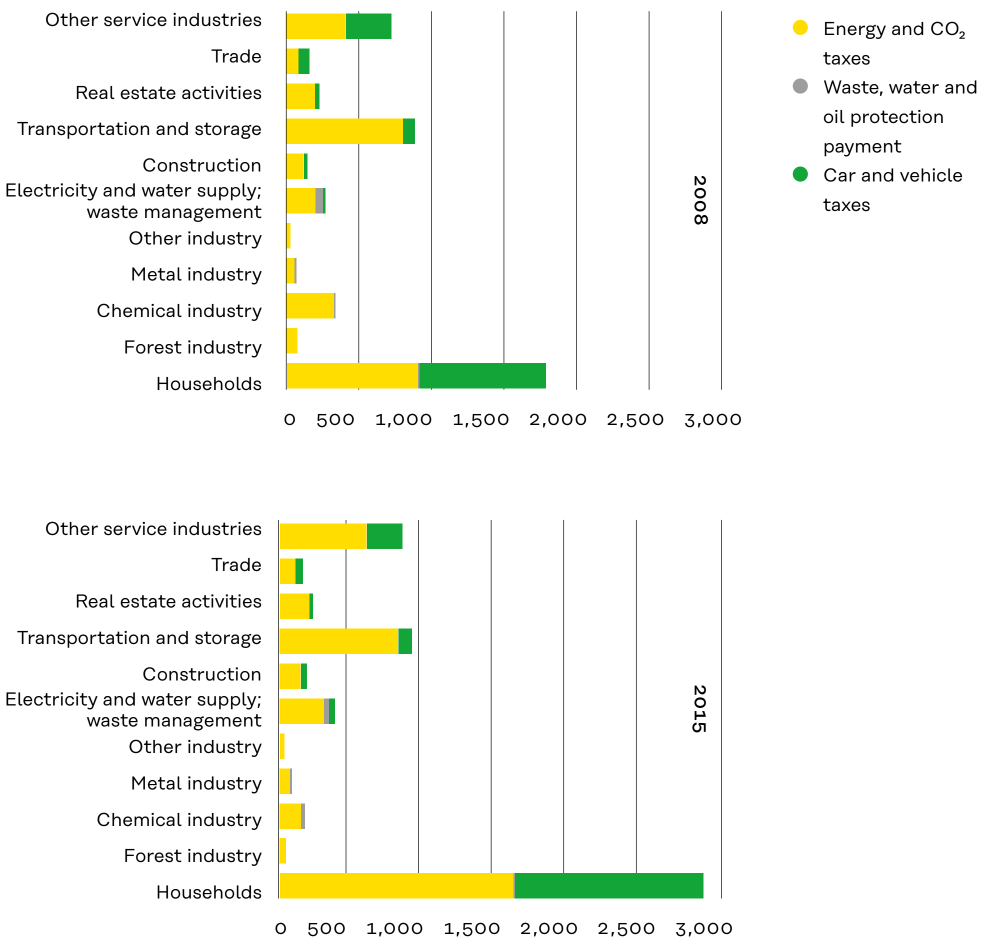


Source: Statistics Finland

8. The current prices are deflated with the income level index of Statistics Finland from 2005 to 2017 (2005=100 in the index) to adjust them over the purchasing power changes. The consumer price index (CPI) is not used since the price of motor fuels is included in it and the CPI does not always reflect changes in salaries and therefore the change in consumer's purchasing power. On the other hand, the income level index does not reflect the change in retirements or social benefits, which also form a major part of some consumer's income. Therefore, the purchasing power correction reflects only the change for the majority of Finnish consumers on average, but not for all of them.

The majority of the energy taxes were paid by households. Industrial users face lower electricity tax rates and the intermediate use of fuels in industrial production is exempted from excise taxes; see Figure 5.

FIGURE 5: ENVIRONMENTAL TAX PAYMENTS BY SECTOR, 2008 AND 2015



In the following bullet points we analyse briefly the current understanding of the potential innovation/technology, CO_2 and fiscal effects of the Finnish energy taxes.

1. **Innovation/technology effects** – The opportunity of Finnish fuel taxes to affect global innovations in vehicles is limited (because of Finland's small market size). On the other hand, electricity taxes could potentially affect local innovations to reduce energy usage. Further, both tax forms can provide incentives for individuals and firms to invest in new technologies that are more energy/emission efficient. These investment impacts are typically long-term impacts

and therefore their potential to affect CO_2 emissions will most likely also take place in the longer run. However, in Finland the potential of the CO_2 and energy taxes to stimulate investments in lower-emitting vehicles has also been limited by the global supply of lower-emission vehicles and their prices. For example, electric vehicles (EVs) are still significantly more expensive than similar internal combustion engine (ICE) vehicles despite the heavy preferential tax treatment (see the section on car taxes, p. 11) and their total usage costs have been historically higher than in similar ICE vehicles. As soon as the purchase price of EVs decreases a bit more and their total usage costs become equal or lower compared to ICE vehicles, the potential of fuel taxes to affect vehicle fleets will improve significantly (Nylund et al., 2015 and 2017).

To our knowledge, there are no robust analyses on the effects of Finnish energy taxes on innovations and investments in new technologies. Yet, with regard to fuel taxes, Li et al. (2009), for example, find relatively large effects on new vehicle purchases from fuel prices in the US. They find a 10% increase in price leading to a more than 2% increase in fleet fuel economy in the long run. Leard et al. (2018) find that car rental companies respond best to fuel price increases with their fleets.

Tietenberg (2013) finds that in general carbon taxes can be empirically linked to increases in innovations in many cases and countries, but the evidence is not conclusive and seems to vary per case. Kuo et al. (2016) conclude again that only relatively high CO_2 prices will lead to actual emission reductions in firms regardless of the investment price required to change to less polluting production technology. They studied the responses of individual Taiwanese firms in energy-intensive sectors with game theory and microeconomic analyses. According to their findings low CO_2 emission prices typically only result in the firm paying the CO_2 levy, but not actually reducing emissions. Higher CO_2 prices have more potential to lead to actual emission reductions through new technology investments. Yet, setting such a "sufficiently high CO_2 price" will be case-dependent and probably rather difficult to determine. Yet, for example, Calel and Dechezleprêtre (2015) find that the EU ETS increased low-carbon innovations among the regulated firms by as much as 10%, while not crowding out patenting for other technologies.

2. **CO_2 effect** – The CO_2 effects of fuel and electricity taxes stem in the short run mainly from demand price elasticities that affect the change in demanded quantities. In the longer run, income increases, technology changes and investment changes also affect the estimates. With regard to motor fuels, the estimates on short-run price

elasticities are very small (Ministry of Finance has used an estimate of 0 for elasticity on demand). Further, in the short run all tax increases do not even seem to be transferred to the final price. For example, the price pass-through of the 2011 diesel tax increase in Finland was found to be around 70% (Harju et al, 2016). Longer-run elasticities for fuels are a bit bigger, but still rather small, with global estimates ranging from –0.25 to a maximum of –0.8 (Brons et al, 2008; Coglianese et al, 2016; and Burke and Nishitateno, 2013). These mean that if a fuel tax increase raises the final fuel price by some 1% permanently, this would lead to maximum 0.8% lower fuel demand.

On the other hand, Li et al. (2014) find that consumers respond significantly stronger to fuel tax increases than to fuel price increases. They find that a $0.05 increase in fuel tax in the US would lead to a 0.86% decrease in petrol demand. This elasticity is about three times bigger than is found for the tax-inclusive final price. Similarly, Rivers and Schaufele (2015) also found a 4.1 times higher reduction in petrol demand following the introduction of a carbon tax in British Columbia than would have been expected from a similar increase in the petrol price. Andersson (2017) finds tentative results from a three times larger carbon tax elasticity of demand for petrol than the price elasticity in Sweden. Based on his own findings and previous literature, he concludes that there can be various explanations for this difference in the elasticity. For example, media coverage of tax increases, the long-term persistence of the tax changes and the elimination of free-riding opportunity are included as explanations as to why consumers respond stronger to carbon tax increases than to general price increases in petrol.

The final CO_2 effects are also affected by the income elasticity on fuels and the potential for consumers to change to lower-consuming vehicles.[9] Labandeira et al. (2017) conclude that the price elasticity of diesel is particularly high in the long run for industrial users.

Similarly, electricity price elasticities are generally small in the short run (average estimate –0.12), but larger in the long run (–0.36) based on a meta-analysis. In particular, commercial users' short- and long-run price elasticities were substantially larger than residential users' elasticities (Labandeira et al., 2017). While Labandeira et al. (2017) do not find a general difference in the long-run price elasticities of industrial and residential users (–0.36 for both), Bjørner et al. (2001)

9 However, Allcott and Wozny, 2014, find that consumers do not behave rationally with regard to the comparison of possible future increases in fuel prices and the purchase price of their car. They take into account only around 75% of the potential future increases in fuel prices in their vehicle purchase price.

conclude that electricity-intensive firms within industry have significantly higher price elasticities than less electricity-intensive firms (with 0.37 points higher price elasticities within the same industry).

Despite the relatively small expectations in the potential of motor fuel taxes and electricity taxes to cut CO_2 emissions, a few studies have found a negative impact from energy taxes on emissions in Finland. For example, Lin and Li (2011) find that the Finnish CO_2 taxation lowered the growth rate of total CO_2 emissions per capita by some 1.6% during 1990–2008 compared to a sample of other OECD countries that did not impose a CO_2 tax.[10] The Prime Minister's Office (2000) also estimated that all energy and fuel taxes decreased Finnish CO_2 emissions by a maximum of 7% between 1990 and 1998 based on the historic long-run price elasticity of demand estimates. During this period most of the energy taxes were paid by the transport sector and households (pp. 41–42 of the report) and environmental taxation increased substantially from around 2% compared to GDP in 1990 to almost 3.5% in 1998. Similarly, Andersen (2010) estimated a 6% decrease in Finnish CO_2 emissions from 1994 to 2003 and a 4% decrease in fuel demand as a result of the energy taxes.[11] No ex-post assessments have been made on the more recent CO_2 effects of Finnish energy taxes.

On the other hand, Perrels and Tuovinen (2012) consider that fuel taxes in the early 2000s were not very efficient at reducing CO_2 emissions in the transport sector. They conclude that while taxes might have reduced emissions somewhat via their incentive to buy more fuel-efficient cars per kilometre driven, increasing purchase power at the same time increased demand for (larger) cars and offset the negative effect of fuel taxes on total transport emissions. In addition, with more fuel-efficient cars consumers can drive further with the same cost, which hampers their potential to cut actual GHG emissions. Similarly, Vehmas (2005) concluded that the principle of "the polluter pays" was not fully followed in Finnish energy taxation from 1990 to 2003 because of the various exemptions provided for the manufacturing firms.

10 They find also that during the same time a one percentage point increase in R&D expenditure over GDP decreased CO_2 emissions (growth rate) per capita by over 2%.
11 The estimates are based on econometric calibration of the E3ME model to 1994-2003 data. The impact of the total environmental tax reform to GDP at the same time was +1%.

The literature on motor fuel price elasticities and CO_2 impacts has been produced during a time when the potential to switch to new technology in vehicles was rather limited compared to the current supply of electric cars and (bio)gas motors. Therefore, it could be that the current potential for price elasticities is somewhat bigger than has been found historically. Further, fuel prices should stay also relatively high even if electric vehicle use increases substantially. As most of them in Finland are currently plug-in hybrid electric vehicles (and not fully electric vehicles; see the next section), consumers should still have an incentive to use electricity as the main power source rather than petrol to cut down transport emissions.

Findings from other countries on the (ex-post) effects of carbon taxes on emissions also indicate the potential for energy taxes to decrease emissions. For example, Tietenberg (2013) concludes that carbon taxes in some countries have resulted in high single-digit emission reductions (close to 10%), but these depend heavily on the structure of the carbon tax system. Exemptions from carbon taxes in industry have been associated not only with Finland, but also with Norway and Sweden, with significantly lower reductions. Martin et al. (2014) found a significant reduction in manufacturing plants' emissions resulting from a carbon tax (climate change levy, CCL) of around 16–30 pounds sterling per ton of CO_2 imposed on coal, electricity, natural gas and non-transport liquefied petroleum gas use by industrial and commercial users in the UK. On the other hand, they did not find any impacts from the tax on levels of company turnover, employment or productivity. During the period of analysis, the CCL added 15% to the energy bill of a typical UK business. Further, Morley (2012) finds, using econometric techniques and annual data from EU countries for 1995–2006, a significant negative relationship between the level of environmental taxes (over GDP or tax revenue in total) and CO_2 emissions, but not energy consumption. In other words, it seems that emission reductions were also driven by possible investments in cleaner technologies.

3. **Fiscal effect** – The Ministry of Finance has considered the main objective of the fuel taxes to be fiscal. The revenue obtained through them has also been substantial, equal to around 3% of GDP in 2017, as Figure 3 shows.

One-off car tax and annual vehicle tax

Finland's one-off car tax is based on the CO_2 emissions or weight of the car/van and it needs to be paid when one starts using the vehicle for the first time. It ranges currently from around 3% of final selling price for zero-emission cars (based on CO_2 emissions for g/km of use) to up to 50% for very heavy/polluting vehicles.[12] The car tax has been based on CO_2 emissions since 2008, but the exact tax rates have varied over the years. Until 2007 the new car excise tax was 26% of retail value for all vehicles.

In addition to the one-off car tax, Finland imposes an annual vehicle tax for all vehicles used in Finland. The vehicle tax is also based on the normal CO_2 emissions of the vehicle type and the tax ranges from 70 euros for zero-emission cars to 618 euros annually for vehicles with over 400 g/km CO_2 emissions. Until 2007 annual vehicle tax was fixed at 127 euros per year.

1. **Innovation/technology effects** – Despite the very heavy tax preferences for low-emission cars, the full usage cost of plug-in hybrid electric vehicles (PHEVs) and battery electric vehicles (BEVs) has remained higher than those of similar cars with a combustion or gas-powered engine. This is due to the significantly higher normal purchase price of PHEVs and BEVs compared to relatively similar vehicles based on other engine technologies, while fuel/energy costs are lower for BEVs and PHEVs since electricity is relatively cheap in Finland (Nylund et al, 2015). Therefore, the share of PHEVs and BEVs in the Finnish vehicle fleet has remained low at 0.3% (see Table 2). However, from 2007 to 2015 the average CO_2 emissions of newly registered vehicles decreased by some 30% (from 177 g/km to 124 g/km). A small share of the decrease in new vehicles' emissions and the increased sales of lower-emission vehicles can be attributed to the car taxation (Stitzing, 2016). Yet, most of the changes in the vehicle fleet towards less-emitting technology options seem to stem from the EU legislation that regulates the emissions standards. As Finland is a relatively small market in the total worldwide car market, Finnish legislation is not expected to affect car manufacturers' decisions.

2. **CO_2 effect** – Stitzing (2016) found a negative, but minimal, effect of the 2008 changes in the Finnish car taxation on actual transport CO_2 emissions. The author used detailed microdata to separate the effect of EU-level emission standards on transport emissions from the effects of the Finnish car tax. From 2007 to 2010 the sales weighted average CO_2 emission level of new Finnish cars went down

12 The tax is lower for buses and for lorries: (www.eduskunta.fi/FI/vaski/HallituksenEsitys/Documents/HE_33+2015.pdf).

from 176 to 146 gCO_2/km, but only around 2–3 gCO_2/km of the reduction could be attributed to the car tax changes. Most of the reduction originated from the EU-level emission standards as consumers would have bought cleaner cars despite the tax change. In other words, the maximum of around 3 gCO_2/km decrease in new cars' emissions accounted for some 2% decrease in the average total emissions of new vehicles. Gerlagh et al. (2018) arrive at a relatively similar result for all EU15 countries in general on the emission reduction of vehicle registration taxes.

Earlier, Perrels and Tuovinen (2012) estimated a higher reduction in emissions stemming from the 2008 car tax change. However, the methodology used in their study is less detailed than the methods used by Stitzing (2016). Perrels and Tuovinen estimated that between 2006 and 2011 the average emissions of new cars went down from 179 g/km to 146 g/km and around 13–17 g/km (40–50%) of this reduction could be attributed to the car tax. Technological change accounted for some 12 g/km (36%) of the total according to their assumptions.

However, because of the very gradual change in the total Finnish vehicle fleet (out of the total of 2.6 million vehicles, only around 120,000 or 4.6% are new annual vehicle registrations), even the higher estimates of Perrels and Tuovinen (2012) lead to only a 0.5% reduction in the annual CO_2 emissions of the transport sector in Finland (Finnish government proposal 33, 2015). Taking into account the new estimates of Stitzing (2016) the final CO_2 impact is likely to be even smaller.

TABLE 2: FINNISH VEHICLE FLEET BY TYPE AND PROPULSION OPTION, 2017

	Passenger vehicles	Vans	Buses	Trucks
Petrol	1,916,647	10,519	0	
FFV	4,397	0	0	
Diesel	731,886	308,255	12,577	94,812
Gas	3,332	324	70	23
PHEV	5,804	14	0	0
BEV	1,487	168	5	1
Total	2,663,554	319,280	12,652	94,837

Source: VTT, Lipasto

3. **Fiscal effect** – Recently, the annual tax yield of both the car tax and vehicle tax individually have been around 1000 million euros per year (or 0.4–0.5% over GDP), meaning a total tax yield from these two taxes of around 2 billion euros (Statistics Finland statistics, tax yields per tax 2008-2017).

   However, the cost per reduced CO_2 tonne was around 300–350 euros as a result of the fiscal losses induced by the lower taxation for low-emission vehicles (Perrels and Tuovinen, 2012). Stitzing (2016) calculates even higher losses in car and vehicle tax income (up to 9.5%). This also means a higher price for the emission reductions. On the other hand, consumers were estimated to benefit from the change. In addition, producers of low-emission vehicles were able to increase mark-ups (Stitzing, 2016).

Waste tax

Finnish waste legislation is largely based on EU legislation, but in some cases includes stricter standards and limits than those applied in the EU in general. Tax is levied on all waste deposited at landfill sites, provided that its use is technically feasible and environmentally justifiable, and that by imposing the tax, waste can be made more commercially exploitable.[13] Waste management covers approximately 3% of Finnish GHG emissions.[14]

1. **Innovation/technology effects** – Some indication[15] has been found that the tax has resulted in increased waste usage and supported the creation of a private waste industry. However, these findings are indicative in nature and would need to be confirmed in a wider and more systematic study.

2. **GHG effect** – According to a report by the National Audit Office of Finland (2004a) the waste tax had no significant environmental impacts and the effects attributed to the tax had been mainly fiscal in nature. The Finnish mid-term climate plan (Ministry of Environment, 2017), on the other hand, mentions the waste tax among the measures that have led to reduced emissions from the waste sector since the beginning of the 21st century. However, it is not possible to attribute an exact share of emissions reductions to the waste tax.

13 Environment.fi (2018). Waste charges and taxes. Website. 13.8.2018.
14 Ministry of the Environment (2012). Valtakunnallisen jätesuunnitelman seuranta 1. väliraportti. Page 86.
15 Ministry of Finance (2009) referring to an analysis made by Suunnittelukeskus Oy in 2005 for the Ministry of Environment.

3. **Fiscal effect** – The expected annual tax yield in 2019 is estimated to be 12 million euros.[16]

Excise duty on beverage packaging

The excise duty of 0.51 EUR/l on beverage packaging is intended to direct producers to use recyclable packaging. The excise duty is only collected from beverage packaging, which is not included in the deposit-based recycling system.

1. **Innovation/technology effects** – Hennlock et al. (2014) conclude that all Nordic countries, including Finland, have deposit-refund systems which include beverage packaging such as plastic bottles. Though the systems differ in the number of product types covered, the collection and recycling of packaging covered by the deposit system are in general high (85-95%). The exact effect of the excise duty on beverage packaging as concerns their recycling is not estimated. However, given the high share of beverage packaging in the deposit system, it seems likely that the tax has increased the use of the deposit system and therefore the beverage packaging recycling systems.

2. **GHG effect** – According to the National Audit Office of Finland (2004b), the tax has reduced the amount of waste from recyclable beverage packaging. However, there is no available data on emissions reductions related to this particular excise duty.

3. **Fiscal effect** – The expected annual tax yield in 2019 is estimated to be 16 million euros.[17]

Oil waste duty

Oil waste duty is levied on lubricating oils and preparations to cover the expenses arising from the treatment of oil waste. Motor and heating fuels are exempt from the oil waste duty as they do not generate oil waste.

1. **Innovation/technology effects** – NA.

2. **CO_2 effect** – There is no estimate available regarding the potential CO_2 reductions that could be derived from the oil waste duty.

3. **Fiscal effect** – The revenue generated in 2019 is estimated to be four million euros.[18]

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16 Ministry of Finance (2018). Budget proposal 2019. 13.8.2018.
17 Ministry of Finance (2018). Budget proposal 2019. 08. Eräiden juomapakkausten valmistevero. 13.8.2019.
18 Ministry of Finance (2018). Budget proposal 2019. 08. Öljyjätemaksu.

Oil damage duty

The oil damage duty is levied on oil which is imported into or transported through Finland. The oil damage duty revenue is deposited in the Finnish Oil Pollution Compensation Fund. The Finnish Oil Pollution Compensation Fund provides reimbursement for the costs of oil spills and oil spill responses on land and at sea when the cause of the incident is unknown, or the culpable party is unable to pay the compensation.

1. **Innovation/technology effects** – NA.

2. **CO_2 effect** – There is no estimate available regarding the potential reductions in CO_2 emissions that could be derived from the oil damage duty.[19]

3. **Fiscal effect** – In 2017 the oil damage duty generated 8.4 million euros in revenue.[20]

3 Subsidies and other instruments

In theory carbon pricing is the most cost-effective way to control emissions. Any other regulative measure, such as subsidies or feed-in tariffs for renewable energy, can hinder the proper functioning of the carbon price. However, there are various reasons to use these additional measures as well, including:

1. technology-related positive spillovers to society;

2. imperfect and/or distorting policy measures (for example, the carbon price in ETS is not high enough to cover the true societal costs of emissions or fossil fuel subsidies, see Fischer, 2008);

3. technological lock-in due to high investment costs and long usage times in plants (Unruh, 2002);

4. energy self-sufficiency and promotion of green economic activities.

Finland has also used various types of regulations, subsidy systems and feed-in tariff programmes to support investments in renewable energy, energy efficiency and market access for new technologies. In the following we

19 Correspondence with the Ministry of the Environment, 8 August 2018.
20 Ministry of Finance (2018). Budget proposal 2019. 08. Öljyjätemaksu.

concentrate on the main subsidy systems and the feed-in programme. In addition, Finland has a biofuel blending requirement for motor fuels, which directly affects the functioning of the motor fuel market and entails a shadow price for CO_2 reductions. It is also heavily linked to the motor fuel taxation structure and therefore also to public finances. Therefore, while it is in principle not a direct economic policy instrument, it will be discussed shortly.

Further, Tervonen and Metsäranta (2012) point out that the Finnish public sector (especially local authorities) offers a large variety of direct subsidies to public transportation and indirect tax subsidies. These are not analysed in detail in this report.

Blending requirement for motor fuels

Since 2008 Finland has required that biofuels need to be mixed with fossil motor fuels. The biofuel distribution obligation started as a small percentage and was increased to 6% for 2011 to 2014. It will further increase gradually to 20% by 2020. The latest plans are to extend the biofuel blending requirement gradually to 30% by 2030 for transport fuels and to 10% for heating and machinery fuels.[21]

1. **Innovation/technology effect** – Finnish researchers and firms have been developing different types of new technologies to produce biofuels in Finland and various Finnish companies have also requested EU support for these R&D investments. Since 2011 a few new biofuel factories have been set up in Finland (currently producing biofuels mainly from waste oils and pine oil) and new wood-based biofuel factories are planned. It is possible that the blending requirement has facilitated the investments to some extent by creating a robust demand for biofuel products in Finland until 2020. However, the domestic demand is relatively small in comparison to the investment costs and the domestic policy beyond 2020 is uncertain. Therefore, it seems more likely that final investment decisions have been made based on global demand estimates, which are mainly affected by the policy decisions of other countries (Nylund et al, 2017; Sipilä et al, 2018).

2. **CO_2 effect** – The emission reduction resulting from the blending requirement is estimated to be around 1.6 to 1.7 million tonnes of CO_2 in 2020 depending on eventual biofuel consumption. In 2015 the actual reduction was 1.5 million tCO_2 (Statistics Finland, 2018a). This equals around 2.6% of the total Finnish emissions in 2016 and around 10% of transport sector emissions.

21 Until now the energy content of second-generation biofuels (biofuels produced, for example, from waste material) is considered as being double its actual energy content when calculating the share of biofuels for the purposes of the blending obligation in order to support investment into these advanced renewable biofuels.

3. **Fiscal effect** – The blending requirement legislation was introduced at the same time as the energy taxation reform in 2011. The blending requirement was in the end revenue neutral for the public sector. While it decreased the relative use of fossil fuels, the tax level of diesel fuel in particular was increased in 2011 and in addition the energy tax reform of 2011 introduced (small) tax levels for all biofuels (the Finnish Government's legislative proposal, HE, 197/2010). Without these fiscal changes the effect of the blending requirement could have been negative.

   While the actual production costs of some of the advanced biofuels have been high (even double compared to fossil diesel), the Finnish fuel taxation has diminished the price difference significantly. The final cost of even higher (30%) blending requirements is estimated to be relatively small for most users, but these estimates depend heavily on the uncertain future prices of raw oil products and different biofuels (Sipilä et al, 2018).

Feed-in tariff for renewable energy

Since 2011 Finland has maintained a feed-in tariff scheme to support the introduction of more renewable energy production. The feed-in tariff is available for: 1) new wind power plants; 2) new biogas power plants (gas produced by digestion); 3) new wood-fuelled power plants that also produce heat for use; and 4) forest chip power plants. The tariff is in the form of a price guarantee, which currently equals 83.5 EUR/MWh for a maximum of 12 years, except for forest chip power plants which obtain currently 0-18 EUR/MWh price premiums on top of the electricity price.[22] Previously, wind power plants obtained even higher price guarantee levels.[23] The scheme is ending in 2018 and no new wind power, biogas or wood-fuelled power plants have recently been accepted by the scheme. From the end of 2018 a new technology-neutral, auction-based scheme will replace the feed-in tariff scheme and some 1.4 TWh of annual renewable energy production will be auctioned to the lowest bidders.[24]

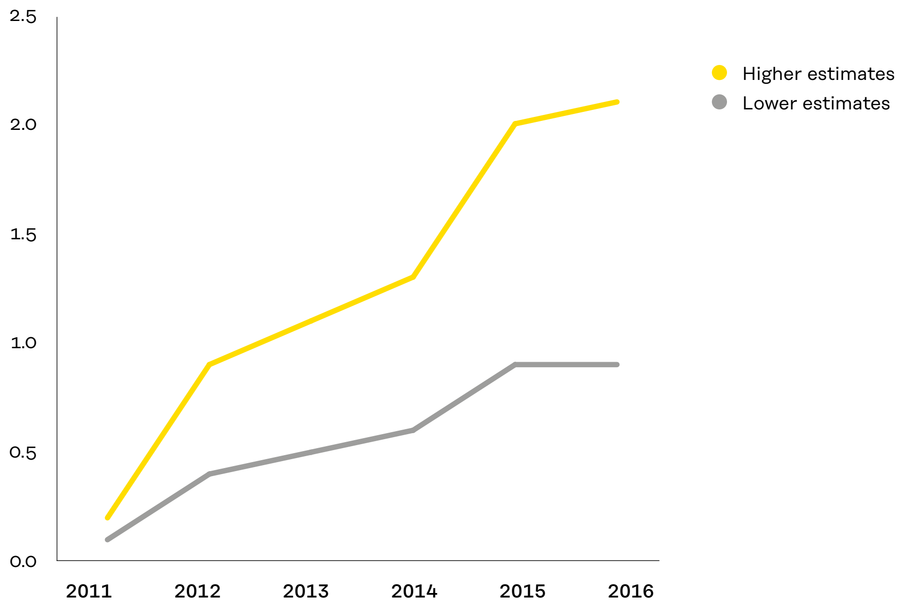
1. **Innovation/technology effect** – The innovation effects of the Finnish feed-in tariff system have not been studied to the best of our knowledge. However, given the large volume increase especially in Finnish wind power production, the system seems to have boosted at least investments in wind power. Indeed, the capacity of wind power

22 The price premiums depend on the price of EU ETS emission allowances and peat tax.
23 www.energiavirasto.fi/web/energy-authority/feed-in-tariff.
24 https://tem.fi/artikkeli/-/asset_publisher/uusiutuvan-sahkon-tuotannon-kilpailutus-toteutuu-syksylla.

has increased rapidly. Based on international literature, Hokkanen and Ollikka (2015) conclude that feed-in tariff systems can boost innovations and investments in the early development of renewable technologies, including wind power. However, the authors also point out that since the forest chip plants do not have to be new, the Finnish feed-in price scheme does not directly create incentives to invest in new innovative technologies in that regard.

2. **CO_2 effect** – The Finnish energy authority provides detailed information on the amount of energy produced by the plants entitled to the feed-in tariff. However, the calculation of the CO_2 reduction obtained by the new renewable capacity depends on the estimates for the CO_2t/MWh of the power types that are replaced. Ollikka (2013) estimates that the feed-in tariff system cut around 0.2–0.5 $MtCO_2$ in 2011 and 0.6–1.9 $MtCO_2$ in 2012. Based on information from the Finnish energy authority on the actual production capacities of the plants in the feed-in tariff system from 2011 to 2016 and different estimates on the replaced grid carbon intensity, the CO_2 reductions accounted for some 1-2% of total Finnish CO_2 emissions. See Figure 6 for annual estimates.

FIGURE 6: CO_2 REDUCTIONS BY THE FEED-IN TARIFF SYSTEM ANNUALLY COMPARED TO THE TOTAL FINNISH CO_2 EMISSIONS



Source: SATU system on plants and production under the feed-in tariff system (obtained from K. Ollikka). Lower estimate assumes an average grid carbon intensity of 103 gCO_2/kWh based on the 2016 average in all Finnish electricity production and higher estimates are based on Lindroos et al. (2012) and their long-term estimates with variation over the different energy sources (for forest chips a value of 200 gCO_2/kWh, for wind power 250 and for biogas 200 gCO_2/kWh).

3. **Fiscal effect** – The feed-in system required around 11 million euros in 2011, but the number of plants allowed in the system increased from 33 in 2011 to around 140 in 2016, which resulted in a total cost of around 170 million euros in 2016 (or around 0.3% of total government spending).[25] Based on the calculations by Ollikka (2013), the CO_2 reduction cost was around 20–70 EUR/tCO_2 for forest chip power plants and around 70–240 EUR/tCO_2 for wind power in 2011–2012. However, the cost estimates depend heavily on the assumed grid carbon intensity replaced. Using the actual production and subsidy data, the cost per reduced tCO_2 in 2016 was 90–170 euros for forest chips and 200–490 euros for wind power, with different estimates on the grid carbon intensity replaced. All these estimates are way above the EU ETS emission auction price level of around 5 EUR/tCO_2 during the same year and around 20 EUR/tCO_2 currently. To conclude, the feed-in tariff system is often rather costly compared to emission trading systems.

Energy Aid and Investment Aid for Key Energy Projects

Finland has provided different types of subsidies to renewable energy and to energy efficiency investments at least from 1995 onwards (Hiltunen, 2004). Energy Aid can be granted to investment projects and studies that: 1) promote the production or use of renewable energy; 2) promote energy savings or increase the efficiency of energy generation or use; or 3) otherwise promote the transition towards a low-carbon energy system.[26] Total annual costs of the scheme have recently been around 40–70 million euros.[27] The scheme has been managed by the Ministry of Economic Affairs and Employment and Business Finland since 2017. The scheme provides support for around 10–50% of the investment costs with substantial variation by case. The scheme includes strict rules on what types of applicants and projects can be covered by the Energy Aid.[28] In 2015 the majority (around 75%) of the Energy Aid went to the support of renewable energy investments, 25% to support energy efficiency projects and a very small amount to energy analyses and audits.[29]

25 https://tuotantotuki.emvi.fi/.
26 https://tem.fi/en/energy-aid.
27 Finnish Government's budget proposal 2018.
28 For example, investment projects related to operations belonging to EU ETS cannot be subsidised (www.businessfinland.fi/en/for-finnish-customers/services/funding/sme/energy-aid/).
29 https://tapahtumat.tekes.fi/uploads/9c018976/Pekka_Grnlund-8160.pdf.

In addition to the Energy Aid, the current government decided to allocate an additional 100 million euros for renewable energy and new technology investments for the period 2016–2018. In comparison to the Energy Aid programme, this additional Investment Aid for Key Energy Projects (IAKEP) programme targets larger investments (investments over 5 million euros compared to a minimum amount of 10 000 euros for Energy Aid) and new technologies.[30] Since the programme has only recently started, no ex-post evaluations are available as yet.

1. **Innovation/technology effect** – Rauhanen et al. (2015) analysed Finnish firm subsidies (including Energy Aid) and concluded that robust causal-effect analyses of their impacts are generally not available because of the difficulties in finding good, random controlled trial settings. Significant selection bias issues hinder most of the analyses and the associated conclusions. No specific analyses have been made on the impacts of Energy Aid or IAKEP. However, in general, Business Finland systematically monitors the impacts of their grants, which are often associated with an increase in investments and employment (Tekes, 2014; Koski et al., 2017).

   According to international literature, the potential impacts of firm subsidies typically depend on the firm and subsidy type. R&D subsidies have often been found to increase innovations especially in smaller firms (Rauhanen et al., 2015). Einiö (2014) found that one euro in R&D subsidy in Finland increased general R&D investments by 1.4 euros. Dechezleprêtre & Popp (2015) recommend more public support for clean technology R&D. The authors do not find any evidence of diminishing returns to energy R&D funding and propose the EU allocate some 10% of the ETS auction allowance revenues to R&D funding until 2025.

   While part of the Energy Aid might go to R&D investment, the majority goes to general investment support (to renewable energy and energy efficiency). The impacts of general investment subsidies are less clear based on global literature, much of which lacks good causal studies however. Some studies find small positive impact on investments, while others suggest that the subsidies have just replaced investments that would have taken place anyway. Further, investment subsidies are not found to increase general productivity (Rauhanen et al., 2015).

30 The aim is to increase the use of renewable energy in a sustainable way so that its share will rise to more than 50% and self-sufficiency to more than 55% during the 2020s. The Government Programme has also set goals for raising the share of renewable transport fuels to 40% by 2030, for ceasing the use of coal in energy production in Finland and for halving the use of imported oil for domestic needs during the 2020s (https://tem.fi/en/investment-aid-for-key-energy-projects).

2. **CO_2 effect** – Taking into account that the Energy Aid and Investment Aid for Key Energy Projects have particularly supported investments in renewable energy, it is likely that they have reduced CO_2 emissions by supporting the usage of renewable and low-emission energy. The exact amount of the possible CO_2 reductions is not known.

3. **Fiscal effect** – In total, the Finnish Government provides subsidies of around 60–70 million euros under the Energy Aid and Investment Aid for Key Energy Projects programmes annually. These account for some 0.1% of the total government spending in 2018.

Agri-environmental support

The 2014–2020 Rural Development Programme for Mainland Finland includes several forms of support targeted at farmers, including environmental payments.

1. **Innovation/technology effects** – The innovation effects of the programme are not known.

2. **CO_2 effect** – According to the follow-up study on the impacts of agri-environmental measures (Ministry of Agriculture and Forestry, 2014) covering the years 2008 to 2013, the only measures that directly addressed the reduction of gaseous emissions were the long-term grass cultivation of peat fields and special aid agreements for slurry injection in cropland. The study also concludes that while "other measures have indirectly affected gaseous emissions, the impact of agri-environmental support on reducing gaseous emissions from agriculture has been negligible".

3. **Fiscal effect** – In 2019 the estimated total for agri-environmental support will be approximately 291 million euros, or around 0.6% of total tax yield (Ministry of Finance, 2018).

4 Conclusions

After the introduction of the first, while rather minimal, CO_2 tax in 1990, Finland has used a variety of economic instruments to control GHG emissions and to protect the environment. The price of CO_2 has increased over time and currently fuels are taxed at the level of 62 EUR/tCO_2. Table 4 summarises the main instruments used and the current understanding of their fiscal, CO_2 and innovation effects.

Finnish CO_2 tax for motor fuels and energy content tax for fuels and electricity form a substantial fiscal tax yield of around 2.1% of GDP. Currently most of these taxes are paid by consumers and the transport service sector, but historically they targeted all primary energy use. The main purpose of these taxes has been fiscal, and they are not expected to have a major impact on CO_2 reductions (via a decrease in the demanded fuel/electricity quantities) in the short run. However, some studies suggest that in the long run these types of taxes can lead to energy efficiency-improving investments and CO_2 emission reductions. Using data from the early 1990s when the energy taxation covered all primary energy use, significant CO_2 reductions have been associated with it.

Finland imposes a one-off car tax on sales of new cars and an annual vehicle tax on all vehicles in use. Both are based on the CO_2 emissions of the vehicles since 2008 with the aim of increasing the energy efficiency of vehicles and the use of new less-emitting technologies. The tax preference for low-emission cars is extensive, but because of significantly higher prices they have not yet spread widely in Finland. After the introduction of the new car and vehicle taxes in 2008, the average CO_2 emissions of newly registered vehicles decreased by some 30%. However, only a small share of this decrease and increased sales of lower-emission vehicles can be attributed to the car taxation. Most of the changes seemed to result from the EU-level emissions standards regulation. While the car and vehicle taxes have provided tax income of nearly 0.9% of GDP, the tax structure change in 2008 decreased the share. In comparison to the relatively minimal emission cut the price of the CO_2 reduction is considered relatively high.

Finnish waste tax is levied on all waste deposited at landfill sites, provided that its use is technically feasible and environmentally justifiable, and that by imposing the tax, waste can be made more commercially exploitable. Some studies suggest that the tax has resulted in increased waste usage and supported the creation of a private waste industry. Yet, the actual impact of the tax on GHG emissions is not known and the tax yield from it is relatively low.

In addition to the subsidies and taxes, the requirement that biofuels need to be mixed with fossil motor fuels was introduced in 2011. It is possible that the blending requirement has facilitated investments in new biofuel technologies and factories to some extent, but it seems more likely that final investment decisions are mostly driven by global demand estimates. Based on the current emission accounting rules, it is estimated that the blending requirement will cut around 1.6 to 1.7 million tonnes of CO_2 in 2020 (around 2.6% of the total Finnish emissions in 2016 and around 10% of the transport sector emissions). The blending requirement was eventually revenue neutral for the public sector. Without energy tax changes at the same time, its effect is likely to have been negative on fiscal balance.

Summary of the effects of Finnish national green economic instruments 1990–2018

Instrument	Fiscal budget size (2017)	Fiscal effect	CO_2 effect	Innovation effect
Tax instruments and payments				
CO_2 tax (motor fuels, coal and gas)	1340 mEUR (0.6% of GDP)	↑↑	↓ (Ind.)	↑ (Ind.)
Energy content tax (all fuels, including electricity)	3320 mEUR (1.5% of GDP)	↑↑	↓ (Ind.)	↑ (Ind.)
Annual vehicle and new car sales tax	2180 mEUR (0.9% of GDP)	↓/o	↓/o	↑ (Ind.)
Waste tax	12 mEUR	↑	↓/o (Ind.)	↑ (Ind.)
Excise duty on beverage packaging	16 mEUR	↑	↓/o	↑ (Ind.)
Oil waste duty	4 mEUR	↑/o	n.a.	n.a.
Oil damage duty	8 mEUR	↑/o	n.a.	n.a.
Subsidies and other instruments				
Blending requirement for motor fuels	-	o	↓↓	↑/o (Ind.)
Feed-in tariff for renewable energy	170 mEUR (0.3% of public spending)	↓	↓↓	↑ (Ind.)
Energy Aid and Investment Aid for Key Energy Projects	60–70 mEUR (0.1% of public spending)	↓	n.a.	↑ (Ind.)
Agri-environmental support	290 mEUR (0.6% of public spending)	↓	o	n.a.

Ind. = Indicative research results or mixed results on the topic. (↑)↑ = (strong) positive effect from the tax/subsidy; o = no effect; (↓)↓ = (strong) negative effect from the tax/subsidy; n.a. = effect not known. GE = Government Expenditure

Since 2011 Finland has maintained a feed-in tariff scheme in the form of a price guarantee to support the introduction of more renewable energy production. The innovation effects of the Finnish feed-in tariff scheme have not been studied, but there is some evidence suggesting that the system has boosted investments in wind power as the capacity of wind power has increased rapidly within it. The scheme has reduced CO_2 emissions by some 1–2% of the total CO_2 emissions (depending on the assumption on the carbon intensity of the grid replaced). The scheme cost 170 million euros in 2016 (or around 0.3% of total government spending). The final cost per tonne of CO_2 reduced was relatively high for most renewable energy forms supported and the costs are estimated to be significantly higher than the EU ETS auction price.

The Energy Aid programme and Investment Aid for Key Energy Projects have mainly provided investment support to renewable energy and energy-saving projects. They have cost the Finnish Government around 60–70 million euros (or 0.1% of spending) annually. The CO_2 impacts of the programmes are not known. In addition, the innovation effects of the programmes have not been studied in detail but based on international literature these programmes have the potential to increase innovations and low-carbon investments, especially in smaller firms.

The excise duty on beverage packaging has reduced the amount of waste from recyclable packaging. However, there is no available data on emissions reductions related to this excise duty and the annual tax yield is low. In addition to the previously mentioned taxes and payments, Finland imposes oil waste duty and oil damage duty. No information is available on their innovation or CO_2 effects. They also provide relatively minimal tax yield. Last, the 2014–2020 Rural Development Programme for Mainland Finland includes several forms of support targeted at farmers, including environmental payments. The GHG impact of the programme has been negligible and its innovation effects are not known.

5 Lessons learned and discussion

In general, economic climate policy instruments can assist in emission reductions, while providing substantial fiscal income and boosting innovations at the same time. However, they need to be carefully designed. This section summarises the key lessons learned from the Finnish instruments and the other academic literature on economic climate policy instruments. The section focuses on the design elements and broader implications of the Finnish experience rather than individual instruments. This is because the effectiveness of individual instruments is context specific.

First, while the causal impacts of specific policy instruments can be difficult to estimate, it would be better to have a more systematic approach to evaluating ex-post the effects of national policy instruments. At the moment, national ex-post assessments are limited. Public authorities should make sure that the use of public policy instruments, including their impacts and effectiveness, are more systematically analysed.

Second, when CO_2 and energy taxes are targeting firms' energy use, they often have the potential to cut emissions faster than when targeting the energy use of consumers. CO_2 and energy taxes imposed on consumers can provide substantial fiscal income, but their CO_2 effects are typically limited and take longer to materialise. Therefore, one of the most efficient ways to introduce a CO_2 tax is to target primary energy consumption. Also, further improvements to the functioning of the EU ETS seem essential to cut emissions. Emission cuts in the transport sector have generally been more challenging than in the non-transport sectors but a drop in the price of electric cars, and therefore in their full usage cost, could change this in the future. With this change in mind, it is also important to continue providing incentives though fuel and vehicle taxation for the transition to low-emission vehicles. The Finnish experience with waste tax and beverage packaging duties suggests that taxes can provide incentives to reduce waste and boost circular economy activities.

The OECD (2018) considers the lowest necessary price to be 30 EUR/tCO_2 for all CO_2 emissions at this moment increasing to 60 EUR/tCO_2 by 2030 (the low-end estimate for 2030, which is also the mid-range price estimate for 2020). According to their estimates, in 2015 only 26% of Finnish CO_2 emissions had a carbon price of at least 60 EUR/tCO_2 and 42% a price of at least 30 EUR/tCO_2. In other words, 58% of Finnish CO_2 emissions did not yet command a high enough price. Therefore, Finland needs to consider how to improve the pricing of emissions. In the design of carbon tax systems, the economic losses have often been found to be minimised when the new, additional carbon tax revenue is used to lower existing distortionary taxes (such as labour taxes). In other words, the last 30 years of research on carbon taxes recommends the use of environmental tax reforms to boost emissions cuts while minimising the adverse impacts on the economy (Timilsinas, 2018).

Last, considering the fast pace required to reduce GHG emissions, the most effective policies or policy packages are required to accelerate emission reductions. While the economic literature typically suggests carbon pricing as the most cost-effective way to cut emissions, other policy instruments might also be useful in some circumstances. For example, if the expected level of carbon tax needed to stimulate the policy outcomes/ technologies (such as renewable energy) is high and potentially causing economic losses, alternative policies might be more suitable (Timilsinas, 2018). In Finland subsidies and regulations have played a role in supporting CO_2 emission cuts, but the price of the emission reductions associated with the renewable energy feed-in-tariff scheme in particular has been relatively high. In addition, the blending requirement for biofuels has decreased transport sector emissions. Similar cuts in transport sector emissions in such a short time would have potentially required significantly higher CO_2 taxes on fossil motor fuels. The relative merits of using overlapping regulations (such as both tax incentives and regulations to advance low-carbon technologies) should always be carefully assessed. For example, the target sectors of subsidies should be carefully selected to ensure that they add value, do not distort other policies (such as the EU ETS) and their costs are kept reasonable.

References

Allcott, H. and N. Wozny (2014): "Gasoline prices, fuel economy and the energy paradox", in *The Review of Economics and Statistics*, 96(5): 779–795.

Andersen, M. (2010): "Europe's experience with carbon-energy taxation", *S.A.P.I.E.N.S* 3(2) 2010.

Andersson, J. (2017): "Cars, carbon taxes and CO_2 emissions", Grantham Research Institute on Climate Change and the Environment Working Paper No. 212, London School of Economics.

Arlinghaus, J. (2015): "Impacts of Carbon Prices on Indicators of Competitiveness: A Review of Empirical Findings", OECD Environment Working Papers, No. 87, OECD Publishing, Paris.

Bjørner, T. B., M. Togeby and H. H. Jensen (2001): "Industrial companies' demand for electricity: evidence from a micropanel", *Energy Economics* 23, p. 595–617.

Brons, M., Nijkamp, P., Pels, E. and P. Rietveld (2008): "A meta-analysis of the price elasticity of gasoline demand: A SUR approach", *Energy Economics* 30, 2105–2122.

Burke, J. and Nishitateno, S. (2013): "Gasoline prices, gasoline consumption, and new-vehicle fuel economy: Evidence for a large sample of countries", *Energy Economics* 36, 363–370.

Calel, R. and Dechezleprêtre, A. (2016): "Environmental policy and directed technological change: evidence from the European carbon market". *Review of Economics and Statistics*, 98 (1). pp. 173–191.

Coglianese, J., Davis, L. W., Kilian, L. and Stock, J. H. (2016): "Anticipation, Tax Avoidance, and the Price Elasticity of Gasoline Demand", *Journal of Applied Econometrics* 32(1), 1–15.

Dechezleprêtre, A. and Popp, D. (2015): "Fiscal and Regulatory Instruments for Clean Technology Development in the European Union". CESIFO Working Paper no. 5361. Center for Economic Studies and IFO Institute.

Einiö, E. (2014): "R&D Subsidies and Company Performance: Evidence form Geographic Variation in Government Funding based on the ERDF Population Density Rule", *The Review of Economics and Statistics*, October 2014, 96(4): 710-728.

European Commission (2016): Study on Assessing the Environmental Fiscal Reform Potential for the EU28 – Final Report, European Commission, 07.0201/2015/709017/ENV.D.2.

Fischer, C. (2008): "Emissions pricing, spillovers, and public investment in environmentally friendly technologies", *Energy Economics* 30: 487-502.

Gerlagh, R., Bijgaart, I. van den, Nijland, M. and Michielsen, H. (2018): "Fiscal Policy and CO_2 Emissions of New Passenger Cars in the EU", *Environmental Resource Economics* (2018) 69, pp. 103–134.

Harju, J., Hokkanen, T., Laukkanen, M., Ollikka, K. and Tamminen, S. (2016): Vuoden 2011 energiaverouudistuksen arviointia, Valtioneuvoston selvitys- ja tutkimustoiminnan julkaisusarja 61/2016.

Hennlock, M., M. zu Castell-Rüdenhausen, M. Wahlström, B. Kjær, L. Milios, E. Vea, D. Watson, O. J. Hanssen, A. Fråne, Å. Stenmarck and H. Tekie (2014): "Economic Policy Instruments for Plastic Waste – A review with Nordic perspectives", Nordic Council of Ministers 2014.

Hiltunen, M. (2004): Economic environmental policy instruments in Finland, Finnish Environmental Institute 676en.

Hokkanen, T. and Ollikka, K. (2015): Energia- ja ilmastopolitiikan uudet tuulet, VATT Policy Brief 3–2015.

Koski, H., A. Kotiranta, M. Pajarinen, P. Rouvinen and I. Ylhäinen (2017): Tekesin vaikuttavuuden tavoitteet pitkällä aikavälillä, Tekes Katsaus 337/2017.

Kuo, T. C. and Hong, I-H. and Lin, S. C. (2016): "Do carbon taxes work? Analysis of government policies and enterprise strategies in equilibrium", *Journal of Cleaner Production* 139, pp. 337–346.

Labandeira, X., J. M. Labeagac and X. López-Otero (2017): "A meta-analysis on the price elasticity of energy demand", *Energy Policy* 102, pp. 549–568.

Leard, B., McConnell, V., and Zhou, C. Y. (2018): The Effect of Fuel Price Changes on Fleet Demand for New Vehicle Fuel Economy, RFF Working Paper.

Li, S., C. Timmins and R. H. von Haefen (2009): "How Do Gasoline Prices Affect Fleet Fuel Economy?", *American Economic Journal: Economic Policy 2009*, 1:2, 113–137.

Li, S., J. Linn and E. Muehlegger (2014): "Gasoline Taxes and Consumer Behavior", *American Economic Journal: Economic Policy 2014*, 6(4): 302–342.

Lin, B. and Li, X. (2011): "The effect of carbon tax on per capita CO_2 emissions", *Energy Policy* 39, 5137–5146.

Lindroos, T., Monni, S., J. Honkatukia, S. Soimakallio and I. Savolainen (2012): Arvioita uusiutuvan energian lisäämisen vaikutuksista Suomen kasvihuonekaasu päästöihin ja kansantalouteen, VTT Technology 11, 2012.

Martin, R. and de Preux, L.B. and Wagner, U. (2014): "The impact of a carbon tax on manufacturing: Evidence from microdata", *Journal of Public Economics* 117, pp. 1–14.

Ministry of Agriculture and Forestry (2014). Maatalous ympäristötuen vaikuttavuuden seurantatutkimus (MYTVAS3) – Loppuraportti. Pp. 10, 262–263.

Ministry of Environment (2017): Valtioneuvoston selonteko keskipitkän aikavälin ilmastopolitiikan suunnitelmasta vuoteen 2030. Ympäristöministeriön raportteja 21 | 2017.

Ministry of Finance (2009): Jäteverotuksen kehittäminen, Valtiovarainministeriön julkaisuja 18/2009.

Ministry of Finance (2018): Budget proposal 2019. 43. Ympäristökorvaukset, luonnonmukainen tuotanto, neuvonta ja ei-tuotannolliset investoinnit (siirtomääräraha 3 v).

Morley, B. (2012): "Empirical evidence on the effectiveness of environmental taxes", *Applied Economics Letters* 19 (18): 1817–1820.

Muuls, M., J. Colmer, R. Martin and U. J. Wagner (2016). Evaluating the EU Emissions Trading System: Take it or leave it? Grantham Institute Briefing Paper No. 21.

National Audit Office of Finland (2004a): Jäteverotus. Tarkastuskertomus 87 / 2004.

National Audit Office of Finland (2004b): Juomapakkausten haittavero. Selvitys 24.3.2004.

Nylund, N.-O., Tamminen, S., Sipilä, K., Laurikko, J., Sipilä, E., Mäkelä, K., Hannula, I. and Honkatukia, J. (2015): Biopolttoaineet 2020–2030 tavoitteissa ja liikenteen muu uusiutuva energia: Vaikutukset ilmaston ja kansantalouden kannalta, VTT Research Report.

Nylund, N.-O., J. Laurikko, J. Honkatukia, K. Sipilä, I. Hannula, E. Kurkela and Y. Solantausta (2017): Tieliikenteen 40%:n hiilidioksidipäästöjen vähentäminen vuoteen 2030: Vuoden 2016 päivitys, VTT Tutkimusraportti VTT-R-OO7 41–17.

OECD (2018): "Effective Carbon Rates 2018: Pricing carbon through taxes and emissions trading", OECD Publishing, Paris.

Ollikka, K. (2013): Uusiutuvien energiamuotojen tukeminen, *Kansantaloustieteellinen aikakauskirja* 109, 3/2013.

Perrels, A. and Tuovinen, T. (2012): "The Effectiveness of Differentiation of the Finnish Car Purchase Tax according to Carbon Dioxide Emission Performance", Government Institute of Economic Research, Research Report 168.

Prime Minister's Office (2000): Environmental and Energy Taxation in Finland - Preparing for the Kyoto Challenge, Summary of the Working Group Report, Prime Minister's Office Publication Series 2000/4

Rauhanen, T., S. Grönberg, J. Harju and T. Matikka (2015): Yritystukien arviointi ja vaikuttavuus, Valtioneuvoston selvitys- ja tutkimustoiminnan julkaisusarja 8/2015.

Rivers, N. and B. Schaufele (2015): "Salience of carbon taxes in the gasoline market", *Journal of Environmental Economics and Management* 74, pp. 23–36.

Sipilä, E., H. Kiuru, S. Tamminen, M. Laukkanen, P. Palonen, N.-O. Nylund and K. Sipilä (2018): Biopolttoaineiden kustannustehokkaat toteutuspolut vuoteen 2030, Valtioneuvoston selvitys- ja tutkimustoiminnan julkaisusarja 63/2018.

Statistics Finland (2018a): Finland's Seventh National Communications under the United Nations Framework Convention on Climate Change, Ministry of the Environment and Statistics Finland, Helsinki.

Statistics Finland (2018b): Suomen kasvihuonekaasupäästöt 1990–2017. Statistics Finland, Helsinki.

Stitzing, R. (2016): Essays on Empirical Microeconomics, Aalto University publication series, Doctoral dissertations 209/2016.

Tekes (2014): Tekesin ja innovaatiotoiminnan vaikutukset 2014, Tekes.

Tervonen, J. and H. Metsäranta (2012): Liikennejärjestelmän tuet, Liikenneviraston tutkimuksia ja selvityksiä 6/2012.

Tietenberg, T. (2013): "Reflections – Carbon Pricing in Practice", *Review of Environmental Economics and Policy* 7(2), 2013, pp. 313-329.

Timilsinas, G. R. (2018): "Where Is the Carbon Tax after Thirty Years of Research?", World Bank Policy Research Working Paper 8493.

Unruh, G.C. (2002): "Escaping carbon lock-in", *Energy Policy* 30: 317–325.

Vehmas, J. (2005): "Energy-related taxation as an environmental policy tool – the Finnish experience 1990–2003", Energy Policy 33 (2005), 2175–2182.

Appendix

TABLE: ENERGY TAXES IN FINLAND 1990-2017, CURRENT PRICES (STATISTICS FINLAND, 2018A, P.141)

Date	Energy taxes, strategic stockpile fees and oil pollution fees *											
	Fuels 1)							Electricity				
								Consumption		Production		
	Motor-gasoline, unlea-ded [2)]	Diesel fuel [3)]	Light fuel oil [12)]	Heavy fuel oil	Hard coal [11)]	Natu-ral gas	Peat	Electricity, I [4)]	Electricity, II [5)]	Nuclear power	Hydro power	Imports
	c/l			c/kg	€/t	c/nm³	€/MWh	c/kWh				
Excise taxes [10)]												
01/01/1990	21.53	16.82	0.34	0.34	2.69	0.17	0.34	-	-	-	-	-
01/01/1995	45.12	27.5	3.02	3.12	19.53	0.94	0.59	-	-	0.4	0.07	0.37
01/07/2005	58.08	31.59	6.71	5.68	43.52	1.82	-	0.73	0.44	-	-	-
01/01/2007	58.08	31.59	6.71	5.68	43.52	1.82	-	0.73	0.22	-	-	-
01/01/2008	62.02	36.05	8.35	6.42	49.32	2.016	-	0.87	0.25	-	-	-
01/01/2011	62.02	36.05	15.7	18.51	126.91	8.94	1.9	1.69	0.69	-	-	-
01/01/2012	64.36	46.6	15.7	18.51	126.91	8.94	1.9	1.69	0.69	-	-	-
01/01/2013	64.36	46.6	15.99	18.93	131.53	11.38	4.9	1.69	0.69	-	-	-
01/01/2014	66.61	49.31	15.99	18.93	131.53	11.38	4.9	1.89	0.69			
01/01/2015	67.45	50.26	18.39	21.84	153.24	15.36	3.4	2.24	0.69			
01/01/2016	67.45	50.26	21.05	25.08	177.36	17.34	3.4	2.24	0.69			
01/04/2016	67.45	50.26	21.05	25.08	177.36	17.34	1.9	2.24	0.69			
01/01/2017	69.57	52.67	22.52	26.83	189.84	18.53	1.9	2.24	0.69			
Energy content tax [8)]												
01/01/2011	50.36	-	7.7	8.79	54.54	3	-	-	-	-	-	-
01/01/2012	50.36	30.7	7.7	8.79	54.54	3	-	-	-	-	-	-
01/01/2013	50.36	30.7	6.65	7.59	47.1	4.45	-	-	-	-	-	-
01/01/2014	50.36	30.7	6.65	7.59	47.1	4.45	-	-	-	-	-	-
01/01/2015	51.2	31.65	6.65	7.59	47.1	6.65	-	-	-	-	-	-
01/01/2016	51.2	31.65	6.65	7.59	47.1	6.65	-	-	-	-	-	-
01/01/2017	52.19	32.77	7.05	8.05	49.93	7.05	-	-	-	-	-	-

Date	Energy taxes, strategic stockpile fees and oil pollution fees *											
	Fuels 1)							Electricity				
								Consumption		Production		
	Motor-gasoline, unlea-ded [2]	Diesel fuel [3]	Light fuel oil [12]	Heavy fuel oil	Hard coal [11]	Natu-ral gas	Peat	Electricity, I [4]	Electricity, II [5]	Nuclear power	Hydro power	Imports
	c/l			c/kg	€/t	c/nm³	€/MWh	c/kWh				
Carbon dioxide tax [9]												
01/01/2011	11.66	-	8	9.72	72.37	5.94	-	-	-	-	-	-
01/01/2012	14	15.9	8	9.72	72.37	5.94	-	-	-	-	-	-
01/01/2013	14	15.9	9.34	11.34	84.43	6.93	-	-	-	-	-	-
01/01/2014	16.25	18.61	9.34	11.34	84.43	6.93	-	-	-	-	-	-
01/01/2015	16.25	18.61	11.74	14.25	106.14	8.71						
01/01/2016	16.25	18.61	14.4	17.49	130.26	10.69						
01/01/2017	17.38	19.9	15.47	18.78	139.91	11.48						
Energy tax [7]												
01/01/2011	-	-	-	-	-	-	1.9	1.69	0.69	-	-	-
01/01/2013	-	-	-	-	-	-	4.9	1.69	0.69			
01/01/2014	-	-	-	-	-	-	4.9	1.89	0.69			
01/01/2015	-	-	-	-	-	-	3.4	2.24	0.69			
01/01/2016	-	-	-	-	-	-	3.4	2.24	0.69			
01/04/2016	-	-	-	-	-	-	1.9	2.24	0.69			
01/01/2017	-	-	-	-	-	-	1.9	2.24	0.69			
Strategic stockpile fees												
01/07/1984	0.72	0.39	0.39	0.32	1.48	-	-	-	-	-	-	-
01/01/1997	0.68	0.35	0.35	0.28	1.18	0.084	-	0.013	0.013	-	-	-
Oil pollution fees [6]												
01/01/1990	0.28	0.031	0.031	0.037	-	-	-	-	-	-	-	-
01/01/2005	0.038	0.042	0.042	0.05	-	-	-	-	-	-	-	-
01/01/2010	0.113	0.126	0.126	0.15	-	-	-	-	-	-	-	-

* see the full tax table: http://ec.europa.eu/taxation_customs/tedb/taxDetails.html?id=4077/1496136747

All rates based on energy content, local emissions and CO_2-emissions. For example liquid biofuels have lower tax rate per litre thanks lower energy content and emissions.

1) Fuels in electricity production tax-exempt since 1 January 1997
2) Reformulated, since 1 January 1993, also sulphur-free since 1 September 2004. Fossil fuel
3) Sulphur-free, sulphur content < 50 ppm since 1 July 1993, sulphur content < 10 ppm since 1 September 2004. Fossil fuel.
4) Tax class I: others
5) Tax class II: industry, data centers, mining, professional greenhouses (also agriculture through tax rebates)
6) Fee for imported oil and oil products: EUR 1.50/t
7) Energy tax included in excise taxes
8) Energy content tax included in excise taxes
9) Carbon dioxide tax included in excise taxes
10) Excise taxes contain energy content tax,, carbon dioxide tax, and energy tax
11) Excise taxes for hard coal is in the heat production. In CHP use excise tax is lower.
12) Fossil fuel.Sulfur free

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SITRA.FI/EN
Itämerenkatu 11-13
PO Box 160
00181 Helsinki
Finland
Tel. +358 294 619 991
@SitraFund