The Excess Cost of Supplementary Constraints in Climate Policy: The Case of Sweden's Energy Intensity Target

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Sammanfattning[1]

Riksdagen antog år 2009 två kvantitativa mål för energipolitiken: dels ett mål för energiintensiteten i den samlade produktionen (BNP) och dels ett mål för andelen förnybar energi av den totala energianvändningen. Å ena sidan kan införandet av mål för användningen och tillförseln av energi uppfattas som naturligt med tanke på den koppling som finns mellan energianvändning och utsläpp av växthusgaser. Å andra sidan kan sådana mål vara restriktioner för styrningen mot klimatmålet, det vill säga krav på i vilken omfattning minskad energiförbrukning respektive bränslekonvertering ska användas för att uppnå klimatmålet. Sådana restriktioner innebär sannolikt att klimatpolitiken fördyras.

Det svenska energiintensitetsmålet innebär att energiintensiteten år 2020 ska vara 20 procent lägre än år 2008. Den gängse uppfattningen har varit att detta mål är lätt att uppnå, i synnerhet i beaktande av förväntningar på ekonomisk tillväxt och den framtida klimatpolitiken. Om energiintensitetsmålet uppnås inom ramen för klimatpolitiken innebär det inga ytterligare kostnader för samhället utöver de som klimatmålet leder till. Däremot, om energiintensitetsmålet är högt satt innebär det extra kostnader för samhället och kan i praktiken också innebära en skärpning av klimatpolitiken. Det är därför relevant att uppskatta hur stor den samhällsekonomiska kostnaden är för att ha ett särskilt mål för energiintensiteten.

Det övergripande syftet med denna rapport är att studera de samhällsekonomiska kostnaderna för att uppnå både energiintensitetsmålet och klimatmålet via förändrade koldioxid- och energiskatter. Analysen vilar på insikten att klimat- och energiskatterna till stora delar har gemensamma skattebaser och därför styr mot båda målen. Användandet av ekonomiska styrmedel för att uppnå utsläppsmål och mål för specifik resursförbrukning, till exempel energi, har ett brett stöd i den ekonomiska litteraturen och ligger väl i linje med den färdplan som stakats ut för den sammanhållna klimat- och energipolitiken. Regeringen har emellertid redan beslutat om informationsinsatser, investeringsstöd och en ny period av programmet för energieffektivisering i industrin (PFE). Dessa åtgärder kommer tillsammans med åtgärder som beslutats på EU-nivå att minska behovet av att höja klimat-

[1] Sammanfattningen överensstämmer till stora delar med den som återfinns i en rapport från 2010 som Konjunkturinstitutet författade till Expertgruppen för miljöstudier - ”Målet för energieffektivisering fördyrar klimatpolitiken”.

och energiskatterna. Därmed är inte sagt att strategin är billigare än den skattestyrning som studeras i den här rapporten.

I rapporten analyseras de samhällsekonomiska kostnaderna av olika nivåer på klimat- och energiskatterna i termer av påverkan på BNP år 2020. För att beakta relevanta effekter på energianvändning och utsläpp, samt övriga effekter på ekonomin används Konjunkturinstitutets allmänjämviktsmodell EMEC. Den kvantitativa analysen utgår ifrån ett basscenario som är i linje med förväntningarna på den ekonomiska utvecklingen utifrån det aktuella ekonomiska läget år 2008. Eftersom förväntningarna på den ekonomiska utvecklingen har förändrats till följd av den internationella finanskrisen genomförs en känslighetsanalys som beaktar detta. Analysen utgår också från den färdplan för klimatpolitiken som stakades ut i propositionerna om en sammanhållen klimat- och energipolitik. Utsläppen i den icke handlande sektorn ska till år 2020 minska med ca 20 miljoner ton koldioxidekvivalenter i förhållande till 1990 års nivå. Utvecklade ekonomiska styrmedel förväntas bidra till detta med en utsläppsminskning om 2 miljoner ton.

Huvudslutsatsen från modellsimuleringarna är att energiintensitetsmålet inte uppnås inom ramen för den planerade klimatpolitiken. För att nå klimatmålet krävs att koldioxidskatten år 2020 uppgår till 1,85 kronor per kilogram koldioxid (i 2008 års penningvärde). För att även nå energiintensitetsmålet på ett kostnadseffektivt sätt krävs en höjning till 2,20 kronor per kilogram koldioxid. Detta innebär en årlig BNP-förlust som år 2020 uppgår till ca 3 miljarder kronor. Ett annat alternativ är att höja koldioxidskatten till 1,85 kronor per kilogram koldioxid och samtidigt höja energiskatterna med 50 procent. Detta alternativ ger en BNP-förlust på 9 miljarder kronor år 2020. Klimatmålet överskjuts i båda fallen med 0,5 miljoner ton om inte en motsvarande justering görs av andra planerade åtgärder, till exempel minskad användning av flexibla mekanismer.

En anledning till att energiintensitetsmålet blir svårt att nå är att elsektorn förväntas växa och nettoexportera 23 TWh år 2020. Kärnkraftsproduktionen förväntas vara högre år 2020 jämfört med år 2008. Eftersom kärnkraftverkens värmeförluster belastar den totala energianvändningen i Sverige kommer produktionsökningen att bidra till en högre energiintensitet.

Om utsläppshandeln användes fullt ut skulle Sverige kunna sänka koldioxidskatten, men ändå nå klimatmålet. Men för att nå energiintensitetsmålet krävs inhemska klimatåtgärder eftersom import av utsläppsrätter inte förväntas bidra till den önskade minskningen av energiintensiteten. Om utsläppshandeln inte utnyttjas tillfullo blir det dyrare att nå det svenska klimatmålet för den icke handlande sektorn. Ett exempel på utsläppshandelns kostnadsfördel i klimatpolitiken är att kostnaden kan sänkas för att uppnå den utsläppsminskning med 2 miljoner ton som enligt klimatpropositionens färdplan ska ske med utvecklade ekonomiska styrmedel. En grov uppskattning är att besparingen under år 2020 uppgår till ungefär 6 miljarder kronor. Uppskattningen utgår ifrån att koldioxidskatten höjs marginellt för att finansiera ett statligt inköp av utsläppsrätter (kvotenheter). I detta fall skulle emellertid energiintensiteten inte minska så mycket som krävs för att nå energiintensitetsmålet.

Finanskrisen ger sannolikt långvariga effekter på BNP. BNP bedöms bli ca 4 procent lägre år 2020 jämfört med rapportens basscenario (som bygger på prognoser innan finanskrisen var ett faktum). Den lägre produktionsnivån innebär att klimatmålet kan uppnås med nuvarande nivå på koldioxidskatten, däremot leder strukturella förändringar troligen till en högre energiintensitet. Finanskrisens inverkan på energiintensiteten medför att en kraftfullare styrning av energianvändningen är nödvändig för att nå energiintensitetsmålet.

En relevant fråga är om de kostnader som energiintensitetsmålet innebär för samhället har en motsvarande intäktssida som motiverar dem ur ett samhällsekonomiskt perspektiv. Mål för användningen av enskilda resurser riskerar att bli välfärdshämmande eftersom de inte tar hänsyn till den totala resursförbrukningen, till exempel kan en minskad energianvändning innebära att mer kapital måste användas (i form av ökade investeringar i energibesparande teknik). Detta betyder nödvändigtvis inte att styrning av energianvändningen inte är önskvärd, utan att mål och medel bör riktas mot energianvändningens välfärdspåverkande följdeffekter, till exempel förorenande utsläpp. Energianvändningen bör därefter betraktas som en endogen variabel som bestäms av energipriserna och de styrmedel som vidtas för att korrigera misslyckanden på energimarknaderna.

Abstract

From the perspective of climate policy, a target for energy efficiency could imply costly overlapping regulation. We estimate, using a computable general equilibrium model of the Swedish economy, the potential economic cost of attaining the national 2020 energy intensity target by means of tax policy instruments. Our analysis shows that the efforts to meet the energy intensity target will also reduce carbon dioxide emissions, but at excessive costs compared to alternative climate policy instruments. Moreover, attainment of the energy intensity target will call for policy instruments additional to those needed for fulfilling the national climate policy target. The results are sensitive to the development of the nuclear energy production as the definition of energy intensity includes conversion losses in electricity production.

Keywords: climate policy, energy efficiency, carbon tax, overlapping regulation, general equilibrium, Sweden.

1 Introduction

EU's climate and energy policies are guided by three interrelated targets for 2020: reducing emissions of greenhouse gases (GHG emissions), increasing the share of renewables in energy supply and improving energy efficiency. The member states have reached burden-sharing agreements for the GHG emissions target and the renewability target, but not for the energy efficiency target. In 2009, the Swedish parliament decided upon a national target for energy efficiency. The target requires a 20 percent reduction in the energy intensity of aggregate output by 2020 compared to 2008. The overall objective of the present paper is to analyse the economic cost to the Swedish economy of attaining the energy intensity target.

The three targets guiding climate and energy policy are directed at different links of the emissions-generating chain; from the supply of energy to its final use. Measures intended to stimulate conversion from fossil fuels and energy efficiency will reduce GHG emissions as well. From the policy-maker's view, the renewability and energy efficiency targets will act as restrictions on climate policy. If binding, these restrictions may lead to excessive costs for reducing GHG emissions, e.g. there may be too much of energy efficiency and too little of fuel conversion. A national target for energy efficiency may also restrict utilisation of international emissions trading in an optimal way.

In Böhringer et al. (2009) three computable general equilibrium (CGE) models are used to assess the costs of attaining EU's climate and renewability targets. A conclusion drawn is that the renewability target could raise the cost of achieving the climate target by up to 90 percent. It is an open question whether the beneficial effects, e.g. on security of energy supply, justify this extra cost.

By using an approach similar to that of Böhringer et al. (2009), we estimate the costs to Sweden for achieving its energy intensity and climate targets by adjusting the present carbon dioxide and energy taxation. To our knowledge, no other studies have focused on estimating the cost of attaining energy efficiency targets in Sweden or other countries. The focus on tax instruments is motivated by the fact that the Swedish road map laid out for an integrated climate and energy policy heavily depends on economic policy instruments.

Further, the utilisation of economic policy instruments to achieve emissions targets, and resource-use targets, is widely supported in the economics literature (Baumol and Oates, 1988; Helfland et al., 2003; Fischer and Newell, 2007). As taxes may be considered a first-best solution, the costs estimated in the present paper may serve as a benchmark for future analysis on alternative instruments that may be used for attaining the Swedish climate and energy-intensity targets.

The economic cost of attaining the targets are reported in terms of GDP loss compared to a baseline scenario. In order to consider the relevant repercussions on energy use, emissions and economic activity, a CGE model called EMEC[1] is applied to estimate the GDP response. The study focuses solely on the emissions reduction and energy intensity targets.

The carbon dioxide tax is levied on, largely, the same tax base as the energy tax, and thus the tax instruments examined will simultaneously affect both targets. Dimensioning taxes with multiple targets is a delicate matter. For example, increasing the carbon dioxide tax leads to reduced emissions of carbon dioxide, improved energy efficiency and enhanced incentives for use and supply of renewable energy. This interaction means, among other things, that all three targets must be considered when dimensioning taxes affecting the targets. If instead every tax is set to achieve only one particular target, the consequence will probably be that the overall policy overshoots some targets, or, in other words, that total taxation will be too harsh.

A priori, the energy intensity target may appear easy to attain, especially in view of expectations on economic growth and the climate policy decided upon by the Swedish government. Our question is whether the emissions reduction measures, which are necessary for meeting the climate target, are sufficient to attain the energy intensity target as well. If so, the energy intensity target is not binding and will not entail any additional costs to the economy other than those involved in reaching the climate target. If not, the energy intensity target may result in additional economic costs, and in the end a more ambitious climate policy.

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[1] EMEC was developed at the National Institute of Economic Research (NIER); see Östblom and Berg (2006).

The paper has the following outline: In Section 2 we discuss the attainment of climate and energy policy objectives in relation to policy instruments suitable for designing an integrated climate and energy policy. We also discuss the definition of the energy intensity target. In Section 3 we present the baseline scenario for Sweden for 2020. In Section 4 we analyse the effects of different policy designs, in terms of energy use, carbon dioxide emissions and economic growth. Finally, we discuss the results of the study in Section 5, where we also give some conclusions regarding the design of an integrated climate and energy policy.

2 Climate and Energy Policy Targets

Environmental and energy policies in Sweden (and the EU) are based on a set of quantitative targets for indicators of environmental quality and for use of resources. Sweden's national targets are intended to make environmental policy concrete, to communicate the government's ambitions to firms and consumers and to lay the groundwork for follow-up and evaluation of the policy pursued (Government Bills 1997/98:145 and 2000/01:130). To some extent, certain targets have been adopted in compliance with international agreements, such as the climate target and the renewability target, for which there are corresponding provisions at the EU level.

The target levels serve as a guide to politicians and authorities in their exercise of policy control. From the perspective of the economy, targets for the use of particular resources (including environmental resources) are efficient if and only if no other level of resource utilisation would result in greater welfare. Any targets for emissions of substances that are harmful to the environment should be set at levels where the marginal cost of harm due to the emissions is equal to the marginal cost of reducing emissions.[2] If an emissions target is incorrectly set, achieving the target will mean inefficiency in the economy's resource allocation. Whether the targets are justified or not, from a standpoint of efficient resource allocation they should be met at the lowest possible welfare cost to society; i.e. control of target achievement should always aim at cost effectiveness. Achievement of cost effectiveness calls for appropriate policy instruments.

Since the early 1990s, Sweden has pursued an explicit policy of reducing GHG emissions. This policy contributed to an emissions reduction of about 10 percent during the period 1990-2009. A succession of climate policy targets were in effect in Sweden during this period, and climate policy was partly centralised under the EU. Since 2005, the EU system of trading in emissions allowances (EU ETS) is the primary instrument for regulating GHG emissions from energy-intensive industries.

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[2] Emissions (except carbon dioxide) can be reduced by abatement equipment by changing the production process or by cutting back on the production or consumption of emission-generating goods and services. In all cases, reduction entails a cost.

In 2008, the Swedish Parliament adopted a long-term climate target for sectors of the Swedish economy that do not participate in emissions trading within the framework of the EU ETS. The long-term target means that emissions related to the non-trading sector are to decrease by 40 percent in 2020 compared with the 1990 level. This corresponds to a reduction by some 20 million tonnes of carbon dioxide equivalents. International emissions trading is allowed to contribute to the target achievement. This means that to some extent the Swedish government may purchase emissions reductions realised in other countries and offset them against domestic emissions.

The proposed Climate Bill of 2008 lays out a road map for achieving the climate target. It is estimated[3] that the actual emissions reduction from 1990 through 2007, together with the forecast reduction in the period 2008-2020 based on national measures adopted through 2008, will contribute some 10 million tonnes towards the climate target. Implementation of joint EU decisions is anticipated to contribute 1.6 million tonnes. Future investments in other EU countries and other types of flexible mechanisms are expected to provide one-third of what is needed to reach the target.

It is calculated that additional national economic policy instruments will provide the remaining 2 million tonnes of the reduction in carbon dioxide equivalents. Some economic policy measures have already been adopted, including more limited exemptions in the carbon dioxide tax[4] and subsidies for improving energy efficiency.[5] The remainder of the reduction is to be achieved primarily through raising the carbon dioxide tax (Government Bill 2008/09:162, p. 239).

In addition to these climate targets, Sweden currently has two overall targets for energy use; these are referred to as energy efficiency targets. In accordance with the EU Directive (2006/32/EG), in 2009 the Swedish Parliament adopted the target of a 9 percent improvement of overall energy efficiency in Sweden by the year 2016 compared to average energy use in the period 2001-2005.[6]

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[3] See ”Sweden’s Fifth National Communication on Climate Change”, Department Series DS 2009:63.

[4] See ”Certain Selective Tax Questions Raised by the Budget Bill for 2010”, Government Bill 2009/10:41.

[5] The Government estimates that decisions already taken will reduce emissions by 1.4 million tonnes.

[6] Improvement in energy efficiency refers to potential or theoretical conservation of energy. For example, no consideration is given to the possibility of increasing the use of machinery or vehicles that consume less

2.1 The Swedish Energy Intensity Target

In 2009 the government decided that a target be adopted for the level of energy intensity in 2020. According to this energy intensity target, the ratio between total energy use and GDP in constant prices should be 20 percent lower in 2020 than in 2008 (Government Bill 2008/09:163). As formulated, this target means that energy use in absolute numbers will depend on how the economy develops through 2020. The target applies to both final energy use and energy use in energy production, which consists primarily of distribution and conversion losses in the electric power sector.[7]

The energy intensity target can be formulated as

$$\frac{E(2020)}{Y(2020)} \leq 0.80 \times \frac{E(2008)}{Y(2008)}, \tag{1}$$

where E is total energy use in Sweden in 2008 and 2020, respectively, and Y is GDP in the same years. Equation (1) states that energy intensity in 2020 has to decrease at least 20 percent compared to 2008. Expressed in terms of the respective average growth rates, e and y,

$$\left(\frac{1+e}{1+y}\right)^{12} \leq 0.80, \tag{2}$$

which, after log-approximations of both sides, yields

$$e - y \leq -0.0186. \tag{3}$$

For example, with an average GDP growth of 2 percent during the period 2008-2020, energy use must not increase by more than 0.14 percent per year, on average, if the target is to be met. With higher GDP growth, a correspondingly higher (in percentage points) rate of increase in energy use is allowed, and vice versa.

2.2 Are Energy Use Targets Warranted from an Economic Standpoint?

Continuous improvement of resource utilisation is important for the increases in welfare and contributes to the achievement of climate targets and other environmental targets at

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energy; i.e. actual use of energy need not be 9 percent lower in 2016 if the target is met. The target is assessed to be attainable with the control measures already in place (SOU 2008:25).

[7] International marine and aviation bunkers are assumed to be included in the formulation of the target.

the lowest possible cost to society. From an economic view, however, targets for energy use are questionable. Since the targets focus on the use of particular resources rather than on total use of resources, setting targets for particular factors of production entails suboptimisation. The use of policy instruments to attain targets for specific resources may thus lead to greater resource use and to welfare losses. From the perspective of welfare maximisation, what matters are the sequent effects of energy use and not the use of energy per se. Targets and policy instruments should be directed at the causes of these sequent effects, such as pollutant emissions. The use of energy should thereafter be treated as an endogenous variable; that is, the amount and structure of energy use should be determined by energy prices and by the policy measures used in response to environmental and other problems related to energy use.

The policy-maker ultimately wants to internalise the social costs and benefits of economic activity in the economic decisions taken by consumers and producers. However, complete internalisation through price regulation is only possible if there are no market imperfections that disrupt price signals, such as imperfect information, principal-agent problems or institutional problems that limit the possibility of individuals to act on price signals. By definition, such imperfections cannot be effectively solved with economic policy instruments but require the use of other means. The extent of these problems and how to solve them cost effectively is a subject of debate.

According to estimates, some potential measures to reduce energy use are beneficial to energy consumers, yet are not undertaken (see e.g. Government Report SOU 2008:110 and IEA, 2008). If this is the case, it is a sign of inefficiency, which can be explained partly by lack of information and/or by institutional problems (Sanstad and Howarth, 1994; Jaffe et al., 2005; Gillingham et al., 2009). On the other hand, studies showing a potential for improving energy efficiency at no or negative cost may neglect welfare costs related to quality and comfort, risk aversion and the sacrifices involved in installation and conversion (Sutherland, 1991; Sanstad and Howarth, 1994; Jaffe et al., 2004). Whether there is a cost-effective potential, which will not be realised in the absence of government intervention, is an empirical question not dealt with in the present paper. On the other hand, we note that the problem itself does not warrant setting a general target for improving energy efficiency; control should be directed at the underlying market problems that may cause inefficiency in the energy use of certain operators.

Setting targets for energy use is not unique to Sweden. The EU has been a prime mover in this regard and has set a guideline target of reducing the use of primary energy[8] (in relation to a reference development) by 20 percent by the year 2020 (Summit Meeting of the European Council 2007, 7224/1/07 REV 1).[9] The formulation of Sweden's energy intensity target, however, has no direct connection with EU's target.

2.3 Why an Intensity Target?

The choice between an absolute and a relative target for energy use ultimately depends on how policy-makers wish to manage uncertainty regarding the development of the economy. If the size of the GDP in 2020 were known in advance, each level of energy intensity (energy use/GDP) would correspond to a unique level of absolute energy use in 2020. Thus, the ambition embodied in the target does not depend on whether the target is specified in terms of an absolute quantity of energy or a ratio; instead, the level of ambition is determined by how high the target has been set. There is a difference, though, between ways of formulating the target concerning its flexibility when the GDP deviates from its expected path of development.

When the development of GDP is uncertain, the formulation of the target will differ as regards energy use and the implied marginal cost of reducing it, and thus also as regards the expected inefficiency that arises (Ellerman and Sue Wing, 2003; Newell and Pizer, 2003). The absolute target refers to a given quantity at a certain point in time, whereas with the intensity target the quantity is adjusted according to the development of the economy. If GDP develops more favourably than forecast, it is expected to be more expensive to keep energy use below a certain level. With an intensity target, the level of energy use allowed is adjusted so that the cost of taking measures is held down in case of high GDP growth. Unexpectedly poor growth in GDP may mean that an absolute target is temporarily met without the use of policy instruments, whereas an intensity target may become more ambitious in such a scenario.

[8] Primary energy refers to energy found as a natural resource and not processed by humans (e.g. coal, oil and wood used for fuel).

[9] Unlike the case of climate and renewability targets, there is no directive that apportions the burden of target achievement among member countries; the target applies to the EU as a whole. Member countries, however, have a duty to prepare action plans for improving energy efficiency.

2.4 Energy Taxation in Sweden Through 2020

Policy-makers have a choice of many different policy instruments, such as building codes, investment subsidies, information campaigns and energy taxation. In Sweden, energy taxes have historically been regarded largely as fiscal taxes, i.e. as instruments to raise revenue for the national treasury. Recently this view to some extent has been challenged as the energy tax rates are to be set proportionally to the energy content of the different tax bases, i.e. the use of certain energy carriers (DS 2009:24). Such a change in energy taxation makes it more appropriate for controlling the use of energy. However, the effect of energy taxes on energy intensity is likely reduced by the fact that energy taxes might have negative effects on GDP.

3 Baseline Scenario for 2020

The baseline scenario reported here is a product of collaboration among three public authorities: the National Institute of Economic Research, or NIER, the Swedish Energy Agency and the Swedish Environmental Protection Agency. Within the framework of this collaboration, long-term forecasts for energy use and GHG emissions have been prepared for 2020; these forecasts and the projected development of the Swedish economy are all consistent.[10]

Energy intensity is estimated to decrease by 15 percent from 2008 to 2020 in the baseline scenario, with our notation,

$$\frac{E(2020)}{Y(2020)} \Big/ \frac{E(2008)}{Y(2008)} = 0.85, \tag{4}$$

thus falling short of the targeted 20 percent reduction. One reason is that the provision (domestic supply) of energy is expected to grow at a higher rate compared to the final domestic use during the period, according to the energy forecast. We show below that the energy intensity will be some 3 percent higher in 2020 than in a situation where energy supply has developed at the same rate as energy use.

Total energy use consists mainly of so-called final domestic use, i.e. heating fuels, electric power and motor fuels, used as inputs in the production of goods and services or consumed by households and the public sector. It also includes international marine and aviation bunkers, use for "non-energy purposes" and conversion and distribution losses. Of these, conversion losses account for the major part and consist primarily of unutilised heat losses in the production of electric power.[11] Altogether, total use of energy equals total supply of energy, including net imports of electric power, as reported in energy balances.

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[10] The emissions forecast in 'Sweden's Fifth National Communication on Climate Change' (Department Series DS 2009:63) corresponds to the main scenario in the energy forecast as reported by the Swedish Energy Agency (2009a) for 2020. The economic development, international energy prices and prices of emission allowances are taken as given in these forecasts. In our analysis, the baseline scenario was calibrated to the emissions and the energy use reported in the forecasts (see Broberg et al., 2010, for details).

[11] In 2020 the total use of Swedish electric power is expected to be 138 TWh and the gross supply of electric power 319 TWh (Swedish Energy Agency, 2009a). Thus, in the electric power sector more than half of the energy generated is "lost" before it reaches the final users.

In EMEC, final domestic use is rigorously modelled; economic policy measures operate on this portion of energy use via price formation and demand. For the purpose of calculating total energy use, it is assumed that the ratio between total use and final domestic use, for a particular year, is given (according to the base scenario). Let this ratio be denoted $k(t)$ for year t. The energy intensity target can then be formulated as

$$\frac{k(2020)\times E^S(2020)}{Y(2020)} \le 0.80 \times \frac{k(2008)\times E^S(2008)}{Y(2008)}, \tag{5}$$

where E^S stands for final domestic use of energy.

The ratio $k(t)$ increases with higher net exports of electric power as the conversion and distribution losses related to export of electricity are included in total use, whereas final domestic use does not include export of electricity.

For the year 2008 this ratio was 1.54, and for 2020 it is forecast to be 1.60. This means that compared to the case where the ratio is unchanged, energy intensity must decrease by an additional 3 percentage points in order for the target to be met ($1.54/1.60 \times 0.80 = 0.77$).

For 2020, gross supply of nuclear power is forecast to be approximately 40 TWh higher than in 2008 (Swedish Energy Agency, 2009a; 2009b). The increase in supply will result in greater heat losses totalling about 26 TWh, which is equivalent to roughly 4 percent of the energy provided in 2008. This will increase the Swedish energy intensity.

In addition to increased supply of nuclear power, electricity from renewable sources of energy will also increase. Net export of electricity is forecast to increase by 21 TWh from 2008 to 2020 (Swedish Energy Agency, 2009a and 2009b). Although the net export of electricity is deducted from gross energy supply and is not included in domestic energy use, it becomes a relevant variable in the analysis, since conversion and distribution losses related to production of the electricity exported are included in the total use of energy in Sweden.

The significance of the electric power sector for energy intensity can be illustrated by a simple calculation. Assume that the exported electricity is generated by the same composition of energy sources as the total supply of electricity. Then the forecasted increase in net export of electricity, 21 TWh, will correspond to a gross supply of 49 TWh including conversion losses amounting to 28 TWh, which is equivalent to some 4.5 percent of the energy supply in 2008. When making the reasonable assumption that electricity exports have only a marginal effect on GDP,[12] the export increase of 21 TWh raises the energy intensity of GDP by 4 percentage points in 2020 without affecting the energy usage of final consumers in Sweden. Sweden's ambition to be a net exporter of electricity will thus burden the country's reported energy use and make it more difficult to meet the energy intensity target.

[12] As an approximation, the contribution to GDP corresponds to the market value of 21 TWh (a maximum value added, when assuming the costs of inputs and production factors and crowding-out effects to be zero). With an electricity price of €50/MWh, this means that there is a contribution to GDP not exceeding €1 050 million, or roughly 0.3 percent of Sweden's GDP in 2008.

4 Results from a CGE Model

In the following, we report on a number of model simulations where the point of departure is the baseline scenario. Assessment of all relevant effects of changing the energy and carbon dioxide taxation on energy use, emissions and GDP requires a general equilibrium perspective on the issues studied. A CGE model is basically a system of equations that describe the behaviour of consumers and producers. The solution to the equation system is reached by adjusting prices so that equilibrium is achieved simultaneously in all markets. Such a model can be used to study interventions in a market economy. Through price adjustments, the economy moves from one equilibrium situation to another, exhibiting changes in the endogenous variables such as production structure, use of resources, emissions, income and consumption. The economic effects of alternative policy designs are evaluated by comparing the values of endogenous variables in the alternative scenarios with those in the baseline scenario.

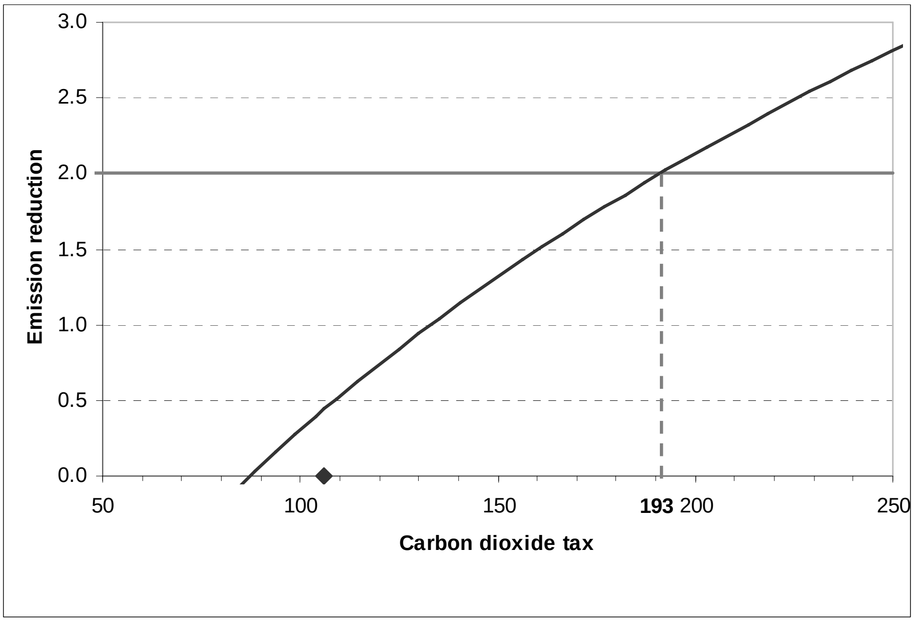
First we show how carbon dioxide emissions and the energy intensity of GDP will be affected in 2020, when varying the carbon dioxide tax rate and the energy tax rate. The results reflect the magnitude of the tax changes required to achieve the climate and energy intensity targets with the Swedish Government's proposed road map as a starting point. The cost of meeting the targets depends, among other things, on the choice of policy instrument mix. Here, we show, in terms of GDP loss in 2020, the difference in cost of using the carbon dioxide tax, the energy tax or a combination of both taxes to achieve the policy targets.

4.1 Sufficient Measures to Reach the Targets

In the simulations reported below, we include already decided future changes in the tax system that are not included in the baseline scenario. However, we disregard effects and costs of investment subsidies and similar measures decided after 2008. The starting point for the simulations is that the general level of the carbon dioxide tax rate is €106 per tonne of carbon dioxide (at 2008 price levels).[13] The tax changes already decided upon yield a reduction in carbon dioxide emissions (compared with the baseline scenario) of almost 0.5 million tonnes. Figure 1 shows that an increase in the carbon dioxide tax from €106 to €193 is necessary to reduce carbon dioxide emissions by 2 million tonnes, which is necessary to reach the reduction target of 20 million tonnes, under the assumptions in our calculations.

Figure 1 Reductions of Carbon Dioxide Emissions for Various Tax Rates in Comparison to the Baseline Scenario in 2020

Emissions reductions in millions of tonnes CO_2; tax rates in €/tonne (2008 prices)



♦ = current tax rate

Source: Calculations with the EMEC model.

An increase in the carbon dioxide tax also reduces energy use. A tax increase to €193, however, will not suffice to achieve the energy intensity target, and must therefore be supplemented with other measures.

The relationship between energy use and emissions of carbon dioxide means that the carbon tax could be combined with the energy tax[14] in several ways to give just about the

[13] All prices in this paper are translated from SEK to EUR, assuming a constant exchange rate over time. In 2008 the annual average SEK/EUR exchange rate was 9.61 and the carbon dioxide tax was SEK 1.02 per kilogram.

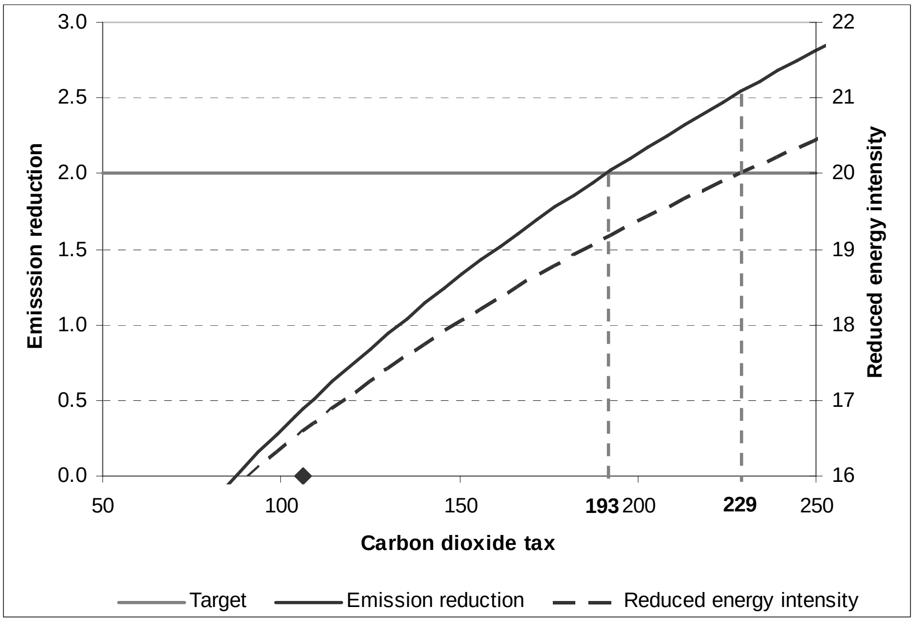
[14] The energy tax is levied on the use of various fossil fuels and electric power.

same effect on emissions and energy use. Holding the carbon dioxide tax at €193, for example, and raising the energy tax by an average of 50 percent would be sufficient to reach the energy intensity target, i.e. decreasing the energy intensity by 20 percent by 2020. This increase in energy tax would mean that emissions of carbon dioxide would decrease even further, and, in total, economic policy instruments would then contribute with more than 2 million tonnes of the emissions reductions.

Figure 2 shows that another way of meeting the energy intensity target involves raising the carbon dioxide tax rate to €229. This tax rate is higher than that called for by the climate target and would reduce emissions by about 2.5 million tonnes compared to the baseline scenario. In other words, the tax increase would have the effect of overshooting the emissions reduction target by 0.5 million tonnes carbon dioxide equivalents.

Figure 2 Carbon Dioxide Reductions Compared to the Baseline Scenario 2020 and Energy Intensity Decreases 2008-2020 at Various Tax Rates

Emission reductions in millions of tonnes CO_2, energy intensity in percent; tax rate in €/tonne (2008 prices)



♦ = current tax rate

Note: The Y-axis on the left shows the reduction of carbon dioxide emissions in 2020 compared to the baseline scenario 2020. The Y-axis on the right shows the percentage change in energy intensity of GDP from 2008 to 2020.

Source: Calculations with the EMEC model.

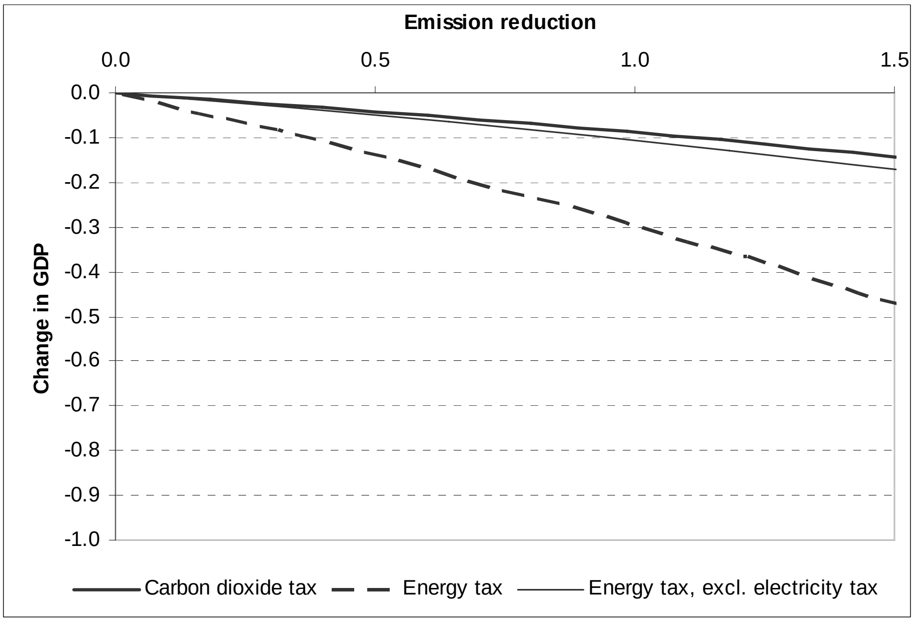
4.2 Economic Cost of the Measures

The carbon dioxide tax as well as the energy tax can be used as policy instruments, but in which combination will the taxes serve as the most effective policy instrument to achieve the energy intensity target? The results of our simulations show that an additional increase of the carbon dioxide tax of €36 (from €193 to €229) would decrease GDP by 0.07 percent (equivalent to €300 million) in 2020. The alternative policy of maintaining the tax at €193 and instead increasing the energy tax by 50 percent would decrease GDP by 0.21 percent (equivalent to €950 million).

Figures 3 and 4 provide a more comprehensive view of the effectiveness of taxes as policy instruments to control GHG emissions and energy intensity, respectively. In the two figures, we compare GDP losses in 2020 for the different tax instruments applied to achieve certain emission and energy-intensity reductions.

Figure 3 Emission Reductions and Corresponding GDP Change in 2020 for Compared Tax Instruments

Emission reductions in millions of tonnes CO_2; GDP changes in percent



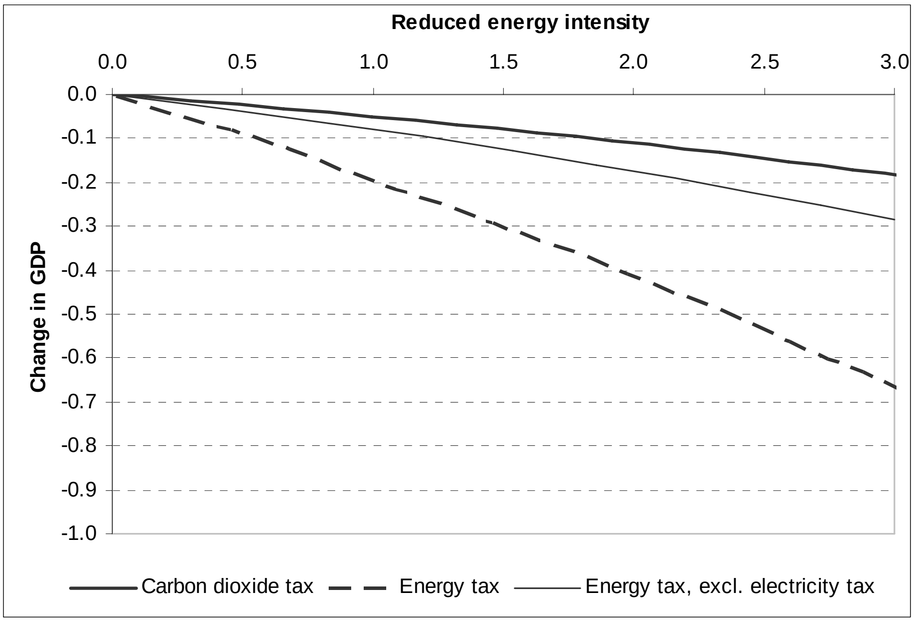
Source: Calculations with the EMEC model.

Figure 3 shows that the carbon dioxide tax reduces emissions at the lowest cost in terms of GDP loss. The GDP loss in 2020 would then be about 0.15 percent (roughly equivalent to €650 million), whereas an increase in the energy tax is a much more expensive policy alternative for reducing emission. We should note that by increasing the energy tax, with the exception of the electricity tax, the reduction cost of the energy tax, depicted by the thin solid curve, falls close to that of the carbon dioxide tax as depicted by the bold solid curve. This finding is not surprising, since when excluding the electricity tax, the remaining components of the energy tax share most of the tax bases with the carbon dioxide tax.

The slopes of the curves, in Figure 3, approximate the increase of marginal costs to society for emission reductions. A closer examination of the curves reveals that the dotted curve, depicting marginal costs when using the energy tax to reduce emissions, slopes steeper at the origin than does the bold solid curve, depicting marginal cost when using the carbon dioxide tax to reduce emission, at an emission reduction of 1.5 million tonnes. This suggests that using the carbon dioxide tax in combination with the energy tax will increase the costs of reducing emissions over the interval from zero to 1.5 million tonnes. So, using the carbon dioxide tax only may be considered cost-effective compared to the policy alternatives studied here, as measured by potential GDP losses.

Figure 4 Energy Intensity Reductions and Corresponding GDP Changes in 2020 for Compared Tax Instruments

Energy intensity reductions in percentage points and GDP Changes in percent



Source: Calculations with the EMEC model.

An increase in the carbon dioxide tax is the least expensive alternative to reduce also the economy’s energy intensity as shown in Figure 4. Decreasing the energy intensity by 3 percentage points using the carbon dioxide tax would reduce GDP by about 0.18 percent in 2020, whereas a corresponding decrease in energy intensity achieved by using the energy tax would reduce GDP by about 0.67 percent in 2020. The difference in GDP loss between these two alternative tax instruments would affect the annual cost by some €2 200 million. Excluding the electricity tax when using the energy tax to decrease the energy intensity would result in significantly smaller GDP losses as shown by the thin solid line in Figure 4. Apparently, the tax on electricity seems to be a relatively costly way, in terms of GDP loss and compared to the alternative tax instruments analysed here, to reduce the energy intensity of the Swedish economy. This finding is explained by the following conditions. First, the tax on electricity is mainly levied on households and the service sector since the industry sector, in practice, is exempt from the energy tax. Second, the use of electricity in the taxed sectors is relatively price-inelastic, which means that price increases will result in relatively small decreases in electricity demand. The energy tax on electricity, thus, requires a greater percentage increase, compared to the energy tax on fossil fuels, to achieve a given percentage decrease in energy use. A greater tax increase also induces a greater negative impact on GDP, and this explains why the energy tax on electricity has relatively little effect on the energy intensity of GDP.

The electricity-intensive industries in Sweden are exempt from the tax on electricity.[15] Because of this tax exemption, an increase in the electricity tax in other sectors could theoretically increase electricity use in the economy as more resources would be employed in the electricity-intensive industries. Moreover, this effect is reinforced as an increase in the electricity tax is expected to lead to less demand for electricity in the taxed sector and therefore to a lower electricity price (price excluding the electricity tax). The magnitude of the price decrease depends on the elasticity of energy supply. The price faced by the tax-exempt electricity-intensive industries would thus decrease, possibly counteracting the purpose of the tax increase because of higher demand for electricity in the tax-exempt sector.

[15] The electricity-intensive industries currently pay a tax on electricity of €0.5/MWh. An exemption from the tax is granted to firms participating in programmes to improve energy efficiency (called PFE).

5 Summary and Policy Conclusions

Fairly recently, supplementary constraints have been introduced in Sweden's climate policy. When binding, constraints on the minimum levels of energy efficiency and the share of renewable energy can lead to excessive costs for the climate policy. In the present paper, we analyse the economic costs of attaining the Swedish 2020 climate and energy intensity targets. The main conclusion is that the target of reducing the energy intensity by 20 percent by 2020 is not considered attainable within the framework of the current climate policy, according to our simulations using the NIER's CGE model. Achieving this goal will require additional measures such as raising the energy tax or the carbon dioxide tax. We find that attainment of the energy intensity target by use of tax instruments implies an overshooting of the climate target. Thus, the energy intensity target can be viewed as raising the level of ambition, and thereby the costs, for climate policy.

Whether the additional costs are warranted from a welfare standpoint is an open question, as there is no obvious intrinsic value in improving the energy efficiency of the Swedish total output. Instead, the sequent welfare effects, such as less impact on the environment and higher productivity, should be in focus. Policy-makers should focus directly on sequent effects on welfare and consider energy use as an endogenous variable dependent on energy prices and choice of policy instruments. We question the Swedish policy of having an energy intensity target that curtails growth in welfare because it considers only the use of a single production factor and not the total use of resources.

The carbon dioxide tax and the energy tax have largely the same tax bases and could therefore be combined in a number of ways to attain the climate and energy-intensity targets. The analysis presented here indicates that raising the carbon dioxide tax is the least costly tax instrument to use for attaining both the energy-intensity target and the climate target. According to our results, the rate of the carbon dioxide tax should be raised from €106 to 193 (at 2008 price levels) to attain the climate target. This tax hike would result in a 0.15 percent annual GDP loss in 2020, which is equivalent to a cost of more than €650 million. This tax increase would, however, not be sufficient to reach the energy intensity target; target attainment would require a carbon dioxide tax increase to €229. In that case, the additional cost in terms of GDP loss in 2020 would be approximately €300 million according to our simulations. The energy intensity target would also be attained with a raise of the carbon dioxide tax to €193 together with a 50 percent increase in the energy tax, yet the annual GDP loss in 2020 would then total around €1 600 million. In both cases, the climate target is exceeded by about 0.5 million tonnes. With the adoption of a target for energy intensity, improvements in energy efficiency, previously considered as a way to meet the climate target, may paradoxically increase the cost of climate policy measures.

It should be pointed out here that we have only analysed policy instruments in the sphere of taxation. Whether economic policy instruments effectively serve the purpose depends on whether market operators react optimally to price signals. If this is not the case, there is reason to consider other policy instruments, such as administrative policy instruments or information campaigns. The Swedish Government has already decided on information campaigns, investment subsidies and a new period for the programme for improving energy efficiency in the industry. These measures, together with steps taken at the EU level, will reduce the need to raise climate and energy taxes. This does not mean, however, that such strategies will cost less than using taxes as policy instruments.

A growing electric power sector, dependent on nuclear power, generating sizable heat losses and harbouring clear ambitions to increase exports, is the principal reason why the discrepancy between gross energy supply and final energy use is expected to increase by about 49 TWh during the period 2008-2020. As presently designed, this factor will raise the cost of achieving the energy intensity target. The explanation is that conversion and distribution losses in the electric power sector are included in the total use of energy in Sweden. Thus, while Sweden's energy use does not include exports of electricity, it does include the conversion and distribution losses occasioned when producing the electricity exported. This means that other countries can cut their energy use by importing Swedish electricity, and similarly, the energy use would decrease in Sweden if electricity were imported instead of domestically produced. As a consequence, Sweden will find it harder to meet its national target for energy intensity when the electric power sector is expanding into the foreign market and particularly so if the supply of nuclear power, having large conversion losses, is increased.

With the current definition of energy intensity, we note a policy conflict between the ambitions of exporting electricity and attainment of the energy intensity target, which is burdened by electricity exports and favoured by electricity imports. We thus find reasons to consider whether this conflict in energy policy calls for a more refined formulation of the energy intensity target. A redefinition of the energy intensity, considering only conversion and distribution losses in proportion to Swedish final use, would be more in line with the climate target. The energy intensity target would then be achieved within the framework of climate policy.

The energy intensity target will impose restrictions on the instruments that could be applied in the Swedish climate policy to attain the climate target. For example, the Swedish climate target could be met through purchasing a sufficient number of quota units (according to the burden sharing agreement) and financing the purchase by marginally increasing the carbon dioxide tax. A rough estimate is that the annual saving in the year 2020 from expanding emissions trade instead of raising taxes would be about €620 million in the baseline scenario (Broberg et al. 2010). A consequence of this could be a slight increase in both GDP and energy use. Our assessment of the model results indicates that the energy intensity of GDP would increase due to such an expansion in emissions trading. Attainment of the energy intensity target, thus, seems to require that climate policy measures, more expensive than the expansion of emissions trading, be considered in Sweden. The climate policy would then be realised at unnecessarily high costs.

The financial crisis has certainly changed the conditions for the medium-term development of the Swedish economy; see NIER (2010). The GDP for 2020 is forecast to fall almost 4 percent below that used in the 2008 energy and emissions forecasts. The forecasted growth rate of energy use has been revised downward, because of the new medium-term economic forecast, yet less than for the forcasted GDP. World market growth is forecast to decrease substantially, and the downward revision of Swedish exports is three times that noted for GDP. This means that there will be a shift towards production for the domestic market in favour of service industries and at the expense of export-intensive manufacturing industries. This will increase the expected 2020 energy intensity of GDP and make it more difficult to attain the energy intensity target. However, in this new view of the future, the emissions of carbon dioxide in 2020 will be lower, which will make attainment of the climate target easier.

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