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Author: Bjertnæs, Geir H.

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Avoiding Adverse Employment Effects from Electricity Taxation in Norway: What does it cost?

By Geir H. Bjertnæs, Statistics Norway, Research Department. Telephone +4721094430.E-

mail: ghb@ssb.no

Abstract:

Welfare analyses of energy taxes typically show that systems with uniform rates perform better than differentiated systems. However, most western countries include some exemptions for their energy-intensive export industries and thereby avoid this potential welfare gain. Böhringer and Rutherford (1997) find that uniform taxation of carbon emissions in combination with a wage subsidy preserves jobs in these industries at a lower welfare cost compared with a differentiated system. The wage subsidy scheme generates a substantial welfare gain per job saved. This study, however, finds that welfare costs are substantial when less accurate policy measures, represented by production-dependent subsidies, protect jobs in Norwegian electricity-intensive industries. The welfare cost per job preserved by this subsidy scheme amounts to approximately 60 percent of the wage cost per job, suggesting that these jobs are expensive to preserve. A uniform electricity tax combined with production-dependent subsidies preserves jobs at a lower welfare cost compared with the current differentiated electricity tax system.

Keywords: Energy taxes, Political feasibility, Competitiveness, CGE models

JEL classification: F41, H21, Q43, Q48

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1. Introduction

While discriminatory energy taxation may to some degree be legitimised for welfare reasons (see, e.g., Richter and Schneider, 2003), most of the empirical literature indicates that the existing exemptions and tax rebates tend to be costly compared with uniform systems (Ballard and Shoven, 1987; Böhringer and Rutherford, 1997; Bye and Nyborg, 2003). Despite these findings, several countries have exempted energy-intensive export industries from energy taxation; see OECD (1995). The

potential loss of competitiveness, and hence the down scaling of industry, creates political pressure from unions, local governments, and political parties aimed at preserving employment in these industries. Studies of the trade-offs between overall efficiency and political pressure aimed at preserving employment in the energy industry find that uniform energy taxation combined with a wage subsidy scheme outperforms a differentiated energy tax system in terms of efficiencyⁱ; see Böhringer and Rutherford (1997) for the German case, and Felder and Schleiniger (2002) for the Swiss case. The main explanation for this finding is that compared with a differentiated energy tax system, the more targeted wage subsidy schemes generate smaller distortions between sectors and reduce distortion in the labour market. Böhringer and Rutherford (1997) also argue that wage subsidies generate an increase in capital use in the rest of the economy, thereby indirectly offsetting some of the excess burden of capital taxes within the German economy. These improvements in efficiency result in a substantial welfare gain per job saved by the German wage subsidy scheme.

While EU pressure against discriminatory policies excludes direct wage subsidies to specific sectors, there are a range of policy measures that offer substantial support to specific sectors, which are judged legitimate within the EU system. These measures include subsidies for transport in rural areas, transitory support schemes, and differentiation of taxes/subsidies according to type of activityⁱⁱ (see <http://www.regjeringen.no/nb/sok.html?id=86008&quicksearch=esa> for a discussion of Norwegian measures). Faced with fewer and less accurate national policy measures, the welfare costs of job-preserving subsidy schemes are likely to increase. Hence, research on job-preserving subsidy schemes that face less resistance within the EU is warranted.

In this study, we consider a subsidy scheme representing EU-legal measures to preserve employment in electricity intensive industries, and we analyse the result and trade-offs between efficiency gains from uniform electricity tax reform and local employment concerns. The reference reform and computable general equilibrium (CGE) model of Bjertnæs and Fæhn (2008), which calculates the

welfare gains of extending the current Norwegian electricity tax base to include electricity consumption in the manufacturing industry, is employed as a reference reform. This reform is accompanied by production-dependent subsidies designed to preserve the initial level of employment in electricity-intensive industries within the present studyⁱⁱⁱ. These sector-specific subsidies constitute a simple and tractable way of introducing a package of EU-legal subsidy schemes into a CGE model framework. Relevant details connected to each specific EU-legal policy measure are excluded to capture the common effects of such measures. Some of the revenue generated by the electricity tax reform is used to finance the subsidy scheme, while the remaining revenue is recycled through a percentage cut in the payroll tax rate to all firms. The introduction of the electricity tax increases welfare by removing one of several favourable policy measures in this industry; however, the production subsidies constitute a new favourable measure, which decreases welfare. About half of the revenue generated is recycled through a reduction in the payroll tax. The revenue recycling lowers the substantial tax wedge in the labour market and hence increases welfare. Overall, these policies increase welfare. Hence, a uniform electricity tax combined with production-dependent subsidies preserves jobs at a lower welfare cost compared with the current differentiated electricity tax system. This finding is consistent with previous results.

To further illuminate the trade-offs between efficiency and local/regional employment concerns, this study compares the welfare costs of preventing job loss by imposing the subsidy scheme with the costs of preserving the existing exemptions of the electricity tax system. The welfare gain of extending the current Norwegian electricity tax base to include electricity consumption in the manufacturing industry, divided by the number of full-time jobs removed annually from this industry equals 432,000 NOK^{iv}, or 1.5 times the average wage cost. The welfare loss of introducing the subsidy scheme^v, divided by the number of full-time jobs saved annually by the subsidy scheme in the electricity-intensive industry amounts to approximately 174,000 NOK. These welfare costs per job are substantial, even though transaction costs connected to inflexible capital and labour markets are not

included in the calculations. In contrast, Böhringer and Rutherford (1997) report a substantial welfare gain per job that is preserved by their wage subsidy scheme. The results of Böhringer and Rutherford (1997) seem to rely on a considerable welfare gain generated by capital expansion within the non-energy sectors. This welfare gain is not supported by empirical evidence, nor do they offer a theory to support it. The results of Böhringer and Rutherford (1997), however, are not directly comparable to the results in this study. First, Böhringer and Rutherford study a German carbon tax combined with wage subsidies, while this study focuses on a Norwegian tax on electricity consumption combined with sector-specific production-dependent subsidies. The agents and variables affected by these reforms differ substantially. Hence, the economic effects are likely to differ. Second, the analysis in Böhringer and Rutherford is conducted within a static framework, while the present study is conducted within a dynamic framework. The dynamic approach captures differences in the short and long run response of the Nordic price of electricity. Such equilibrium responses affect the number of jobs lost when electricity taxes are increased. These features are not captured by the static approach. The substantial difference in results supports the view that each job-preserving policy scheme requires a separate study. General results on the welfare effects of job-preserving subsidy schemes are not likely to prevail as each case is different. This study, however, discovers a case where the job-preserving scheme is costly for the society. Such cases are neglected by the previous literature.

The paper is organised as follows. Section 2 presents some background information and the methodological aspects of the analysis, including the basic features of the CGE model. Section 3 outlines and explains the results while section 4 concludes.

2. Method and model

2.1. Background

The main objective of this analysis is to calculate the welfare effect of a subsidy scheme designed to preserve employment in Norwegian electricity-intensive industries when a uniform electricity tax is introduced. Previous analyses indicate that trade-offs between efficiency and political feasibility are relevant to the Norwegian electricity policy. Bye et al. (1999) find that imposing a uniform electricity price would improve welfare, but would do so at the expense of electricity-intensive industry sectors. The flexibility of the local labour market, however, is crucial for the effects on welfare and the unemployment outcome. Bye (2000) finds that restrictions on the mobility of labour in the energy industry, combined with wage rigidity, are likely to erode most of the potential welfare gains associated with a uniform CO₂ tax reform in the Norwegian economy.

Political pressure against adverse employment effects resulting from electricity taxation is likely to be larger in the short and medium run than the long run. The local labour market is less flexible in the short and medium run because firms can resort to voluntary quits in the long run. Fehr and Hjørungdal (1999) find that short and medium run flexibility in local labour markets, in combination with government actions, is likely to result in modest job search costs in most local communities in the event of an electricity price increase in Norwegian electricity-intensive industries. A sensitivity test shows that the welfare costs per job preserved do not differ significantly from the results derived when the subsidy schemes are time constrained.

The electricity-intensive sectors comprising the industries *Manufacture of Metals (43)*, *Manufacture of Pulp and Paper Articles (37)*, and *Manufacture of Industrial Chemicals (37)* are responsible for almost 1/3 of the total electricity consumption in Norway, and they generate about 10-15 percent of the total export revenues (including oil and gas). At present, these industries enjoy several favourable policy

measures, including low payroll taxes due to their rural locations^{vi}, low electricity prices due to favourable long-term power contracts, and exemptions from energy taxes; both the consumer tax on electricity and the CO₂ tax. Because these industry sectors predominantly use hydropower, this analysis focuses on the electricity tax system.^{vii} In the present system, final consumers, primary industries, and service industries, including transportation and construction, pay an electricity tax rate of 0.095 NOK/KWh^{viii}, while all manufacturing industries are exempted.

2.2. The design of the analysis

All our reform scenarios are changes from a business-as-usual (BAU) scenario. The BAU is a projection of the Norwegian economy, where all exogenous variables are set in accordance with the reference scenario in the Long Term Program of the Norwegian government; see Norwegian Ministry of Finance (2001). Policy variables are kept at their real 1999 levels. The government's budget balance is maintained at the BAU level in all our scenarios.

In the *reference reform* scenario, the current electricity tax exemptions of the manufacturing industries are abolished. Compared with the BAU scenario, the *reference reform* consists of two components:

- i) *the electricity tax component*, where the manufacturing industries are faced with an electricity tax at the same level as the tax already imposed on households and remaining industries, and
- ii) *the electricity tax revenue recycling component*, where the revenue is recycled back to representative consumers through a uniform percentage pay roll tax rate decrease for firms in all sectors. The government's budget is balanced by this adjustment in the pay roll tax.

In the *job-preserving reform* scenario, the same electricity tax reform is accompanied by production-dependent subsidies designed to preserve employment within each of the electricity-intensive export sectors. Thus, compared with the BAU scenario, the *job-preserving reform* scenario will influence two additional components: iii) *the production subsidy component*, where production in each of the

electricity-intensive export sectors is subsidised to preserve the BAU level of employment in these sectors in each future period, and *iv) the subsidy financing component*, where the subsidy scheme is financed by lowering the cut in the payroll tax rate. This will result in a smaller percentage payroll tax rate decrease compared with the decrease in *the reference reform*. The government's budget is balanced by this adjustment in the payroll tax.

The two components in the subsidy scheme are considered separately by simulating the *subsidy financing* scenario, where the electricity tax reform in the *reference reform* scenario is accompanied by *the subsidy financing component*. The cut in the payroll tax is the same as in the *job-preserving reform* scenario, but there are no production subsidies. The remaining revenue from the uniform electricity tax is transferred as a lump sum to the representative consumer. The government's budget is balanced by this lump sum transfer. Hence, the reform consists of components *i)*, *ii)*, and *iv)*. The objective of this scenario is to quantify the shadow cost of this smaller reduction of the payroll tax rate when the subsidy scheme is introduced. Reforms and components are presented in table I.

Table I: Reforms and components.

Reform:	<i>Reference reform</i>	<i>Job-preserving reform</i>	<i>Subsidy financing scenario</i>
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Component:			
<i>The electricity tax component</i>	x	x	X
<i>The electricity tax revenue recycling component</i>	x	x	X
<i>The production subsidy component</i>		x	
<i>The subsidy financing component</i>		x	X

2.3. Basic features of the computable general equilibrium model

2.2.1. General features

The numerical intertemporal general equilibrium model of the Norwegian economy gives a detailed description of the structures of economic policy, production, and consumption in the Norwegian economy. The model has 41 private and 8 governmental production activities; see Table III in the appendix. Fæhn and Holmøy (2000) have provided an extensive verbal description of the model. Heide et al. (2004) present a formal one-sector version. The model assumes completely flexible markets in all communities, and zero transaction costs connected to inflexible capital and labour markets. Consequently, there is no local unemployment, and the reported welfare gains due to the electricity tax reform do not include transaction costs connected to inflexible capital and labour markets.

2.2.2. Consumer behaviour

In this model, consumption, labour supply, and savings result from the decisions of an infinitely lived forward-looking representative household that maximises the present value of utility by borrowing or lending, subject to an intertemporal budget constraint. This constraint is derived from an economy-wide intertemporal budget constraint that follows from not allowing foreign debt or wealth to explode

in the long run. This requires that the discounted value of each period's net imports equal initial net claims on foreigners. The constraint implies that the current account must be zero in the long run. The forward-looking behaviour of households provides a consistent welfare measure, defined as the sum of discounted period-specific utilities. This measure is determined by a money-metric volume indicator for consumption measured in utility units, derived by deflating the current consumption expenditure by the costs of living index. Utility in each period originates from material consumption and leisure consumption and is specified by an origo-adjusted Constant Elasticity of Substitution (CES) function, where material consumption is allocated across 26 different consumer goods and services in a nested structure; see Aasness and Holtsmark (1995) and Bye and Holmøy (1997). The origo adjustment allows income elasticities to vary among goods. Domestic and imported products are imperfect substitutes according to the Armington hypothesis. The price of imported products is fixed. Hence, changes in relative prices between domestic and imported goods are generated by changes in the price of domestic goods. All prices, however, are treated as exogenous by the representative consumer.

2.2.3. Producer behaviour, technology and product markets

Producer behaviour is generally specified at the firm level. The manager of the firm is assumed to be rational and forward-looking and to maximise the present value of the cash flow to owners; for details, see Holmøy et al. (1993) and Holmøy et al. (1994). The production technology is described by the CES tree structure in figure I in the appendix. There are decreasing returns to scale in the composite factor input. All the factors are completely mobile and malleable^{ix}.

The domestic market structure is assumed to be a large group case of monopolistic competition, where each firm has some market power in their respective home markets. According to evidence on mark-up pricing by Norwegian firms (see Klette, 1999; Bowitz and Cappelen, 2001), market power is small; most industry mark-ups are set to 5 percent. Each firm produces a variety of a product that is an imperfect substitute for other varieties of this product (represented by Spence-Dixit-Stiglitz

preferences). The elasticity of substitution among the varieties of a product is calibrated to be consistent with the estimated mark-up ratios.^x

World prices are assumed to be unresponsive to domestic demand and supply. The export markets and the home markets are assumed to be segregated because of firms' adjustment costs of reallocating deliveries between the two markets. The production of each domestic variety is determined so that domestic demand equals domestic supply, given that the prices of each domestic variety are set equal to the marginal cost plus the mark-up factor. The production of export deliveries is determined so that the marginal cost equals the world market price. The export and import of goods within the same category of products are treated as separate goods because such products tend to differ substantially despite belonging to the same category. Firms are heterogeneous with respect to productivity. An entry/exit condition determines the number of firms in an industry so that the net profit of the least productive firm equals a fixed entry cost.

The only net-export price that responds to changes in domestic behaviour is the electricity price. The Norwegian electricity market is part of a Nordic competitive market where domestic supply and demand affect the common Nordic market price. The relation between the Nordic electricity price, and Norwegian net imports, is consistent with a numerical Nordic electricity market model^{xi}; a net import increase of 1 TWh increases the Nordic price by 0.03 eurocents/KWh. The Norwegian supply of electricity is based on hydropower, which is fixed, and gas power, which is implemented as a backstop technology. The supply of gas power is assumed to expand when the Nordic price of electricity exceeds the cost of investing and producing gas power. Existing gas power plants produce electricity as long as the Nordic price of electricity exceeds variable production costs. A more detailed description of the electricity market is found in Bjertnæs and Fæhn (2008).

2.2.4. The government

The government collects taxes, distributes transfers, and purchases goods and services from the local industries and abroad. The total government consumption 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.

3. Results

3.1. The Reference Reform: Effects of equalising the electricity tax

This section outlines the main effects of the *reference reform*, while a more detailed description is given in Bjertnæs and Fæhn (2008).

The direct increase in the input prices of electricity of 0.095 NOK/KWh, measured in 1999 NOK, represents a 30 percent price increase in most manufacturing industries along the path. For the energy-intensive export industries, the percentage price increase is larger because they initially enjoy low electricity prices, partly because of lower distribution costs per KWh, and partly because of favourable long-term price contracts with the government. In the first year, the direct price increase averages 60 percent for the energy-intensive export sector, while the average increase is 47 percent in the long run. The initial effect of the revenue recycling is to reduce the payroll tax rate by about 6 percent (i.e., from 13.1 percent to about 12.3 percent).

The responses to these reform elements are reported in table II. The down scaling of the electricity-intensive export industries contributes to a current account deficit. The payroll tax cut, which leads to a cost reduction, is not sufficient to neutralise the current account deficit. The equilibrium wage rate is pushed down to increase the export of labour intensive products and to lower imports because the

wage drop leads to lower domestic prices. Hence, the drop in the wage rate contributes to balance the current account. The downscaling of the electricity-intensive export sectors, together with the gas power generation, has strong implications for capital demand because these sectors are highly capital-intensive. Thus, investments fall: the aggregate capital stock falls by 0.38 percent in the long run. This, along with a 0.06 percent reduction of labour supply due to the wage fall, explains the longrun GDP fall of 0.35 percent. The GDP fall only constitutes about 1/5 of the reduction in gross production, while 4/5 of the reduction originates from a fall in intermediate goods. This mostly takes place in the electricity-intensive export sector, whereas other industries, including several manufacturing industries, increase their output. All industries, except the electricity-intensive export sector, face cost reductions due to a lower wage cost, reduced prices of capital goods and intermediates and reductions in the Nordic electricity price. The latter takes place as a consequence of the downscaling of the electricity-intensive export sector, which leads to a substantial reduction in electricity demand.

The price increase on electricity used in the manufacturing industry has led firms in electricity-intensive industries to substitute electricity-intensive machinery with labour. This explains why their percentage fall in employment only constitutes about half of their percentage fall in production. An increase in net electricity export in the short run reduces the Nordic price of electricity. The reduction in the Nordic price of electricity moderates both this substitution effect and the downscaling effect. A price increase on domestic electricity-intensive goods also tends to moderate the downscaling effect. Overall, about 2400 full time jobs are reallocated away from electricity intensive industries in 2010, increasing to approximately 3600 in 2030.

The welfare gain of this *reference reform* measured as the present value of utility changes in all periods is 0.04 percent, which is substantially lower than the long-run impact on the utility level. The reduction in consumer prices on leisure and material consumption is more modest in the earlier

periods. Hence, a substitution of consumption of leisure, goods and services takes place towards later periods.

The small welfare effect is due to both small effects on resource allocations as well as various allocation effects pulling in opposing directions. The main contributors are reductions of two tax wedges in the economy that, in isolation, tend to improve welfare. The first is the initial electricity price discrimination between different industries. The second is the reduction of the, initially large, tax wedge on labour income. The reform is also associated with a modest terms-of-trade loss in the electricity market that pulls the welfare gain downwards. Because Norway is a net exporter of electricity in the reference reform scenario, the Nordic price decrease of electricity generates a terms-of-trade loss. Note that the theory of optimal second best policy (Lipsey and Lancaster (1956)) is unable to determine whether an equalisation of electricity tax rates, which implements partial production efficiency with respect to electricity, implies a gain or loss of welfare.

Table II: Effects of the reference reform, the job-preserving reform, and the subsidy financing reform (% changes from the BAU scenario).

Year	Reference reform			Job-saving reform			Subsidy financing reform		
	2010	2030	Steady st	2010	2030	Steady st	2010	2030	Steady st
GDP	-0.02	-0.17	-0.35	-0.02	-0.12	-0.16	-0.06	-0.26	-0.44
Material cons.	0.03	0.09	0.09	0.03	0.05	0.04	-0.04	-0.01	-0.01
Labour supply	0.07	-0.02	-0.06	0.04	-0.02	-0.00	0.02	-0.13	-0.13
Full* consumption	-0.005	0.056	0.077	-0.008	0.030	0.029	-0.022	0.038	0.048
Wage rate, consumers	-0.33	-0.63	-0.70	-0.11	-0.25	-0.22	-0.56	-0.94	-0.94
Price, mater. cons.	-0.52	-0.74	-0.77	-0.26	-0.31	-0.29	-0.53	-0.72	-0.76
Export	-0.87	-2.22	-4.20	-0.54	-1.18	-1.81	-0.91	-2.36	-4.28
Import	-1.00	-1.52	-1.26	-0.54	-0.76	-0.54	-1.05	-1.59	-1.3
Payroll tax rate	-5.2	-7.0	-5.6	-2.8	-3.2	-2.8	-2.8	-3.2	-2.8
Labour force, Manu.metals	-7.1	-13.3	-21.1	0	0	0	-7.1	-13.5	-21.2
Gross prod.Manu. metals	-14.4	-21.5	-27.6	-9.2	-11.5	-11.9	-14.4	-21.6	-27.6
Electr.price Manu.metals	36.3	49.9	49.6	38.5	50.5	50.4	36.2	49.9	49.6
Electr.use Manu.metals	-30.4	-40.8	-46.1	-25.8	-39.8	-45.9	-30.4	-40.9	-46.2

*Full consumption constitutes a composite of material consumption and leisure.

3.2. The job-preserving reform scenario: Effects of the subsidy scheme

3.2.1. Effects of the subsidy scheme

The *job-preserving reform* scenario contains two additional components, *the production subsidy component (iii)* and *the subsidy financing component (iv)*, besides those already present in the *reference reform* scenario. Comparing the welfare levels in these two scenarios reveals the total

welfare costs of preserving the BAU-level of employment in energy-intensive industries with the implemented subsidy scheme.

The simulations reveal that the welfare gain of the *job-preserving reform* scenario amounts to 60 percent of the welfare gain of the *reference reform* scenario. Hence, 40 percent of the welfare gain generated by the electricity tax reform is lost when the subsidy scheme is introduced.

The *subsidy financing* scenario decreases the effects of the subsidy scheme by comparing this scenario with the *reference reform* scenario and the *job-preserving reform* scenario, respectively. The *subsidy financing* scenario includes the electricity tax reform components in addition to the *subsidy financing component*. The latter component consists of setting the payroll tax rate decrease to be identical to the payroll tax rate decrease in the *job-preserving reform* scenario, and transferring the remaining revenue lumpsum to the representative consumer. Hence, no subsidies are introduced to prevent a fall in employment in electricity-intensive industries in this scenario. The effects of the electricity tax reform components are analysed in section 3.1 and will not be repeated here.

3.2.2. Effects of the subsidy financing component:

Comparing the *subsidy financing* scenario with the *reference reform* scenario reveals the effects of the *subsidy financing component*. This component consists of a higher overall payroll tax rate, where the consequently higher revenues are transferred lump-sum to the representative consumer.

The first round effect of the higher payroll tax rate in the *subsidy financing* scenario is an increase in labour costs, which reduces production, especially in exports where product prices are exogenously determined in the world market. The cost increase is shifted on to domestic prices, inducing substitution towards imports. These effects lead to a current account deficit and excess labour supply. Comparing simulations of the *subsidy financing* scenario with the *reference reform* scenario shows

that the general equilibrium effect on the steady state wage rate is a reduction of 0.24 percent (from 0.94 percent to 0.70 percent; see table II). The cost decrease due to the wage rate reduction reduces the cost increase resulting from the higher payroll tax rate, which contributes to restore international competitiveness. Some of the cost decrease is shifted on to domestic prices, which leads to substitutions of imports for domestic goods. The external balance is restored at a slightly lower level of both exports and imports. The price on material consumption is almost unaffected, and the real wage rate is therefore reduced. This results in a modest reduction in the aggregate labour supply. The reduction in the wage rate contributes to increase production, especially export production, which increases the demand for labour. This contributes to restore equilibrium in the labour market.

Comparing the welfare level in the *subsidy financing* scenario with that in the *reference reform* scenario shows that raising revenue through uniform payroll tax increases to finance the subsidy scheme results in a welfare cost that amounts to 44 percent of the welfare gain in the *reference reform* scenario. This welfare cost is explained by the reduction in labour supply in combination with a large tax wedge between material consumption and leisure^{xii}. Raising revenues by adjusting other tax rates would have changed the welfare cost according to the marginal cost of public funds that are attached to these tax rates. A detailed discussion of the marginal cost of public funds within the MSG6 model is found in Holmøy and Strøm (1997).

The revenue recycling effect is crucial for the welfare effects of the subsidy scheme because 44 percent of the welfare gain in the *reference reform* is lost when approximately half of the revenue generated is no longer recycled as percentage cuts in the payroll tax rate. The magnitude of the production subsidies needed to preserve employment in electricity-intensive industries determines the amount of revenue needed to finance the subsidy scheme. The level of the production subsidies needed to preserve employment in electricity-intensive industries is determined by the employment effects of both the electricity tax reform and the subsidy scheme. The electricity tax reform has led firms in

electricity-intensive industries to substitute away from electricity-intensive machinery towards more labour-intensive production; see figure I in the appendix. The pre-tax price decrease of electricity in early decades has moderated the down-scaling effect and, thus, the fall in employment. The fall in electricity prices generates a substitution effect away from labour towards electricity-intensive machinery. However, the latter effect is weaker, and the reduction in employment is more modest in early decades compared with later decades. Consequently, the need for subsidies is more modest in early decades, and a smaller part of the revenues generated by the electricity tax reform is redistributed in the subsidy scheme in early decades. These effects have moderated the percentage of employment decreases in these industries, which only amounts to a little over half of the percentage fall in production. This explains why only about half of the revenue generated by the electricity tax reform is recycled through the subsidy scheme, while the remainder is recycled through cuts in the payroll tax rate.

3.2.3. Effects of the production subsidy component:

The effects of the *production subsidy component* financed by lump sum taxation are found by comparing the *job-preserving reform* scenario with the *subsidy financing* scenario. Both the electricity tax reform and the payroll tax rate decrease are identical in both scenarios. The only difference between the scenarios is the *production subsidy component* in the *job-preserving reform* scenario, whereas the equivalent amount of revenue is transferred lump sum in the *subsidy financing* scenario.

In the *job-preserving reform* scenario, production-dependent subsidies are introduced to neutralise the adverse employment effects in energy-intensive industries. The first round effects of introducing production-dependent subsidies in electricity-intensive industries are a cost reduction and a subsequent up-scaling of production, which result in excess labour demand and the accumulation of foreign assets. The resulting steady state wage rate increase is determined by comparing the *job-preserving reform* scenario with the *subsidy financing* scenario. It shows that the steady state wage rate increases by 0.72

percent (from - 0.94 to - 0.22 percent, see table II). There is a marginal decrease in steady state full consumption though present value welfare increases slightly. The wage rate increase contributes to restore the external balance by reducing export and raising import shares. The wage increase also reduces the excess labour demand through both supply and demand effects.

The welfare effect of the *production subsidy component* (with lump-sum financing) amounts to only 4-5 percent of the welfare gain in the *reference reform* scenario. The increase in labour supply contributes positively because of the large tax wedge between leisure and material consumption. However, the substantial expansion of electricity-intensive industries contributes negatively because of favourable taxation, long-term power contracts, and low payroll taxes motivated by their peripheral location and exemption from the CO₂ tax on process-related emissions.

3.3. The welfare cost of saving jobs

3.3.1. The welfare costs

The welfare cost of introducing a job-preserving subsidy scheme may exceed the welfare cost of alternative policies designed to relieve local and regional employment concerns. A reallocation of labour into other sectors is one alternative. To further illuminate the trade-offs between efficiency and local/regional employment concerns, this study calculates the potential welfare gain per job removed from the electricity-intensive sectors due to the imposition of uniform electricity tax reform. The welfare gain of the *reference reform* is divided by the number of full time jobs reallocated away from electricity-intensive industries as a result of the reform. Future full time jobs are weighted with the discount factor of the economy to get a welfare measure per full time job reallocated away from electricity-intensive industries to other sectors. The resulting welfare gain per full time job amounts to 432,000 NOK, which is about 1.5 times the average wage cost. The welfare cost per job saved by the

subsidy scheme is given by the welfare cost of the subsidy scheme introduced in the *job-preserving reform* scenario divided by the number of (weighted) full time jobs reallocated back to electricity-intensive industries. This amounts to 174,000 NOK per full time job preserved in electricity-intensive industries.

3.3.2. A comparison with previous studies

Comparing our results with those derived by Böhringer and Rutherford (1997) reveals substantial differences. First, the two analyses focus on different economies and different types of energy tax bases. Böhringer and Rutherford (1997) study three CO₂ tax reform scenarios, where each scenario is designed to achieve identical emission targets. They find that introducing uniform emission taxation satisfies emission targets at a lower welfare cost compared with a scenario where energy intensive export industries are exempted from the emission tax, which is consistent with the results of this study. However, a uniform emission tax combined with a wage subsidy designed to preserve employment in energy intensive export industries satisfies emission targets at a lower welfare cost compared with the scenario with uniform emission taxation. The lower welfare cost amounts to a gain of more than 10,000 Deutch Mark per job saved in energy-intensive export industries. This result holds when the generated tax revenues are recycled to balance the government budget through lump-sum transfers, wage tax cuts, or capital tax cuts. This result contrasts sharply with the welfare cost of 174,000 NOK per job saved that we report in this study. It should be noted that in Böhringer and Rutherford's study the wage subsidy scheme scenario requires a higher tax rate on CO₂ emissions compared with the scenario with uniform rates. This higher emission tax rate, which also leads to more revenue recycling, increases the welfare cost and does not therefore explain the gain per job saved. The explanation offered is rather that the wage subsidy scheme is "Pareto-superior due to second-best effects. First, direct wage subsidies lower the distortionary effects of labor taxation. Second, wage subsidies... cause an increase in capital use in the rest of the economy, thereby indirectly offsetting some of the excess burden of capital taxation". Note that the excess burden of capital taxation is reported to be twice as

large as the excess burden of labour taxation. In contrast, the production subsidy scheme of this study reallocates resources towards electricity-intensive industries, which is less productive because of other favourable conditions. The production subsidies indirectly contribute to lower the distortion in the labour market; however, the welfare cost of raising revenue to finance the subsidies by far exceeds the gain of introducing the subsidies.

3.3.3. Labour market rigidities

The welfare gain of removing exemptions within the electricity tax system (given by *the reference scenario*) is likely to diminish when rigidities in the labour market are considered. Rigidities in the labour market prevent labour from being freely allocated into other productive sectors. Hence, potential welfare gains connected to the reallocation of labour are diminished; see Bye (2000). The welfare gain of removing exemptions within the electricity tax system combined with production-dependent subsidies designed to preserve employment in electricity-intensive sectors (i.e., *the job-preserving reform scenario*) is not affected by rigidities within the labour market connected to these sectors. The reason for this is that there is no reallocation of labour as jobs are preserved within this scenario. Hence, the welfare gain of *the job-preserving reform scenario* is unaffected by such rigidities. The reported welfare costs per job saved, however, are likely to diminish when rigidities are incorporated. The cost is likely to diminish because reallocation of labour becomes more costly. Hence, saving jobs becomes less costly from the point of view of a social planner.

4. Conclusion

Welfare analyses of energy taxes typically show that systems with uniform rates perform better than differentiated systems. However, most western countries include some exemptions for their energy-intensive export industries and thus avoid this potential welfare gain. Studies of the trade-off between overall efficiency and political pressure aimed at preserving employment in the energy industry find

that uniform energy taxation combined with a wage subsidy scheme outperform a differentiated energy tax system in terms of efficiency; see Böhringer and Rutherford (1997) for the German case, and Felder and Schleiniger (2002) for the Swiss case. This study contributes to the literature by analysing the trade-off between efficiency gains from a uniform electricity tax reform and local employment concerns, when production-dependent subsidies are introduced to preserve employment in Norwegian electricity-intensive industries. We find that a uniform electricity tax combined with production-dependent subsidies preserves jobs at a lower welfare cost compared with the current differentiated electricity tax system. However, preserving these jobs is found to be costly. The welfare cost per job preserved by the subsidy scheme amounts to 174,000 NOK or approximately 60 percent of the wage cost per job. In contrast, Böhringer and Rutherford (1997) report a welfare gain per job preserved by their wage subsidy scheme. Hence, government actions to create new jobs might be a desirable alternative.

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ⁱ Several studies find that a modest share of the welfare gain generated by imposing uniform energy taxation or removing existing tax exemptions is lost when subsidy and transfer schemes are used to preserve equity values in the energy industry, rather than preserving employment; see Bovenberg and Goulder (2001) for the US case, Vollebergh et al. (1997) for the EU case, and Bjertnæs and Fæhn (2008) for the Norwegian case.

ⁱⁱ The former Norwegian electricity tax system, which was banned by the EU because of differentiation between sectors, is very similar to the present and legal electricity tax system which differentiates according to activity where electricity used for manufacturing is exempted.

ⁱⁱⁱ Bjertnæs and Fæhn (2008) examine the social costs of compensating electricity-intensive export industries in Norway for their profit losses due to the imposition of the same electricity tax on all industries. The social costs are modest because the tax increase is partly neutralised by a drop in the Nordic price of electricity, and because compensation can be designed to release productivity gains.

^{iv} The exchange rate equalled 8.41 NOK/Euro in December 2009.

^v The level of welfare with uniform taxation of electricity combined with the subsidy scheme minus the level of welfare with uniform taxation of electricity.

^{vi} This type of differentiation is included in this study because the EU is likely to accept this type of policy from 2007.

^{vii} Compared with CO₂ taxes, the arguments in favor of taxing electricity in Norway are based less on environmental reasoning and more on a question of raising public revenue. The effects on foreign emissions (carbon leakage) are of course a challenge when a single country's actions are considered.

^{viii} This equals approximately 1.1 Eurocents/KWh when 1 EUR = 8.41 NOK.

^{ix} One exception is the production of electricity; see Holmøy et al. (1994).

^x To maximize profits, the firm sets the markup ratio equal to $\sigma/(\sigma-1)$, where σ is the substitution elasticity among varieties.

^{xi} Johnsen (1998) documents the Nordic electricity market model. See Holmøy et al. (1994) for a detailed description of the domestic supply and demand for electricity.

^{xii} The elements in this tax wedge are a marginal tax on labour income (approximately 40 percent on average), indirect consumer taxes (including an average VAT of 22 percent), the payroll tax (averaging about 13 percent in the BAU system), and a 5 percent markup in the domestic industry.

Appendix: Exogenous estimates of the BAU scenario

The BAU scenario is a growth path for the Norwegian economy from 1999 to 2050. Variables in the base year, 1999, are calibrated to the Norwegian National Account. This base year data is somewhat

old and is a drawback for the present study. This base year, however, does not suffer from odd circumstances or radical business cycles. The BAU growth path is generated by incorporating estimates of exogenous parameters. The endogenous BAU variables are generated by solving the model when these exogenous BAU parameters are incorporated. Most exogenous estimates in the BAU scenario are drawn from the baseline scenario in the Long Term Program (LTP) for Norway; see the Norwegian Ministry of Finance (2001) for detailed documentation. Exogenous factors primarily include policy variables, world market assumptions, population growth, technological change, and the development of the exogenously determined industries, the most important being the public sector and offshore oil and gas production. Policy variables are kept at their (real) 1999 levels and, in particular, all manufacturing industries are exempted from the electricity tax in the BAU. World market prices increase 1.5% yearly. While the population growth rate is estimated to be 0.44% as an annual average during the next five decades, the corresponding rate of growth of the workforce is only expected to be 0.29% because of an ageing population. A Hicks-neutral technological change of 1.3% annually is assumed in the private industries; in the public sector, the rate is 50% lower. Factor inputs in the public sector grow by 0.9% as a yearly average. Norwegian income depends heavily on oil and gas exploitation. The offshore sector is characterised by a significant annual downscaling of 2% on average during the period. Oil and gas prices are expected to grow somewhat faster than other world market prices, on average 1.7% annually. To a large extent, the former natural resource wealth will be turned into financial assets to ensure that Norway has a substantial currency income flow in the future. The return flow is based on a 7.3% international interest rate.

Tables and figures

Table III: Nongovernment production activities in MSG-6

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 I: The separable factor use structure of the firms in MSG-6

