Reaching the inflection point for electricity consumption: the effect of a local utility led DSM programme

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Abstract

Since the utility of Geneva (the largest multi-utility in Switzerland) started its DSM programme in 2009, the electricity consumption of the Geneva region has been levelling off, while the trend for Switzerland as a whole is still increasing (albeit at a somewhat lower pace).

In absolute terms, during the last five years, Geneva was able to slightly diminish its electricity consumption while maintaining high economic and population growth; in other words: being on track of the goals of the 2050 Swiss Energy Strategy several years before the adoption of the 2050 Swiss Energy Strategy by Swiss authorities!

This paper discusses this finding by analysing the various factors influencing electricity consumption, i.e. population, GDP, local temperature and legislation.

In addition, using the example of the Geneva DSM programme, we test a simple bonus-malus mechanism and discuss the possibility to use such mechanism to incentivate utilities to develop DSM programme across the country in a harmonized way.

We conclude that a bonus-malus mechanism based on the comparison of local electricity consumption with the national average combined with a charge levied on the final consumer's electricity bills may be part of a policy package allowing to achieve the Swiss nuclear phase out.

Introduction

Even if energy efficiency on the demand side is today considered as the cheapest option for saving resources and avoiding emissions, there is a strong supply side focus in Switzerland as in most other countries of Europe. In the wake of the European 2020 climate and energy package (20-20-20 targets), and the decision of Germany and Switzerland to phase out nuclear energy after the Fukushima disaster, demand side management (DSM) tools and visions are gradually gaining momentum.

From this perspective, utilities, due to their understanding of the energy sector and their client relations, are more and more considered as part of the solution, even if a majority of them are, for the moment, not involved or interested in implementing energy efficiency and have no incentive to change this situation.

Switzerland is at the very beginning of implementing demand side management (DSM) and therefore, only very little data and information are available on the level of energy consumption and on the improvement of energy efficiency; rather than suggesting a new evaluation tool, the main objectives of this paper are to:

- conduct a observation-based analysis whether Swiss utilities are able to produce negawatts;
- present key indicators and suggest global tools for assessing the effectiveness of efficiency programmes operated by utilities;
- discuss and identify critical aspects of a simple mechanism for a Swiss energy efficiency bonus-malus scheme for utilities.

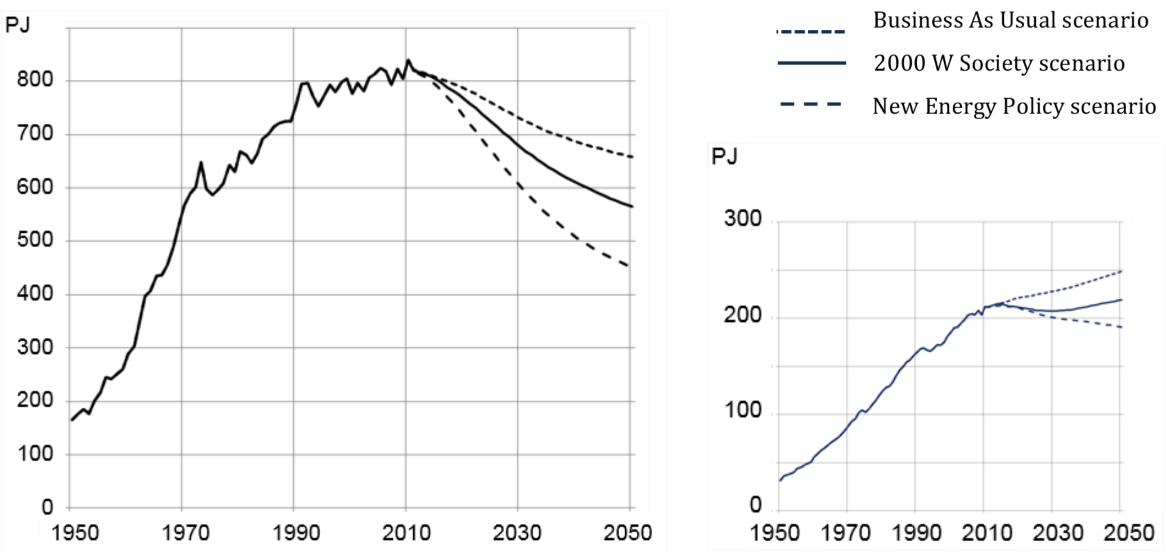

Figure 1. Past and projected final energy use (left: without international air traffic) and electricity (right) according to the Swiss Energy Strategy (Prognos 2012).

Context: electricity efficiency in Switzerland and Geneva

THE VISION OF A 2,000 W SOCIETY

Two thousand watts is approximately the current world average rate of total energy use per person. In a 2,000 W society the total energy consumption, divided by the population, divided by the time is equal to 2,000 W (or 48 kWh per day). It is moreover envisaged that the use of fossil fuel would be ultimately limited to no more than 500 W per person.

The vision was developed in 1998 by the Swiss Federal Institute of Technology as a response to concerns about climate change, energy security, and the future availability of energy resources. It is supported by the Swiss Federal Office of Energy, the Association of Swiss Architects and Engineers, cities and other bodies.

The 2,000 W objective should be compared to averages of around 6,000 W in Western Europe, 12,000 W in the USA, 1,500 W in People's Republic of China, 1,000 W in India, 500 W in South Africa and 300 W in Bangladesh. Switzerland is currently using an average of around 5,000 W per inhabitant and it was last a 2,000 W society in the 1960s. (See Figure 1[1].)

Achieving a 2,000 W society implies reaching an inflection point for total final energy consumption very soon, and, for the most ambitious scenario, also for electricity consumption.

SWISS ENERGY STRATEGY 2050

The Swiss Federal Council has developed a long-term energy policy ("Energy Strategy 2050") based on 2,000 W society perspectives. It has produced a package of measures aimed at securing the country's energy supply over the long term, including efficiency goals for utilities. The main goal of the new energy policy is to reduce the total CO_2 emissions across all sectors of the economy (conversion sector, transportation, buildings, industries and services) to 1.5 t/y/inhabitant.

Nuclear phase out is part of the Energy Strategy 2050 of the federal government. This is a large challenge as nuclear power generation represents around 40 % of the Swiss electricity production mix (one of the highest ratios in the world). On the other hand the country is endowed with substantial hydro resources which represent almost 60 % of the electricity mix and will play a crucial role in the energy transition. Nuclear energy must be replaced, until 2050, by energy efficiency measures, and new renewables (solar, wind, biomass, geothermal energy). The existing five nuclear power plants are to be decommissioned when they reach the end of their safe service life, and will not be replaced by new ones.

LOCAL ENERGY STRATEGY OF GENEVA

With a population of half a million people, Geneva represents between 5 and 10 % of the Swiss Confederation in terms of GDP, energy consumption, etc.

The energy strategy adopted by the canton of Geneva is in line with the 2,000 W Society strategy because it aims at reducing the average energy consumption per person, per year by approximately 50 % in 2050 compared to 2000, without nuclear energy. This ambitious goal means energy efficiency gains of 2 % per year, compared to the business as usual trend of 1 % per year.

The objective of reducing final energy demand (including electricity) by 35 % in the period from 2000 to 2035 (including 9 % decrease for electricity) is laid down in the General Energy Strategy 2013 of Geneva[1].

SIG (Services industriels de Genève), the energy utility of the canton of Geneva, is a publicly owned company. Its main mission is to supply the state of Geneva with water, natural gas, electricity, district heating, telecommunications, as well as to treat and recycle both liquid and solid waste. Moreover, SIG has developed activities in the field of optic fiber, audits and energy services. SIG counts 1,700 employees and has an annual turnover of €1 billion. Per annum, around 6 TWh of thermal energy

1. 2,000 Watt Society Scenario: Referred to as "package of measures" in Prognos (2012).

are consumed in Geneva: more than a half is distributed by SIG (natural gas). Morever around 3 TWh (100 %) of electricity are distributed by SIG, ¾ of which are imported.

In 2008 SIG launched the DSM programme éco21[2] to help its clients to diminish electricity consumption without sacrificing their comfort and competiveness, on the contrary: éco21 has developed the local green business and necessary skills for the energy transition.

The main objective of a DSM programme is to offset the drivers which increase energy consumption by energy efficiency improvement. The programme éco21 may be considered as a co-producer of energy savings, as a facilitator which does not sell any products or services, but which encourages consumers to use efficient technologies and adopt efficient behaviours.

For this purpose, SIG has already invested €53 M on a voluntary basis (approximately €10 M/y or 1 % of the annual turnover of the company). A team of 15 equivalent full-time employees is responsible to develop and implement efficiency measures and plans in partnership with third-party providers. éco21 incentivizes energy savings among all types of consumers (households, firms and communities), mainly through three levers:

- financial incentives;
- support and advices;
- advertising.

While éco21 resembles current DSM programmes as implemented in North America since decades, it is one of the first in Switzerland and SIG is considered as front-runner in DSM. The programme is regularly evaluated by the University of Geneva[3].

In the next sections we will look at three different approaches to assess the impact of the DSM programme on electricity consumption:

- simple comparisons of past trends of electricity consumption at national versus local level;
- an attempt to explain the role of various external factors and policy measures for energy efficiency and electricity demand;
- annual comparison with and without correction factors through a bonus-malus calculation.

Comparison of electricity consumptions trends at national versus local level

COMPARISON OF REAL TRENDS

In 2008, a DSM programme for electricity (called éco21) was implemented in Geneva. In 2009, the year of global economic recession, new efficiency standards for appliances were implemented in Switzerland (and Geneva)[2]. We compare the 4-year period 2006–2009 to the 4-year period 2010–2013, and the 5-year period 2004–2008 to the 5-year period 2009–2013 with the 2008–2009 period as turning point.

According to Figure 2 and 3 the growth of energy consumption was higher in Geneva than in Switzerland before 2008 (resp. 2009), but that has been stabilised, while the Swiss trend is still increasing. It seems that the additional introduction of the éco21 DSM programme has led to the stabilization of electricity use in Geneva.

In the next section we will describe the main efficiency drivers responsible of this inflection point.

RESPECTIVE WEIGHT OF MAIN EFFICIENCY DRIVERS

In Figure 5, bottom up estimation of éco21 programme savings impact are represented by the difference between the green dotted curve and the red curve representing the real values. These savings were determined in past and ongoing research projects (conducted by the University of Geneva) which are part of SIG's monitoring activities.

According to Prognos (2012) the difference in growth rates of annual electricity consumption between the scenarii "business as usual" and "new energy policy" is between 0.25 % p.a. and 0.75 % p.a. for the period 2010–2015 and 2015–2020 respectively[4]. On this basis we estimate the efficiency improvement by tightened energy efficiency standards at the national level at 0.5 % p.a. (this assumption requires further analysis). Adding this wedge to the development without éco21 programme (green dotted line) results in the violet dashed curve.

Other efficiency drivers

In our reasoning above we did not take into account additional efficiency drivers, e.g. energy performance contracting (EPC), facility management, ESCOs, smart metering/smart grids, and so on. They do exist in Switzerland but low energy prices and the relatively low interest of the market for energy issues make them not very profitable for the time being, especially for large publicly owned utilities. It is worthwhile to mention here briefly the problem of overlaps when commercial approaches such as EPCs and public approaches such as DSM programmes coexist within the same utility. This may induce governance issues which should not be underestimated and may also deserve further analysis.

Another critical point is that we do not take into account values, beliefs and other socio-cultural drivers. A culture of sustainable development does exist in Geneva and as in many other countries and regions (Denmark, Vorarlberg, etc.) the energy framework is formed here as part of a struggle against nuclear power. Following a referendum, an anti-nuclear article was introduced into the constitution of the State of Geneva in 1986, after the Chernobyl disaster. These aspects and the impact on the population's behaviour (for e.g. choices for sufficiency) need to be studied in more detail by future research.

COMPARISON WITH CORRECTION FACTORS THROUGH A BONUS-MALUS CALCULATION

The 2015 policy debate in the Swiss parliament is seriously taking into account the option of implementing a bonus-malus mechanism in connection with an energy saving obligation scheme for utilities. The underlying idea of the policy makers is to reward the utilities which achieved efficiency goals and penalize the others.

2. In January 2009, the lowest accepted energy efficiency level for lamps sold in Switzerland was the efficiency class E. Since September 2012, efficiency class C is required for all lamps, which means the disappearance of incandescent traditional bulbs. In January 2012, minimum energy efficiency standards for appliances were tightened and expanded to further appliances as TVs, circulation pumps, fluorescent lamps, lighting, set-top boxes, refrigerators and freezers. Moreover, an energy label was introduced for TVs while the energy labels for refrigerators, freezers, washing machines and dishwashers are same as in the EU.

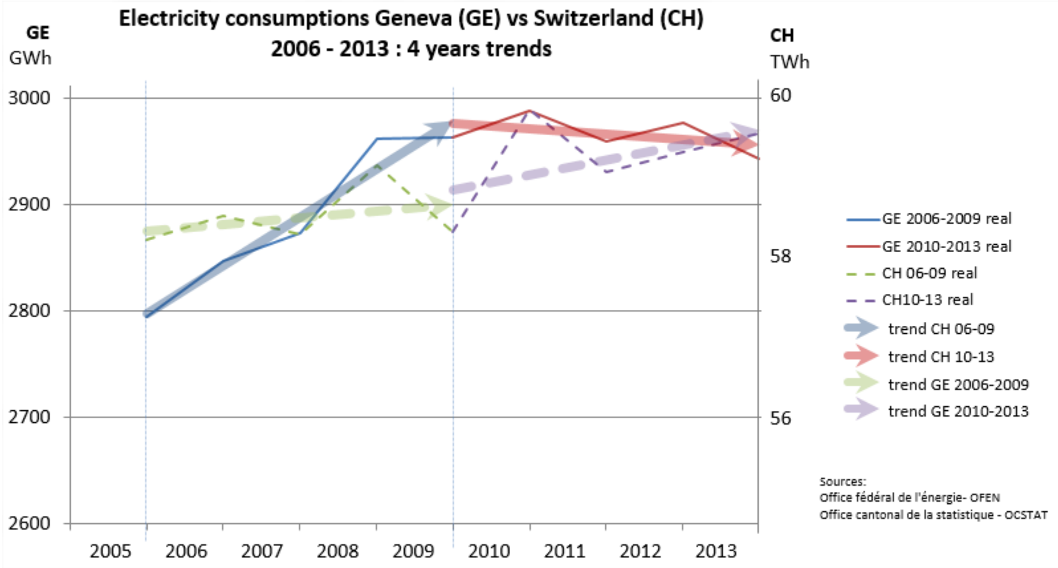

Figure 2. Development of electricity use in Geneva and Switzerland: 4 years trends.

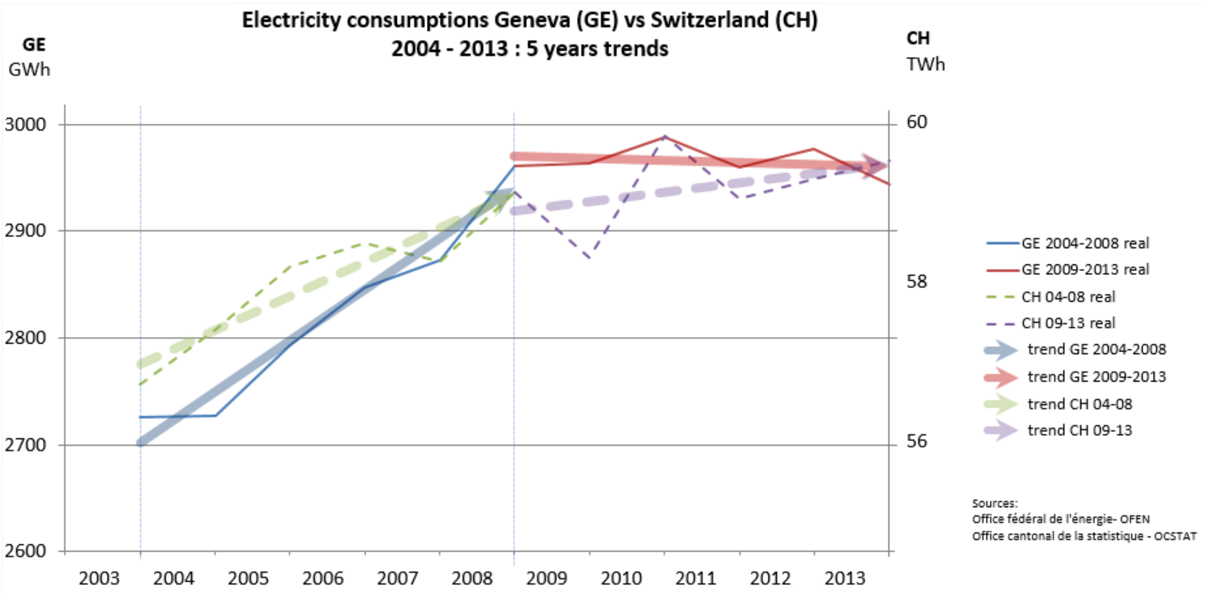

Figure 3. Development of electricity use in Geneva and Switzerland: 5 years trends.

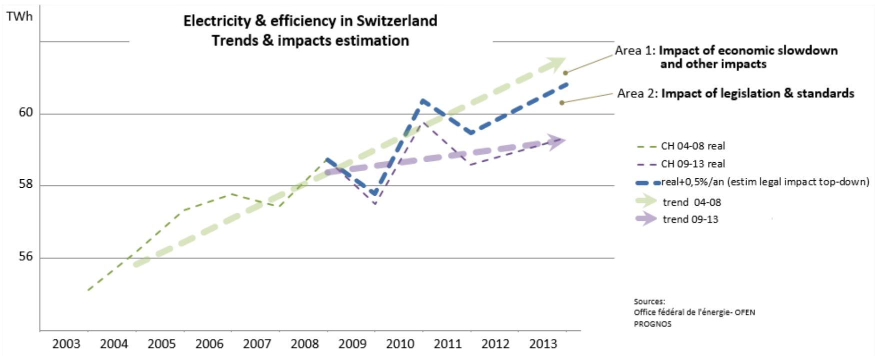

Figure 4. Development of electricity use in Switzerland: policy and economics impacts.

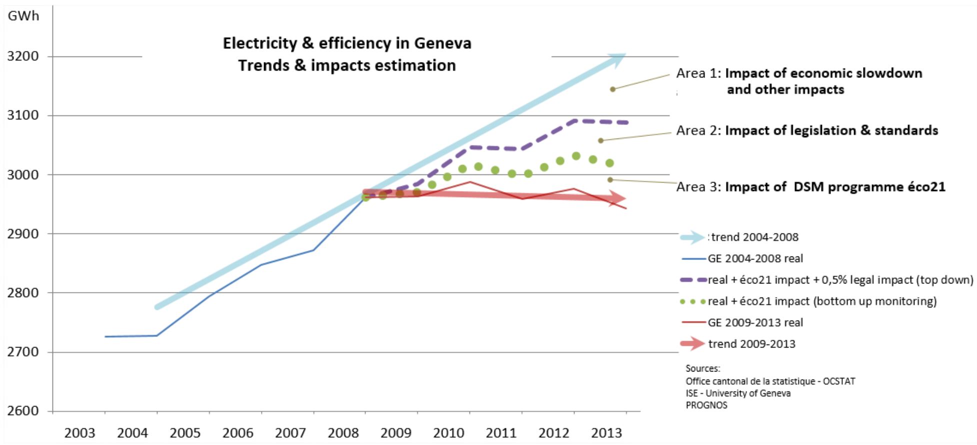

Figure 5. Development of electricity use in Geneva: policy, economics and DSM programme impacts.

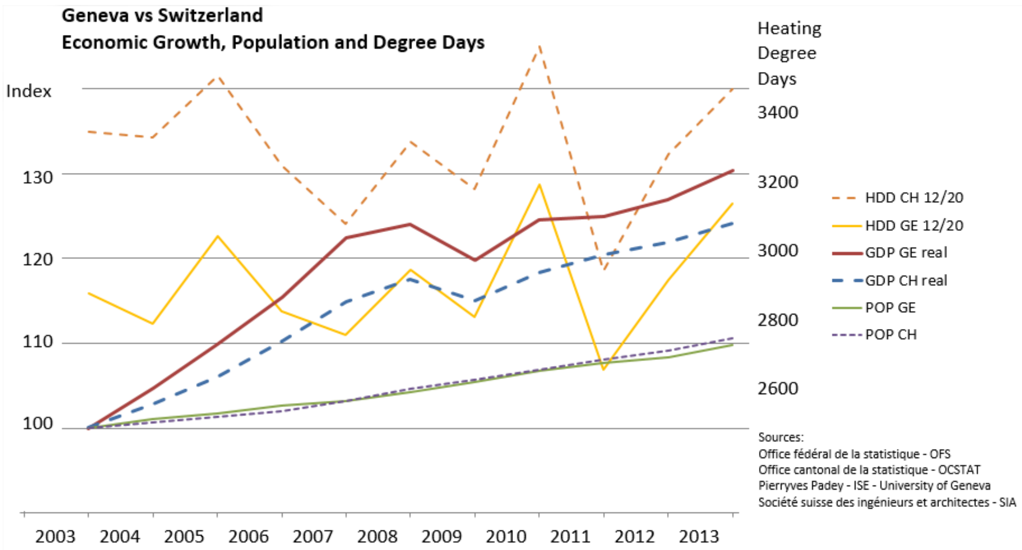

Figure 6. Comparison of key factors of energy use in Switzerland and Geneva: GDP, population and Heating Degree Days.

As a calculation method is required and in order to compare the performance of utilities across Switzerland, we will here shortly describe external factors influencing the energy consumption.

Correction factors

Weather

While Geneva is milder than Switzerland as a whole, the patterns across the years are very comparable. The course of the number of Degree Days (HDD) across the year is therefore more sawtooth-like in Switzerland than in Geneva. However, a notable difference between Geneva and Switzerland is the use of electricity for heating purposes: between 5 and 7 % of Swiss households are heated with electricity, while restrictive legislation prohibited electric heating in Geneva (except for buildings already constructed at the time of the entry into force of the Act, i.e. less than 1 % small buildings, mainly the single-family houses of the 1960s). We correct for these differences in the further course of our analysis (see Figure 7).

To weight the meteorological impact on the electricity consumption EGE of Geneva, we will use:

EGEstandard = f × EGEreal,
where f = (0.98 + 0.02 × (HDDrefGE / HDDGEreal))

To weight the meteorological impact on the Swiss electricity consumption ECH, we will use:

ECHstandard = f × ECHreal,
where f = (0.85 + 0.15 × (HDDrefCH / HDDCHreal))

Economy

While there are differences in economic structure (share of industry sector, tertiary sector, …) between Geneva and Switzerland, the overall development has been similar in the past eight years (see Figure 6). Swiss and Genevan GDP have enjoyed a steady growth (with the exception of the economic slowdown in 2009). Geneva's GDP is higher than the Swiss average. In terms of GDP per capita, Geneva is ranked 3rd at the national level, behind Basel-City and Zug. Since Geneva is a financial

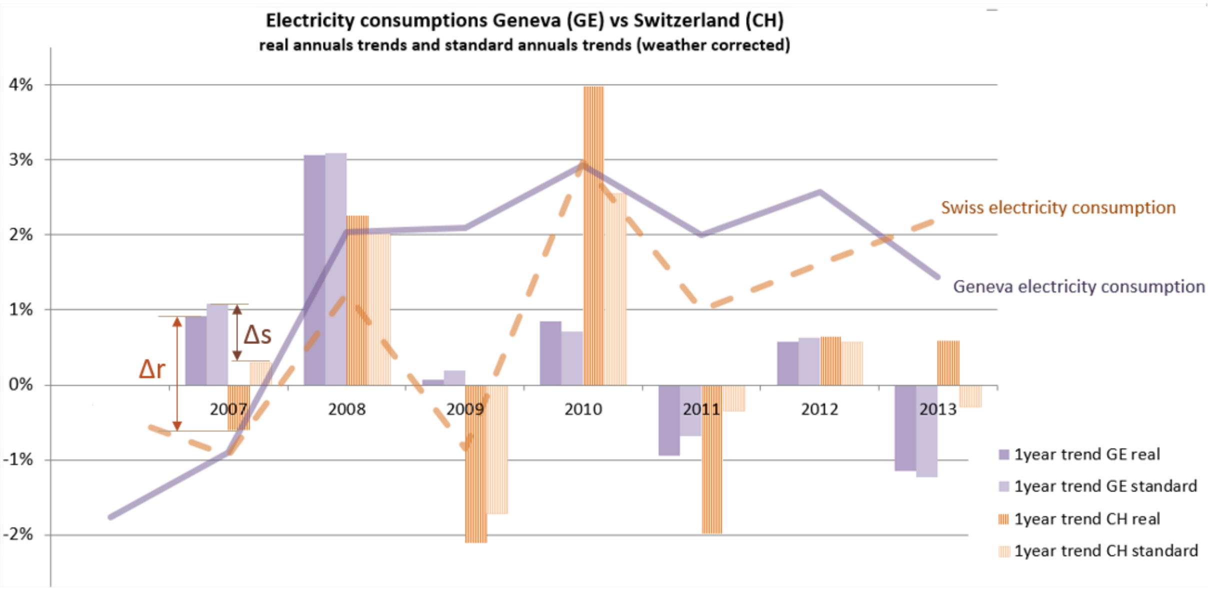

Figure 7. Development of annual electricity use with and without temperature correction.

center, it is plausible that GDP grows faster than in Switzerland while the difference in physical growth is likely to be much smaller; we therefore do not correct for this difference, while acknowledging that further research is required.

Demography

Due to the nearly identical trajectories we did not correct for population growth.

Substitution

Substitution of inefficient fossil fuel-based technologies by more efficient electric technologies and development of efficient decentralized energy technologies are very similar in Switzerland as in Geneva. Solar self-consumption rates are low, installation of heat pumps remained stable both in Switzerland and Geneva during the considered period. For these reasons we did not include a technology substitution factor in our calculations.

Bonus-malus calculation

As explained above we propose here a simple approach for implementing a bonus-malus scheme at the utilities level: the difference in annual energy efficiency change between a given canton (here Geneva) and the national change in annual energy efficiency is multiplied by the canton's energy use to arrive at the relative savings or relative overconsumption, expressed in GWh.

Multiplying this value by a price for energy efficiency ("negawatts") results in the annual bonus or malus. Based on the éco21 experience we chose a value of 50 €ct per first-year kWh saved (translating to 5 €ct/kWh assuming an average 10-year technical lifetime of the measures).

The calculation was conducted with and without temperature correction in Switzerland and in Geneva respectively[3]. According to our calculations the bonus-malus system results in certain volatility in both cases: without temperature correction ranging from a malus of €32.2 M in 2009 to a bonus of €46.9 M in 2010, and in the case of temperature correction ranging from a malus of €28.3 M in 2009 to a bonus of €27.1 M in 2010.

In order to reduce volatility it could be of interest to spread the bonus/malus payments over a longer period of time, for example according to the lifetime of the efficiency actions.

In the year 2011, Geneva would have had paid a malus if no climate correction was applied while it would have had received a bonus with climate correction. This is due to the particularly mild weather in 2011 which drastically reduces the heating requirements in Switzerland as a whole. It should, however, be considered that these calculations are sensitive to the choice of the factor f (defined above as the share of electric space heating and hot water) which would require further analysis.

According to these calculations, after several years, the cumulative bonus-malus with temperature correction seems close to the real programme costs. It even seems possible for a utility to make a profit with a successful DSM programme (last line of column *SUM 2010–2013*).

In order to kickstart and sustain DSM programmes it seems commendable and even indispensable to recoup a part of the programmes costs through a charge to be levied on the final consumer's electricity bills.[4] This could also counteract the volatility introduced by a yearly bonus-malus system.

The use of the average Swiss annual energy efficiency improvement as reference seems consistent, straightforward and easy to implement, thereby overcoming prominent problems of evaluation (as double counting, spill over effects, free rider effects). It can also avoid additional complexity due to a bonus-malus calculated on a modelized reference curve based on the historical consumption evolution of each canton or each utility.[5]

3. Degree days are typically published per canton while they are not readily available for Switzerland as a whole. The reference temperatures underlying the degree days for Switzerland may differ from the reference temperatures underlying the degree days for Geneva. Further analysis is required on this point. We apply the temperature correction across years in Switzerland and in Geneva respectively, thereby making some assumptions which still need to be verified.

4. As first approximation, according to the éco21 experience, a levy of 5–10 % of electricity distribution costs or 0.35 to 0.7 €cent/kWh distributed seems appropriated

5. The option discussed within the Swiss parliament is a decentralised bonus-malus system based on local electricity consumption reference scenarii.

Table 1. Simulation of bonus–malus mechanism using historical power consumption data of the éco21 programme – with and without temperature correction.

		2007	2008	2009	2010	2011	2012	2013	*SUM 2007-2013*	*SUM 2008-2013*	*SUM 2009-2013*	*SUM 2010-2013*
Calculation with real datas												
trend CHreal	%	-0.6%	2.3%	-2.1%	4.0%	-2.0%	0.6%	0.6%				
trend GEreal	%	0.9%	3.1%	0.1%	0.8%	-0.9%	0.6%	-1.1%				
Delta trends (Δr)	%	-1.5%	-0.8%	-2.2%	3.1%	-1.0%	0.1%	1.7%				
Delta trends (Δr)	GWh	-44	-24	-64	94	-31	2	51				
price	€ct/kWh y1	50	50	50	50	50	50	50				
Bonus-malus	M€	-21.8	-11.9	-32.2	46.9	-15.5	1.0	25.5	***-8.0***	***13.9***	***25.8***	***57.9***
éco21 budget	M€	1.7	1.5	2.9	9.6	9.8	9.2	7.8	*42.5*	*40.7*	*39.2*	*36.4*
Profitability	M€	-23.5	-13.4	-35.0	37.3	-25.3	-8.2	17.8	*-50.4*	*-26.9*	*-13.4*	*21.6*
Calculation with temperature correction factor												
trend CHstandard	%	0.3%	2.0%	-1.7%	2.5%	-0.4%	0.6%	-0.3%				
trend GEstandard	%	1.1%	3.1%	0.2%	0.7%	-0.7%	0.6%	-1.2%				
Delta trends (Δs)	%	-0.8%	-1.1%	-1.9%	1.8%	0.3%	-0.1%	0.9%				
Delta trends (Δs)	GWh	-22	-31	-57	54	10	-2	28				
price	€ct/kWh y1	50	50	50	50	50	50	50				
Bonus-malus	M€	-11.1	-15.4	-28.3	27.1	5.0	-0.8	14.0	***-9.5***	***1.6***	***17.0***	***45.3***
éco21 budget	M€	1.7	1.5	2.9	9.6	9.8	9.2	7.8	*42.5*	*40.7*	*39.2*	*36.4*
Profitability	M€	-12.9	-16.9	-31.1	17.5	-4.9	-9.9	6.2	*-52.0*	*-39.1*	*-22.2*	*8.9*

Further analysis is required in order to understand the effects of large-scale implementation over longer periods of time and interaction with other policy mechanisms.

Conclusions

While growth in electricity consumption before 2009 was much higher in Geneva than in the rest of Switzerland, it is now negative whereas the trend at national level is still growing. The main cause of this inflection seems to be the deployment of éco21, the DSM programme led by the local utility of Geneva.

Where national government or international institutions establish standards for efficiencies of appliances, utilities are able to implement additional negawatts successfully due to their understanding of the energy sector and their client relationship. As third player, private companies make use of the market opportunities for energy efficiency. A synergistic interaction of these three drivers needs to be ensured in order to maximize the efficiency gains while minimizing the costs. Suitable boundary conditions must be put in place in order to avoid counter-productive overlaps between the three mechanisms.

According to the Swiss energy policy 2050, it seems appropriate to extend DSM programmes to whole Switzerland; a bonus-malus mechanism based on the comparison of local consumption versus national consumption may be part of such policy package. In order to kickstart and sustain DSM programmes, it seems commendable to recoup parts of the programme costs through a charge to be levied on the final consumers electricity bills and to share best-practices as éco21 between utilities.

It is unquestionable that Switzerland will need more efficiency programmes but the big challenge is to ensure stable funding and fair distribution of their benefits in terms of increased economic activity, employment, preservation of the environment, increased energy independence and quality of life.

Regarding the calculation of an acceptable bonus and malus mechanism for the stakeholders, the optimal mix between a complex and reliable bottom-up analysis (as used by academic researchers) and a simple top down approach (as asked by policy makers) is still work in progress.

Endnotes

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2 Cédric Jeanneret, Pascale Le Strat, Guy Wuilleret, "éco21. Stabilisation of electricity consumption in Geneva: a project driven by a strong political will and the skills and dynamism of a public service utility", eceee Summer Study, 2011.

3 Jean-Luc Bertholet, Daniel Cabrera, Bernard Lachal, Theodora Seal: Institut for Environmental Sciences, University of Geneva. Cédric Jeanneret: éco21 programme, Services Industriels de Genève, Evaluation of Energy Efficiency program in Geneva – Evaluation methodologies for two subprograms using bottom-up approach, IEPEC Energy Efficiency, 2010.

4 Prognos 2012 in Energy Strategy 2050, Swiss Federal Office of Energy, 2013.