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Air emissions accounts

Decomposition of Switzerland's fossil CO_2 emissions

Between 2000 and 2013, fossil CO_2 emissions from the Swiss economy fell by 4% whereas household emissions increased by 1%. Without improvements in energy efficiency, in 2013 the Swiss economy would have generated 11% more fossil CO_2 than in 2000. Meanwhile, households would have generated 19% more fossil CO_2 to heat their dwellings and 26% more for mobility. Calculated for the first time by the Federal Statistical Office (FSO), these estimates are the result of factor decomposition analyses applied to environmental accounts.

How can we explain the change in fossil CO_2 emissions from the economy and households seen between 2000 and 2013? What has been the impact of technical improvements and changes in fuels in the context of economic and demographic growth?

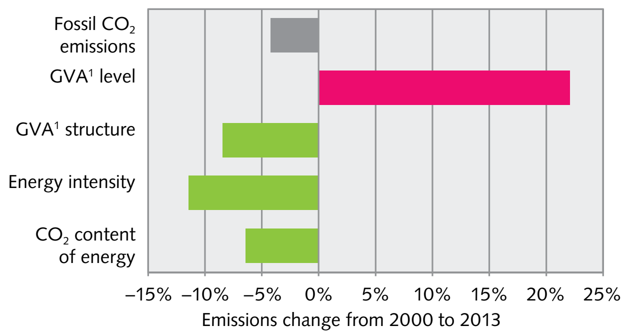
The growth in CO_2 emissions is the result of several concurrent causes. The individual impact of these causes cannot be directly identified, because the contribution from each cause is hidden among the overall increase of emissions. Due to the use of coherent data sources, particularly from the environmental accounts, the factor decomposition analysis makes it possible to isolate the contribution from various different causes to the evolution of emissions (see methodological note p. 4). The decomposition analysis therefore highlights the factors that have the greatest impact on CO_2 emissions and explains the overall growth in emissions over time.

Fewer emissions thanks to a more efficient economy

Four main factors were used to analyse fossil CO_2 emissions from the economy (G 1):

- the level of economic activity (represented by the real total gross value added, GVA)
- the contribution from the different economic sectors to the total GVA (structure of the GVA)
- the energy used per GVA unit (energy intensity)
- the quantity of CO_2 generated per energy unit used (energy content in CO_2)

Decomposition of fossil CO_2 emissions from the economy between 2000 and 2013 G 1



[1] Gross value added

Source: FSO – Environmental accounts

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All other things being equal (*ceteris paribus*), the production system from the year 2000 would have led to a 22% increase in fossil CO_2 emissions in 2013 to satisfy the GVA increase (G 1). Moreover, all other things still being equal, the general decline in energy intensity would have enabled a 11% decline in fossil CO_2 emissions. More economical use of energy and better insulation of buildings, for example, have both contributed to greater energy efficiency. The change in the structure of the GVA would have contributed to an 8% decrease in emissions, with sectors containing high emission activities losing ground to less polluting activities. Finally, 6% of emissions would have been caused by the change in fossil fuel CO_2 contained in energy. The use of energy agents that generate less CO_2 (e.g. substitution of heating oil for gas or gas for wood) has enabled a decrease in the fossil CO_2 content of energy (change of the energy mix).

It should be noted that the production and transportation of imported goods generate emissions abroad that are not included in the analyses presented here (see page 4).

Secondary sector: efficiency and structural change

Between 2000 and 2006, fossil CO_2 emissions increased by 9% in the secondary sector. Changes in the GVA structure and the decrease in energy intensity were not sufficient enough to compensate for the increase in economic activities (G 2).

This upward trend shown by emissions in this sector has reversed since 2006. Therefore, emissions from the secondary sector ultimately show a decrease of 2% between 2000 and 2013. An acceleration has been seen in the decrease of the share of the most polluting activities (GVA structure). The decrease in energy intensity, which mainly occurred thanks to the improvements in the chemical industries and the manufacture of non-metal, mineral products (cement, glass, etc.), has also contributed to reducing the total emissions of the secondary sector. The variation in emissions due to the substitution of fuels (CO_2 content in energy) has a low impact on the overall growth of emissions in the secondary sector.

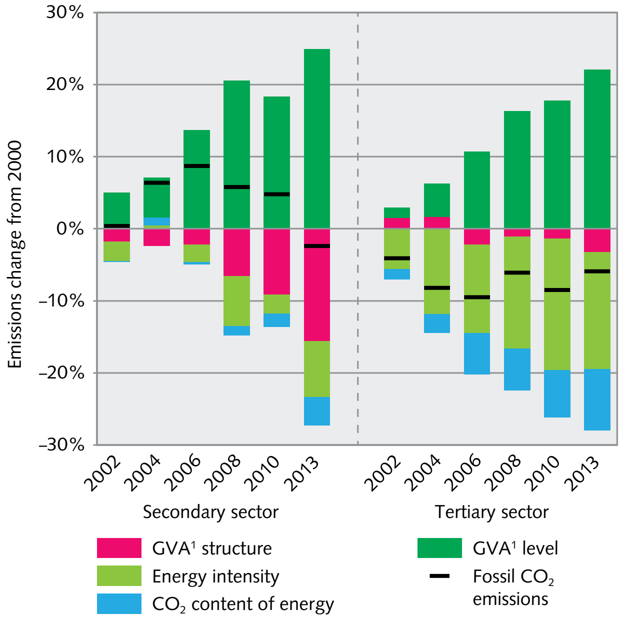
Tertiary sector: efficiency and fuel substitution

In the tertiary sector, energy intensity has constantly fallen since 2000. In 2013 and all other things being equal, energy intensity would have enabled a 16% drop in fossil CO_2 emissions compared with 2000. Fuel substitution would have led to an additional 9% decrease in fossil CO_2 emissions. This decrease can mainly be attributed to the transition to

Fossil CO_2 emissions

Fossil CO_2 emissions are emissions from the combustion of fossil fuel energy agents (petrol, natural gas, coal, ...) and cement production. In 2013, fossil CO_2 emissions corresponded to 47 million tonnes according to the air emissions accounts, with the economy accounting for 57% (primary sector 2%, secondary sector 26%, tertiary sector 29%) and households accounting for the rest. CO_2 emissions may also be released from biomass combustion (wood, biofuels, ...). CO_2 emissions from biomass were estimated at 7 million tonnes for Switzerland in 2013.

Decomposition of fossil CO_2 emissions from the secondary and tertiary sectors **G 2**



[1] Gross value added

Source: FSO – Environmental accounts © FSO, Neuchâtel 2015

heating facilities powered by energy agents that produce less fossil CO_2 (gas instead of fuel oil, wood instead of gas, etc.). In fact, in the sectors where a large share of emissions is generated by the heating of premises (financial, scientific, administrative activities linked to human health and social activities), the fall in emissions compared with 2000 as a result of the use of more ecological energy agents is greater than the sector average and would have exceeded 20%.

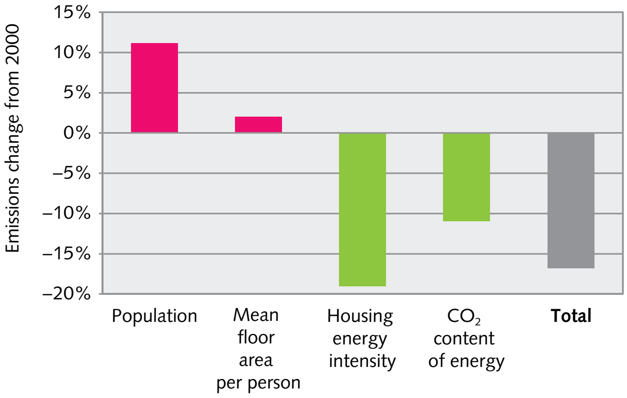
Overall, between 2000 and 2013, fossil CO_2 emissions from the tertiary sector fell by 6% despite the considerable increase in economic activities (+ 26%).

Dwelling improvements show their effect

The factors considered for the decomposition of fossil CO_2 emissions from the heating of households are as follows:

- Permanent resident population
- Average living area per person
- Energy intensity of dwellings (energy consumed per surface unit)
- CO_2 content of energy used for heating (CO_2 released per energy unit consumed)

Decomposition of fossil CO_2 emissions from households heating between 2000 and 2013 G 3



Source: FSO – Environmental accounts © FSO, Neuchâtel 2015

To compare years with different weather conditions, the energy consumption and CO_2 have been climatically adjusted according to the number of heating degrees-days[1] observed.

The drop in fossil CO_2 emissions (climatically adjusted) for heating households between 2000 and 2013 was 17%. All other things being equal, the decrease of the energy intensity of dwellings would have made it possible to reduce CO_2 emissions by 19% between 2000 and 2013 (G3) thanks to more efficient heating techniques, better insulated dwellings and more environmentally friendly heating habits. The substitution of heating fuels for energy agents that generate less fossil CO_2 such as fuel oil for natural gas or gas boilers for wood-fired boilers, heat pumps or solar heating systems, would have resulted in an additional decrease of 11%. However, the growth of the resident population and the increase in living area per person would have led to an increase in emissions of 11% and 2%.

Technical improvements to vehicles not enough to lower emissions

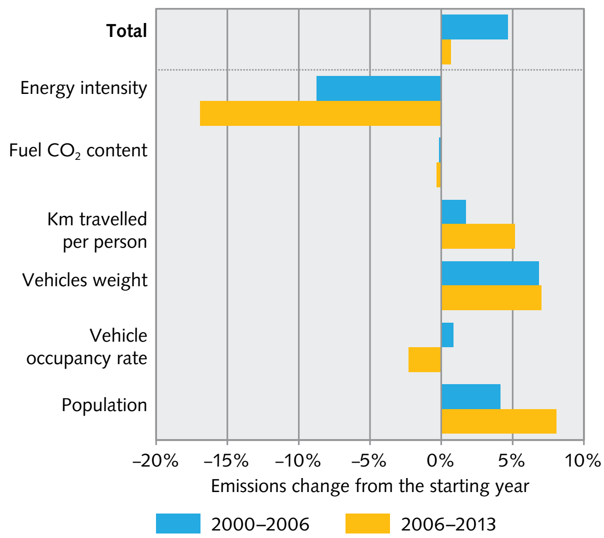
Emissions from household car transport were broken down by the following factors:

- Permanent resident population
- The vehicle occupancy rate
- The weight of vehicles
- The kilometres travelled per person
- Fossil CO_2 content of fuels (CO_2 released per energy unit consumed)
- Energy intensity of cars[2]

[1] The heating degrees-days are obtained by adding the daily differences between the outside temperature and the inside temperature (20°C) for every day on which the average outside temperature is below 12°C.

[2] The energy intensity of vehicles (energy used per kg transported and km covered) notably depends on the energy efficiency of vehicles, from the driving behaviour of motorists, the flow of traffic, the quality of infrastructure (road surface), etc.

Decomposition of fossil CO_2 emissions from household transport[1] G 4



[1] Excluded emissions abroad and from motorcycles

Quelle: FSO – Environmental accounts © FSO, Neuchâtel 2015

Between 2000 and 2006, emissions from household private transport increased by 5% (G4). The increasing weight of vehicles equipped with ever increasing amounts of safety equipment and comforts explains this increase. During the same period, the decrease in the vehicles occupancy rate would have resulted in a 1% increase in emissions.

Between 2006 and 2013, the total increase in emissions of 1% is more modest than for the previous period. The growth of the resident population and that of the weight of vehicles are the main factors behind the increase in emissions (8% and 7% respectively). In contrast, the energy intensity characterised by the decrease in the consumption of car fuel per km and kg and the increase in the vehicles occupancy rate contribute to the reduction of emissions (–17% and –2% respectively).

The decrease in emissions linked to changes in the CO_2 content in fuel[3] is negligible (0.3%). However, with diesel engines generally being more efficient than petrol engines, the change of fuel also results in greater energy efficiency (energy intensity factor).

[3] Diesel and natural gas release less CO_2 than petrol per energy unit produced. Substituting fuel thus results in a decrease of emissions. This factor also takes into account the decrease in emissions due to the increased use of electric vehicles.

The influence of activities abroad

The production and transport of imported goods generates emissions abroad that are not included in the decomposition analyses presented here. The absence of "hidden" emissions in the calculations influences the results, particularly the emissions due to changes in the production composition and the energy intensity.

The factor linked to the GVA structure is susceptible to the delocalisation of branches (moving an entire activity out of Switzerland), while the energy intensity factor varies if processes which require a lot of energy within one sector are relocated abroad (e.g. if a manufacturing company imports parts instead of producing them in Switzerland).

Similarly, emissions generated abroad during the production and the transformation of energy are not taken into consideration. Moreover, considerable amounts of emissions can be hidden in imported energy, especially in the case of electricity produced in coal-fired power stations. Therefore, although, during the decomposition analysis performed here, it is considered that the substitution of a fossil energy agent with electricity always leads to a decrease in CO_2 emissions, in reality, this decrease may be low or even non-existent depending on how the electricity is produced.

Environmental accounts

The decomposition analyses presented in this publication are based on data taken from the air emissions accounts and energy accounts. These statistics are part of the environmental accounts which in turn are satellite accounts from the national accounts. They are in keeping with the UN's System of Environmental-Economic Accounting (SEEA) and complement the national accounts with an environmental dimension by respecting their concepts, definitions, classifications and accounting regulations. They make it possible to show the interactions between the environment and the economy.

The data from the environmental accounts are different from those of the Switzerland's greenhouse gas inventory under the Kyoto protocol or the Swiss overall energy statistics, because adjustments were carried out in order to keep the coherence with the national accounts.

Methodological note

The Index Decomposition Analysis (IDA) is a technique used to quantify the contribution from the main factors responsible for variations of an aggregated variable. The basic hypothesis of an IDA for CO_2 emissions is to consider that the emissions, E, can be attributed to the processes described by the factors A, B, C, … (equation 1).

$$E = A \times B \times C \quad (1)$$

For example, we can imagine that the emissions from cars in a country depend on the country's motor vehicle population, the number of kilometres travelled by each car per year and the CO_2 emissions per vehicle. The chosen factors must be *coherent*, this means that the product of their units of measure must equal the unit of measure of the emissions and there must be a *causal link* between the parameters and the CO_2 emissions. It would not be appropriate to use the average size of drivers as a factor because the emissions do not depend on this parameter.
With the help of a mathematical transformation, the variation of emissions that took place between two years t_0 and t_1 may be broken down into a sum:

$$E_{t_1} - E_{t_0} = \Delta E = \Delta E_A + \Delta E_B + \Delta E_C \quad (2)$$

The effect of the factors A, B and C on the growth of emissions ΔE_A, ΔE_B and ΔE_C is calculated *with all other things being equal* (ceteris paribus). The value of ΔE_A thus corresponds to the change in emissions that is caused only by factor A, i.e. as if factors B and C had remained constant over time. This breakdown makes it possible to separate the effects of the different parameters from the overall growth of emissions. By using the previous example, we can distinguish between the increase in emissions caused by the expansion of the motor vehicle population and that due to greater mobility of persons.
There are several mathematical transformations to move from equation 1 to equation 2. The results presented in this publication were obtained by using the *Log Mean Divisia Index I* method (LMDI I). This method was chosen because of its solid theoretical bases and flexibility. However, because of approximations inherent to the method, the variation of the variable used to calculate a factor may deviate from the actual variation of the factor. Using the previous example, the variation of the factor linked to the motor vehicle population can be slightly different from the variation of the number of registered vehicles.

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