CROSS Scenarios v2025-06

Modelling protocol

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Contents

List of Tables

1 Introduction

This modelling protocol summarizes the assumptions for the CROSS scenarios version **CROSS-v2025-06** (Marcucci and Guidati, 2025). It includes:

1. The assumptions related to the scenario definition, i.e. CO_2 and renewable targets and limits to electrification (Section 2);

2. Harmonising assumptions and and reference values and ranges for other variables that are relevant for the development of the future Swiss energy system (Section 3). Table 1 lists all variables covered in this document. Variables marked in the harmonising column are those expected to be aligned across models for the CROSS model comparison v2025.

Table 1: Harmonising assumptions

Variable	**Harmonising**
Population and GDP (Table 3)	×
Heating degree days (Table 3)	×
ERA (Tables 4 and 5)	×
Energy service end use demands	
Space heating (Table 6)	×
Warm water (Table 7)	×
Process heat (Table 8)	×
Electricity from appliances (Table 9)	×
Passenger and freight demand (Table 10)	×
Fossil and sustainable aviation fuels demand (Table 11)	×
Resources (Table 12)	
Hydropower	
Solar photovoltaics	
Wind	
Biomass	
Import prices (Table 13)	
Oil	
Gas	
Hydrogen	×
Net transfer capacities (Table 14)	
Investment costs technologies (Table 15)	
Solar PV	×
Wind	×
Other electricity generation technologies	
Efficiencies heat pumps and EVs (Table 16)	×

2 Scenarios definition

The CROSS scenarios v2025-06 are defined along three key dimensions: climate policy, renewables and imports targets and fallibility of charging infrastructure for electric vehicle (EVs).

Climate policy dimension

This dimension is shaped by the Climate and Innovation Act (Swiss Federal Council, 2022), which legally mandates net-zero GHG emissions by 2050, covering all sectors and GHGs, including aviation but does not specify a required share of domestic reductions. We, therefore, consider two variants based on the geographic source of emissions reductions:

- Abroad variant: Allows a share of emissions reductions to be achieved via carbon dioxide removal (CDR) abroad, with a minimum of 90% domestic reductions by 2050. For the cost of using Internationally transferred mitigation outcomes (ITMOs), the carbon price calculated by global models in achieving the net-zero target can be used: an interquartile range of 200–900 US$$_{2010}$ and an average of 500 US$$_{2010}$ (Riahi et al., 2021).
- Domestic variant: Assumes that Switzerland meets its net-zero target solely through domestic efforts, i.e., 100% of emissions reductions occur within the national territory.

Table 2 summarizes the values for each variant. The details on the current regulation and the estimation of the emissions targets can be found in the CROSSv2025-06 scenario description (Marcucci and Guidati, 2025).

Renewable and imports target

This dimension models the policy mandates on renewable electricity production and winter electricity import constraints as well as a counter-factual scenario without such targets.

- RES-target variant: Implements the Energy Act targets (UVEK, 2024), requiring at least 35 TWh of electricity produced with new renewables (solar, wind, biomass, and geothermal. Excluding hydropower) by 2035 and 45 TWh by 2050, and limiting winter electricity net imports to 5 TWh.
- NoRES-target variant: A counter-factual case with no binding targets on renewable generation or restrictions to winter electricity imports, letting the system evolve based on techno-economic optimization.

EV charging infrastructure availability (Electrification)

This dimension captures uncertainty around the pace of the deployment of EV charging infrastructure:

- Full variant: Assumes unrestricted rollout of EV charging infrastructure, enabling EVs to meet up to 100% of private passenger transport energy demand by 2050.
- Limited variant: Reflects potential bottlenecks in infrastructure deployment, limiting the EV share of passenger transport energy demand to 60% by 2050.

Scenario overview

Figure 1 depicts the overview of the scenarios, resulting by combining the three dimensions previously described. Table 2 presents the values needed to implement the CROSSv2025-06 scenarios.

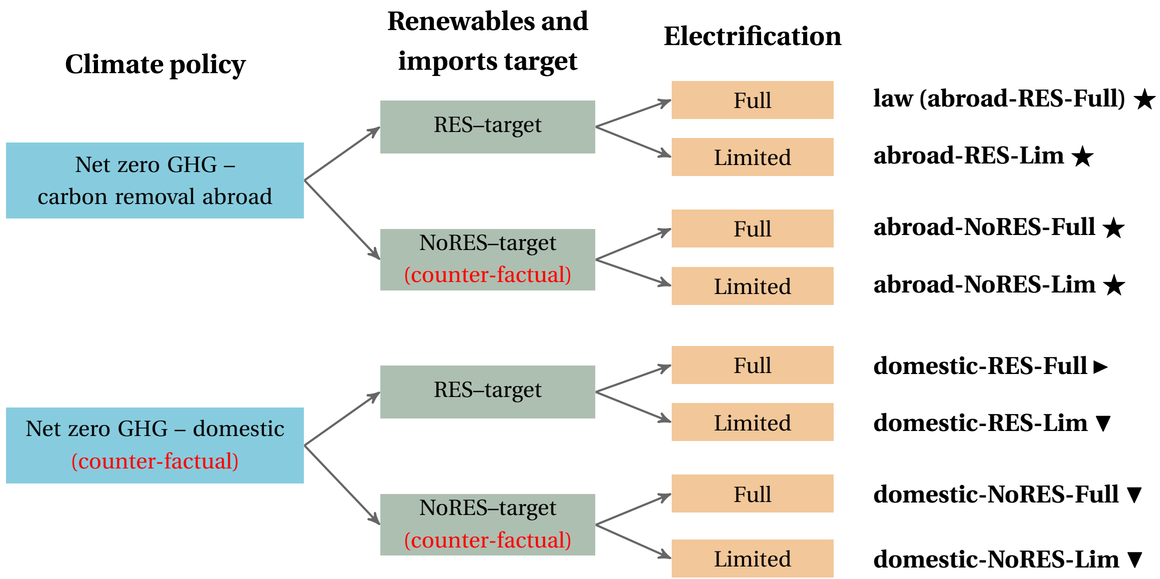

Figure 1: CROSS-v2025-06 scenarios overview. Counter-factual scenarios (i.e., those without policy enforcement) are shown in red. The priority level of the scenarios is indicated as follows: ★ high, ► medium and ▼ low.

Table 2: CROSS-v2025-06 scenarios

Climate policy	Domestic			Abroad		
	2030	2040	2050	2030	2040	2050
Maximum GHG domestic emissions ($MtCO_2$)	36.5	21.1	0.0	36.5	23.3	8.7
Maximum GHG compensation abroad ($MtCO_2$)	7.3	6.6	0.0	7.3	8.7	8.7
Energy-related emissions target ($MtCO_2$)	23.9	10.9	−8.0	23.9	13.1	0.8
Renewable and imports target	RES-target			NoRES-target		
		2035	2050		2035	2050
Minimum electricity produced with new renewables (solar, wind, biomass, and geothermal. Excluding hydropower) (TWh)		35	45		-	-
Winter electricity net imports (TWh)			5		-	-
Electrification	Full			Limited		
	2030	2040	2050	2030	2040	2050
Maximum share of EVs in final demand of passenger vehicles (%)	15	60	100	15	40	60

3 Reference values for model input parameters

This section summarizes values for different input parameters of energy system models. The complete description of the estimation can be found in Marcucci and Guidati (2025).

3.1 Population, GDP and HDDs

Table 3: Population, GDP and HDDs

	2010	2020	2030	2040	2050	2010–2050	Reference
Population (Million)							
Reference	7.9	8.7	9.4	9.9	10.2	0.66% p.a.	A-00-2025 (BFS, 2024a, 2025b)
High	7.9	8.7	9.7	10.5	11.2	0.89% p.a.	B-00-2025 (BFS, 2024a, 2025b)
Low	7.9	8.7	9.2	9.3	9.2	0.40% p.a.	C-00-2025 (BFS, 2024a, 2025b)
Number of households (Million households)							
Reference	3.5	3.9	4.3	4.6	4.8	0.84% p.a.	AM-00-2020 (BFS, 2024c, 2021)
High	3.5	3.9	4.3	4.8	5.1	1.02% p.a.	BM-00-2020 (BFS, 2024c, 2021)
Low	3.5	3.9	4.2	4.4	4.5	0.65% p.a.	CM-00-2020(BFS, 2024c, 2021)
Working population (full-time equivalent)							
Reference	3.7	4.2	4.6	4.9	5.0	0.71% p.a.% p.a.	A-00-2025 (BFS, 2025a,c)
High	3.7	4.2	4.7	5.1	5.4	0.94% p.a.	B-00-2025 (BFS, 2025a,c)
Low	3.7	4.2	4.5	4.5	4.4	0.43% p.a.	C-00-2025 (BFS, 2025a,c)
GDP ($BCHF_{2017}$)							
Reference	611.3	703.6	875.0	1032.4	1190.6	1.68% p.a.	BIP-A (BFS, 2024b, SECO, 2025)
High	611.3	703.6	895.7	1093.7	1305.3	1.91% p.a.	BIP-B (BFS, 2024b, SECO, 2025)
Low	611.3	703.6	854.4	967.6	1068.0	1.40% p.a.	BIP-C (BFS, 2024b, SECO, 2025)
Heating degree days (HDDs)							
RCP2.6	3770	3351	3296	3248	3219	−0.39% p.a	Berger and Worlitschek (2019)
RCP4.5	3770	3350	3255	3166	3080	−0.50% p.a	Berger and Worlitschek (2019)
RCP8.5	3770	3353	3254	3141	2993	−0.57% p.a	Berger and Worlitschek (2019)

Data available at https://sweet-cross.ch/data/macroeconomic-drivers-cross/2025-06-06/ and https://sweet-cross.ch/data/heating-degree-days-cross/2022-09-30/

3.2 Building stock - Energy reference area (ERA)

The total ERA for the different sectors is shown in Table 4 and the ERA for the residential sector by age and building type in Table 5.

Table 4: Energy Reference Area by sector (Mm2)

	2010	2023	2030	2040	2050	2010–2050
Residential (Mm2)						
Reference	428.4	509.2	546.1	576.1	597.7	0.84% p.a.
High	428.4	509.2	562.8	616.1	659.2	1.08% p.a.
Low	428.4	509.2	528.7	533.1	530.2	0.53% p.a.
Commercial (Mm2)						
Reference	213.0	248.6	264.3	277.5	287.0	0.75% p.a.
High	213.0	248.6	271.7	295.1	313.9	0.97% p.a.
Low	213.0	248.6	256.7	258.6	257.4	0.47% p.a.
Industry (Mm2)						
Reference	87.4	95.1	100.5	106.6	111.8	0.62% p.a.
High	87.4	95.1	101.4	108.7	115.1	0.69% p.a.
Low	87.4	95.1	99.7	104.2	107.8	0.53% p.a.

Data available at https://sweet-cross.ch/data/era-cross/2025-06-06/

Table 5: Residential ERA (Mm2) and specific useful energy demand (kWh/m2/year) by building type and construction period

Construction period	2018	2020	2030	2040	2050	2020–2050	Specific demand (kWh/m2/year)
	Energy reference area (Mm2)						
Single family houses							
<1920	41.7	41.4	39.6	37.3	34.6	−0.60% p.a.	92.9
1920-1945	22.0	21.8	20.6	19.0	17.0	−0.82% p.a.	104.3
1946-1960	20.8	20.6	19.9	18.8	17.3	−0.59% p.a.	110.1
1961-1970	18.8	18.7	18.2	17.3	16.2	−0.48% p.a.	109.1
1971-1980	24.9	24.9	24.3	23.5	22.2	−0.38% p.a.	89.7
1981-1990	27.6	27.6	27.2	26.5	25.4	−0.28% p.a.	76.1
1991-2000	24.5	24.5	24.2	23.7	22.7	−0.25% p.a.	75.2
2001-2010	23.7	23.7	23.5	23.1	22.1	−0.23% p.a.	65.2
2011-2017	13.6	13.6	13.6	13.4	13.1	−0.13% p.a.	44.4
>2017							40 in 2020, 25 in 2050
Reference	1.7	1.8	16.8	26.7	36.3	10.57% p.a.	
High	1.7	1.8	21.0	36.8	51.7	11.88% p.a.	
Low	1.7	1.8	12.4	16.0	19.5	8.30% p.a.	
Multi family houses							
<1920	37.7	37.7	37.5	37.2	36.6	−0.10% p.a.	77.3
1920-1945	21.8	21.8	21.7	21.6	21.4	−0.06% p.a.	81.3
1946-1960	27.9	27.9	27.8	27.3	25.5	−0.30% p.a.	73.0
1961-1970	37.8	37.8	37.8	37.5	36.3	−0.14% p.a.	78.4
1971-1980	34.1	34.1	34.1	34.0	33.5	−0.06% p.a.	72.9
1981-1990	27.6	27.6	27.6	27.6	27.4	−0.02% p.a.	72.4
1991-2000	25.7	25.7	25.7	25.7	25.6	−0.01% p.a.	60.2
2001-2010	30.3	30.3	30.3	30.3	30.3	0.00% p.a.	47.3
2011-2017	25.3	25.3	25.3	25.3	25.3	0.00% p.a.	29.4
>2017							35 in 2020, 20 in 2050
Reference	7.0	5.3	50.4	80.2	109.0	10.57% p.a.	
High	7.0	5.3	62.9	110.3	155.1	11.88% p.a.	
Low	7.0	5.3	37.3	48.0	58.4	8.30% p.a.	

Data available at https://sweet-cross.ch/data/era-cross/2025-06-06/

3.3 Energy service demands

From the harmonized drivers in Table 3 and the ERA in Table 4, we calculate the future energy service demands in the different end-use sectors (see details of the estimation in Marcucci and Guidati (2025)). All the demands estimated in this section correspond to end-use energy demand (EUD).

Table 6: Space heating end-use demand (TWh)

	Climate	2010	2023	2030	2040	2050	2010–2050
Residential (TWh)							
Residential							
Reference	Constant	46.4	32.7	38.3	38.5	37.9	−0.50% p.a.
	RCP 2.6	46.4	32.7	37.2	36.8	35.9	−0.63% p.a.

Table 6: Space heating end-use demand (TWh) (continued)

	Climate	2010	2023	2030	2040	2050	2010–2050
	RCP 4.5	46.4	32.7	36.9	36.0	34.5	−0.73% p.a.
	RCP 8.5	46.4	32.7	36.7	35.6	33.4	−0.81% p.a.
High	Constant	46.4	32.7	38.8	39.6	39.5	−0.40% p.a.
Low	Constant	46.4	32.7	37.7	37.2	36.0	−0.63% p.a.
Commercial (TWh)							
Reference	Constant	21.1	14.3	17.0	17.2	17.2	−0.51% p.a.
	RCP 2.6	21.1	14.3	16.5	16.5	16.3	−0.64% p.a.
	RCP 4.5	21.1	14.3	16.3	16.1	15.7	−0.74% p.a.
	RCP 8.5	21.1	14.3	16.3	15.9	15.2	−0.82% p.a.
High	Constant	21.1	14.3	17.2	17.8	18.0	−0.39% p.a.
Low	Constant	21.1	14.3	16.7	16.6	16.3	−0.64% p.a.
Industry (TWh)							
Reference	Constant	4.6	2.5	2.8	2.6	2.4	−1.65% p.a.
Reference	RCP 2.6	4.6	2.5	2.7	2.4	2.3	−1.78% p.a.
Reference	RCP 4.5	4.6	2.5	2.7	2.4	2.2	−1.88% p.a.
Reference	RCP 8.5	4.6	2.5	2.7	2.4	2.1	−1.96% p.a.
High	Constant	4.6	2.5	2.8	2.6	2.5	−1.58% p.a.
Low	Constant	4.6	2.5	2.8	2.5	2.3	−1.74% p.a.

Data available at https://sweet-cross.ch/data/end-use-energy-demand-cross/2025-06-06/

Table 7: Warm water end-use demand (TWh)

	2010	2023	2030	2040	2050	2010–2050
Residential (TWh)						
Reference	7.0	7.1	7.0	6.8	6.6	−0.13% p.a.
High	7.0	7.1	7.2	7.2	7.2	0.10% p.a.
Low	7.0	7.1	6.8	6.4	6.0	−0.39% p.a.
Commercial (TWh)						
Reference	3.3	2.5	2.3	2.1	1.9	−1.30% p.a.
High	3.3	2.5	2.3	2.2	2.1	−1.08% p.a.
Low	3.3	2.5	2.2	1.9	1.7	−1.57% p.a.
Industrial (TWh)						
Reference	0.69	0.52	0.48	0.45	0.42	−1.23% p.a.
High	0.69	0.52	0.50	0.47	0.46	−1.00% p.a.
Low	0.69	0.52	0.47	0.42	0.37	−1.50% p.a.

Data available at https://sweet-cross.ch/data/end-use-energy-demand-cross/2025-06-06/

Table 8: Process heat end-use demand (TWh)

	2010	2023	2030	2040	2050	2010–2050
Commercial (TWh)						
Reference	0.58	0.63	0.66	0.70	0.75	0.65% p.a.

Table 8: Process heat end-use demand (TWh) (continued)

	2010	2023	2030	2040	2050	2010–2050
High	0.58	0.63	0.67	0.75	0.82	0.88% p.a.
Low	0.58	0.63	0.64	0.66	0.67	0.38% p.a.
Industrial (TWh)						
Reference	18.3	16.3	15.6	14.9	14.4	−0.60% p.a.
High	18.3	16.3	16.0	15.7	15.8	−0.38% p.a.
Low	18.3	16.3	15.2	13.9	12.9	−0.87% p.a.

Data available at https://sweet-cross.ch/data/end-use-energy-demand-cross/2025-06-06/

For models that disaggregate process heat demand by temperature ranges, the following distribution can be applied: 25% below 1000 °C 25% between 100–2000 °C and 50% above 2000 °C

Table 9: Electricity demand from electric appliances (TWh)

	2010	2023	2030	2040	2050	2010–2050
Residential (TWh)						
Reference	13.2	12.1	11.7	11.1	10.6	−0.54% p.a.
High	13.2	12.1	12.0	11.8	11.7	−0.31% p.a.
Low	13.2	12.1	11.4	10.4	9.6	−0.80% p.a.
Commercial (TWh)						
Reference	15.9	14.2	14.0	13.7	13.3	−0.44% p.a.
High	15.9	14.2	14.3	14.5	14.6	−0.21% p.a.
Low	15.9	14.2	13.7	12.8	12.0	−0.71% p.a.
Industrial (TWh)						
Reference	15.1	13.4	13.2	12.9	12.7	−0.42% p.a.
High	15.1	13.4	13.5	13.7	14.0	−0.19% p.a.
Low	15.1	13.4	12.9	12.1	11.4	−0.69% p.a.

Data available at https://sweet-cross.ch/data/end-use-energy-demand-cross/2025-06-06/

Table 10: Transport demand

	2010	2023	2030	2040	2050	2010–2050
Passenger transport demand (Billion passenger-kilometer)						
Motorized personal transport						
Reference	90.9	93.8	95.7	94.5	91.2	0.01% p.a.
High	90.9	93.8	98.2	100.5	100.2	0.24% p.a.
Low	90.9	93.8	93.2	88.6	82.4	−0.25% p.a.
Buses						
Reference	2.5	2.9	3.1	3.4	3.6	0.93% p.a.
High	2.5	2.9	3.2	3.6	4.0	1.17% p.a.
Low	2.5	2.9	3.0	3.2	3.3	0.67% p.a.
Passenger rail						
Reference	21.1	24.3	25.5	28.0	29.9	0.87% p.a.
High	21.1	24.3	26.2	29.8	32.8	1.11% p.a.

Table 10: Transport demand (continued)

	2010	2023	2030	2040	2050	2010–2050
Low	21.1	24.3	24.9	26.3	27.0	0.62% p.a.
Freight transport demand (Billion ton-kilometer)						
Road						
Reference	16.9	16.2	17.0	18.7	20.2	0.45% p.a.
High	16.9	16.2	17.4	19.8	22.2	0.68% p.a.
Low	16.9	16.2	16.6	17.5	18.1	0.18% p.a.
Freight rail						
Reference	9.8	9.9	10.9	11.9	12.8	0.66% p.a.
High	9.8	9.9	11.2	12.6	14.0	0.89% p.a.
Low	9.8	9.9	10.7	11.1	11.4	0.39% p.a.

Data available at https://sweet-cross.ch/data/end-use-energy-demand-cross/2025-06-06/

Table 11: Aviation fuel demand (TWh)

	2010	2019	2023	2025	2030	2040	2050	2010–2050
Total demand of aviation fuels (TWh)								
Reference	17.1	22.5	19.9	19.8	20.3	21.2	22.0	0.63% p.a.
High	17.1	22.5	20.2	19.8	21.3	23.7	26.3	1.08% p.a.
Low	17.1	22.5	19.7	19.8	19.5	19.1	18.7	0.22% p.a.
Demand of sustainable aviation fuels (TWh)								
Reference			0	0.40	3.2	9.1	15.4	
High			0	0.40	3.3	10.1	18.4	
Low			0	0.39	3.0	8.2	13.1	

Data available at https://sweet-cross.ch/data/end-use-energy-demand-cross/2025-06-06/

3.4 Resources

Table 12: 2050 potential of renewable resources

Resource	Variant			Reference
	Reference	High	Low	
Hydropower (TWh/a)	36.4	38.4	34.8	Boes et al. (2021)
Solar photovoltaics (TWh/a)				
Rooftop	40	50	30	High: BFE (2019), Low: Bauer et al. (2019)
Facades	4	8	0	High: Remund et al. (2019)
Mountains	3	30	0	Reference: Remund et al. (2019), High: Dujardin et al. (2021)
Total	47	88	30	
Wind (TWh/a)	4.3	15.0	1.7	Reference: BFE (2020b), High: Dujardin et al. (2021), Low: Cattin et al. (2012)
Biomass (PJ/a)				Guidati et al. (2021)
Wood				

Table 12: 2050 potential of renewable resources (continued)

Resource	Variant			Reference
	Reference	High	Low	
Forest Wood				
Continued stock increase	26.0	26.0	26.0	
Moderate stock reduction	32.3	32.3	32.3	
Large stock reduction	39.4	39.4	39.4	
Wood from landscape	4.8	4.8	4.8	
Wood residues	7.7	7.7	7.7	
Waste wood	16.6	18.2	15.0	
Animal manure (dry)	26.3	26.3	26.3	
Green waste				
Collected organic waste	8.3	9.1	7.5	
Agricultural bioproducts	2.6	2.6	2.6	
Fresh sewage sludge (dry)	6.0	6.5	5.8	
Mixed fossil / organic waste (PJ/a)				Guidati et al. (2021)
Other waste fraction	39.2	43.0	35.1	
Municipal waste	28.9	31.7	26.1	

Data available at https://sweet-cross.ch/data/biomass-potentials-cross/2025-06-06/

3.5 Imports and exports

Table 13: Import price of energy carriers (CHF/GJ). Prices are based on the WEO 2024 (IEA, 2024)

	2017	2020	2023	2030	2040	2050	2020–2050	Reference
Oil								
Reference			13.4	11.8	10.3	9.5	−1.27% p.a.	Announced pledges (IEA, 2024)
High			13.4	13.0	12.6	12.3	−0.33% p.a.	Stated policies (IEA, 2024)
Low			13.4	6.9	4.9	4.1	−4.3 % p.a.	Net zero (IEA, 2024)
Gas								
Reference			11.5	5.7	4.9	4.9	−3.08% p.a.	Announced pledges (IEA, 2024)
High			11.5	6.2	7.2	7.3	−1.66% p.a.	Stated policies (IEA, 2024)
Low			11.5	4.2	3.9	3.8	−4.02% p.a.	Net zero (IEA, 2024)
Hydrogen								
Reference		94.4		77.2		62.8	−1.35%p.a.	Meili et al. (2025)
High		131.9		108.1		87.8	−1.35%p.a.	Meili et al. (2025)
Low		66.1		54.2		43.9	−1.36%p.a.	Meili et al. (2025)

Data available at https://sweet-cross.ch/data/import-prices-cross/2025-06-06/

3.6 Carbon sequestration

Recent studies found that CO_2 storage potentials in Switzerland are low (Diamond et al., 2019) and to achieve net zero emissions, storage alternatives must be found abroad. Estimates for the storage potential in the North Sea amount to more than 100 $GtCO_2$ (IOGP, 2019). In CROSS, we assume that

Table 14: Annual net transfer capacities (GW) from ENTSO-E (2022, 2024)

	Historical	Reference grid	TYNDP24 scenario					
			Distributed Energy			Global Ambition		
From-to	**2020**	**2030**	**2035**	**2040**	**2050**	**2035**	**2040**	**2050**
Switzerland–Austria	1.2	1.2	1.4	1.5	1.7	1.2	1.2	1.2
Switzerland–Germany	4.0	4.2	5.3	6.3	6.3	5.0	5.0	5.0
Switzerland–France	1.4	2.2	2.2	3.2	3.2	2.2	3.2	3.2
Switzerland–Italy	3.9	5.8	5.8	5.8	5.8	5.8	5.8	5.8
Austria–Switzerland	1.2	1.2	1.4	1.5	1.7	1.2	1.2	1.2
Germany–Switzerland	2.7	4.4	6.0	7.0	7.0	5.7	5.7	5.7
France–Switzerland	3.7	4.5	4.5	5.5	5.5	4.5	5.5	5.5
Italy–Switzerland	1.9	3.1	3.1	3.1	3.1	3.1	3.1	3.1

Data available at https://sweet-cross.ch/data/net-transfer-capacities/2025-06-06/

Switzerland has access to the storage potential in the North Sea. This potential is unlimited and has a prices of transport and storage of 100 CHF/tCO_2 for transport (BFE, 2020a, Abbildung 15).

4 Technologies

4.1 Investment costs

Table 15: 2050 Investment costs for electricity, heat and hydrogen technologies (Meili et al., 2025)

Technology	**Size**	**Inv. cost (CHF/kW)**		
		Reference	**Low**	**High**
Electricity production (cost per kWe)				
Solar PV	0–10kWp	1526	825	2227
	10–30kWp	1024	603	1446
	30–100kWp	654	325	983
	100–300kWp	690	371	1009
	300–100kWp	568	350	786
Wind onshore		1871	1497	2246
Hydropower RoR	< 10MW	6337	3931	8743
Gas turbine	100–500MW	1089	717	1750
Geothermal	Binary cycle	3365	2356	4711
	Flash steam	3780	2402	5159
Electricity storage (cost per kWe)				
Li-Ion battery	Large scale	76	53	106
	Small scale	670	469	938
	Utility scale	969	396	1542
Heat production (cost per kWth)				
Air source heat pump	5 kWth	4462	6027	3170

Table 15: 2050 Investment costs for electricity, heat and hydrogen technologies (Meili et al., 2025) (continued)

Technology	**Size**	**Inv. cost (CHF/kW)**		
		Reference	**Low**	**High**
	10 kWth	2488	3355	1766
	20 kWth	1806	2432	1284
	70 kWth	1019	1372	722
Ground source heat pump	5 kWth	6257	8761	4384
	10 kWth	4255	5957	2974
	20 kWth	3481	4874	2437
	70 kWth	2598	3634	1817
	100 kWth	2581	3617	1809
	200– 500 kWth	1749	2452	1222
Wood-pellets boiler	5 kWth	5290	7410	3700
	10 kWth	3930	5500	2750
	20 kWth	2050	2860	1430
	70 kWth	730	1020	510
	100 kWth	780	1090	540
	200 kWth	560	790	390
	350 kWth	388	551	271
	500 kWth	343	487	244
Wood-chips boiler	70 kWth	932	653	1305
	100 kWth	825	571	1270
	200 kWth	590	417	1152
	350 kWth	417	290	590
	500 kWth	390	272	553
Gas boiler	5 kWth	4800	3360	6720
	10 kW th	2570	1800	3600
	20 kWth	1320	920	1850
	70 kWth	480	340	680
	100 kWth	430	300	600
	200– 500 kWth	240	170	340
Oil boiler	5 kWth	6110	4280	8550
	10 kWth	3290	2300	4600
	20 kWth	1700	1190	2380
	70 kWth	620	430	860
	100 kWth	600	420	840
	200–500 kWth	370	260	520
Solar thermal	10 m2	1562	1091	2189
	50 m2	897	627	1253
	100 m2	791	552	1111
	200 m2	727	504	1015
District heating	5 kWth	1752	1230	2450
	10 kWth	1416	988	1984
	20 kWth	1388	969	1938
	70 kWth	1146	801	1602
	100 kWth	1086	760	1520
	200–500 kWth	995	697	1384
Hydrogen production (cost per kWAC or KWH2)				

Table 15: 2050 Investment costs for electricity, heat and hydrogen technologies (Meili et al., 2025) (continued)

Technology	Size	Inv. cost (CHF/kW)		
		Reference	Low	High
Electrolyser	5 MWAC	1222	855	1711
	100 MWAC	890	623	1246
Steam reforming with CCS		1490	1043	2086

Data available at https://sweet-cross.ch/data/technologies-investment-costs-cross/2025-06-06/

4.2 Efficiencies

For the CROSS scenarios v2025-06 we harmonise the efficiencies of heat pumps and electric vehicles. Efficiencies of both heat pumps and electric vehicles depend on various parameters.

- The efficiency of EVs depends on the external temperature. In winter, the efficiency is reduced due to heating needs, lower recuperation and higher rolling resistance. The efficiencies provided in Table 16 are for EVs at moderate ambient air temperatures with summer tyres.
- The coefficient of performance (COP) of heat pumps is strongly affected by the temperatures of the heat source and the heat sink. Meili et al. (2025) presents a detailed methodology to calculate the electricity needs for air source and ground source heat pumps depending on the temperature of the heat source and sink. In Table 16 presents an average seasonal performance factor.

Table 16: Efficiencies in CROSS scenarios (Meili et al., 2025)

Technology	Efficiency		
	Reference	Low	High
Passenger vehicles (kWh/100 km)			
Small private EVs at moderate temperature and with summer tyres	19	14	23
Heat pumps – Average COP			
Air-source heat pump	2.3	2.7	3.4
Ground-source heat pump	4.42	4	4.8
Water-source heat pump	4.6	4.3	4.9

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Abbreviations

$BCHF_{2017}$	Billion Swiss Franc 2017
CDR	Carbon dioxide removal
CHF	Swiss Franc
COP	Coefficient of performance
ERA	Energy reference area
EUD	End-use demand
EV	Electric vehicle
GDP	Gross Domestic Product
HDD	Heating degree days
ITMO	Internationally transferred mitigation outcome
MFH	Multi family house
RCP	Representative concentration pathway
SFH	Single family house