The Swiss TIMES Electricity Model (STEM-E)

Updates to the model input data and assumptions

(Model Release 2)

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Table of Contents

List of Figures

List of Tables

List of Appendixes

1. Introduction

The Swiss TIMES electricity model (STEM-E) is an analytical tool developed by the Paul Scherrer Institute. The development of STEM-E and its input data and assumptions are reported in the model documentation [15]. STEM-E has previously been used to quantify and analyze a number of electricity supply scenarios [17][16][31][1]. Importantly, the development of STEM-E is ongoing, and recently the model has been updated in terms of demands, technology characteristics, resource potentials, trade interconnectors and electricity taxes. In this document the updated assumptions and input data are reported.

The assumptions reported here have been used for the analysis in PSI's *Energie Spiegel* Nr. 21 [23][18].

2. Model development

The overall model framework and structure are same as in the model documentation (§2 in [15]). The discount rate is updated to 2.5%, to reflect the rate assumed in the 2050 Swiss Energy Strategy published by the Swiss Federal Office of Energy (SFOE) [7].

3. Electricity demands

The future electricity demand, for which electricity supply is optimized by STEM-E, is an exogenous input to the model. There are large uncertainties in development of future Swiss electricity demand, as illustrated in Table 1, which summarizes demand projections from various studies [4][3][5][11][12][19][25][26][27][29][30][31].

In the latest update, the electricity demands from the three Swiss Energy Strategy (SES) scenarios [7][2] viz. WWB, POM and NEP (Figure 1) have been applied. The electricity demand in the year 2050 is assumed to remain constant beyond 2050[3]. The future electricity load curve (demand profile) is still assumed to be the same as

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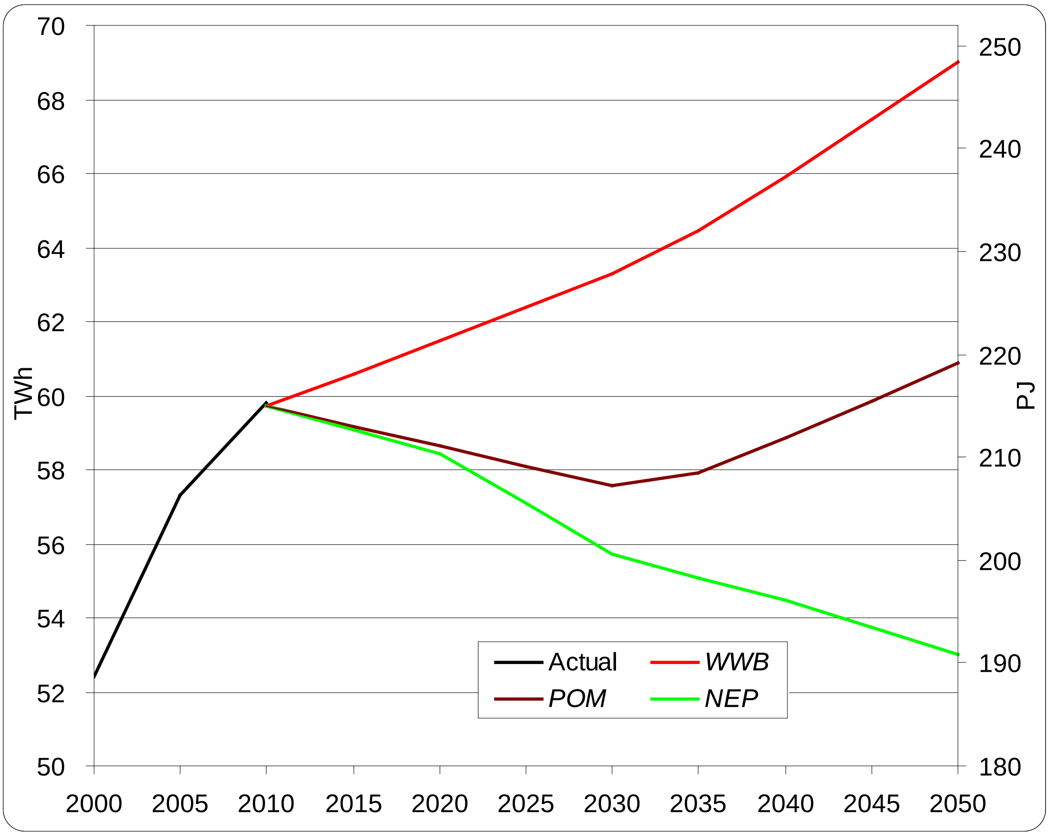
[1] For the analysis in [31], slightly a different set of renewable resource assumptions is used.

[2] In the context of the Swiss federal government's public consultation [6] on the 2050 Swiss Energy Strategy, the Swiss Federal Office of Energy (SFOE) published in September 2012 three energy and electricity demand scenarios, namely: Weiter Wie Bisher (*WWB*) (i.e. Business as usual); Politische Massnahmen (*POM*) (i.e., Policy Measures) and Neue Energiepolitik (*NEP*) (i.e. New Energy Policy) [7]. Earlier versions of two energy scenarios—*WWB* and *NEP*— were published by the SFOE in May 2011 [5].

[3] Even though long-term (i.e., beyond 2050) demand pathways are highly uncertain, including a representation of this long-term electricity demand enables STEM-E to consider more consistently investment options in long-lived electricity supply technologies.

today's load curve (see Figure 2 in [15]). It is worth noting that the SES scenarios assume a large penetration of electric vehicles and heat pumps. The impact of these new demands on the specific shape of the electricity demand curve is not considered. The impact of demand reductions through efficiency measures on the shape of the load curve is also not considered.



Source: BFE [7]

Figure 1: End use electricity demand assumption in STEM-E

In the SES scenarios, the basic energy demand drivers (i.e. population, economic growth, housing stock, floor area, and transport demand) are the same across all the three scenarios. However, both the *POM* and *NEP* scenarios incorporate a broad package of energy efficiency measures to reduce energy and electricity demands [10]. STEM-E optimises only the electricity supply side for a given set of electricity demands, and does not model demand reductions through efficiency measures or behaviour change. Accordingly, STEM-E is unable to provide insights regarding the cost or feasibility of realizing a certain level of demand reductions.

Table 1: Review summary of Swiss electricity demand prognosis

Source	2015	2020	2025	2030	2035	2040	2045	2050
	In *PJ*							
BFE, 2007: EP-2035 (Hi)$^{+}$ [4]	229	239	248	255	260			
BFE, 2007: EP-2030 (Low)$^{+}$ [4]	212	206	198	193	186			
BFE, 2011: SES2050-WWB [5]	226	238	245	252	259	267	276	285
BFE, 2011: SES2050-NEP [5]	219	223	219	215	211	208	205	202
BFE, 2012: SES2050-UVEK^{++} [9]	216	232	232	232	232	227	224	224
BFE, 2012: SES2050-WWB [7]	218	221	225	228	232	237	243	249
BFE, 2012: SES2050-POM [7]	213	211	209	207	209	212	216	219
BFE, 2012: SES2050-NEP [7]	213	210	206	201	198	196	194	191
Policy goal <5% $^{+++}$(wrt 2000) [3]	213	211	209	207	205	202	200	198
PSI/Weidmann, 2012: Base [31]	217	221	247	260	268	271	269	269
PSI/Weidmann, 2012: CP^ [31]	217	221	244	253	261	280	288	290
PSI/Weidmann, 2012: CPN^ [31]	216	215	234	239	238	233	238	236
PSI/ETS, 2009: SMM-Base [30]	219	230	241	253	268	277	287	285
PSI/ETS, 2009: SMM-CP^ [30]	223	232	248	262	271	284	303	306
PSI/ETS, 2009: SMM-CP^-NoNuc [30]	224	226	239	249	256	254	245	243
PSI/Marcucci, 2012: BAU$^{\sim}$ with Nuclear [19]	212	234	246	257	263	269	272	276
PSI/Marcucci, 2012: CS$^{\sim}$ with Nuclear [19]	191	202	197	193	192	191	188	185
PSI/Marcucci, 2012: CS$^{\sim}$ no nuclear [19]	196	209	206	203	204	205	226	247
ETH, 2011: Hoch [11]	228	244	254	264	275	286	297	308
ETH, 2011: Mittel [11]	223	234	240	246	251	256	260	264
ETH, 2011: Niedrig [11]	218	224	223	222	221	221	221	221
VSE, 2012: S1 Verstärkt [29]	226	237	243	250	257	263	268	272
VSE, 2012: S2 Intensiv [29]	225	236	239	243	246	247	247	246
VSE, 2012: S3 Fundamental [29]	225	234	233	232	231	225	214	202
SATW,2012: Referenz [25]		223	226	228	230	235	240	245
SATW,2012: Beeinflusste [25]		205	204	203	202	204	206	209
ETS (2009): Ref [12]	224	233	242	250	259	261	264	266
ETS (2009): ETS [12]	220	225	230	234	239	239	240	240
Swiss Cleantech (2011) [26]	224	230	238	248	256	263	271	281
Swiss Cleantech (2012) [27]	225	234	243	256	259	259	265	277

Data in gray font are based on linear interpolation between reported data years.

$^{+}$ Highest and lowest demand among all the scenarios in [4]

$^{++}$ Estimated/approximated from figure in [9]

$^{+++}$ Based on extrapolation of the government's target [3] to cap electricity demand at 5% above the level in 2000

^ CP and CPN refer climate policy and climate policy without new nuclear investments

~ BAU and CS refer to business as usual and climate stabilization scenarios

4. Electricity generation technologies

4.1. Existing power plants

In the earlier version of STEM-E, historical 'capital' investment in existing power plants was not included in the cost optimisation (since this investment has already been made). Thus the model accounted for only the fixed and variable operation and maintenance (O&M) costs and fuel cost for the existing power plants. While this approach of excluding historical investment does not affect the model solution (e.g. choice on future technology investment), it makes comparisons difficult between the generation cost in the base year base and future years. On the other hand, the historical investment profile is difficult to determine, particularly in the case of hydroelectric plants dating back to pre-1945 (see Table 4 in [15]).

In the updated STEM-E, an 'estimated' annuity is applied for the existing nuclear and hydro plants (see Table 4 in [15] for the existing capacity of hydro and §4.1.2 for nuclear). The annuity of hydro plants is assumed based on the estimated refurbishment costs (Table 3 in [15]) with an 80-year life and a discount rate of 2.5%. For the existing nuclear plants, the annuity is estimated based on a capital cost of 3500 CHF/kW, a 50-year lifetime and 2.5% discount rate. The annuity is applied only for the remaining capacity in each period[4].

4.1.1. Nuclear technology

In the previous version of STEM-E, nuclear power plants (existing and future) were characterised as 'annual' base-load plants (i.e., they were assumed to operate at a constant load factor throughout the year). Historical statistics on nuclear generation indicate, however, that there are large seasonal variations in electricity output [8]: for example, the average capacity factor in summer is 68% versus over 95% in other seasons (Figure 2). Thus, nuclear power plants (both existing and future) are now characterised as a 'seasonal' base-load technology.

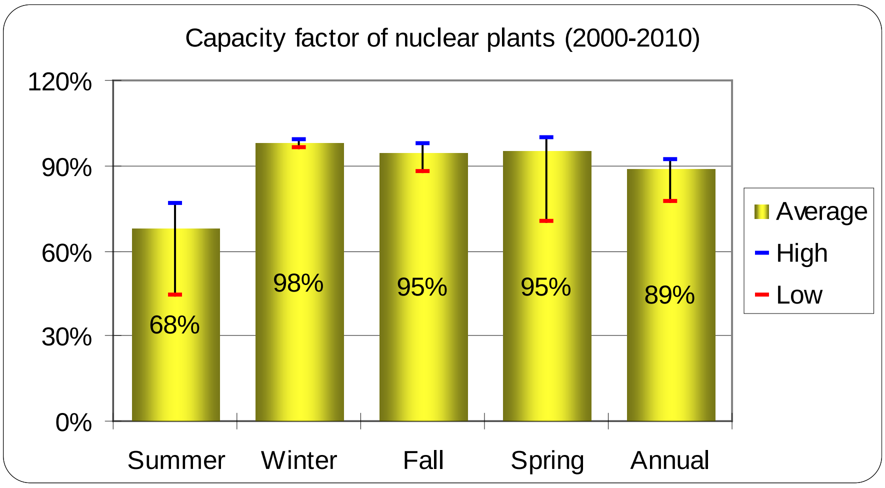


Figure 2: Historical capacity factors of the Swiss nuclear plants

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[4] Total cost of nuclear generation in 2010 from STEM-E is about CHF 1.3 billion compared to CHF 1.35 billion in [7]. However, the hydro electricity cost in 2010 is CHF 1.66 billion versus 2.7 billion in [7].

4.1.2. Pumped hydro storage

In the previous version of the model (also in [31][17]), pumped hydro storage was assumed to be diurnal, meaning that electricity could be stored each day and produced the same day (p. 16 in [15]). In the updated model, inter-day storage technology is also included, such that electricity can, for example, be stored on weekends and produced on weekdays. Total cumulative electricity storage volume (defined through inputs to pumps) is limited to 7.56 TWh per year, which is equal to the electricity used for pumps in the SES scenarios [5]. However, no limit on pumped generation capacity or reservoir volume at the timeslice level is included.

The inter-daily storage mechanism enhances management of large base-load power plants, particularly on weekends. However, a methodological limitation with the implementation of inter-day storage in TIMES specifies that the stored electricity can only be released at an uniform level over the following day, rather than at selected timeslices (e.g. at peak hours)—for example, electricity stored on a Sunday must be released uniformly across weekdays.

4.1.3. Wind turbines

In the previous version of STEM-E, wind turbines were characterised as a seasonal base-load plant (i.e., a constant load factor for each season). Now, a diurnal wind resource curve is implemented based on hourly wind data from Chasseral [20], which is close to one of the possible windfarm sites in Switzerland [2] [5]. The availability (on average) of wind turbines for generation is now specified according to the wind profile shown in Figure 3[6]. As illustrated, the availability of wind during the daytime is relatively lower than at night.

4.1.4. CHPs

Gas and biomass CHP generation is now characterised as a seasonal base-load technology, which enables the model to use the full installed capacity of CHP in winter.

Since heat demand is not included in STEM-E, a “heat credit” is implemented for heat output from CHPs. The heat credit is equivalent to cost of natural gas replaced

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[5] Although the wind data from the one location is not a representative sample, seasonal availability estimated based on monthly wind speed from many locations (Figure 11 in [15]) are somehow consistent with the seasonal wind profile from Chasseral.

[6] It is important to note that wind turbines are not forced follow the wind profile. Instead, this profile represents the availability factor. Thus, the model could choose not to schedule wind turbine for balancing electricity supply and demand, although it may be an expensive option.

by the heat output of CHPs, assuming an equivalent amount of heat would otherwise be produced from a gas boiler with an efficiency of 90%. A full heat credit is applied for the fall and winter seasons, whereas in summer and spring a credit is applied for only 33% of the calculated gas savings (i.e. because heat demand is assumed to be lower in summer/spring). The heat credit is applied to heat from all types of CHP, i.e. including heat produced from biogas CHPs.

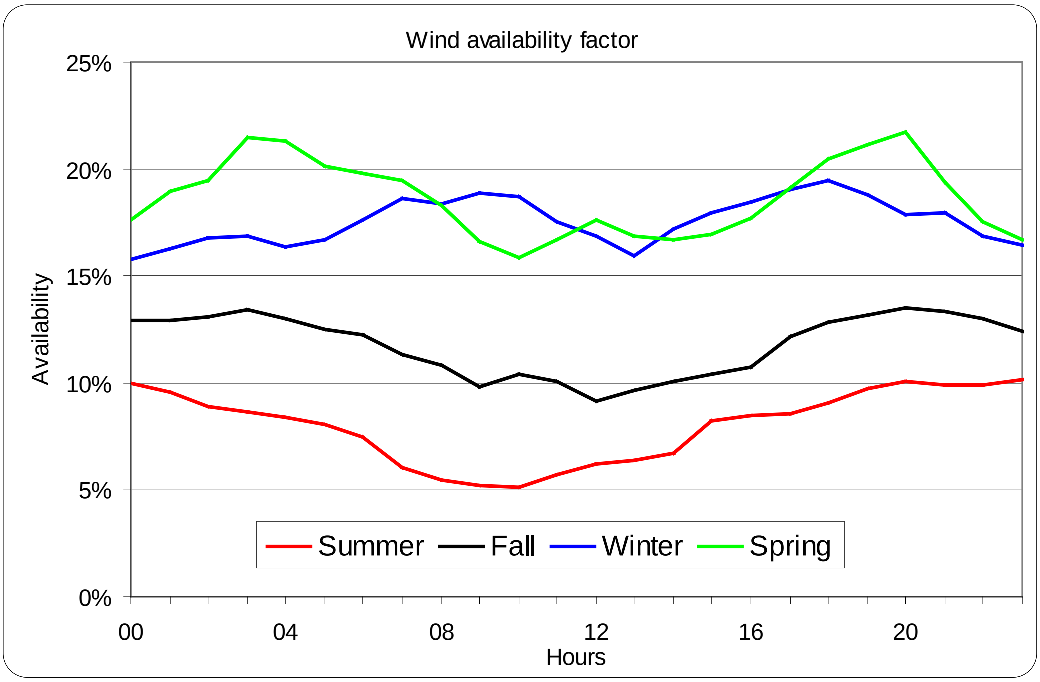

Figure 3: Availability factor for wind turbine

It is important to note that neither the capital/O&M costs of the gas boiler, nor the cost of a heat distribution network are considered. Further, no carbon credit is applied to the heat produced from CHP. To avoid overestimating the potential or CHP, the total heat credit is also capped at 60% of total space heating and 50% of total hot water demands in the SES final energy demand [5].

Since there is no heat demand in the model, we do not analyse any distributed CHP scenarios.

4.2. New and future technologies

The new and future technologies in STEM-E remain the same as in the model documentation (Table 9 in [15]). Table 2 shows an indicative levelised cost of electricity supply from key technologies based on technical and fuel price assumptions in 2050. The actual inputs to the model comprise the individual cost components (e.g., capital cost, O&M costs, fuel costs), and thus the optimisation is not based only on levelised cost.

Table 2: Indicative cost of electricity supply in 2050

Supply technology	**Capital cost (*CHF/kW*)**		**Levelised cost @ 2.5% discount rate (*Rp/kWh*)**	
	2010	**2050**	**2010**	**2050**
Nuclear	4250		5.9 ^	
Natural gas	1150	1050	11.4 ^^	15.4 ^^ *
New hydro	6560 - 10000		4.5 - 13.9	
Solar PV	6500	1950	29.5	10
Wind	2150	1750	19.5	14.5
Geothermal		6650		16.5
Biomass	6000	3800	14.3	8.9
Electricity imports	434 (interconnector)			ϕ16.1 (8.5-22.8 **)

^ Including decommissioning and waste disposal levy of 1 Rp/kWh
^^ Including CO_2 price from WWB scenario in Table 6
* Based on a gas price assumption of 18.6 CHF/GJ or 6.7 Rp/kWh_{th} in 2050
** An annual average electricity price assumption of 43.7 CHF/GJ (15.7 Rp/kWh). Including interconnector costs, the average cost is 16.14 Rp/kWh and seasonal and hourly price varies between 8.54 and 22.77 Rp/kWh.

4.2.1. Nuclear

For analyzing scenarios where investment in new nuclear power plants is allowed, the upper bound on investment (Table 12 in [15]) is now updated to 6.4 GW (in line with the SES electricity supply variants *A* and *B* [5]). A unit size of 1 GW for new nuclear plants (and 550 MW for gas) power plants is now applied (using a mixed-integer formulation).

For new nuclear plants, the availability factor is updated to 80% (from the previous assumption of 90%) to reflect more conservative assumptions on operation and maintenance. Note, the levelised generation cost of nuclear in STEM-E is comparable with the recent cost estimates from the SES study [22].

5. Energy resources

The review summary on renewable potentials (Table 11 in [15]) has been updated in Table 3. In some studies, potentials are not explicit and thus in these cases Table 3 reports renewable deployment in the year 2050. The renewable resource potentials used in STEM-E are updated as in Table 4. The full renewable potential is available for deployment within the given periods (with actual deployment determined by the cost optimisation in STEM-E).

Table 3: Review summary of renewable energy resource potentials in 2050

Energy source	**SATW (2012)** [25]	**VSE (2012)**** [29]	**BFE (2012)** **/+ [14]	**BFE (2011)** [5]	**Cleantech (2011)** ** [26]	**ETS (2009)** [§] [12]	**PSI (2005)** [§] [14]
	In TWh_e						
Hydro	36 – 42	35 – 40	Existing: 35.5 New: 4.57 (excluding 4 *TWh* pumped hydro)	Existing: 37.49 New: 5.08 (excluding 5 *TWh* pumped hydro)	Large: 28.8 Small: 5.01	Small hydro: 4 – 5 (5.7)	5.8 (< 10 MW) & 1.2 (< 1 MW) (in 2035: 5.8 (< 10 MW) & 1.1 (< 1 MW))
Solar PV	12 – 18	4 – 14	11.0	15 – 18 10.4**	24.36	8 – 12 (9.8)	11 GW 9.4 – 13.7 TWh_e
Wind	2 – 4	2 – 4	4.2	4**	3.57	2 – 3 (4)	1.15 + 2.8 TWh_e
Biomass	3.2 – 4.2	2 – 4	1.1 (+ 2.4[&])	5.7 4.73**	1.64 (+1.62+2.38[&])	5 (9)	91.94 TWh_t (Theoretical)
Geothermal	4 – 5	2 – 3.5	4.4	4.4**	5.11	1.5 – 3.5 (5)	2 – 3 TWh (2035) Very high (2050)

** Deployed in 2050

[§] Estimated potentials for 2050

+ Full potential is more or less deployed in 2050

[&] Wastes/Biogas

Table 4: Updated renewable energy resource potentials in STEM-E

Resources	**2010**	**2035**	**2050***	**Sources/Remarks**
	TWh_e			
Solar PV		5.5	9.7	[12]; 2035 data is based on interpolation
Wind		1.2	2.6	Wind park of 1.2 TWh by 2035 and 50% of 2.8 TWh potential from the other site specific potentials by 2050 [24]
Geothermal		1.1	4.4	As in the SES assumption [7][5] (this is to make up the BFE's objective to have 21 TWh of renewable by 2050)
Waste/biogas	2.2	2.2	2.2	Maintained at today's level
Biomass	0.8	1.9	3.8	Based on [24] i.e. one-third of the biomass would be used for electricity generation; 2035 data is based on interpolation
Hydro existing /refurbished	35.5	35.9 (34.4+1.55)		Historical average hydro output of 34.4 TWh is adopted (note, 2010 was slightly above average). Additional 1.55 TWh is assumed to be gained on refurbishment of the existing hydro plants. New hydro potential of 2.38 TWh is based on expert judgment. Thus, total hydro potential in 2050 is 38.3 TWh.
Hydro new		2.4	2.4	
Total renewables *(excluding Hydro)*	***3.0***	***11.9***	***22.8***	
Total renewable (including hydro)	**38.5**	**50.2**	**60.9**	
Pumped hydro		7.56	7.56	Based on the 2050 SES scenarios [7]. Pumped hydro is treated separately from the hydro potential. There is no limit assumed for capacity of pumped hydro.

* The potential from 2050 is maintained for the rest of the model horizon

5.1.1. Hydro

Hydro resource potentials in Table 10 in [15] have been updated as in Table 4. Figure 4 shows the historical hydro electricity generation. Annual average hydro output is about 34.4 TWh after adjusting[7] for generation from pumped hydro. The historical average hydro generation is adopted as the future potential in the model. An additional 1.55 TWh is assumed to be gained on refurbishment of the existing hydro plants (see Table 10 in [15]). The refurbishment cost is assumed to be 35% of the cost of new hydro plants. Thus, a total of 35.9 TWh is assumed to be available from existing hydro plants.

New hydro potential is updated to 2.38 *TWh* (compared to 4 *TWh* in earlier version of the model) based on expert judgment. Thus, total hydro potential in 2050 is 38.3 (34.4+1.55+2.33) TWh compared to 40 TWh in the 2050 Swiss Energy perspectives [7].

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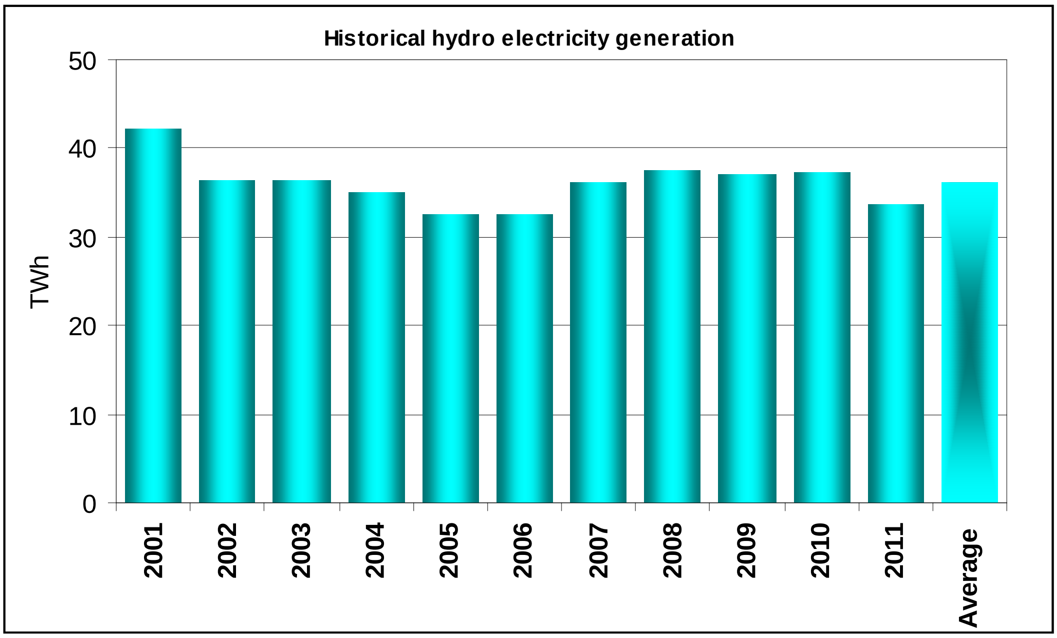
[7] 80% of the electricity consumed in pump is considered as pumped hydro generation.



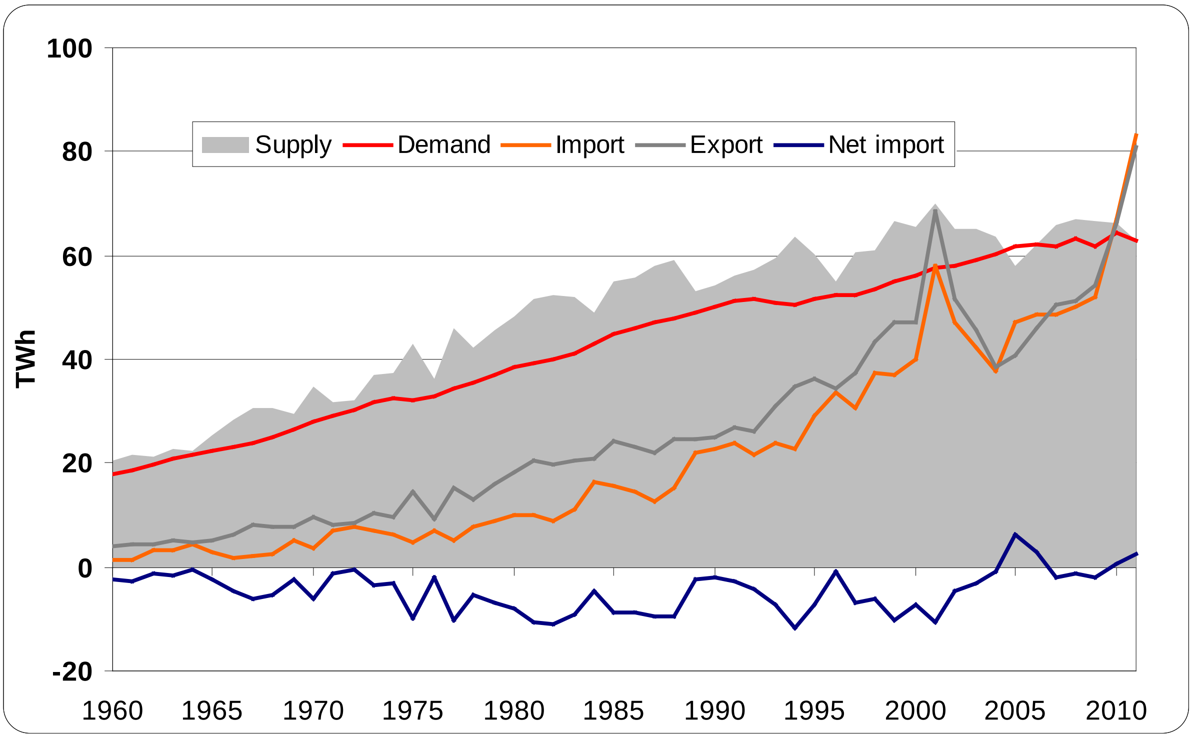
BFE, 2012 [8]

Figure 4: Historical generation of hydro power plants

6. Electricity interconnectors

For imported (and exported) electricity, the price assumption is updated to that of the 450 ppm climate scenario of the ADAM project [1] (versus the Reference scenario in the model documentation (Table 12 in [15]) and in the earlier analysis [17][31]). Now the annual average cost of electricity in 2050 is 43.7 CHF/GJ or 15.74 Rp/kWh. For expansion of interconnectors, a capital cost (434 CHF/kW [21]) is included in the model. However, this cost is subject to high uncertainty, dependent on interconnector length, and site and operating conditions (as are transmission losses). When the capital and O&M costs of interconnectors are included, the average electricity price is 16.14 Rp/kWh and the hourly price ranges from 8.54 to 22.77 Rp/kWh.

Previously, import and export interconnectors from the four neighbouring countries were modelled based on [28]. The import and export interconnectors are modelled as two separate infrastructures. However, to our understanding, some interconnectors are used for import and exports at different time of the day or year. This created inconsistencies in calibrating the model to historical trade volume, particularly since in the recent years the trade volume has increased considerably (Figure 5). This methodological issue in modelling the interconnectors is to be addressed. For the time being the maximum capacity of existing interconnectors reported in [28] and [25] is adopted. However, for the future years electricity trade volume is limited to 100 PJ (or 27 TWh) to avoid arbitrage trading that does not impact technology choice in Switzerland.



Source: BFE, 2012 [8]

Figure 5: Historical electricity supply and demand balance

Table 5: Assumptions on capacity (GW) of international interconnectors

	Austria	**Germany**	**France**	**Italy**	**Total**
	In *GW*				
	Based on Swiss Grid [28]				
Export	1.45	4.2	2.8	4.7	**13.15**
Import	2.5	4.3	1.7	1.9	**10.4**
	Based on SATW (2012)* [25]				
Export	1.2	4.4	1.3	4.2	**11.1**
Import	0.54	2.1	3.2	1.8	**7.6**
	STEM-E data**				
Export	1.45	4.4	2.8	4.7	**13.35**
Import	2.5	4.3	3.2	1.9	**11.9**

* The highest capacity from two seasons is taken from Table 4.1, p. 100 [25]
** The maximum capacity from both data set has been adopted.

7. Taxes and subsidies

A carbon dioxide (CO_2) tax is applied to emissions from natural gas-based plants. However, CO_2 emissions from other thermal power plants (e.g. waste incineration or biomass) are not taxed. Table 6 shows the CO_2 tax implemented in the model, based on the assumptions in SES [7].

Table 6: CO_2 tax for the electricity sector

	NEP	WWB/POM
	In *CHF/t-CO_2* *	
2010	15.6	15.6
2020	46.8	39.5
2030	109.2	47.8
2035	124.8	52.0
2040	135.2	55.1
2050	142.5	58.2
2100	142.5	58.2
	In *Rp/kWh_e***	
2010	0.8	0.8
2030	3.8	1.6
2050	4.2	1.7

* Currency conversion : 1 $US\$_{2010} \approx 1.04\ CHF_{2010}$

** Estimated cost of CO_2 per electricity output based on the assumptions on gas power plant efficiency in Table 9 in [15]

Source: BFE [7]

The federal electricity surcharge (i.e. KEV[8] for promotion of renewable energy) of 0.9 Rp/kWh_e from 2013 is included (as a tax) based on [5]. It is worth noting that KEV is applied to the entire electricity demand and does not affect the choice of supply technology.

The tax revenue (from the electricity surcharge or CO_2 tax) are not assumed to be recycled as subsidies for renewable electricity or demand reduction measures.

8. Corrections

Table 7 indicates some errors or omissions in the original documentation [15]. In addition, the following bugs have been fixed:

- Existing CHP plants were mistakenly characterised as dispatchable plant. They are now characterised as seasonal base-load plant.

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[8] Bundesabgabe zur Förderung erneuerbarer Energie (KEV) in [5] p. 12

- In the retirement schedule of the existing nuclear plants[9], the previous version of the model estimated the lifetime as the end of a specified model period, rather than the specified year. This caused a net[10] overestimation of the contribution from the existing nuclear power plants (~ 5.44 GW-year equivalent till 2034). This has been now corrected and the existing technologies are now schedule to retire on the exact years.

- Similar to nuclear, retirement of the existing hydro power plants are changed.

Table 7: Corrections to the model documentation [15]

Page	Section/ paragraph /line		Existing text	Corrected text
6	§ 2.1.3	Reference in line 4	[27]	[16]
25	Table 9	Unit of Fixed OM cost	*CHF/kW*	*CHF/kW/y*
30	Table 11*	Long term potential in 3rd column	83 91.94 TWh_t 331 PJ (Theoretical)	21.6 TWh_t (91.94 TWh_t) (Theoretical) Wastes – 28 PJ (or 6 TWh)
		Footnote *	Biomass includes wastes and 25% of biomass is treated as biogas.	Biomass includes wastes, sewages gas and manure. 25% of biomass is treated to be biogas mainly from waste water.
32	Table 12	2nd column: Unit of costs	CHF_{2010}/PJ	CHF_{2010}/GJ
40	References	Ref. no. 29	[29]	As in [14] in this document
52	Appendix VI	Unit of Fixed OM cost	*CHF/kW*	*CHF/kW/y*

* Note, Table 11 is now revised and simplified as Table 3 in this document

9. References

[1]. ADAM - Adaptation and Mitigation Strategies: Supporting European climate policy (2010). <http://www.adamproject.eu/>

[2]. BFE (2004) Konzept Windenergie Schweiz. Grundlagen für die Standortwahl von Windparks, Bundesamt für Energie, Bundesamt für Umwelt, Wald und Landschaft, Bundesamt für Raumentwicklung, Bern. <http://www.news.admin.ch/NSBSubscriber/message/attachments/18670.pdf>

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[9] The existing nuclear power plants are modelled to retire as follow: "the first reactor at the Beznau is scheduled to retire in 2019 followed by the second reactor and the Muhleberg nuclear reactor in 2022. The Goesgen nuclear plant is scheduled to retire in 2029 followed by the Leibstadt nuclear plant in 2034" [15]

[10] Underestimation of contribution from Beznau I by one year (retires in 2017 instead 2019) (1*365 MW); Goesgen by two years (2028 instead 2029) 2*970 MW) and over estimation of Leibstadt by six year (2040 instead 2034) (6 * 1.19 MW).

[3]. BFE (2001) EnergieSchweiz: Das Nachfolgeprogramm von Energie2000. Bundesamt für Energie, Bern. <http://www.solarpeace.ch/solarpeace/Download/20010101_EnergieSchweiz.pdf>

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[6]. BFE (2012) Energiestrategie 2050 und ökologische Steuerreform - Bundesrat eröffnet Vernehmlassung zur Energiestrategie 2050. <http://www.bfe.admin.ch/energie/00588/00589/00644/index.html?lang=de&msg-id=46133>

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Appendix I: STEM-E database file

Model	**Swiss TIMES electricity model (STEM-E)**
Author	*Kannan Ramachandran*
Organisation	Energy Economics Group Laboratory for Energy Systems Analysis Paul Scherrer Institut, 5232 Villigen PSI, Switzerland.
Database name	STEM-E-R2 (28 November 2012)
Sectors	Electricity sector
Start date	01.09.2009
First release	14.06.2011(STEM-E-R1)
Second release	28.11.2012 (STEM-E-R2)
References	R. Kannan and H. Turton (2011) Documentation on the development of the Swiss TIMES Electricity Model, *PSI Bericht Nr. 11-3*, Paul Scherrer Institut, Switzerland R. Kannan and H. Turton (2012) The Swiss TIMES Electricity Model (STEM-E) - Updates on model data and assumptions – Updates to the model input data and assumptions, Paul Scherrer Institut, Switzerland
Key model outputs	Kannan R, Turton H. (2012) Cost of ad-hoc nuclear policy uncertainties in the evolution of the Swiss electricity system, *Energy Policy*, 50: 391-406. <http://dx.doi.org/10.1016/j.enpol.2012.07.035 > Kannan R., Turton H. (2012) A long-term electricity dispatch model with the TIMES framework, *Environment Modeling and Assessment*. DOI:10.1007/s10666-012-9346-y Weidmann N., Kannan R., Turton H. (2012) Swiss climate change and nuclear policy: a comparative analysis using an energy system approach and a sectoral electricity model, *The Swiss Journal of Economics and Statistics*, **148** (2): 275-316 PSI (2012) Die Neue Schweizer Energiepolitik: Woher kommt der Strom? *Energie Speigel Nr. 21* Kannan and Turton (2012) Swiss electricity supply options: A supplementary paper for PSI's Energie Spiegel Nr. 21, Paul Scherrer Institut, Switzerland.
Status	**Second Release (November 2012)**