1st Swiss Energy Modelling Platform
Scenario description

This draft: 23.03.2017. Changes compared to last version are highlighted

1. Purpose, focus, and overview of scenarios

The purpose of the 1st SEMP study is to use energy-economic models to assess emissions, energy and economic outcomes from a plausible range of Swiss policies to reduce greenhouse gases (GHGs). The major motivating questions for the scenarios are:

- What are the costs of de-carbonization of the Swiss economy?
- How do the environmental and economic outcomes depend on alternative regulatory designs to price carbon? What are the effects of differentiating carbon price across fuels and sectors?
- How might technological improvements and technological availability influence the answers to the above questions?

Current policy proposals indicate that Swiss climate policy is moving into the direction of a steering based policy framework, where emissions shall be reduced by giving price signals to consumers and producers in the Swiss economy. This SEMP study therefore aims at assessing the cost of reaching Swiss climate targets for 2050 using different carbon pricing options including economy-wide uniform carbon taxes and policy designs in line with current proposals. We hence consider the Swiss emission trading scheme (ETS) in its current form and in a form where it is coupled to the EU's ETS. For non-ETS sectors, emissions may be priced by a uniform carbon tax or, as recent policy proposals suggest, by a carbon tax that differentiates between motor and thermal fuels. The study therefore intends to provide insights on how several realistic ways of designing future Swiss climate policy would impact different aspects of the economy and the energy-system.

SCCER CREST

In cooperation with the CTI

Energy funding programme
Swiss Competence Centers for Energy Research

Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Swiss Confederation

Commission for Technology and Innovation CTI

Table 1 presents an overview of the scenarios. To have a core set of scenarios across which inter-model comparisons are possible, we define a set of 7 basic scenarios that all modeling teams shall run (highlighted in red in Table 1). The other 9 scenarios are optional and provide sensitivity analyses with respect to either the policy or technology dimension.

Table 1: Overview over scenarios and their distinguishing assumptions

Technology Dimension				
		Default	**Alternative assumptions**	
GDP potential (energy demand)		Ref	High	Ref
Availability of renewable energy sources		Default	Default	Low
Energy efficiency		Default	Default	Default
Policy Dimension				
Business as Usual		BAU	BAU_log	
	2050 Target			
Economy-wide CO2 tax	1.5 t CO_2e p.c.	15TPC	15TPC_log	15TPC_ren
	1.0 t CO_2e p.c.	10TPC	10TPC_log	10TPC_ren
ETS and uniform CO2 tax	1.5 t CO_2e p.c.	15TPC_etsUni		
	1.0 t CO_2e p.c.	10TPC_etsUni		
ETS and differentiated CO2 tax	1.5 t CO_2e p.c.	15TPC_etsDiff		
	1.0 t CO_2e p.c.	10TPC_etsDiff		
EU ETS and uniform CO2 tax	1.5 t CO_2e p.c.	15TPC_EUETS		
	1.0 t CO_2e p.c.	10TPC_EUETS		

2. Harmonized of scenario assumptions

To increase the comparability of the modeling results we aim at harmonizing the general trends in the development of the economy and the energy system: population, economic growth potentials, energy demand and conditions on the world markets for fossil fuels. The idea is to calibrate baseline developments (GDP and energy demand) to the following scenario description.

Scenario drivers

Table 2: Harmonized modeling assumptions[1]

	2010	2020	2035	2050[2]	Reference
Population (million)	7.79	8.68	9.80	10.30	*BFS Scenario. A-00-2015. Available at https://www.bfs.admin.ch/bfs/de/home/statistiken/bevoelkerung/zukuenftige-entwicklung.html*
Working population (million full time equivalents)	3.85[3]	4.31	4.58	4.63	
Crude oil prices (2010 $/barrel)[4]	78	105	120	129	*2010 value: 2011 IEA World Energy Outlook Projections: 4DS Scenario in 2015 IEA Energy technology Perspectives*
Gas prices (2010 $/MBtu)	7.5	10.4	11.7	12.4	
EU electricity prices (2013 EUR/MWh)	133	150	160	159	*EU Reference Scenario 2016: EU Energy, Transport and GHG emissions - Trends to 2050. Avaiable at https://ec.europa.eu/energy/sites/ener/files/documents/ref2016_report_final-web.pdf*
Cooling degree day[5]	120		235	280	*"Klima Wärmer" scenario in BFE 2050 Energy Perspectives, pp. 80-81, avaiable at http://www.bfe.admin.ch/themen/00526/00527/06431/index.html?lang=en&dossier_id=06421*
Heating degree day[5]	3586		3002*	2831**	

[1] Variables for periods between those indicated can be derived by linear interpolation of given targets (this applies for all the variables in this document)

[2] Models that include time periods beyond 2050 will make individual developments beyond 2050 consistent with trends up to 2050.

[3] 2009 value

[4] Crude oil projections do not reflect current low market prices. Our projections assume that the latter are an anomaly that will be corrected in the long run.

[5] Assuming: (1) 2035: A temperature increase in the winter months September-May of 1C and in the summer months June-August of 2C; (2) 2050: A temperature increase in the winter months October-April of 1.5C, in the summer months June-August of 2.5C, and in May and September of 2C]

* 12% increase from the 1984-2002 average ** 17% increase from the 1984-2002 average

Business as usual (BAU) scenario

The BAU scenario is calibrated to the harmonized scenario drivers and the following GDP and demands:

Table 3 Harmonized drivers in the BAU scenario[1]

		2010	2015	2020	2035	2050[2]	Reference
GDP potential[3] (relative to 2010)	Ref	1	1.046	1.18	1.43	1.66	*Calibration years: BFS, Gross domestic product: expenditure approach, Table 3b. Available at https://www.bfs.admin.ch/bfs/de/home/statistiken/volkswirtschaft/volkswirtschaftliche-gesamtrechnung/bruttoinlandprodukt.assetdetail.323503.html Projections from: SECO 2015*
	High	1	1.046	1.23	1.58	1.86	*Simlab*
Energy demand (relative to 2010)	Ref	1	0.92	0.937	0.839	0.782	*BAU (WWB) scenario from BFE 2050 Energy Perspectives, p 96. Available at http://www.bfe.admin.ch/themen/00526/00527/06431/index.html?lang=de&dossier_id=06421*
	High	1	0.92	0.969	0.894	0.856	*Simlab*
Electricity demand (relative to 2010)	Ref	1	0.996	1.05	1.097	1.175	*BAU (WWB) scenario from BFE 2050 Energy Perspectives, p 96. Available at http://www.bfe.admin.ch/themen/00526/00527/06431/index.html?lang=de&dossier_id=06421*
	High	1	0.996	1.08	1.17	1.25	*Simlab*
Fossil energy demand by ETS sectors (relative to 2010)	Ref	1	0.876*	0.858	0.621	0.388	*Simlab*
	High	1	0.876*	0.861	0.626	0.395	*Simlab*

In the policy dimension, BAU scenarios should be calibrated to following existing policies:

Table 4 Harmonized policies in the BAU scenario[1]

	2010	2015	2020	2035	2050[2]	Reference
CO2 tax on thermal fuels (CHF/tCO_2)	36	60	120			CO2 Ordinance, Chapter 8: CO2 Levy. Available at https://www.admin.ch/opc/en/classified-compilation/20120090/index.html
CO2 tax on motor fuels (CHF/tCO_2)	0					CO2 Ordinance. https://www.admin.ch/opc/en/classified-compilation/20120090/index.html
Permit price in CH ETS (2010 USD/tCO_2)	N/A	Free**				
Cap of CH ETS relative to 2013 emissions	N/A	0.965	0.878	0.617	0.356	The cap in year t is computed with the formula (1-(t-2013)*0.0174) using the yearly reduction factor of 1.74% used in the EU ETS until 2020

[1] Variables for periods between those indicated can be derived by linear interpolation of given targets (this applies for all the variables in this document)

[2] Models that include time periods beyond 2050 will make individual developments beyond 2050 consistent with trends up to 2050.

[3] Models shall make individual assumptions about labor productivity that are in line with the GDP projections given by SEMP.

* Simlab estimate

** In BAU, the Swiss ETS is active but not coupled with the EU ETS. With trends in fossil fuel demand by ETS sectors described in Table 3, the cap of the CH ETS will be overshot. In order to achieve the capped emissions that are to be achieved in the BAU, assume that emissions implied by trends in Table 3 are achieved at permit prices according to Table 9 and endogenously determine the Swiss ETS permit price by applying the cap in the fourth row of this table.

Technologies

Table 5 Harmonized technology assumptions

Technology	Assumption
Nuclear	Nuclear power plants are phased out by 2034 according to expectations about the live span of the power plants currently in operation
CCS	No CCS until 2030. After 2030, models may make their own assumptions about CCS and report them.

Renewable resources

We analyze two cases: a **default** case where the modeling teams use their usual assumptions and a **low** case with limited deployment of renewables as described in the following able.

Table 6: Harmonized assumptions on renewable resources

Scenarios	Resource	2010	2020	2035	2050
Default	All renewables	free choice			
Low	Wind (TWh)	0.0366	0.3	1	2
	Solar (TWh)	0.0936	1.5	2	5
	Biomass (TWh)	0.18	1.3	2.5	2.5
	Biomass (percent of fuel mix in total primary energy)	0	10	10	10
	Geothermal (TWh)	0	0	0	0

Other assumptions

For all the other modelling assumptions (elasticities of substitution, technology characteristics, etc.) each participating model uses its own data.

Currency

The currency of the 1st SEMP is CHF_{2010}.

Table 7 Currency

Dollars	The 2010 exchange rate between USD and CHF was approximately 1 and shall be assumed to remain constant

Euros	The exchange rate between CHF and EUR was approx. 0.75 in 2010 and 0.93 in 2015 and shall be assumed to remain constant after that
Deflator	Consumer prices index (the difference between the CPI and the GDP deflator is less than 0.75%). Taken from the Swiss Statistics (http://www.portal-stat.admin.ch/lik_rechner/d/lik_rechner.htm), CHF2010 = 100:

2008	2009	2010	2011	2012	2013	2014	2015
99.807	99.327	100	100.192	99.519	99.326	99.326	98.171

3. Emissions targets

We consider two **emissions targets** frequently mentioned in Swiss policy papers**:** 1.0 t CO_2e and the 1.5 t CO_2e per capita. Given SEMP's assumptions about the Swiss population in 2050, both targets lie well within the range of 15-30 percent of Swiss emissions in 1990, the range of emission levels identified as the Swiss targets in its Intended Nationally Determined Contributions (INDC).

Table 8 presents the GHG targets and the consequences on energy demand and electricity demand. Each model is asked to consider the most general target it can represent for its policy scenarios and compute more specific demands endogenously.

Table 8: Assumptions about policy targets in terms of overall GHG emissions and CO2 emissions

	Target	**2010**	**2020**	**2035**	**2050**	**Reference**
GHG or CO2* emissions relative to 2010 levels: GHG without LULUCF: 54.37 Mt CO_2e Total CO_2 without LULUCF: 45.027 Mt CO_2 Total Energy CO_2: 42.603 Mt CO_2	1.5 tCO_2e	1	0.849	0.571	0.284	Emission levels in 2010 taken from the GHG Inventory 1990-2014 (Updated CRF tables 2016)
	1.0 tCO_2e	1	0.824	0.510	0.189	
Electricity demand (relative to 2010)		1	0.975	0.9375	0.9	Prognos (2012) 2050 Energy Strategy available at http://www.bfe.admin.ch/themen/00526/00527/index.html?dossier_id=05024&lang=en
Total energy demand (relative to 2010)		1	0.873	0.653	0.536	

* Given that not all models cover (all) GHG emissions, these targets are translated into CO2-only emission targets for models that consider CO2 only.

Important assumptions

- All emission targets must be met in the respective years and no banking or borrowing of emission allowances between periods is permitted.
- Emissions from international aviation are not included.
- After 2050: Models running beyond 2050 shall make individual assumptions about a reasonable continuation of climate policy and report their assumptions.

4. Carbon pricing

We consider four alternative CO2 pricing designs:

1. Economy-wide CO2 tax: Models should implement an uniform carbon tax across the whole economy
2. ETS and uniform CO2 tax: Non-ETS sectors emissions are priced by a uniform carbon tax
3. ETS and differentiated CO2 tax: Non-ETS sectors emissions are priced by a carbon tax that differentiates between motor and thermal fuels
4. EU ETS and uniform CO2 tax: Assume a coupling of the EU ETS and the Swiss ETS after 2020. Models that do not cover the permit market in the EU ETS shall assume the permit price in the EU ETS to be exogenous and the price level to be according to Table 9.

Table 9: EU ETS permit price

	2010	2020	2035	2050	Reference
EU ETS permit price (2010 €/t CO2e)	15	15	57	239	Scenario "energy efficiency" of the impact assessment for the EU Energy Roadmap 2050 (page 37) available at https://ec.europa.eu/energy/sites/ener/files/documents/sec_2011_1565_part2_0.pdf

ETS

- The ETS has a cap from 2013 onwards. The cap in year t can be derived from ETS emissions in 2013 ($emiETS_{2013}$):

$$cap(T) = emiETS_{2013}*(1-(t-2013)*0.0174).$$

- For scenarios where the ETS is assumed to be present, the overall emission targets is assumed to be met if non-ETS emissions are not greater than the annual overall emission target minus the ETS emission cap and industries included in emissions trading comply with the ETS rules.
- GHG emitters in the **electricity sector** are, in line with EU regulation, included in the ETS.
- **Gas power plants**: According to the CO2 Act, gas power plants compensate their emissions with a minimum share of 50% for domestic compensation, i.e. obtained from the other sectors. The rest can be compensated by using international emission reduction units. Assume that CO2 emissions from gas power plants are taxed by a tax equal to 0.5*(Foreign price) + 0.5*(Domestic CO2 tax).
- Emissions from **aviation** are assumed not to be covered by the ETS.

Differentiated taxes

The current political discussion reveals a preference for not putting a CO_2 tax on transport fuels. This is motivated by the preexistence of considerable mineral oil tax rates on transport fuels. In order to compare the economic efficiency of a uniform CO_2 tax on all fossil fuels and a tax system that puts a lower CO_2 tax on transport fuels than on thermal fuels, additional policy scenarios that **differentiate CO_2 taxes by fuel** type are introduced, the standard scenario assuming that CO_2 is taxed uniformly across fuels. In the scenario with differentiated CO_2 taxes, the CO_2 taxes on thermal and transport fuels shall be set such that tax rates (TR_thermal and TR_transport) are related by

$$TR\_transport = 0.25*TR\_thermal.$$

The tax rate on mineral oils is assumed to remain at current levels, i.e. at 73.12 Rappen per litre for gasoline and 75.87 Rappen per litre for diesel oil.

Revenue recycling

The design of climate policy is assumed such that the revenue of the Swiss government remains constant across different baseline and policy scenarios for any given year. This is achieved by recycling the difference between government revenue under climate policy and the revenue in the baseline. The revenue is to be recycled via per-capita lump-sum transfers. Models that recycle ETS permit revenue and revenue from taxing emissions in the industry via reductions in the social contributions bill may continue doing so. ETS permit revenue is the revenue the Swiss government obtains from selling the emission allowances according to cap(T) at the current periods ETS permit price.