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Designing an electricity tax system in presence of international regulations and multiple public goals:
An empirical assessment

Abstract:
The European competition rules restrict governments' opportunity to differentiate terms of energy accessibility among firms and industries. This easily runs counter with regional and industrial goals of national energy policies. Norway levies a tax on use of electricity, but exempts main industrial usages. This analysis assesses alternative, internationally legal, designs of the system in terms of their effects on efficiency and distribution, including industrial objectives. Among the reforms we explore, removing the exemptions would be the most effective way of raising revenue, but it would be politically costly by deteriorating the competitiveness of today's favoured industries. An entire abolishment of the electricity tax, and replacing revenue by increased VAT, would generate a more equal distribution of standard of living and, at the same time, avoid the trade-off between efficiency and competitiveness.

Keywords: Tax reform; Multiple policy goals; Computable general equilibrium model

JEL classification: D31, D58, F15, H21, H23, J68, L52

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1 Introduction

A typical feature of electricity tax systems has been that exemptions or concessional rates have been granted to certain industries, usages or geographical areas (OECD, 2001). Differentiation is problematic because it distorts competition. European legislation and enforcement authorities go far in prohibiting discriminatory taxation practise among enterprises. This analysis explores possible adaptations of the energy taxation system of a small European economy, Norway, in response to EU's ban on industrial discrimination. Our perspective is the practical of the national policymaker, who makes decisions in a second-best world and has to consider the simultaneous effects on multiple domestic policy objectives.

In common with several countries both inside and outside the European Economic Area, Norway taxes the use of electricity in households and industries (OECD, 2007). Electricity consumption faces a tax of 1.2 Eurocents/KWh. The tax serves more or less explicit public goals. A traditionally cited concern, that had more substance before the recent decades' market liberalisations, was the securing of a sound balance within the market for scarce energy. Often, environmental arguments also back the desire to regulate demand. Most applied energy technologies have negative external effects on nature, health and/or climate. This is also true for Norway. Until today hydroelectric power installations have supplied the Norwegian grids and have caused harm on natural landscapes, waterfalls and rivers. At present, gas power with CO_2 emissions is the marginal Norwegian power technology. Another given argument for taxing energy use is that in policymakers' chase for public revenue, energy stands out as a more acceptable tax base among their voters than alternatives like income or property value (Goulder, 1994).

In order to meet distributive goals in the regional and industrial policy area, exemptions have traditionally been granted to areas in the far north, as well as to the manufacturing sector. The preference of certain sectors is at variance with the EU environmental aid rules of 23 May 2003. Norwegian manufacturers were therefore referred to EFTA's Surveillance Authority (ESA) for illegally receiving aid likely to distort international competition. This in turn led to a temporary exemption from the electricity tax for all commercial undertakings during the first six months of 2004. The last half of 2004, however, saw the enforcement of a tax differentiation scheme based on type of electricity usage – a legitimate construction according to EU rules – rather than type of economic output. The system exploits numerous derogation clauses and temporary provisions in EU law, hence resulting in virtually the same balance of industries and level of revenue as the former system.[1]

This article assesses three alternative systems that also comply with the ESA requirements. We look at their performance in terms of their effects on the following traditional tax policy aims: (i) minimising efficiency costs of generating tax revenue, (ii) maintaining the competitiveness of manufacturing enterprises in peripheral areas, and (iii) promoting a fair real income distribution among households. Energy and environmental policy goals are not considered. While acknowledging environmental externalities from energy production and consumption, we do *a priori* dismiss the electricity tax as a suitable environmental policy instrument, as it does not differentiate between environmentally friendly and harmful use of power. As such it does not offer any encouragement to consumers or producers to opt for environmentally friendly energy. More effective and well-established forms of environmental taxation are available and should be devoted to environmental goals.[2]

Section 2 describes the reforms and assesses them in light of the relevant theoretical rules derived within the literature. While being valuable rules of thumb, stylised results on optimal taxation are not directly applicable within this empirical, multi-goal setting. Only reforms that are politically and practically feasible are real candidates, and their pros and cons in terms of several objectives need to be balanced. In order to study such impacts we apply an empirical macroeconomic model. It is outlined in section 3. We numerically analyse three different adaptations to the EU directives in section 4. The first, *The ordinary tax rate reform*, introduces the current electricity tax rate among all users and usages, including all energy purposes of the manufacturing industries. The second, *The enterprise exemption reform*, excludes all commercial undertakings from the tax base, while the third, *The complete removal reform*, considers a full dismantling of the system. This is the only reform in our study that affects household distribution noteworthy. We, thus, omit other alternatives with potential distributive effects, like progressive systems. We come back to this limitation of our scope in section 4.3. In section 5 we sum up the analyses, and the reforms are compared with respect to the achievements and possible trade-offs they imply.

Our main result is that a complete removal of the electricity tax system financed by an increase in the general VAT complies with all the national policy objectives. We obtain a more equal distribution of

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[1] Other European examples of differentiated tax systems include the Swedish, Dutch and Italian systems (see Norwegian Ministry of Finance, 2004).

[2] There are cases where indirect tax instruments are optimal. However, settings where direct instruments are optimal are more relevant to our case (see the discussion in Green and Sheshinski, 1976).

the standard of living among households at virtually no cost in terms of efficiency losses or changes in the competitiveness of industries. Keeping the electricity tax system, but extending the tax base to all usages, would be the most effective way of raising revenue, but it would be more costly in terms of industrial policy aims and income distribution.

2 Electricity tax reforms and political objectives

All the reforms we study imply shifts in two policy instruments, first, changes in the electricity rates and, second, a budget-balancing change in one other revenue generator. When compared to the *Business-as-Usual (BaU) scenario* (that represents the current differentiated electricity tax system), *The ordinary tax rate reform* comprises:

- *The ordinary rate component:* The manufacturing industries are faced by an electricity tax rate at the same level as the rate already imposed on households and remaining industries.
- *The revenue recycling component:* The revenue is recycled back through a uniform percentage pay roll tax rate decrease for all firms.

The enterprise exemption reform has the following two components:

- *The enterprise exemption component:* The ordinary rate posed on primary industries and service industries is replaced by a zero rate, as already applies to the manufacturing industries.
- *The financing component:* The loss of revenue from exempting enterprises is regained by increasing the percentage VAT rate on all goods.

The two parts comprising *The complete removal reform* are:

- *The complete removal component:* The ordinary rate posed on primary industries, service industries, and households is replaced by a zero rate.
- *The full financing component:* The loss of revenue from dismantling the whole electricity tax system is regained by increasing the percentage VAT rate on all goods.

Though tax revenue is, per definition, unaltered, the reforms imply changes in the composition of tax bases. This has implications for the macroeconomic allocation of resources and thus the efficiency costs of financing public expenditures. Practically all taxation involves efficiency costs. The question is whether other sources of revenue come at a lower socio-economic cost than the differentiated electricity tax system of today.

Economic theory offers some useful rules of thumb on how electricity tax reforms are likely to affect the social cost of collecting revenue. First, the regulatory environment in which firms operate should be the same for all. This point, in isolation, suggests that a uniform rate would be more socially efficient than the current system. This conclusion applies unless market deficiencies or aspects of the political system already divert resources to less productive undertakings and should be corrected by arrangements in favour of the manufacturing sector.

Another theoretical finding suggests that taxing factor inputs should be avoided. To ensure efficient input of resources it might be better to tax household rather than commercial consumption (Diamond and Mirlees, 1971). This favours exempting the business sector from electricity tax, as we do in the second and third reform.

A third point is that taxing consumption, like taxing income, reduces people's time spent on work in favour of more leisure time, see Goulder and Williams (2003). Effective taxation of income from labour in Norway, which comprises direct labour income tax, payroll tax, VAT and other indirect taxes including the electricity tax, is high. Reforms that reduce this tax wedge, or otherwise stimulate labour supply, might therefore reduce the efficiency cost of collecting taxes. In all the systems we study, the electricity tax components in isolation alter the public budget balance and have to be counteracted by changes in other revenue-generating taxes. We look at adjustments in VAT rates and pay roll tax rates, which both take part in the price wedge in the labour market. *Á priori* we can say that reductions in the pay roll tax rate in the first reform will contribute to improve economic efficiency within the labour market and reinforce the welfare gains of equalising electricity tax rates. In the second and third reform the VAT rates are raised. In isolation, this will expectedly reduce the efficiency of time spending.

A fourth principle, which applies to consumption taxes, was articulated initially by Ramsey (1927) and says that inelastic goods like electricity should be taxed at a higher rate than other goods, in order to minimise distortions. The Norwegian indirect tax on household consumption of electricity consists of both the electricity tax and ordinary VAT on consumption, and hence, is in line with this principle. In the third reform we reduce the tax on final consumption of electricity at the cost of increasing the overall VAT rate. According to Ramsey (1927) we should expect an isolated social efficiency loss due to this tax swapping.

These principles of economic efficiency are deduced within simple models under stylised conditions. The design of actual electricity tax systems is, however, restricted by national and international legislation, practicability assessments and political objectives. The efficiency of the electricity tax needs to be considered within the regulatory environment where the reforms take place. We do this by applying a detailed empirical general equilibrium (CGE) model, described in the next section.

Some of the efficiency principles mentioned above seemingly run counter to distributive aims. Industrial and regional distribution motives suggest giving certain industries concessional rates, as opposed to the principle of equal regulatory environments for all. In the Norwegian political setting, there has been a willingness to facilitate the continued competitiveness of the power-intensive productions of metals, chemicals and pulp and paper. Subsequently, these industries have enjoyed several benefits. Besides electricity tax exemptions, they face low-price power contracts, low payroll taxes in the areas they are located, and exemption from CO_2 taxes. Apart from these industries' importance as job creators and prosperity sources in many rural areas, the policy is motivated by their role as prime export industries. Given Norwegian economy's special – some would say exposed – situation with offshore oil and gas as the main sources of foreign exchange, ensuring further competence and viability of exposed mainland sectors is crucial. In section 4 we make use of the macroeconomic model to determine how far alternative electricity tax designs for the commercial sector affect the competitiveness of the power-intensive industry, in particular.

A further distributive issue concerns the electricity tax levied on households. Generally speaking, reducing indirect taxes on goods consumed at a relatively higher rate by low-income households would be beneficial from a redistribution point of view. The wider the gap in budget shares between low- and high-income households, the better the distributive effect. Electricity consumption has relatively high budget shares in low-income households, and stands out as an obvious candidate for tax reduction from a distribution angle. Note that efficiency considerations referred to above came to the opposite result. The literature on optimal taxation finds that necessities should be taxed with higher rates on pure efficiency grounds. However, when equity concerns are introduced, subsidies may render optimal (see Myles 1995). In section 4.3 we analyse the distributive effects of the third *Complete removal reform*, which is the only reform that affect household distribution noteworthy. By comparing the distribution and efficiency effects in money-metric terms we provide a clarification of the trade off between these two concerns.

3 The macroeconomic equilibrium model

3.1 General features

The model is a version of the empirical macro economic model MSG6 of the Norwegian economy. The model is calibrated against the Norwegian national accounts and supplemented with detailed information on energy flows according to the Norwegian energy accounts. The model is disaggregated into 40 private (see Table 1) and 8 governmental production activities and provides a relatively detailed representation of production, consumption, trade and economic policy interventions. It is an equilibrium model in the sense that the determination of market prices clarifies the markets for goods, services and production factors. Products and factors can be moved between applications and across borders. Labour is, however, only mobile domestically. The country participates in the international financial markets and faces an exogenous interest rate. The model provides a relatively exhaustive representation of the policy instruments available to the government, and how they affect private sector behaviour and overall economic welfare in terms of efficiency. Assuming the authorities maintain a balanced budget, changing the electricity tax must be balanced by changes to other budget items. For a more extensive and formal description of the applied model version, confer Bjertnæs and Fæhn (2008).[3]

3.2 Consumer behaviour

Consumption, labour supply, and savings result from the decisions of an infinitely lived representative, forward-looking household, which maximises its welfare, defined as the present value of utility. It can adjust its utility among periods by borrowing or saving at the given interest rate subject to an intertemporal budget constraint. This constraint is derived from an economy-wide intertemporal budget constraint, which follows from not allowing foreign debt or wealth to explode in the long run. The forward-looking behaviour of households provides a consistent welfare measure, defined as the sum of discounted period-specific utilities. Utility in each period depends on the consumption of leisure time, along with consumption of 26 different goods and services (including the energy goods electricity, fuels for heating and fuels for transport), nested in a Origo-adjusted Constant Elasticity of Substitution (OCES) utility tree structure; see Figure 1 (Aasness and Holtsmark, 1995). As the representative agent assumption excludes information on household distribution of income and consumption, our assessment of redistributive effects is based on detailed household information underlying the aggregate representation in MSG6. These data are organised in the micro-simulation

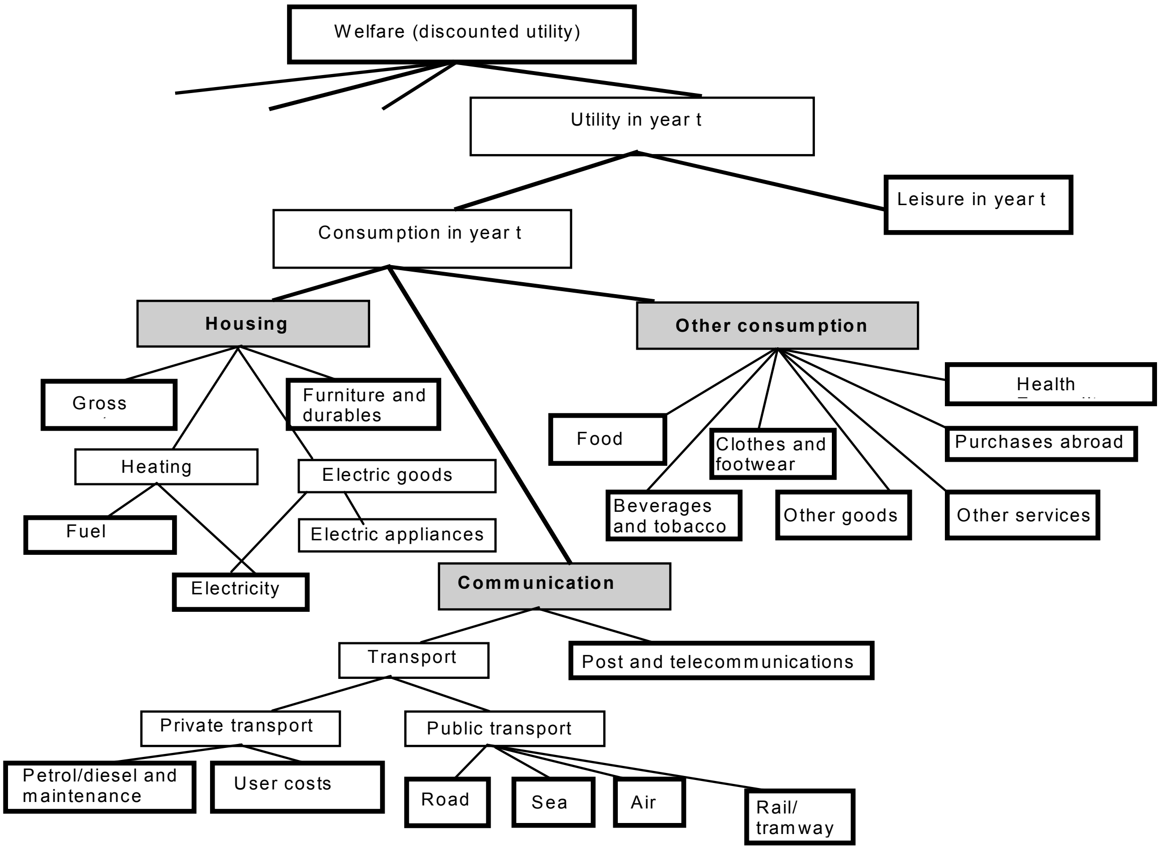
[3] Heide et al. (2004) present a formal, one-sector version.

model, LOTTE (Statistics Norway, 2006). Section 4.3 describes the method of calculating redistributive impacts among income groups.

Table 1: Non-government production activities in MSG6

Agriculture
Forestry
Fishing
Breeding of Fish
Manufacture of Fish Products
Manufacture of Meat and Dairy Products
Production of Grain, Vegetables, Fruit, Oils, etc.
Production of Beverages and Tobacco
Manufacture of Textiles, Apparel, and Footwear
Manufacture of Furniture and Fixtures
Production of Chemical and Mineral Products, incl. Mining and Quarrying
Printing and Publishing
Manufacture of Pulp and Paper Articles
Manufacture of Industrial Chemicals
Gasoline Refining
Diesel Fuel Refining
Heating Fuels, Paraffin, etc. Refining
Manufacture of Metals
Manufacture of Metal Products, Machinery, and Equipment
Hired Work and Repairs
Building of Ships
Manufacture and repair of oil drilling rigs and ships, oil production platforms etc.
Construction, excl. Oil Well Drilling
Ocean Transport – Foreign
Finance and Insurance Servicing
Crude Oil Exploration
Natural Gas Exploration
Servicing in Oil and Gas Exploration
Pipeline Transport of Oil and Gas
Production of Electricity
Power Net Renting
Sales and Distribution of Electricity
Car and Other Land Transportation
Air Transport
Railroads and Electrical Commuters
Ocean Transport – Domestic
Post and Tele Communication
Wholesale and Retail Trade
Dwelling Servicing
Other Private Servicing

Figure 1. The preference structure of the household in the MSG6 model.

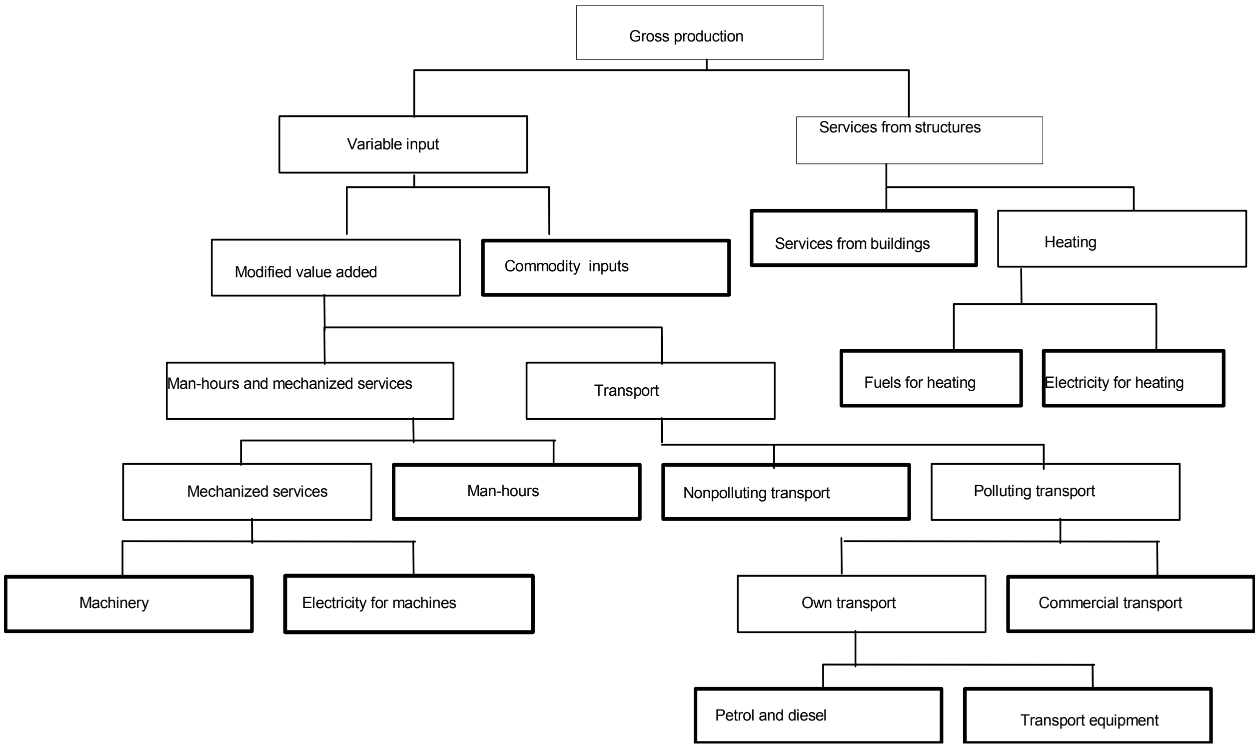


3.3 Producer behaviour, technology and product markets

Producer behaviour is generally specified at the firm level. Managers of firms are assumed to be rational and forward-looking and to maximise the present value of the cashflow to owners. This behaviour implies maximisation of profit in each period, which originates from sales in domestic and export markets net of variable costs and a fixed period-specific investment cost in entrepreneurship (knowledge, network, risk etc.). Variable inputs are nested in a detailed tree-structure of CES-aggregates; see Figure 2, with individual elasticities of substitution at each level (see Mysen (1991) and Alfsen et al. (1996) for their empirical foundation). All factors are completely mobile and malleable, including labour.[4]

[4] One exception is the production of electricity; see Holmøy et al. (1994).

Figure 2: The separable factor use structure of the firms in the MSG6 model.



Each industry consists of numerous companies of varying size and productivity. Thus, production can increase either by increasing within-firm production, where there is decreasing returns to scale[5], or by establishing new firms. Firms enter until after-tax profits of the marginal firm equals zero. The marginal firm is the least effective, thus giving rise to another source of decreasing returns - at the industry level.

Each firm produces one variety of the industry-specific product that is an imperfect substitute for the other varieties. Increasing the use of the product by increasing the number of varieties is assumed to be more efficient than increasing the amounts of the existing varieties. Agents have so-called *love of variety* preferences; see Dixit and Stiglitz (1977). The domestic market structure is assumed to be a large group case of monopolistic competition, where each firm has some market power in their home markets. According to evidence on markup pricing by Norwegian firms (Klette, 1999 and Bowitz and

5 Elasticities of scale are set to 0.83 in all industries, which fit Norwegian econometric findings of moderate decreasing returns (Klette, 1999).

Cappelen, 2001), market power is small; in most industries markups are set to 5 percent of marginal costs.[6]

In the world markets domestic firms have no market power and the prices are assumed unresponsive to domestic demand and supply. Thus, the country cannot have endogenous terms-of-trade gains by adjusting export quantity. The only exception is the Nordic electricity price; see next subsection. The export markets and the home markets are assumed to be partly segregated, in the sense that there are adjustment costs involved in reallocating deliveries between the two markets. This is modelled by a constant-elasticity-of-transformation function, which implies that the production functions for the two markets are separable. Somewhat analogously, domestic and imported products are modelled as imperfectly substitutable, according to the Armington hypothesis. This, along with the segregation assumption of markets, allows the development of the domestic prices to deviate from the exogenous world market prices according to evidence.

There are some exemptions to this general modelling of firms. Relatively homogenous raw materials like oil, natural gas, fish, agricultural products, and electricity are specified at the industry level, rather than firm level. They obtain the same price in domestic and world markets, and the model determines trade in *net* terms, only. Due to heavy policy regulations, production within agriculture, fisheries and offshore oil and gas exploration, along with public servicing, are set exogenously.

3.4 The electricity market

The only international price that responds to changes in domestic behaviour is the electricity price. The Norwegian electricity market is part of a Nordic, competitive market and domestic supply and demand empirically affect the market price. We have introduced an estimated relation in the CGE model between the Nordic price and Norwegian net imports. It predicts that an increase of 1 TWh in net imports increase the Nordic price by 0.03 eurocents/KWh. The estimations are made on simulated data from a numerical, Nordic electricity market model.[7]

The electricity production is modelled in particular detail and engineering data are explored to represent technologies; see Holmøy et al (1994). The current Norwegian supply of electricity is based on hydropower. This supply is assumed to grow exogenously, but at a decreasing rate, to represent the

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[6] The elasticity of substitution among the varieties of a product is calibrated to be consistent with the estimated markup ratios. In order to maximise profits, the firm sets the markup ratio equal to $\sigma/(\sigma-1)$, where σ is the substitution elasticity among varieties.

[7] Aune and Hansen (2008) document the estimations, while Johnsen (1998) documents the Nordic electricity market model.

limited possibility to develop new hydropower capacity. Along the paths, gas power capacity is endogenously faced in as a back- stop technology when the marginal willingness to pay for electricity equals or exceeds the long-run marginal cost of expanding the gas power that includes investment costs.

Domestic demand for electricity is the sum of demand from each production and consumption sector. Market equilibrium requires that domestic demand equals the sum of domestic supply and net import. This implies that before gas power is faced in, harmonisation of the electricity tax limits domestic demand and stimulates net export accordingly. In later stages, when gas power is the marginal technology, domestic electricity generation contracts, and more of the available Norwegian gas is exported.

3.5 The government

The government collects taxes, distributes transfers, and purchases goods and services from the industries and abroad. Overall government expenditure is exogenous and increases at a constant rate. The model incorporates a detailed account of the government's revenues and expenditures. In the policy experiments it is required that the nominal deficit and real government spending follow the same path as in the baseline scenario, implying revenue neutrality in each period.

4 Numerical results

4.1 Reform 1: The ordinary tax rate reform

4.1.1 Main allocative and macroeconomic effects

As outlined in section 2, *The ordinary tax rate reform* has two components, an increase to the ordinary electricity tax rate in manufacturing industries, and a cut in the pay roll tax rates of all enterprises. The direct effect of the former is to increase the input prices of electricity by 1.2 Eurocents/KWh, measured in 1999 prices. This represents a 30 per cent electricity price increase in most manufacturing industries along the path. For the power-intensive manufacturing industries the percentage price increase is larger as they initially enjoy low electricity prices. This is partly due to lower distribution costs per KWh, and partly due to favourable long-term price contracts with the government (that expire in 2010-2012). In the first year, the direct price increase averages 60 percent for the power-intensive manufacturing industries, while the increase is 47 percent on average in the long run. The revenue recycling reduces the payroll tax rate by between 5 and 6 percent along the path.

The results of the equilibrium responses to these changes are summed up in Table 2.[8] The two reform components have opposite effects on domestic prices. The electricity tax increase implies a contraction of output in the power-reliant manufacturing industries. Their subsequent drop in input demand causes decreased pre-tax electricity prices, wages and other factor prices. Since the power-reliant manufacturing industries are important export revenue generators, a real depreciation has to take place in the long run, also explaining the fall in domestic factor prices.[9] The revenue recycling counteracts the wage rate reductions, both by increasing labour demand and by improving the competitiveness of domestic firms. The net effect of the total reform is, nevertheless, to reduce domestic wages by 0.7% in the long run; see Table 2.

The demand reductions in the Nordic electricity market are significant. The Norwegian production of gas power is reduced, and the introduction is postponed by 5 years (from 2012 to 2017). Norwegian net electricity export increases. The price responses in the Nordic markets are substantial in the first 15 years. However, after about 15 years the electricity price remains virtually unaffected. At that stage, gas power represents the marginal source in the Nordic market, and the costs of gas power do not respond to the Norwegian reform.

Long run GDP falls by 0.35 per cent. While a small reduction of labour supply of 0.06 per cent follows the wage drop, the main explanation to lower production is a fall in the aggregate capital stock of 0.38 percent. The capital demand is seriously affected by the downscaling of the electricity-intensive export sector and the gas power generation, which are both highly capital-intensive.

Table 2 *The ordinary tax rate reform*: main economic effects. Percentage deviation from BaU.

Period	2005	2015	Steady state
Payroll tax rate	-5.4	-5.8	-5.6
Pre-tax electricity price	-18.2	-4.7	-0.9
Nominal wage rate to workers	-0.3	-0.7	-0.7
Consumer price index	-0.6	-0.7	-0.8
Production in power-intensive manufacturing	-12.0	-12.1	-20.0
Production of electricity	1.3	-4.0	-8.9
GDP	0.04	-0.11	-0.35
Real capital	0.08	-0.27	-0.38
Consumption	0.05	0.06	0.09
Labour supply	0.09	-0.04	-0.06
Utility	0.00	0.05	0.08
Export	-0.93	-1.11	-4.20
Import	-1.30	-1.45	-1.26

[8] A more thorough description of the macroeconomic responses of the model is available in Bjertnæs and Fæhn (2008).

[9] The nominal exchange rate is numeraire in the model.

Consumption of goods and services is allowed to increase in this economy, as resources are diverted from export production. In the long run, consumption increases 0.09 per cent at the expense of export, which falls by 4.20 per cent. Utility of the representative consumer increases by 0.08 per cent in the long run, both due to increased consumption and increased leisure.

4.1.2 Costs of revenue generation

As this reform involves a widening of the base of the ordinary electricity tax rate, the government can for a given budget reduce revenue from other tax bases. The efficiency aim of the government weighs towards picking a tax that is presumably already inefficiently high. We have chosen the pay roll tax, motivated by the initial considerable marginal tax on labour.

The simulations reveal that this tax shifting increases social efficiency, measured as the welfare of the representative household, by 0.04 per cent. Measured in per capita terms, this amounts to 29.1 € as an annual average.[10] The welfare effect was expected to be small, as the reform involves but minor changes in the tax systems. The modest effect is also a result of various allocations pulling welfare in opposite directions. The main positive contributions are reductions of two tax wedges in the economy, the initial electricity price discrimination among industries and the taxation of labour income. The reform is also associated with a modest terms-of-trade loss in the electricity market that pulls the welfare downwards. As Norway is a net exporter of electricity in this reform scenario, the Nordic price decrease of electricity generates a terms-of-trade loss.

Analysing the effects of the electricity tax component, in isolation, reveals that only a quarter of the welfare gain is due to this component, while the residual ¾ stems from adding the pay roll tax recycling. Still, the positive outcome of uniforming the electricity tax rate, *per se*, indicates that the recommendation from the theoretical literature of striving to equalise regulatory interventions among firms also applies in the empirical Norwegian economic setting. The gain is caused mainly by the reforms' effect of diverting electricity and other resources from the power-intensive sector, where social returns are low in consequence of industrial policy, as well as narrow margins in export production. This confirms results from other applied studies of industrial policy measures provided for the power-intensive sector. Bye and Nyborg, 2003 find that exempting these industries from the ordinary CO_2 tax is inefficient for the economy at large, while Bye et al., 1999 find similar results with respect to the sector's low-price power contracts. The gains of re-injecting resources into the economy

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[10] This is computed by dividing the present value of the welfare (at a discount rate equal to the interest rate) by 4.6m inhabitants.

via pay roll tax reductions are mainly explained by the reduction of the high effective tax rate on labour.[11] Besides reducing the tax wedge, this, in isolation, increases the labour supply. While the labour supply reaction to the electricity tax change is to drop by 0.21 per cent in the long run, most of this is offset by the pay roll tax reduction.

The welfare computations we make rest on the assumption that resources can move costlessly among industries; see section 3. By this, we omit short-term adjustment costs associated with reallocations. In practice we know that restructuring takes time and that unemployment and other unutilised resources represent costs in connection with such processes. Fehr and Hjørungdal (1999) analyse adjustment costs in affected Norwegian regions associated with standardising the price of electricity. They find that restructuring capacity is good for most of the regions, while certain municipalities are less resilient. Lessons from other restructuring processes show, according to the study, that restructuring can indeed proceed quickly and painlessly.

4.1.3 Impact on industrial distribution and competitiveness

ESA's objection concerns the favourable treatment of the exposed domestic manufacturing sector. One of our questions is therefore to what degree compliance with the EU law will have to damage competitiveness of this sector. Competitiveness can be viewed from different angles. We let *international competitiveness* mean the ability of Norwegian firms to compete in terms of cost with foreign firms in the same industry. We also speak of an industry's *domestic competitiveness* as its ability to access domestic resources relative to other industries.

The direct impact of including the manufacturing sector into the ordinary tax base is to raise the costs of the firms, especially of the power-intensive. However, before concluding on the likely effects on their competitiveness, we also need to understand how the reforms affect the remaining economy. First, changes in other parts of the economy may eventually feed back to the manufacturing firms through altered prices. The most important factors would be changes in the pre-tax price of power, along with changes in other factor prices in response to cost, substitution and demand effects in a range of markets. Second, in order to assess the impact on domestic competitiveness, we need to decide how the manufacturing industry is affected relative to other industries. For the moment we let other areas of the tax system proceed unchanged, and transfer the extra tax revenue directly to the household sector.

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[11] In a CGE study using the same model MSG6, Holmøy and Strøm (2004) show that the marginal cost of funds are more or less identical by use of VAT and payroll tax. Both recycling mechanisms reduce the effective taxation of labour.

Table 3 reports long-term results of the model analysis. Column I shows the relative changes in the industries' international competitiveness defined as the relation between the producer price abroad and at home. This ratio will correspond to the relative marginal cost level, as the markups are constant. If the domestic price level falls, competitiveness rises, and Norwegian firms will claim a larger share of the home market (column II) and of the external market, measured as percentage changes in Norwegian exports (column III). These changes will be mirrored by the relative change in the industry's ability to attract domestic resources, reflected by its activity level as a share of the total economic activity (column V). Relative changes in domestic competitiveness depend on the cost changes relative to that of the economy as a whole (column IV)[12].

Table 3: *The ordinary tax rate reform*: long-term competitiveness and market share effects. Percentage deviation from BaU.

	International competitiveness			Domestic competitiveness	
	I Competitiveness[a]	**II** Domestic market shares[b]	**III** Export	**IV** Competitiveness[a]	**V** Production share[c]
Power intensive manufactures	-2.21	-0.19	-21.84	-3.10	-19.65
Other manufactures	0.64	0.70	1.01	-0.20	1.55
Raw materials and services	1.01	0.23	1.01	0.15	1.19
Electricity	-	-	-	0.03	-6.40

[a] Changes in international competitiveness are defined as the changes in the relative marginal cost levels abroad and at home, while changes in domestic competitiveness measure the cost level changes in the industry relative to that of the economy at large.

[b] Domestic market share changes are changes in deliveries from domestic producers relative to imports.

[c] Production share changes are operationalised as the changes in industry output levels relative to economy-wide output.

-: Not defined.

As Table 3 shows, imposing the ordinary tax rate on all industries, including the manufacturing industries, will deteriorate the competitiveness of the power-intensive sector, as expected, and shrink the market shares abroad and at home. In particular, the production of goods for export will fall drastically. The impact on the rest of the manufacturing industries – which also enjoy electricity tax exemptions before the reform – would be much less dramatic. In fact, over the longer term other manufacturing industries would see a slight *improvement* to its international competitiveness as falling wage levels would eventually outweigh the effect of the electricity tax rise. Other factor inputs, such as capital, will partly be imported at unaffected foreign prices, and experience a more temperate fall in price. The reform would hence stimulate relatively labour-intensive undertakings most. The model is based on today's industry pattern and current technological evidence. How this labour-intensive part of the economy will look like in the distant future, is of course difficult to say. New activities could spring up and existing ones disappear.

[12] This is measured as the producer price at home for the sector relative to a production-weighted average price for the whole economy, from which we omitted the oil and gas sector.

The fact that the producer price of power falls in this reform (see Table 2), reflects that some of the higher tax burden is shifted on to power suppliers in the Nordic market. The international competitiveness of Norwegian power producers is not affected, because the producer price reduction applies to *all* competitors in the Nordic market. But the domestic competitiveness of the Norwegian power producers will be impaired. First, the highly capital-intensive nature of the power sector means domestic competitiveness would be harmed by wage rates falling more than rates on capital. Second, they will suffer from that part of the willingness to pay for electricity goes to paying higher taxes rather than underwriting power production costs. These effects combine to reduce power production's share of Norwegian production activity (column V).

In this analysis, we have not taken into account that some of the extra tax revenue from extending the tax base could be devoted to keep up the competitiveness of the power-intensive manufacturing sector. We address various forms of compensation to the power-intensive sector in Bjertnæs and Fæhn (2008) and Bjertnæs (2005). The findings suggest that at least 50 per cent of the efficiency gain connected with introducing ordinary tax rates in the manufacturing sector could be retained, even after compensation.[13] Although these results at first glance diminish the force of the competitiveness argument of tax-exempting the manufacturing sector, the studied compensation schemes are stylised illustrations that lend little attention to juridical or practical aspects. We cannot, therefore, conclude on this basis that industry policy goals can, in practice, be achieved without erasing the entire efficiency gain of extending the tax base.

4.2 Reform 2: The enterprise exemption reform

4.2.1 Main allocative and macroeconomic effects

All enterprises are exempted from the electricity tax system in this reform, thus reducing the tax burden on primary industries and service producers. The direct effect is to decrease the input prices of electricity by 1.2 Eurocents/KWh in these productions, measured in 1999 prices. The loss of revenue is regained by increasing the percentage VAT rate on all goods, and in the long run it increases by 0.8 percent, as reflected in Table 4.

Domestic input prices tend to increase, as is seen for both the pre-tax electricity price and the wage rate in Table 4. The reason is increased pressure in the factor markets when the tax burden on

[13] In terms of wages or capital income saved, the compensations can nevertheless be regarded substantial. The schemes studied in Bjertnæs (2005) do, for example, cost up to 25,000€ per job saved.

enterprises in the primary and service industries is relieved. The opposite impulse from higher VAT rates does not fully offset this. Electricity demand stimulates domestic electricity production. As for the previous reform, the Nordic electricity price responds most markedly in the earlier periods, and we see a crowding-out of net export during the first 15 years.

Table 4: *The enterprise exemption reform*: main economic effects. Percentage deviation from BaU.

	2005	2015	Steady state
VAT tax rate	1.4	1.3	0.8
Pre-tax electricity price	0.8	0.0	0.0
Nominal wage rate to workers	0.1	0.1	0.1
Consumer price index	-0.0	0.0	0.0
Production of electricity	0.4	1.2	1.3
GDP	0.06	0.06	0.04
Real capital	0.23	0.24	0.17
Consumption	0.00	0.00	0.02
Labour supply	-0.01	0.00	-0.00
Utility	0.00	0.00	0.01
Export	–0.01	0.01	0.01
Import	-0.02	0.02	0.03

The macroeconomic changes are even smaller than found in the previous reform case. GDP increases slightly, as do exports and consumption in the long run. Long run utility shows a very modest increase. This is explained by more consumption, while leisure (and labour supply) is virtually unaffected.

4.2.2 Costs of revenue generation

As we saw in the previous reform case, harmonising the electricity tax contributes positively to efficiency. Harmonising the tax among industries at a zero rate results in an efficiency gain of 0.01 per cent, or 8.6 € annually per capita on average compared to a differentiated system. Besides the effects of harmonisation, the gain reflects a terms-of-trade gain stemming from increased export prices of electricity and a slight increase in labour supply. The gain is about the double of the gain we found in case of harmonising at the ordinary tax rate. However, this doubling only reflects that the drop in the public budgets is not yet offset by costly tax funding.

We take financing into account by increasing the VAT rates proportionally.[14] This causes the efficiency gain to fall to a fifth, or to an annual average of 1.8 € per person. It is nevertheless positive,

[14] The VAT rates in the system of 1999 varied to a larger degree than today. Most importantly, services had zero rates.

indicating that exempting the industry is not more costly than maintaining the current tax rules. It has virtually no effect on labour supply, but provides a minor terms-of-trade gain through higher export prices of electricity. It is also worth noting that the reform implies a shift of tax burden from input factors to consumer goods. The positive welfare outcome provides some support for the principle of letting consumers bear the brunt of commodity taxation via VAT rather than taxing inputs (cf. Diamond and Mirlees, 1971).

4.2.3 Impact on industrial distribution and competitiveness

The main purpose of the current discriminatory system is to facilitate competitive conditions for the power-intensive export industries. *The enterprise exemption reform* does not alter their electricity tax rates. However, we also need to understand how the reforms affect the remaining economy and cause feedbacks into the power-intensive manufacturing before concluding on the effects on their competitiveness.

Table 5 shows the competitiveness impacts of the enterprise exemption component. The changes are small both in terms of international and domestic competitiveness of Norwegian firms. The direct effect of the tax reductions is to stimulate firms within the primary and tertiary sectors, but usually their electricity input constitutes small fractions of total costs. Thus, we see only modest pressure on the labour force and a slight wage rate increase. Nor does the change in taxation have much of an effect on the pre-tax price of power. Consequently, we see only marginal skewing of the domestic resource distribution in the direction of raw material production, servicing and power production. The fall in international competitiveness for the power-intensive manufacturing sector is minimal, and in the long run we even find a slight improvement of competitiveness in the foreign markets, which reflects that lowered prices on domestic services benefit the export industries. Removing the tax on all commercial electricity use thus seems to succeed well in giving attention to the competitiveness of the manufacturing sector.

Table 5: *The enterprise exemption reform*: long-term competitiveness and market share effects. Percentage deviation from BaU.

	International competitiveness			Domestic competitiveness	
	I Competitive-ness[a]	**II** Domestic market shares[b]	**III** Export	**IV** Competitive-ness[a]	**V** Production share[c]
Power intensive manufactures	-0.01	-0.02	0.04	-0.07	-0.04
Other manufactures	-0.01	-0.02	0.03	-0.07	-0.04
Raw materials and services	0.08	0.03	0.26	0.02	0.02
Electricity	-	-	-	-0.06	1.46

[a] Changes in international competitiveness are defined as the changes in the relative marginal cost levels abroad and at home, while changes in domestic competitiveness measure the cost level changes in the industry relative to that of the economy at large.

[b] Domestic market share changes are changes in deliveries from domestic producers relative to imports.

[c] Production share changes are operationalised as the changes in industry output levels relative to economy-wide output.

-: Not defined.

4.3 Reform 3: The complete removal reform

4.3.1 Main allocative and macroeconomic effects

The first round effect of removing the electricity tax completely is a reduction in the household price of electricity in addition to the input cost reductions within servicing and primary production. The increase in demand for electricity gives an impetus to domestic power generation and reduces net export. These effects are stronger than in the case of enterprise exemptions, only, but still modest due to relatively low price elasticity of household demand.

Some main economic responses are reported in Table 6. The increase in demand for electricity leads to a marginal increase in the Nordic price of electricity, but even in the short run, only about 5 per cent of the tax reduction accrues to producers through higher prices. In the long run, as elaborated above, the producer price is virtually unaffected, and the whole tax cut benefits the consumers that directly face the tax removal.

The loss of revenue is regained by a uniform percentage increase of the VAT rates on goods and services. In the long run it increases by 4.3 percent. The VAT component contributes to increase consumer prices, and in equilibrium this more than offsets the consumer price reductions caused by the electricity tax removal so that the consumer price index increases. This effect is stronger than the positive effect on wages and results in lower real wages and a subsequent labour supply decrease. GDP falls marginally in the long run, as does consumption. Due to a small increase in leisure, long run utility does not decrease.

Table 6: *The complete removal reform:* economic effects; percentage deviation from BaU.

Period	2005	2015	Steady state
VAT tax rate	5.1	5.0	4.3
Pre-tax electricity price	2.1	0.1	0.2
Nominal wage rate to workers	0.0	0.1	0.1
Consumer price index	0.3	0.3	0.2
Production of electricity	1.4	4.4	6.8
GDP	-0.02	0.02	-0.02
Real capital	0.09	0.18	0.10
Consumption	-0.05	-0.04	-0.00
Labour supply	-0.11	-0.07	-0.05
Utility	0.00	-0.01	0.01
Export	–0.02	0.04	0.06
Import	0.01	0.00	0.00

4.3.2 Costs of revenue generation

When we remove tax on electricity use within households in addition to enterprises, while maintaining revenue levels by increasing the VAT rates, the efficiency gain compared to BaU is half that of exempting enterprises, only. In actual per capita numbers, it is reduced from 1.8 to 0.9 € on average per year. This loss to the economy is consistent with the so-called Ramsey efficiency principle, according to which the consumption of relatively inelastic goods – like electricity – represents the best candidates for taxation. Bye and Åvitsland (2008) confirm that this is a property of the model we use. The loss is further explained insofar as labour supply falls as VAT rates rise. The reform accentuates the inefficiency stemming from the fact that a high efficient tax on labour in the first place has resulted in an already sub-optimally low labour supply from a social point of view. Nevertheless, as there seems to be a net gain, though small, of removing the system completely, our analysis indicates that the revenue argument is not a particularly cogent justification for retaining the differentiated electricity tax as a source of revenue.

4.3.3 Impact on household distribution

From a redistributive perspective, imposing relatively low consumer taxes on electricity would be beneficial. Since electricity expenses constitute relatively high budget shares in low-income households, we would expect these households to gain the most from the tax removal reform; see section 2. This section sets out to quantify the redistributive effect of *the complete removal reform*, when the VAT funding is taken into consideration.

The model used above in analysing impacts on efficiency and industry patterns is not suitable for studying income-distributional aspects of reforms, the reason being its assumption of a representative household; see section 3. We therefore supplement those simulations with an analysis of the income effects within different income categories of the consumer price changes derived above. By quantifying the amount of money redistributed from more and less wealthy individuals, we obtain comparable measures of the achievements of the reform in terms of efficiency and redistribution.

We use three household categories: poor (P), intermediate (M), and wealthy (R). The information on consumption and characteristics of households within these categories is collected from the micro simulation model LOTTE-Konsum 1999, cf. Statistics Norway (2006). It is calibrated against the base year macro figures used in our macro model. The micro simulation model contains 26,825 individuals in 9,964 households, weighted so that they satisfactorily represent the population of Norway across many dimensions. All households are ranked by a measure of the living standard (total consumption spending divided by consumption units on the OECD scale). Table 7 sets out the basic data and calculated results. P's expenses on electricity (1. row) and in total (2. row) equal average expenses of the 20 per cent of households in the lowest living standard bracket. R's are the expenses of the 20 per cent of households in the highest living standard bracket, while M's expenses correspond to those of the remaining 60 per cent.

Over the longer term, after gas power has been phased in, the producer price of electricity will remain unchanged and the entire electricity tax cut will manifest into reduced household prices. By removing the electricity tax of 1.2 Eurocents/KWh plus the VAT imposed on it at 0.3 Eurocents/KWh, we obtain a price fall of 1.5 Eurocents/KWh, or 20 per cent. In these calculations we assume that the expenses related to electricity falls proportionally to the price by holding use of electricity in each household group fixed. The gain of removing the tax will then be as reported in third row of Table 7. The loss of revenue is neutralised by a uniform increase of the VAT rate. We assume further that the rise in expenses caused by higher VAT rates is proportional to total consumer spending.

Table 7. ***The complete removal reform*****: distributive effects among households. 1999 €.**[a]

	Household P	Household M	Household R
Total consumption expenses	15,737	33,276	58,806
Electricity expenses	721	990	1,271
Gain from removal of electricity tax	142	194	250
Loss due to increased VAT	88	186	328
Total effect of reform	54	8	-78
No. of persons per household	1.8	2.3	2.0
Total effect per person	29	4	-39

[a] The figures in rows 1, 2, and 6 are based on the micro-simulation model LOTTE-Konsum 1999, with the method applied by Schroyen and Aasness (2006, Table A2). P = the 20 per cent of Norwegian households with the lowest standard of living, R= the 20 per cent with the highest, and M= the remaining 60 per cent.

The P household spends most of its budget on electricity and benefits more from the tax removal than it loses due to increased VAT. Overall gain per person is 29€. The wealthy household spends least of its budget on electricity and would benefit less from the removal of the tax than it loses because of the rise in VAT. In all, R households forfeit 39€ per person. The middle class (M) benefits slightly from the reform as a whole, 4€ per person.

Our calculations indicate that if Norway rescinded the electricity tax and balanced the loss by raising VAT, the distributive effect would be beneficial. These results seem qualitatively robust to several departures from the original set of assumptions. As we have already argued, the producer price of electricity is insensitive to reduced taxes, also in the shorter term, so that the short-term distributive effect is almost the same as the long-term effect estimated in table 7. Schroyen and Aasness (2006) employ the same microsimulation model but estimate a decile table instead of the simple threefold division used in table 7. Their findings support our main result. Using a similar microsimulation model, Aasness et al. (2002) estimated an inequality measure for the whole population and also found a favourable distributive effect of a combination of lower electricity tax and higher VAT.

Income elasticity for electricity for a household can be defined as the change in per cent of electricity consumption when income (or total consumption expenses) rises by 1 per cent, all other relevant factors being constant. This quantity could be a useful indicator of distribution (see Aasness, 1998, and Aasness and Røed Larsen, 2003). A number of estimates have been run on this type of income elasticity of electricity on data obtained by Norwegian consumer surveys from 1967 to the present (see for instance Biørn, 1978, Aasness, 1998, and Halvorsen et al., 2005). All demonstrate an income elasticity well below 0.5. This suggests that electricity should be taxed lightly from a distributive point of view. They also confirm the result's robustness to changes in income levels and relative prices. However, tests of even lower electricity taxation of households shows that more redistribution will come at the cost of efficiency losses. Recall from the preceding section (4.3.2) that the present reform implies but a very slight welfare gain compared to BaU, due to negative efficiency contributions from substituting general VAT taxation for household electricity taxation. Going further in that direction very soon brings us into ranches where the negative efficiency effects dominate.[15]

We should point out that we are only analysing the effects of reducing current proportional electricity tax rates, replacing them with increased VAT rates. Introducing a system of progressive electricity taxes for the household sector has been proposed, with rates tracking electricity consumption. Amenable to several designs, it would make it possible, in principle, to assuage the negative distributive effects of electricity taxes, even indeed to make distributive effects positive (see Aasness, 1998). It was, however, considered administratively costly and inaccurate as a distributive measure by a government commission set up to examine progressive electricity taxes for the household sector (Norwegian Ministry of Finance, 2004). We have not attempted to analyse these issues. For an inclusive assessment of the distributive effects of various instruments, we refer the reader to Aasness et al. (2002).

5 Conclusions

The main motivation for a reform of the Norwegian electricity tax system in 2004 was to satisfy the ESA requirements of non-discrimination among enterprises. In order to keep up the competitiveness of energy-dependent industries, as well as the public revenues from electricity taxation, a complicated legal system was implemented. In this study we ask whether there are other reform alternatives worth considering, when taking into account conflicting concerns among several public goals and among numerous mechanisms within a realistic economy riddled with imperfections and existing tax wedges. This analysis helps sorting out which economic principles that are at work and come to dominate in the alternative cases, and it concludes on the rounded goal achievements of the reforms.

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[15] Simulations of a twice as large cut in consumers' electricity tax at the expense of even higher rates on remaining goods, yields a distinct welfare loss, equivalent to 11.2 € yearly per capita.

The first reform alternative, which imposes the same tax rate on the manufacturing industries as applies in general, involves the most challenging political trade-offs. On the one hand, the reform violates the expressed governmental objective of keeping up the competitiveness of the power-intensive industries. On the other hand, even though this could involve transitional efficiency costs associated with restructuring of the private sector, we find that the long run economic efficiency improves. This is especially clear when the extra revenue is used to replace former labour taxation. In other words, the revenue generation argument goes in favour of two recommendations from the theoretical literature of, firstly, harmonising tax conditions among enterprises, and, secondly, reducing labour taxation.

In order to avoid the trade-off above, our results suggest a second reform alternative, where tax exemption is provided for all commercial undertakings at the cost of higher VAT rates. This ensures an industrial distribution in agreement with the expressed industrial and regional aims of the government. At the same time, efficiency is found to increase. Thus, again our findings leave no support to the argument that the current discriminatory system should be preserved for public financial reasons. There are benefits from harmonising tax conditions among industries, and these turn out to dominate the increased distortions caused by higher VAT rates, not least through increasing labour taxation and reducing labour supply. An additional positive effect not included is a probable saving of administration costs, as the current system has become fairly detailed in order to comply with the EU legislation. All in all, exempting the commercial sector stands out as a good alternative to the current usage-based tax differentiation system.

The third reform study is primarily motivated by the anticipated favourable redistributive effects. It involves extending the tax elimination to also embrace households, while increasing VAT rates further. This reform seems able to achieve all the goals we have focused on. It satisfies the ESA requirements of non-discrimination, preserves the competitiveness of the power-intensive sector, while at the same time shows favourable efficiency and distributive effects. It looks as if the authorities will not need to weigh and prioritise the different goals we have examined. It is nevertheless worth noting that our results reflect the predicted conflict between taxation principles for efficiency and equity concerns, respectively. Equity principles propose relatively *lenient* taxation of goods with high budget shares in low-income households, like electricity. Opposed to this, the Ramsey efficiency principle proposes to tax necessities with relatively *high* rates. While satisfying the equity principle, the efficiency principle is violated when moving from the second to the third reform scenario. This violation, along with efficiency losses of higher VAT rates through a further discouragement of labour supply, bisects the efficiency gain, but still leaves it positive when compared with the current system.

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