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Reducing Greenhouse Gas Emissions in a Cost Effective Way in Switzerland

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ABSTRACT/RÉSUMÉ

Reducing greenhouse gas emissions in a cost effective way in Switzerland

Switzerland has low greenhouse gas emissions per capita as compared to other countries, which reflects the strong reliance on energy sources emitting few greenhouse gas emissions, especially in electricity generation, and little heavy industry. Greenhouse gas emissions have remained almost the same since 1990, as emission reductions in the residential and industrial sector were offset by increases from the transport sector. It is estimated that, in aggregate, marginal abatement costs are relatively high in Switzerland and meeting the 2020 target of a 20% emission reduction below the 1990 level will necessitate more cost effective policies. In particular, more needs to be done in the road transport sector, the domestic sector with the largest potential for emission reductions at relatively low cost. The incentive for energy saving renovations in rented dwellings could be raised by a better design of existing policies. And the policies in the industrial sector could be made more effective with the transition towards linking the Swiss and the EU emission trading systems.

JEL codes: Q54, Q56, Q58, Q18, R41, R48, H23.

Keywords: Switzerland, greenhouse gas emissions, CO_2, carbon tax, emission trading system, congestion, residential sector, industry, agriculture.

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Réduire les émissions de gaz à effet de serre pour un coût raisonnable en Suisse

Comparée à d'autres pays, la Suisse émet peu de gaz à effet de serre par habitant, car elle recourt en grande partie à des sources d'énergie qui n'en produisent pas beaucoup, notamment dans le secteur de l'électricité, et son industrie lourde est modeste. Ces émissions sont à peu près stables depuis 1990, leur diminution dans les secteurs résidentiel et industriel ayant été compensée par une hausse dans celui des transports. D'après les estimations, les coûts marginaux de la réduction des émissions sont dans l'ensemble relativement élevés en Suisse et des mesures plus efficaces par rapport à leur coût seront nécessaires pour atteindre l'objectif fixé d'ici 2020, à savoir un retour à 20 % en dessous du niveau de 1990. Il faut en particulier accentuer l'effort dans le secteur des transports routiers, lequel présente le potentiel le plus élevé de réduction des émissions à un coût relativement bas. L'incitation en faveur des travaux d'économie d'énergie dans les logements en location pourrait être renforcée moyennant une meilleure conception des mesures existantes. L'action menée dans le secteur industriel pourrait gagner en efficacité moyennant le couplage progressif des systèmes suisse et communautaire d'échanges de crédits d'émission.

Classification JEL : Q54, Q56, Q58, Q18, R41, R48, H23.

Mots-clés : Suisse, émissions de gaz à effet de serre, CO_2, système d'échanges de crédits d'émission, congestion, secteur résidentiel, industrie, agriculture.

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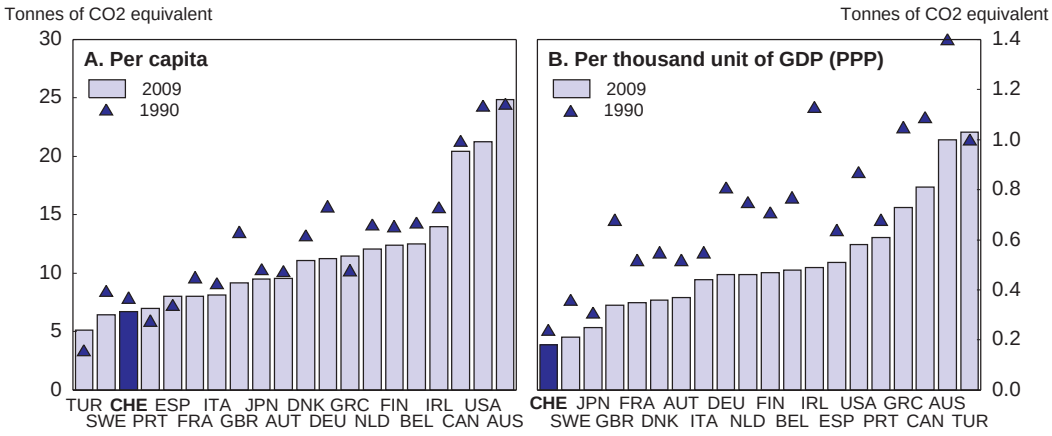
Greenhouse gas emissions reduction – meeting new challenges

Switzerland has been a forerunner in climate change mitigation

Switzerland is characterised by a relatively low level of Greenhouse Gas (GHG) emissions as compared to other countries. In 2009, Switzerland emitted around 7 tonnes of GHG per capita, as compared to the average of 11 tonnes of GHG per capita across OECD countries (Figure 1, left Panel). The low level of greenhouse gas emissions reflects to some extent the strong reliance on renewable or less polluting energy sources, such as nuclear energy and hydro power. It also reflects an industrial structure which is concentrated on service sectors and has a negligible weight of heavy industries.

Figure 1. GHG emissions in a selection of countries, 1990 and 2009

Excluding land-use emissions



Source: UNFCCC database.

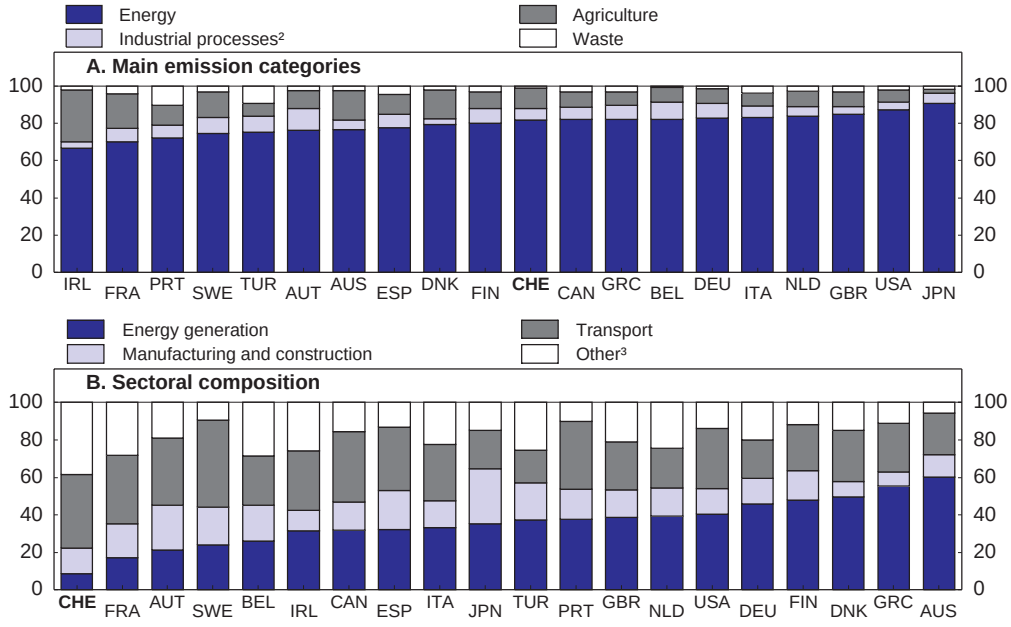
1. This paper is based on the OECD Economic Survey of Switzerland published on 24 January 2012 under the authority of the Economics and Development Review Committee. The paper's contents are hence based on data available up to January 2012. Anita Wölfl was economist in the Economics Department of the OECD at the time of drafting and Patrizio Sicari is research assistant in the Economics Department. The authors would like to thank several OECD colleagues for useful suggestions and comments, notably Pierre Beynet, Hansjörg Blöchliger, Andrew Dean, Bob Ford and Andrés Fuentes from the Economics Department, Nils-Axel Braathen, Jane Ellis and Jan Corfee-Morlot from the Environment Department, and Vaclav Voitech from the Trade and Agriculture Department. The paper benefitted from valuable discussions with representatives of the Federal Department of Environment, Transport, Energy and Communications of Switzerland, and Philippe Thalmann from Ecole Polytechnique Fédéral Lausanne. The authors would like to thank also Maartje Michelson for valuable editorial assistance.

The total level of Swiss greenhouse gas emissions has remained almost constant since 1990, the reference year for the Kyoto protocol. Emissions were just over 10% lower than in 1990 in per capita terms and more than 20% lower as a ratio to GDP (Figure 3.1, right Panel). As emissions of CO_2 account for more than 80% of Switzerland's GHG emissions, the level and change in CO_2 emissions explains most of the patterns in total GHG emissions (FOEN, 2010a).

About 85% of all greenhouse gas emissions in Switzerland come from the generation and the use of energy. Another 10% come from the agricultural sector in terms of non-CO_2 emissions which are not caused by energy use (Figure 2, Panel A). Due to early and effective measures, emissions from waste management are small. Within the energy generation and use category, the largest source of GHG emissions in Switzerland is the transport sector (Figure 2, Panel B), mainly related to high and increasing road transport. The second main source of GHG emissions within this category relates to emissions due to energy use for heating, especially in the residential sector (Figure 2, Panel B).

Figure 2. Structure of GHG emissions, 2009[1]

Excluding land use emissions



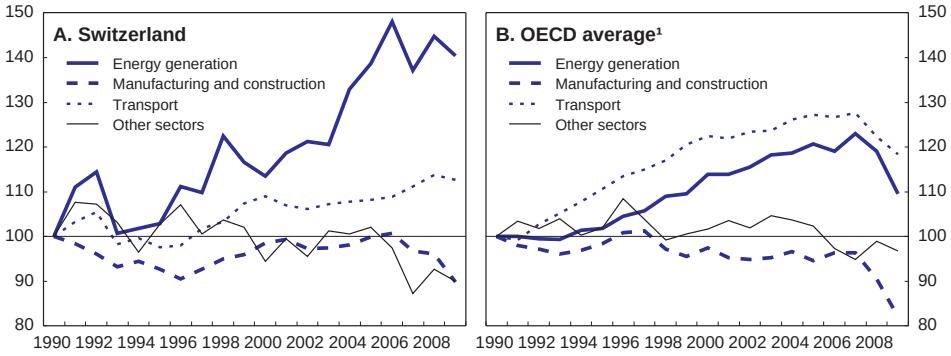
1. The solvents and the residual other sectors categories are not shown due to their absence of quantitative significance.
2. Does not include GHG emissions from fuel combustion in the industrial sector, which are covered within Energy.
3. 'Other' covers emissions from fuel combustion in commercial/institutional, residential, and agriculture, forestry and fishing.

Source: UNFCCC database.

GHG emissions have been reduced significantly since 1990 in the residential and the industrial sector, although some recent reductions in the industrial sector were due to the economic downturn (Figure 3). However, these emission reductions have been offset by a continuous increase in GHG emissions from the transport sector of almost 14% over the same period. The latter is due to the growth in domestic and international traffic, which significantly outweighs other efficiency gains from more efficient engines (FOEN, 2010a). Moreover, while in absolute terms, GHG emissions from energy generation industries are still relatively low in Switzerland, they increased by almost 45% between 1990 and 2009, which is more than double the corresponding average increase in OECD countries.

Figure 3. GHG emissions from fuel combustion over time

1990 = 100



1. Simple average excluding Switzerland and, due to unavailable data, Chile, Israel, Korea and Mexico

Source: UNFCCC database.

GHG emission reduction targets are ambitious, especially if nuclear energy will be phased out …

Under the Kyoto Protocol, Switzerland committed to lower its greenhouse gas emissions compared to 1990 by 8% on average between 2008 and 2012. Towards this target, it is permitted up to a limited extent to credit the purchase of certified emissions reductions from climate protection projects abroad as well as certified sink effects from forest growth. Switzerland can use flexible mechanisms to achieve its emission targets, notably the International Emissions Trading system (IET), the Clean Development Mechanism (CDM), and Joint Implementation (JI).[2] If its emissions remain below the target (48.25 million tonnes of CO_2 equivalent emissions), Switzerland can sell its excess allowances on the UN IET market or carry them over to the post-2012 commitment period. If it fails to meet its commitment, it risks being disqualified from participating in the flexible mechanisms and penalised by an additional deduction from allowed emissions in the subsequent round, with a 30% penalty factor (Grubb, 2003).

The CO_2 Act of 2000, the centrepiece of Swiss legislation concerning climate policy, specifies that the 8% GHG emission reduction target will be met through a 10% reduction of CO_2 emissions from fossil fuel use by 2010, with differentiated targets for heating and process fuels (-15%) and for transport fuels (-8%) (Federal Council, 2009).[3] To achieve this goal, the CO_2 Act accords the highest priority to voluntary action by individuals and firms; these quasi-voluntary actions often being induced or combined with financial incentives. If these measures are not sufficiently effective, market-based instruments, such as taxes or emission trading, are seen as the second most preferred option. Beyond 2012, the Parliament has set the greenhouse gas emission reduction target of at least 20% below the 1990 level by 2020 (Parliament, 2011a). The details of how the target should be met are currently under discussion. According to the proposal of the Federal Council of 2009, at least half of the 2020 target would need to be met through abatement at the domestic level (Federal Council, 2009). The policies and measures proposed aim mainly at a reduction in CO_2 emissions due to its large share in overall greenhouse gas emissions (Federal Council, 2009).

2. See Grubb (2003) for more detail on the economics of the Kyoto Protocol. IET allows Annex I countries to meet their emission reduction commitments at a reduced cost as it allows emissions to be abated first in countries where the costs of abatement are lowest, increasing the efficiency of the Kyoto agreement. The CDM and JI are "project-based mechanisms" that generate emission reductions from particular projects. The CDM is designed to encourage production of emission reductions in non-Annex I countries, while JI encourages production of emission reductions in Annex I countries (Grubb, 2003).

3. See OECD (2007b) for an overview of the institutional setting of climate change policy in Switzerland.

A particular challenge for setting and meeting the 2020 targets arises in the case of the recently decided phasing out of nuclear energy in the aftermath of the natural disasters in Japan in March 2011 (Parliament, 2011b, NZZ, 2011a). In Switzerland, nuclear power (39%) is the second largest source of electricity generation, after hydroelectric plants (56%) and greater than conventional thermal or other plants (5%) (FOE, 2011). Due to technological limits to a much greater use of renewable energy, a shift away from nuclear energy may require more use of gas or other power plants with less favourable GHG emission performance. Under current legislation, if such power plants are built, their operators will have to offset 100% of their emissions.

… and require more cost effective policies

Estimates suggest that additional action is necessary for Switzerland to meet its current Kyoto emission reduction target. According to a reference scenario, estimated net annual GHG emissions over the period 2008-12 would amount to 49.4 million tonnes CO_2 equivalent, 0.8 Mio tonnes more than targeted in the Kyoto protocol. Under an environmentally more pessimistic scenario, based on stronger economic growth, lower energy prices and lower average temperatures between 2010 and 2012, the gap would amount to 1.3 Mio tonnes CO_2 equivalent. The government has started efforts to be able to certify a larger number of international emission compensation credits within the Kyoto target (FOEN, 2011a).

Meeting the reduction target of 20% until 2020 may be even more difficult and will necessitate more cost effective market-based instruments. The question at which cost the 2020 target could be achieved depends on the partition between domestic abatement and international compensation projects (*e.g.*, CDM). While the Kyoto protocol does not set explicit limits, countries typically prioritize domestic action (Grubb, 2003). The financing of international compensation projects has the potential to *i)* reduce emissions at very low cost; *ii)* reduce or at least compensate for carbon leakage[4]; and *iii)* boost transfer of cleaner technologies to developing countries (Capoor and Ambrosi, 2008, Burniaux *et al.*, 2008). However, for these projects to be effective, emission reductions need to be "additional", *i.e.,* on top of baseline reductions that would have resulted also without such projects. Assessing and proving additionality is difficult and creates large transaction costs (Burniaux *et al.*, 2008). Moreover, domestic abatement can produce additional non-negligible benefits, for example in terms of reduced harmful effects for human health (Felder and Schleiniger, 2002).

Cost-effectiveness of climate change mitigation policies is particularly important as Switzerland is characterised by high marginal abatement costs as compared to other countries: model based estimations by Drouet *et al.* 2006 suggest that, by concentrating on CO_2 emissions in line with the government proposal, the 2020 target of a 20% reduction in GHG emissions by 2020 would require a 31% reduction in CO_2 emissions (Table 1). With an efficient policy, as modelled in the form of a uniform CO_2 tax on all firms and individuals as the sole instrument, and assuming 100% domestic reductions, this would imply a tax of 66 USD per tonne of CO_2 emissions in 2010 which would have to increase to more than 450 USD per tonne until 2020. In the EU, due to its higher level of emissions and stronger reductions over the past twenty years, the 2020 target could be achieved with an estimated uniform tax of 7 USD per tonne of CO_2 equivalent emissions in 2010, increasing to 18 USD per tonne by 2020.

4. While the risk of environmental leakage may not be as relevant, Switzerland produces to a large extent emissions abroad embodied in imports and this would justify more compensation abroad, either within or on top of its total emission reduction target. Empirical estimations suggest that, in 2004, the level of CO_2 equivalent emissions of Switzerland would have been about 10.7% higher if emissions embodied in imported goods had been taken into consideration (Federal Council, 2009).

Table 1. Model based estimations of CO_2 prices under the 2020 scenario[1,2]

Reduction in CO_2 equivalent emissions in %	2010	2020	Uniform tax in USD per tonne of CO_2 equivalent emissions	2010	2020
Switzerland	-10	-31	Switzerland	66	468
European Union 25	-8	-17	European Union 25	7	18
Other Non-EU OECD	-4	-13	Other Non-EU OECD	2	10

1. 20% reduction of overall GHG emission by 2020 vis-à-vis 1990, based on the assumption of a uniform CO_2/GHG tax. See Drouet *et al.* (2006) for more assumptions concerning GDP growth rates, energy use and energy prices.

2. Other Non-EU OECD: United States, Canada, Australia, New Zealand

Source: Drouet *et al.* (2006).

In order to achieve cost-effective policies, the following general weaknesses in the Swiss climate policy would have to be addressed:

- One step towards overall efficiency consists in applying the same implicit carbon price within and across broad sectors or uses to ensure that GHG emissions are reduced where it is least costly (Burniaux *et al.*, 2008, de Serres *et al.*, 2010). This is not yet the case in Switzerland. In particular and as discussed below, there is currently no carbon price for transport fuels in private passenger road transport. Hence, more could be done at lower costs for the economy in this sector.
- The focus of current Swiss climate change policy on "quasi-voluntary" measures as first priority before recourse to more effective price-based instruments may produce insufficient and sub-optimal incentives and may also reduce political acceptability of more effective price-based measures. For instance, a broader use of (and higher rates of) CO_2 taxes would create an incentive to invest in new technologies and innovation, and the use of the least-cost technologies (de Serres *et al*., 2010).
- Part of revenues from taxes and levies are earmarked for the financing of specific projects which may reduce their effectiveness and waste resources. Such earmarking should in particular not be used if these taxes and levies are aimed at internalising external effects such as those arising from CO_2 emissions.[5]

In what follows, the policy mixes in road transport, in the residential sector, and in industry and agriculture, are analysed and recommendations are derived on how to improve them so as to make the overall Swiss climate change mitigation policy more cost-effective.

More could be done at low cost in road transport

Emissions from road transport are not yet addressed adequately

Road passenger transport is the sector with the highest CO_2 emissions in Switzerland and CO_2 emissions from road transport have been continuously increasing (Figure 2 above). This is due to strongly increasing road traffic, notably on the national roads and highways where annual person kilometres have doubled between 1990 and 2010 (FOR, 2011). In 2009, about 78% of all private and public passenger transport was done on the roads. Public transport (on road or rail) accounted for 20% of total passenger

5. In its fiscal guidelines, the Federal Department of Finance states: "Earmarking restricts the leeway in setting up fiscal policy priorities and it can create incentives for waste. Moreover, special-funded mechanisms lack especially the necessary transparency." (FDF, 1999).

transport. Also goods transport has been increasing continuously since 1990 and has been shifting more and more onto the roads, with 4% of total transport on roads due to heavy vehicles. Switzerland is important for goods transit transport: In 2009, 38% of all goods transport on roads was related to transit trade (FOR, 2011).

Addressing the problems resulting from increasing demand for private road transport would have a double benefit, as road transport is a main source of a much larger set of external costs for the society beyond CO_2 emissions. Model-based estimations suggest that, in Switzerland, already in 2005, the social costs from road transport in terms of noise, accidents, health, nature, time and climate effects, amounted to more than 9.8 billion CHF, equivalent to 2% of GDP (Table 2). These data are based on models, partly using "willingness-to-pay"- estimates, but may still underestimate the actual costs from transport.

Negative effects for the society result especially from traffic congestion, and this not only refers to time spent on roads that could be used more productively elsewhere, but also in terms of increased CO_2 emissions. CO_2 emissions are particularly high in traffic jams, as fuel consumption is up to two or three times as high in stop-and-go traffic as compared to fluid traffic. In Switzerland, congestion has increased eight-fold over the past 15 years, from 2 000 hours in 1995 to 15 910 hours in 2010, two-thirds of which are due to overuse (FOR, 2011).

Table 2. Estimated external costs from transportation in 2005[1,2]

in Mio CHF

	Total	Road transport		
		Total	Passenger	Freight
Total	9 769	9 315	6 136	1 940
Of which:				
Accidents	2 047	2 017	1 893	124
Noise	1 174	1 101	768	333
Health	1 954	1 834	1 047	787
Buildings	289	274	144	130
Climate	1 264	1 256	1 030	226
Nature and Landscape	797	687	592	95
Other environment	1 004	906	662	245
Congestion	1 240	1 240	--	--

Source: Federal Office for Regional Development,, Transport Policy (2009 estimations).

The current road transport policy does not address CO_2 emissions optimally. The government puts strong emphasis on the mandatory energy label to increase fuel-efficiency of cars and recent legislation sets a new maximum limit on average emissions from new passenger cars by 2015 (Box 1). Such standards and labels can be effective as complementary information and signalling devices if combined with a CO_2 tax on transport fuels (de Serres *et al.*, 2010). However, increased fuel efficiency of the vehicles reduces vehicle usage costs and stimulates additional car use – when not combined with a CO2 tax or a sufficiently high fuel taxes; the latter is not the case in Switzerland. Furthermore, the label is applied to new cars only. It takes several years before the stock of cars is renewed to a sufficiently large extent for this measure to affect CO_2 emissions significantly.

Box 1. Current policies in the transport sector impacting climate policy goals

Price-based measures

The federal government levies a fuel tax and surcharge on motor fuels of about 0.7 CHF per liter. Bio-fuels are exempted from the tax subject to ecological standards. The cantons levy car ownership taxes depending on cylinder volume, horsepower or weight of vehicles and passenger cars; some also take CO_2 emissions into account. The Swiss highway system requires the purchase of a flat rate vignette (toll sticker) for one calendar year, for both passenger cars and trucks (IEA, energy efficiency policies database). It is planned to raise the vignette from the current 40 CHF to 100 CHF per year and to switch to an electronic vignette to reduce the loss of revenues due to fraud, which is estimated at around 10% of annual revenues (NZZ, 2011c). It is also envisaged to introduce a lower rate vignette to reduce the costs for tourists who use the Swiss highways only for a relatively short period per year.

A distance-related electronic heavy vehicle fee (HVF) has been levied in Switzerland since January 2001 (FOSD, 2010a). The HVF applies to heavy vehicles with a permissible laden weight of more than 3.5 tonnes and is calculated based on the number of km driven on Swiss territory, the permissible weight of the vehicle, and vehicle emissions. From an initial rate of 1.68 cents per tkm upon introduction, the charge has been increased to an average 2.70 cents per tkm from 2008. In 2009, the revenues were estimated at around CHF 419 Mio, *i.e.*, about 0.1% of GDP (FOSD, 2010a). The HVF has led to a significant reduction in road use by heavy vehicles over the past ten years. By accepting to raise the weight limit for vehicles at the same time, the fee met the regulations of Switzerland and those of the EU (Braathen, 2004). With Switzerland having been a forerunner, a similar distance-related heavy vehicle fee was introduced in Austria in 2004, in Germany in 2005, and in the Czech Republic in 2007.

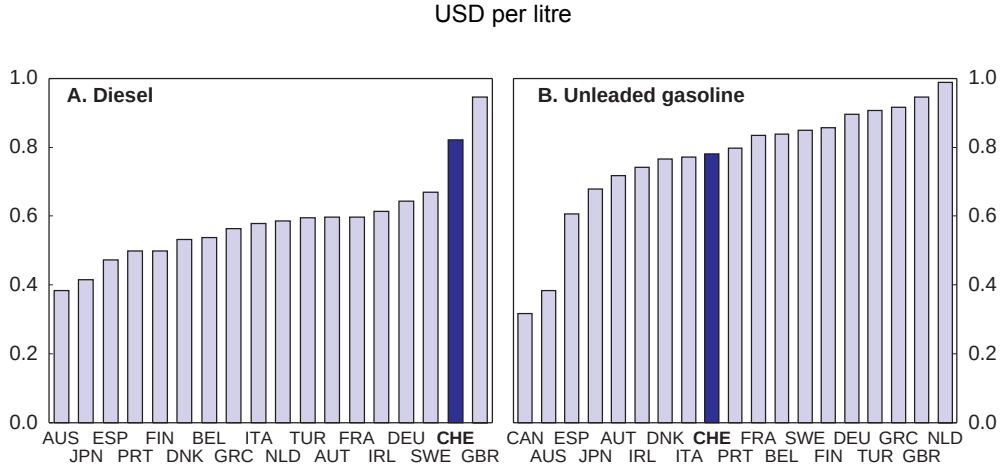
Between 2004 and 2007, a research project on 'mobility pricing' was undertaken, requested by the government, to analyse whether and how road user charges could help to deal with increasing pressures due to growing traffic. Thereby, the concept of mobility pricing aims at controlling and reducing overall road traffic, by looking also at the interdependencies between private road transport and public transport and the shift from road to rail. After rather positive results (FOR, 2007), the government gave green light to test the introduction of road user charges in 2007. However, the proposal was rejected by Parliament.

Regulation and information measures

The energy label (Energieetikette) was introduced in October 2002 to help reduce the average fuel consumption for new cars through more transparency and information for customers at the car purchase. It provides information about fuel consumption in liters/100 km, CO_2 emissions in g/km and the energy efficiency based on the weight of the empty vehicle. The target is a reduction of fuel consumption by 3% on average per year, from 8.4 liters in 2000 to 6.4 liters per 100 kilometers in 2008. As of March 2003, all dealers and car importers had to post the label on all new passenger cars on the market (IEA, energy efficiency policies database). Parliament has recently passed legislation for more stringent emission performance standards for new passenger cars, which are analogous to the EU regulation. The objective is to improve the fuel consumption of cars and to ensure that the average emissions from new passenger cars in Switzerland do not exceed 130 g CO2 /km by 2015.

Moreover, existing car-related taxes and levies do not appear to produce a sufficient incentive to reduce emissions, especially from congestion. This is in particular valid for taxes on the purchase or ownership of cars. Typically, excise duties on fuel consumption (including the climate cent, see below) can be seen to some extent as a substitute for a CO_2 tax due to the close relationship between fuel consumption and CO_2 emissions. However, while high for diesel, the level of the Swiss excise duty on gasoline which is used by the large majority of cars is low as compared to other countries (Figure 4). The effectiveness of the fuel tax is further reduced as long-distance commuting costs are tax deductible. And while the Swiss heavy vehicle fee (HVF, Box 1) is an effective policy instrument, it is only applied to freight transport which constitutes less than 10% of total road transport volume.

Figure 4. Excise duties on transport fuels across selected countries, 2010



Source: IEA.

The policy mix in road transport also relies heavily on investing in road and rail transport infrastructure to meet increasing demand for road transport, and not enough on reducing congestion. Several extension projects are currently being implemented or planned, amounting to about 8% of GDP in total (NZZ, 2011b-d). One problem related to infrastructure investment is the specific earmarking of tax revenues in special funds to finance particular infrastructure projects. While earmarking revenues from taxes or charges can be accepted if they can be justified by the user-pays-principle, earmarking creates the risks that money is spent on projects that are neither necessary nor desirable from an economic point of view, undermining efficiency and potentially leading to over-investment (Blöchliger, 2002, FDF, 1999).[6] The problem arises in particular as the special funds are limited in scope, since they comprise only certain parts of the overall infrastructure costs.

Appropriate road pricing would create an incentive for reduced traffic

CO_2 emissions from increasing road transport should be addressed by introducing a CO_2 levy on transport fuels, and phasing out the tax deductibility of long-distance commuting. Both would best be combined with a congestion charge, which would be most effective in the form of a period- and area - dependent charge so as to tackle traffic congestion at peak demands. Congestion pricing provides an incentive to use the roads in an efficient way (Persson and Song, 2010; and Vickrey, 1992). It shifts demand for road use to times outside peak periods. It would also shift demand for traffic to other modes of transport. This would bring transport prices closer to marginal costs and make the subsidies for public transport less relevant. By reducing and redistributing demand for road use, both, the CO_2 levy on transport fuels as well as congestion pricing can also help to reveal where infrastructure extension or maintenance is necessary, potentially rendering some costly extensions of road infrastructure redundant. It is hence important that the revenues from the CO_2 levy on transport fuels and from the congestion charge are not earmarked for infrastructure financing as this would be counterproductive and would waste resources.

The more flexibly a congestion pricing system can react to traffic flows, the more effective and efficient it would be. The best system would consist in an electronic system which uses satellite navigation technologies as variable pricing based on such technologies would allow pricing close to marginal costs.

6. Estimations suggest indeed a financing gap of the infrastructure fund of about CHF 1.5 billion (0.3% of GDP) in 2020 (Federal Council, 2009).

Even if investment costs for such a system are still relatively high, empirical evidence suggests that such close-to-marginal-cost-pricing would lead to substantial gains in welfare and public revenues, rendering this investment strongly positive financially (OECD, 2008). Pricing should be area wide, for instance all of an agglomeration, to discourage use of non-priced roads; an area-wide system turned out to be also the most preferred system in the mobility pricing project report (FOR, 2007, see below). Finally, an appropriate design of the congestion charge would alleviate possible confidentiality concerns, for instance by transferring the whole management process to an independent regulator.[7]

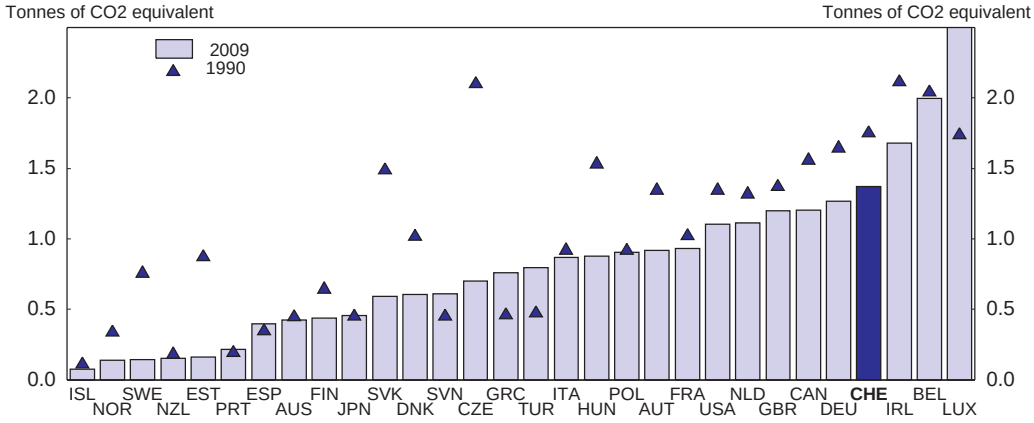
The government has begun efforts to introduce a larger mobility pricing framework in the longer run (see Box 2). While this attempt is promising, more rapid action would be desirable. For instance, a congestion charge could be introduced already together with the introduction of the CO_2 levy on transport fuels. In this case, the level of the CO_2 levy would not have to be as high, since the congestion charge would internalise a large part of the CO_2 emissions. This solution might hence also be more easily acceptable in the general public.

The policy mix in the residential sector could be made more cost effective

Incentives for energy-saving renovations are weak

The Swiss government puts strong emphasis on the reduction of CO_2 emissions in the residential sector. The main objective of the Swiss climate policy is to fully exploit the potential for reduced energy use through increases in the energy efficiency or the broader use of renewable energies for heating. About 20% of all Swiss domestic GHG emissions arise in the residential sector, the highest proportion among OECD countries (Figure 1 above). Furthermore, Switzerland is still characterised by very high emissions per person in the residential sector as compared to other countries (Figure 5).

Figure 5. Role of residential per capita GHG emissions across countries, 1990-2009[1]



1. 2008 for Belgium and Greece.

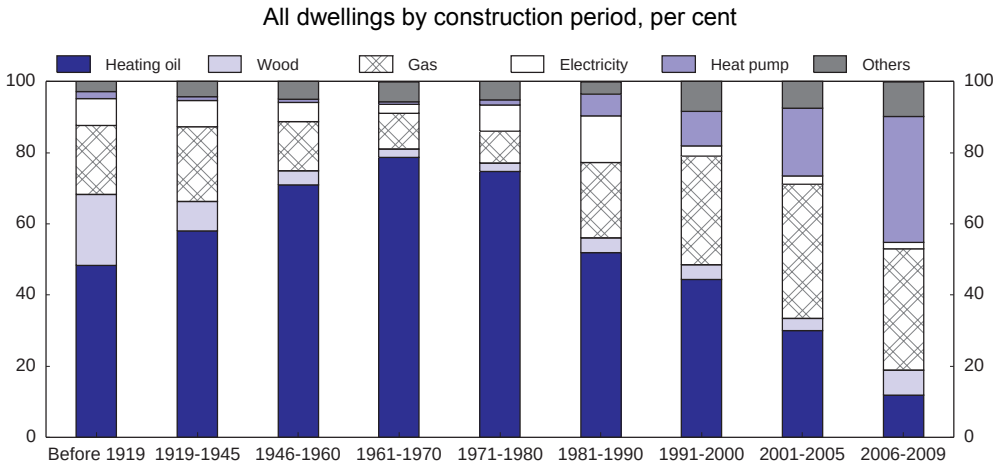
Source: UNFCCC database.

Over the past twenty years, emissions in the residential sector have been reduced by 9%, through a reduction in energy consumption and change in the energy mix (Drouet *et al.*, 2005). However, oil remains by far the most important energy source for heating. More than half of all buildings are heated with heating

7. Confidentiality was one of the main reasons for which for instance the Dutch road pricing system could not be introduced (Kozluk, 2010).

oil, nearly one fourth are heated with electricity (10.4%) or wood (12.2%), 15% of the buildings have a gas heater and 8% have a heat pump (FOS, 2011). Figure 6 suggests also that heating oil is the dominant form of heating in dwellings that have been built before the 1980s, while new houses are increasingly equipped with less polluting sources, such as gas and heat pumps.

Figure 6. Principal energy sources for residential heating



Source: OFS, Buildings and dwelling statistics, 2011.

Renovating dwellings can reduce heat demand by more than 50% and substituting traditional energy sources with renewable energy can create an even larger effect in terms of an aggregate reduction of greenhouse gases (FOEN, 2010a). Relatively strict regulation for new construction is in place which creates an incentive for owners of new houses to use energy sources that produce little CO_2 emissions (Drouet *et al.* 2005). However, there seem to be little incentives to renovate older buildings so as to reduce energy consumption, with adverse impacts on CO2 emissions: about 85% of dwellings are built before the 1980s, with about 45% of all dwellings being more than 50 years old, while only 10% of dwellings have been constructed within the past 10 years (FOS, 2011). And only about 1% of all dwellings are renovated for energy-saving reasons each year (FOEN, 2010c).

While an important reason for this disincentive can be found in high investment costs and the lack of awareness about the financial advantages from energy-saving renovations, the structure of the Swiss housing market also matters. Two thirds of Swiss households live in rental dwellings, mostly in multi-household buildings. Furthermore, unfavourable rent regulation used to reduce the incentive of home-owners or tenants to invest in renovation so as to reduce energy consumption, since home-owners could not pass on investment costs onto higher rents (Drouet *et al.,* 2005). Up to 2008, rent increases due to renovation projects were possible only to the extent to which they induced actual and observable cost savings for the tenants. This led to uncertainties on the side of the owners because such cost savings were difficult to assess a priori, they depended on the energy consumption of the tenant, and were often overshadowed by fluctuating energy prices (Platzer *et al.*, 2008).

Box 2. Swiss climate change mitigation policy in the residential sector

Financial incentives

During ten years, the government provides financial incentives (in the framework of the buildings programme) to promote climate-friendly renovations of residential and commercial buildings, the use of renewable energies, the utilization of waste heat, and building engineering (FOEN, 2010a). The buildings programme is financed by the federal and cantonal governments, and the cantons are responsible for its implementation. The total budget amounts annually to CHF 280 to 300 million, to which the federal government contributes about CHF 200 Mio. Revenues from the CO_2 levy on fossil fuels and the cantons contribute another CHF 80 to 100 Mio per year.

Regulation and information measures

Since 1998, the Swiss Federal Office for Energy has worked in partnership with cantons to promote the "Minergie building standard" and label. This is a voluntary energy-efficient construction standard which sets an overall limit on energy use for heating, hot water, ventilation and air-conditioning for new (38kWh per m^2) and renovated buildings (60kWh per m^2) (IEA, Energy efficiency policies database). Generally, the adoption and enforcement of regulations regarding energy consumption of buildings largely falls within the competency of the cantons. This is reflected in the adoption of model regulations by the Conference of Cantonal Energy Directors, which serve as recommendations to the Cantons in this area. For new buildings, the currently valid model regulations (MuKEN 2008) correspond to the MINERGIE standard. For renovations, MuKEN aims at approximating the MINERGIE standard. The next revision is foreseen in 2014 (MuKEN 2014).

Application of the CO_2 levy on fossil fuels in the residential sector

On 1 January 2008, a levy on CO_2 emissions from fossil heating and process fuels came into force (see also Box 3). The revenue from the levy is restituted to Swiss households through a lump sum per capita transfer (disbursed through the administration of health care insurance fees) In 2010, the levy was raised from originally 12 CHF to 36 CHF per tonne of CO_2, and, since 2010, one third of the revenues from the levy are used for financial incentives in the framework of the buildings programme.

Amendment to rental law

In January 2008, an amendment to the rental law came into force which specifies that certain energy-saving renovation efforts of living spaces and premises undertaken by the owner are to be treated as value-enhancing investments that entitle to rent increases (Rohrbach, 2009). These include efforts but are not limited to i) use energy efficiently; ii) reduce energy losses linked to the structure of the building; iii) reduce emissions from technical equipment; iv) use renewable energy; and v) replace energy intensive household appliances. The reference used to estimate the "additional investment" by the owner that would justify a rent increase concerns these costs that exceed pure reconstitution or maintenance costs (Platzer *et al.*, 2008).

Rental policy should take into account environmental needs more appropriately, …

Incentives to invest in renovation of rental dwellings should be strengthened by further improving rental regulation (OECD, 2010). Since 2008, an amendment of the rental law aims to make it easier for owners to pass on the costs from energy-related investments to the tenants (Box 2). However, there may remain uncertainties at the side of the owners as to whether the renovations can be justified as "value-enhancing", especially as concerns small renovation projects. In the case of large renovation projects, between 50 and 70% of the total renovation costs can be declared as "value-enhancing". The definition of large renovations is, however, subject to strict requirements that may not be fulfilled for energy-saving renovations: they have to concern several parts of the dwelling at the same time; the total renovation costs have to exceed a multiple of (typically at least three times) the annual income from rents; and the owner must have undertaken regular maintenance renovations of the dwellings before, as otherwise even a large renovation would be considered as pure maintenance, for which no rent increase would be justified (HEV, 2010). Within rental regulation, the definition of energy saving renovations should be based on clearly defined criteria, such as the potential gains in energy efficiency and reduction of CO_2 emissions that could be achieved through the renovation. If also the extent to which rents can be raised was linked to the potential energy efficiency, this would allow house owners to appropriate a higher return from the investment, further increasing the incentive for energy-saving renovations.

… the use of the CO_2 levy in the residential sector should be revised, …

In January 2008, an income-neutral CO_2 levy on heating and process fuels came into force when it turned out that the pre-existing measures, notably the federal and cantonal financial incentives and the voluntary energy efficiency (Minergie) standard and label (Box 2), were not effective by themselves in achieving the originally set emission reduction targets. However, there is a need to further raise the CO_2 levy. The level of the CO_2 levy is likely not high enough to induce a sufficient incentive effect for energy saving renovations. Even the higher level of 36 CHF in 2010 is still substantially lower than the estimated efficient uniform CO_2 tax.

From 2010 onwards, one third of the revenues from the CO_2 levy are used for the buildings programme: during ten years, the central government provides additional subsidies to individual households and firms to promote climate-friendly building and renovations of residential and commercial buildings. If rent regulation is improved as outlined above, and a higher level of the CO_2 levy is eventually put in place, the financial incentives for individual renovation projects in the framework of the buildings programme will become redundant and should be phased out. While the buildings programme may address some informational barriers at the side of the households, it risks having large deadweight losses, as it would finance projects which may have been undertaken anyway, and may create thus substantial budgetary costs. The risk of deadweight losses arises in particular since the subsidies in the buildings programme apply to all energy saving renovations and are not targeted at renovations of rented dwellings, where the main market failures arise. Furthermore, it is not guaranteed that the most suitable projects are selected due to incomplete or asymmetric information, further reducing the effectiveness of the subsidies.

During the phase-out period of this programme, the government should make payments allocation gradually more restrictive. The subsidies should be better targeted at energy-saving renovations in rented dwellings. They should also be based on more objective and well-defined criteria, for instance potential gains in energy efficiency, similar to the rental law (above). Furthermore, instead of direct subsidies to individual households, the government should consider a stronger use of market mechanisms so as to reduce the unfavourable effects linked to incomplete information. One possibility here would be to design the subsidies in terms of interest rate reductions for bank credits, depending on the level of potential energy efficiency achieved, as applied for instance in Germany (FMTBU, 2011).

… and both should be complemented with better information

Awareness about options for improved energy efficiency in buildings needs to be improved. Since 1998, the Swiss Federal Office for Energy and the Cantons aim to promote the "Minergie" standard and label for energy-efficient construction and renovation (Box 2). However, only about 13% of new buildings and 2% of renovations in Switzerland have been certified according to this standard so far. Providing information on energy efficiency of dwellings for sale or for rent should be compulsory. This could be achieved, for instance, by designing the Minergie label similar to the EU energy labels where energy efficiency is rated according to a set of classes, and by requiring that it be clearly displayed whenever a dwelling is offered for sale or rent. This would make the Minergie Standard more effective as complementary signalling advice for both home-owners and tenants. Finally, if it was also used for the definition of potential energy efficiency gains in rent regulation and to improve targeting of the subsidies in the buildings programme (above), this would raise the effectiveness of both policies even further.

Incentives to reduce emissions would have to be improved in industry and agriculture

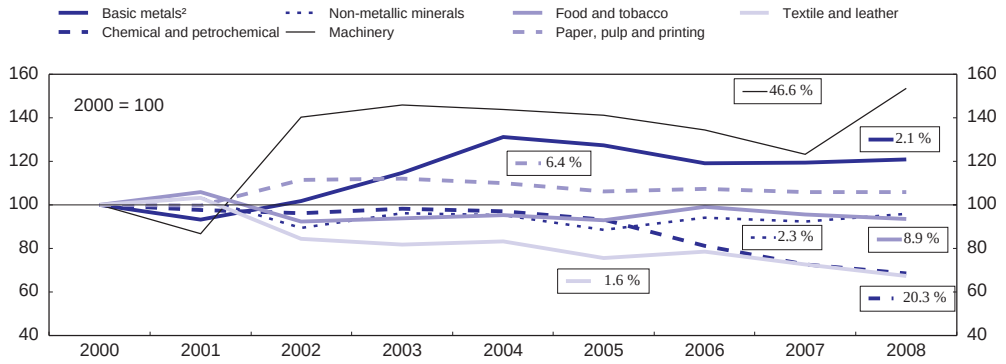
In industry, market based instruments are in place …

In Switzerland, the industry sector is not the primary source of greenhouse gas emissions. Indeed, it appears that the industrial sector has been able to decouple greenhouse gas emissions somewhat from

production, as reflected in greenhouse gas emissions per unit of output that have stabilised over the past 10 to 20 years (Figure 3 above). Some of this effect is due to reduced energy consumption in several industrial sectors, amongst which are those that are typically relatively energy-intensive, such as non-metallic minerals, chemicals, and textiles and leather production (Figure 7). However, energy use has increased substantially relative to production in the energy intensive sectors 'basic metals and paper' and 'pulp and printing'. In particular this is the case for the machinery sector which contributes to about 47% of overall industrial value added (Figure 7).

Figure 7. Energy intensity in the manufacturing sector

Energy consumption as a share of value added in volume[1]



1. Figures in boxes refer to the sectors' 2008 shares in total manufacturing value added at current prices.

2. Iron, steel and non-ferrous metals.

Source: IEA, International energy balances; OECD, STAN database.

In principle, the current policy mix to reduce CO_2 emissions in the industrial sector goes in the right direction as it involves to a large extent market-based instruments (Box 3). *First*, fossil heating and process fuels are subject to the CO_2 levy, which applies also to the industrial sector (but not to the transport sector) (see also Box 2). *Second*, firms that are exempted from the CO_2 levy for competitiveness reasons can (but are not required to) participate in the recently established Swiss emission trading system. *Third*, the so-called Climate Cent Foundation (CCF), a quasi-voluntary initiative by the Swiss oil industry, uses the revenues from a very low additional levy on imported petrol and diesel fuels for domestic and international emission reduction projects (*e.g.* CDM). The latter projects should help compensate for carbon emissions embodied in imports.

In March 2011, Switzerland and the EU started negotiations with a view to linking their emission trading systems (FOEN, 2011b). This would allow Swiss firms to trade in a much larger and liquid system, which has the potential to produce efficient and less volatile prices, and would improve participation of firms in the emission trading system. Most importantly, it provides for a cost effective way to reduce greenhouse gas emissions, which will be crucial in the process of the phasing out of nuclear energy. Currently, the Swiss trading market is too small, as it is limited to those energy-intensive firms that have been exempted from the CO_2 levy on fossil fuels and which voluntarily participate in the system. The government should continue its efforts to link the Swiss system with the EU emission trading system (ETS).

Box 3. Swiss climate change mitigation policy in industry

Application of the CO_2 levy on fossil fuels to industry

The CO_2 levy on fossil fuels (Box 2) applies also to the industrial sector; the revenues are restituted to non-exempted firms in proportion to the total payroll of the firms' employees, via the old age insurance system, thereby putting a relatively higher burden on combustible-energy intensive firms to the advantage of relatively labour intensive ones. Firms can ask to be exempted if they conclude an agreement with the federal government to reduce their CO_2 emissions to a level negotiated bilaterally or in a group. These agreements are typically tailor-made contracts between the firm or groups of firms and the regulator, specifying targets, the timetable for compliance, and penalties (Thalmann and Barazini, 2004).

Emission trading system

The decree on the CO_2 law establishes a limited emissions trading scheme (ETS) for firms that are exempted from the CO_2 levy. The Swiss ETS is a baseline-and-credit system in which each participant has the right to emit a certain level of CO_2 emissions which is individually computed for each participant on the basis of projected production and emissions. When participants fall below their baseline level, they earn emission reduction credits for the additional abatement of CO_2 emissions which they can transfer to the next trading period or sell to other participants. If a firm emits CO_2 in excess of its target, it can buy allowances from other companies (Schürch, 2005). Emission allowances are allocated to the companies free of charge, in accordance with the negotiated targets (FOEN webpage). To cover excess emissions, allowances have to be purchased on the domestic or international markets and/or earned through emission reduction projects abroad. As a rule, foreign certificates may be used to cover a maximum of 8% of the target. In the event of non-compliance, the CO_2 levy is to be paid retroactively for each tonne of CO_2 emitted since exemption was granted. Small companies, for which no reduction target has been stipulated, but which have set a specific target value for their emissions, do not receive any emission allowances. However, they can buy emission credits to fulfill their commitment (FOEN webpage, Schürch, 2005).

Switzerland and the EU entered in negotiations, in March 2011, in view of the linking of the Swiss ETS with the one of the EU. The EU Directive establishing a scheme for emissions trading stipulates that agreements can be concluded with third countries that have ratified the Kyoto Protocol to provide for the mutual recognition of allowances.

Financing of international emission reduction projects

The Climate Cent Foundation is an initiative of the Swiss oil processing industry, introduced so as to avoid the introduction of a CO_2 tax on transport fuels. It is funded by a charge levied on all transport fuel *imports* at a rate of 1.5 cent per liter, generating an annual revenue of around 100 million Swiss Francs. The foundation has committed vis-à-vis the Swiss Confederation to reduce CO_2 emissions by 12 million tonnes over the period 2008 to 2012, of which at least 2 million tonnes within Switzerland, the latter stemming from the transport and industrial sectors. Projects for emission reduction abroad concern those approved by the UN accreditation body generating tradable emission certificates, which Switzerland can claim towards the fulfillment of its reduction target. Thereby, the CCF purchases emission certificates in accordance with the Kyoto Protocol, applying stringent quality requirements (e.*g.* no certificates from projects regarding certain industrial gases). The Swiss authorities do not perform additional substantive evaluation of the projects (FOEN webpage.)

Tax on Volatile Organic Compounds (VOC)

While not considered under greenhouse gas emissions, VOCs are volatile organic chemical compounds that are normally used as solvents or propellant in various industry branches. Once they combine with nitrogen oxides they produce high ozone concentration at low altitudes, which is highly harmful for human health. In January 1998, the tax on the production and importation of VOC came into effect. Exportation is exempted, as well as any industrial use of listed VOCs not implying their emission in the atmosphere. The tax on VOCs is neutral, as its receipts are redistributed to the population through mandatory health insurance. In 2010, tax revenues amounted to about 128 CHF millions. According to FOEN estimates, VOCs emissions in the most polluting sectors (industry, handcraft and households) diminished by 34 % in the period from 1998 to 2004, in anticipation of the introduction of the tax and following its application. Activities generating VOC emissions were scaled back by adopting more innovative production processes or by putting on the market products with a lower VOC-content (FOEN, 2007).

… but incentives to reduce CO_2 emissions remain suboptimal

There is neither a definition of "competitiveness" nor objective "energy intensity" criteria that would justify firms being exempted from the CO_2 levy. In order to qualify for exemption, firms have to conclude an agreement with the regulator to meet a negotiated level of emission reductions. As a result, a relatively large number of firms may receive exemption from the levy for little reason, and even if they compete with foreign firms that have to incur a CO_2 tax, thereby reducing the efficiency of the levy.[8] Based on an econometric evaluation, a similar model, the UK Climate Change Agreements, has proven to perform much worse as concerns CO_2 emissions, and indirectly innovation, as compared to the full application of the UK Climate Change Levy to all firms (OECD, 2008b). The results also suggest that subjecting all firms under the UK Climate Change Levy had no negative impacts on competitiveness (OECD, 2008b). These results would similarly apply to the Swiss case: since the revenues from the Swiss CO_2 levy are restituted to the firms (Box 3), the overall burden on firms, and hence the impact on competitiveness, is limited, reducing the need for exemptions from the levy for competitiveness reason (OECD, 2001). Swiss firms should be obliged to either pay the levy or participate in the emission trading system. For instance, firms in sectors covered by the EU ETS could participate in the emission trading system, while exemptions from the levy should be phased out for firms in sectors not covered by the EU ETS. The government's plan to set up a list of criteria to be met by firms requesting exemption from the CO_2 levy is a first step in the right direction.

Moreover, emission allowances are given for free and emission reduction targets are negotiated bilaterally between the individual firm (or a group of firms of the same sector) and the regulator. These targets are then used in the emission trading system (Box 3). Bilaterally negotiating targets tends to create unnecessary transaction and administrative costs. In particular, firms would have an incentive to negotiate emission targets that they can easily meet, especially since the regulator does not have the same set of information as the firm.[9] Such individually fixed targets tend also to be too generous to create sufficient incentive for trading; hence they entail adverse selection in that only those firms participate that would have reduced their emissions in any case. Giving emission allowances for free is likely to reduce the incentives of firms to cut emissions and hence to participate in permit trading even further, because firms who made large cuts in emissions risk being granted fewer emission permits in the future. Emission targets should be set in the sense of binding emission caps that are valid for the industry as a whole. This would bring the Swiss baseline-and credit-system also closer to a cap-and-trade system which would be required for its linking with the EU ETS anyway. In line with the EU ETS, the government should also gradually start auctioning emission allowances, so as to avoid undesirable dynamic incentive effects that result from grandfathering.[10] Steps in these directions are planned in the draft revision of the CO_2 Act.

The current Swiss ETS has not promoted an efficiently functioning market for credits yet. In particular, the Climate Cent Foundation (CCF) sets the price of the emission allowances, inhibiting emission trading (Schürch, 2005). It can do so owing to its obligation to reduce at least two million tonnes of CO_2 emissions domestically, which it does by purchasing CO_2 emission allowances in the Swiss ETS

8. According to FOEN (2007a), more than 1 600 companies, from ceramics, glass, paper, chemicals, metal and mechanical engineering, plastics, aluminium, food, lime, foundries, and the graphic arts industry, had set voluntary emission reduction limits before (or in the anticipation of) the decision that a CO_2 tax would come into force.

9. Competition-hampering horizontal agreements may also arise as emission reduction targets are set by group discussions of firms of the same industry (Thalmann and Baranzini, 2004, Brau and Carraro, 1999).

10. The EU trading scheme foresees the auctioning of all allowances. Transitional measures are in place for particular sectors, for which in 2013, 80% of the emissions would be free, coherent with the ration valid during 2005 and 2007. Thereafter, the free allocation should decrease each year by equal amounts resulting in 30% free allocation in 2020, with a view to reaching full auctioning in 2027 (EC, 2009).

(Box 3).[11] As a reaction to the Swiss Competition Commission's classification of the CCF as an illicit agreement that restrains competition and which cannot be justified on efficiency grounds, the government has granted a temporary exceptional authorisation, based on the superior, legitimate public interest of environmental protection (OECD, 2010b). The Climate Cent Foundation should not be allowed to distort the emission trading market. The right to collect the climate cent should be replaced by a CO_2 levy on transport fuels as recommended above.

For the post-Kyoto period, the government plans to supersede the voluntary Climate Cent initiative, by obliging fuel importers to compensate at least 25% of the emissions from their fuel imports through reduction measures in Switzerland or abroad (OECD, 2010b).[12] However, market power of individual (or groups of) firms within the Swiss emission trading system may still prevail, notably since importers will be free to arrange a joint procurement of the individually required emission allowances - subject to competition law. This is related to the relatively weak independence, powers and resources of the Swiss Competition Commission (OECD, 2006). Dominant positions or horizontal agreements which impair competition in the Swiss ETS should be prohibited and the powers of the Swiss competition authority and its independence should be further strengthened – as recommended in previous Economic Surveys. The plan by the government to reform the Cartel Act goes in the right direction.

Finally, the financing of international Clean Development Mechanism projects, which is currently done through the Climate Cent Foundation, appears not cost effective, yet poses the risk of large deadweight losses. This is linked to the difficulty of assessing and proving additionality as discussed above. In particular, Swiss authorities do not monitor and control the quality of the projects financed by the CCF beyond what is applied by the UN (FOEN webpage). There is scope for Switzerland to work towards improved environmental quality of the international emission reduction projects, for instance in the form of more active cooperation or involvement towards the set-up of quality standards of UN projects, as is envisaged already.

There is still potential for GHG emission reductions beyond CO_2 in agriculture

Current Swiss climate policy is focussed on the reduction of greenhouse gas emissions via a reduction in CO_2 emissions only. In the CO_2 Act, this is justified by the fact that, in 2008, 84% of all greenhouse gas emissions were CO_2 emissions and by claiming that there would be little potential for further reductions in non-CO_2 greenhouse gas emissions (Federal Council, 2009).[13] Some progress has indeed been made in

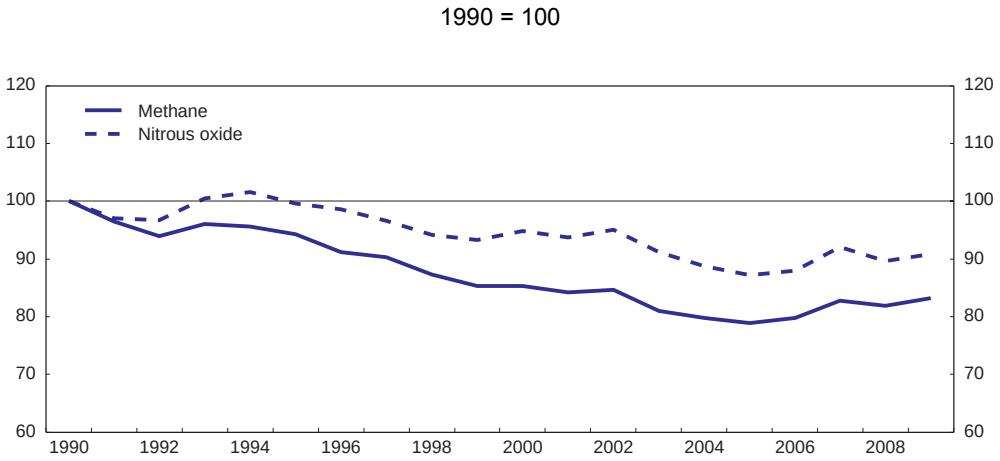
11. In a first round, the foundation paid 70 CHF for one emission allowance, equal to a reduction of one tonne of CO_2, and 100 CHF in a second round (Schürch, 2005). This price is definitively higher than the spot price of 23 CHF that establishes for instance on the EU ETS (Schürch 2005). Interpreting the latter as the market price would raise the question why the foundation sets the price so high. A monopoly buyer of allowances (as which the foundation can be seen) would restrict the amount purchased so as to drive down the price. However, the EU ETS is seen as a very competitive system with a large number of participants which is not the case for the Swiss ETS, notably given its small size and different abatement cost structures (OECD, 2007a). In addition, the foundation is obliged to reduce a certain amount domestically and the only way to do so is by buying allowances. Hence, it sets the price high enough to ensure the willingness of a sufficient number of firms to sell allowances.

12 The actual percentage of compensation will be defined in line with the requirements for the domestic reduction target by 2020. Whether the compensation will be realised by the CCF or a different initiative is left open.

13. Reductions of emissions that impact climate change have been achieved as concerns other gases that are not covered under the Kyoto protocol and are hence not subject to this survey. A prominent example concerns volatile organic chemical compounds (VOC) that are used as solvents or propellant in various sectors. Once they combine with nitrogen oxides they produce high ozone concentration at low altitudes, which is highly harmful for human health, especially in good weather seasons (summer smog). Switzerland

reducing methane and nitrous oxide which stem almost entirely from the agricultural sector and which together contributed, in 2008, to more than 13% of all greenhouse gas emissions in Switzerland (Figure 8, UNFCC database). However, more could be done still. A further reduction of these greenhouse gas emissions could have a sizeable effect in terms of total CO_2 equivalent emission reductions. The impact of one tonne of methane (CH_4) emissions on climate change is equivalent to 21 tonnes CO_2 emissions, and the impact of one tonne of nitrous oxide (N_2O) emissions is equivalent to 310 tonnes of CO_2 emissions (WWF, 2007).

Figure 8. Development in non-CO_2 greenhouse gas emissions in Switzerland



Source: UNFCCC database.

There are currently only limited incentives for emission reductions in the agricultural sector. Neither the CO_2 Act nor the proposal for its revision for the period after 2012 specify a target for greenhouse gas emission reductions in the agricultural sector, and the agricultural sector is exempted from the emissions trading system. To some extent, this can be explained in that currently known and applicable technological measures to reduce GHG emissions in the agricultural sector are limited or mitigation using those measures may be very costly.[14] However, empirical studies point to measures that are already in the pipeline and which could have – once further developed - large mitigation potential (Peter *et al.*, 2009, see also OECD, 2011a).

Moreover, in Switzerland, support to the agricultural production remains high in international comparison (OECD, 2011b). Half of the payments are based on commodity output or input use, some of which with potentially detrimental effects for the environment, especially if they are directly or indirectly linked to the use of fertilisers in the production process or the number of animal stock. Over the past 20 years, efforts have been undertaken to redirect producer support towards direct payments which are

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introduced an incentive tax on the production and importation VOCs in 2000. See for more detail Schoenberger and Mack (2008) and FOEN (2007b).

14. Nitrous oxide is produced mainly through fermentation and to a lower extent from synthetic and commercial fertilizers, while methane is produced mainly by crops and to a lower extent from fertilization (WWF, 2007). As a reference, one cow produces on average about 112 kg of methane per year, which is equivalent to the average CO_2 emissions produced from the annual mileage of a standard private car. Examples for technical measures to reduce emissions are fat addition to beef cattle diet, the use of manure additives and the coverage of liquid manure storage facilities, anaerobic fermentation, and the spreading of slurry with drag hose technology (WWF, 2007, Peter *et al.*, 2009).

typically less distortive (OECD, 2011b) and have less negative environmental effects (WWF, 2007). However, between 2008 and 2010, the largest part of these direct payments consisted still in general direct payments which are mainly granted in the form of payments per hectare of farmland and payments per cattle head (OECD, 2011b).

For the period 2014-17, while the nominal budgetary outlays for support to agriculture are expected to remain broadly constant, draft legislation foresees to continue shifting towards direct payments, and within direct payments, towards those payments that support environmentally friendly production processes (Box 3). These measures go in the right direction. Empirical evidence suggests that decoupling, *i.e.* the move towards direct payments, tends to foster more extensive forms of land management under otherwise similar conditions. This can lead to a reduction of emissions especially from nitrogen fertilisation and therefore the nitrous oxide emissions from fertilised agricultural land (WWF, 2007). The redirection of payments to more environmentally friendly production has the potential to further reinforce this positive effect in terms of greenhouse gas emission reductions.

The government should consider reducing input- and output-based support further (OECD, 2011), as well as targeting remaining support at those projects with the highest potential for environmentally friendly production processes. This should be combined with the introduction of a levy on the emission-producing inputs. Further reducing producer support would induce farms to produce more efficiently, and the levy would induce firms to invest in those efficiency improvements that are also good for the environment. By putting a price on the emission of greenhouse gases that result from agricultural production, this would also increase the overall efficiency of the Swiss climate change policy and would free up resources. Thereby, the CO_2 levy could be based for instance on the use of synthetic fertilisers as is already introduced in Sweden, Finland, Denmark and Austria (WWW, 2007). International standards that regulate the use of synthetic and commercial fertilisers in agriculture would provide for the set of information that is necessary for setting the adequate level of the levy (WWW, 2007). An alternative and possibly less costly way would consist in a system that addresses nitrogen surpluses (OECD, 2004).

Besides environmental effects, such a policy mix would contribute to raising aggregate productivity growth through increased efficiency of farming - as recommended already in earlier Economic Surveys (OECD, 2007c, OECD, 2009). Estimations suggest strong potential for efficiency improvements of Swiss agricultural firms. If all firms produced as efficiently as the currently 25% (50%) best ones, overall efficiency would increase by an average 6% (10%). On aggregate, this would amount to an efficiency gain of 700 Mio CHF, *i.e.*, more than 1% of GDP. This does not take into account future technical improvements which would push the potential for efficiency gains even further (FOA, 2011). Another study that compares Swiss efficiency with the one of farms in the neighbouring German state Baden-Württemberg, characterised by similar topological conditions, reveals that only the best 17-24% of Swiss farms are as efficient as the neighbouring ones (FOA, 2011).

Box 4. A summary of main policy recommendations for cost-effective GHG emission reduction

General

- There is a need to increase the CO_2 levy in line with the national greenhouse gas emission reduction target.

Road transport

- A CO_2 levy on transport fuels should be introduced in order to address strongly increasing emissions from road transport. This would best be combined with the introduction of a variable congestion charge that would be higher in geographical areas under stress and periods of peak demand. Revenues from the CO_2 levy and the congestion charge should be fed into the general budget or restituted.

Residential sector

- The definition of energy-saving renovations and the extent to which rents can be raised should be based on clearly defined criteria, *e.g.*, potential gains in energy efficiency achievable through the renovation.
- Once more effective rent regulation in place, the buildings programme should be phased out by making payment allocation progressively more restrictive.
- Providing information on energy efficiency of dwellings should be compulsory.

Industry

- The government should continue its efforts to link the Swiss emission trading system with the EU system.
- Swiss firms should be obliged to either pay the levy or participate in the emission trading system.
- Within the emission trading system, emission targets should be set in the sense of binding emission caps that are valid for the industry as a whole. The government should also gradually auction emission allowances, in line with the EU ETS.
- The Climate Cent Foundation should not be allowed to distort the emission trading market. The right to collect the climate cent should be replaced by a CO_2 levy on transport fuels as recommended above.
- Dominant positions or horizontal agreements that impair competition in the Swiss ETS should be prohibited.
- There is scope for Switzerland to work towards improved environmental quality of the international emission reduction projects, either domestically or through stronger cooperation with the UN or the EU.

Agriculture

- The government should further reduce input- and output-based support and target remaining support at those projects with the highest potential for environmentally friendly production processes.
- This should be combined with the introduction of a levy on the emission producing inputs, *e.g.* in the form of a levy on fertilisers.

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