> Nitrogen flows in Switzerland in 2020

Baseline scenario and contingency analyses

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> Summary

Current situation

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Nitrogen (chemical symbol N) is a key element for the living natural world. It is the essential building block for the production of proteins and therefore essential for our nutrition. However, through developments in transport, industry, housing and agriculture over the last decades humankind has caused large amounts of reactive nitrogen compounds to be emitted into the air, soil and water. The most important reactive compounds of nitrogen are ammonia/ammonium, nitrogen monoxide/dioxide and nitrate. The emissions lead to an accumulation of nitrogen compounds in ecosystems and affect their interaction with other elements as well. The consequences are eutrophication, nutrient imbalances in plants, the acidification of soils, and the formation of secondary fine particulate matter. This is harmful to people, animals and plants, and their communities. Nitrous oxide and nitrogen trifluoride are also strong greenhouse gases and contribute to climate change (global warming), while nitrate, an important plant nutrient, pollutes drinking water and contributes to eutrophication, particularly of shallow seas (North Sea).

The nitrogen cycle in Switzerland was quantified for the first time in the early 1990s (GSK 1993 and PG N CH 1996). In 2010 the FOEN undertook to update this material flow analysis for Switzerland. “Nitrogen fluxes in Switzerland” (Heldstab et al. 2010) identifies and quantifies the most significant flows of nitrogen compounds between the different parts of the environment for the year 2005. The methodology was reworked compared to previous versions and new nitrogen flows included in the analysis.

This report shows how these nitrogen flows will develop up to 2020 using a probable “baseline scenario”. Contingency analyses are then used to consider the effects on the nitrogen cycle of additional political and social developments up to 2020. Several possible scenarios have been developed for Switzerland in the energy/climate, clean air and agricultural sectors, all of which have impacts on individual nitrogen flows; however, a view of the whole nitrogen cycle has so far been lacking. This report is thus intended to present an overall view. For the different environmental targets for nitrogen compounds, the degree to which targets are achieved and the need for action can then be derived.

Material flow methodology

Material flow methodology

The present study follows the methodological recommendations from “Material flux analysis Switzerland” (SAEFL 1996a), while also building on the study “Nitrogen fluxes in Switzerland. A material flux analysis for the year 2005”, the nitrogen flows, processes and subsystems of which are thus comparable to the present study. The material flow system is composed of the four subsystems of agriculture and forestry, environment, product manufacturing/use, and waste management; these subsystems are considered and analysed individually and as part of the overall system.

The spatial boundaries of the system are provided by the Swiss frontier. In addition to the quantity of each N flow in 1000 tonnes per year (kt N), a margin of error is given for each N flow.

Strategies, scenarios and targets

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The Federal Administration's strategies and scenarios with potential impacts on nitrogen flows are listed. The report also gives nitrogen targets that are either laid down in (national and international) legislation, or have been published in a declaration of intent by Federal agencies.

Baseline scenario 2020

Baseline scenario 2020

A baseline scenario for 2020 shows developments in nitrogen flows and calculations based on existing sector scenarios, literature searches and expert opinions (for examples of emissions into air and water, see Tab. 1). All nitrogen flows in the baseline scenario are then integrated into a nitrogen cycle for Switzerland.

Significant changes to be expected in the period 2005–2020:

> Nitrogen input into the agriculture and forestry subsystem will decrease by approx. 12 kt N, a reduction of almost 7%. The import of mineral fertilisers and nitrogen deposits are falling, while feed imports are rising.
> In the environment subsystem, nitrogen input will also decrease by around 22 kt N. Emissions from agriculture, traffic and combustion processes are decreasing, while those from waste management (ARA, KVA) are increasing slightly. The outputs will drop by approx. 29 kt N: here, the reduction of nitrogen exports via rivers and the atmosphere is the significant factor.
> In the product manufacturing/use subsystem, some flows show slight increases or decreases, but these are essentially cancel each other out overall. The increase of N-imports in foodstuffs should however be noted.
> Inputs in the waste management subsystem increase by 5 kt N, or 10%. This increase is in wastewater as a consequence of population growth.

In summary, population growth, rising imports of foodstuffs and feed, falling imports of mineral fertilisers, and technological progress in gas treatment (motors and combustion processes) are the drivers for the predicted changes.

Contingency analyses

Contingency analyses

In addition to the baseline scenario, three contingency analyses are considered. These contain assumptions that take account of the most recent political developments, which are not yet part of the baseline scenario. They include the Federal Council's fundamentally new Energy Strategy 2050 (E2050) following the 2011 Fukushima disaster, the full implementation of measures contained in the Federal Council's Air Pollution Control Strategy (Clean Air Strategy), and a package of measures (MTFR-IIASA) to reduce nitrogen losses from agriculture by applying known, available technologies.

Attainment of targets and need for action

The results for the baseline scenario and the contingency analyses are compared with environmental nitrogen targets. It appears that, for the relevant nitrogen flows at least, none of the binding national and international reduction targets can be attained by 2020. While the atmospheric NO_x emissions will miss the target by only approx. 3 kt N, agriculture (in terms of NH_3) and the input of nitrogen overall into waters will result in a shortfall of 20–28 kt N, depending on the target considered.

The following developments can be predicted in the most important anthropogenic drivers of the nitrogen cycle: combustion processes (traffic, combustion processes), wastewater and agriculture:

> Combustion processes (traffic, combustion processes): A significant reduction of around 36% in NO_x emissions from traffic can be expected. This will lead to a reduction in deposits on soils and thus in the leaching of nitrogen from soils.
> Wastewater: although the nitrogen load in wastewater is increasing due to the growing population, it may be compensated for by technological improvements in wastewater treatment.
> Agriculture: there are some changes in agricultural nitrogen flows compared to 2005. Overall, nitrogen inputs (from feedstuffs, mineral fertilisers, deposition and nitrogen fixing) will decrease by 5%, while nitrogen removal (through plant and animal products) will increase by 2%. Without further measures, the agricultural nitrogen flows will remain more or less at their current levels.

Tab. 1 > Targets and baseline scenario 2020

Targets and baseline scenario 2020 absolute in kt N and relative in percentage for 2005. All figures are rounded to two significant digits. The target difference shows the difference between the baseline scenario 2020 and the target value.

	Target systems				
	VLI & charge critique	Charge critique	OEA	PA 2014-2017	OSPAR
	Atmospheric emissions				Inputs into water
	NO_x	NH_3	NH_3 from agriculture	NH_3 from agriculture	N
Target (in kt N)	13	31	25	41	42
2005 level (in kt N)	25	51	49	49	72
Reduction needed to reach target (% of 2005 level)	50%	40%	49%	16%	42%
Level in baseline scenario 2020 (in kt N)	16	48	45	45	69
Reduction achieved in baseline scenario 2020 (% of 2005 level)	41%	5.7%	7.8%	7.8%	3.2%
Remaining target deficit in baseline scenario 2020 (in kt N)	3.5	17	20	4.0	28

Abbreviations: UZL: Umweltziele Landwirtschaft (Environmental targets in agriculture), AP 2014-2017: Agricultural Policy for 2014-2017.

The result for the baseline scenario improves when measures from the contingency analysis are included. Thus, if we assume that all the measures of the Clean Air Strategy are implemented as planned, as well as the new energy and climate policy (E2050), the target for the immission limit (IGW) for NO2 could be achieved. For the remaining three targets, the degree of target attainment will be somewhat better than in the baseline scenario, but neither E2050 nor all the additional measures in the Clean Air Strategy will cause sufficient reductions to bring the nitrogen flows substantially closer to the set targets.

The activities currently underway in energy, climate, clean air, waters and agricultural policies generally have synergetic effects on the nitrogen cycle. Conflicts of interest may occur with the use of new combined gas-and-steam power stations, or with increased utilisation of biomass.

The agreed and planned measures alone will not be sufficient to achieve the reduction objectives, at least not by 2020; the need for action is still great. Significant potential for reduction exists only in agriculture; a wide-ranging package of technological measures (IIASA 2011) could achieve further reduction effects in this sector from 2018. There are also potentials in the food sector.

The assumptions and working out of the baseline scenario, and of the contingency analyses, are explained in detail in the Annex.

This report evaluates technological developments and variants and their effects; it does not investigate economic or social impacts.