The information platform energyscope.ch on the energy transition scenarios

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Abstract:

Switzerland like many countries plans to undertake an energy transition and the government proposes different paths for 2035 and 2050 to achieve it. However the authors of this paper felt the need for a better information of the public on the energy matters. A special web-based information platform was introduced in 2015. The platform includes a calculator, a book providing 100 questions and answers on energy and a MOOC for citizens with more than 20 short lectures on the various aspects of the Swiss energy transition. Unlike other interactive energy scenario calculators our calculator offers the possibility to show monthly averages of demand and supply, highlighting the strong seasonal patterns occurring when considering most countries from the central to the northern parts of Europe. The calculator indicates the effects of the user's choices on 6 main indicators (final energy, electricity balance, % of renewables, CO_2 emissions, long term wastes and costs)

While the underlying model has already been published, this paper intends to discuss the reactions following the introduction of such a platform. Reactions from minority, but very active groups, including climate change deniers, ultra-pronuclear and anti-wind power opponents have been noticed and highlight the very emotional nature of the topic. Scenarios for 2050 are presented and discussed as well as examples of a new scenario that can be made using the calculator. All main parameters such a socioeconomic, heating and cogeneration technologies, transportation, electricity generation can be adapted.

Keywords:

Energy scenario, MOOC for citizens, Web-based calculator, Costs, Sustainability.

1. Introduction

Many countries are reconsidering their energy strategies to increase the part of renewable, boost efficiency and in several cases, like in Switzerland, to phase out nuclear power. However it can be observed that the general knowledge of the energy matters is rather weak in a large part of politicians and citizens that might have to vote on energy transition schemes like in Switzerland. Addressing part of these issues the DECC in UK [1] developed a Web-based calculator allowing anyone to develop alternative scenarios for the future. This approach has since been adapted to a few countries around the World and a World calculator is being proposed as well [2]. Furthermore a book contributes to explain the necessary basic information on energy supply and demand technologies [3]. The above calculators are using yearly averages. However the energy demand varies with different time scales and in many countries strong seasonal patterns have to be accounted for. The same applies to some renewable energy supply like solar, hydro and wind in particular. For example the photovoltaic electricity supply of Germany is about a factor 5 smaller in December-January than it is in June-July [4].

Based on these considerations a project of Web-based information platform for Switzerland was launched in March 2013 including a calculator having the possibility to show monthly or seasonal or yearly distributions, together with a book providing 100 questions and answers and a Massive Open On-line Course (MOOC, also called Course for all) for citizens. The platform was launched in April 2015 and this paper intends to share our experience so far and discuss some of the results. The platform is open and available at [5]. The calculator is provided in two versions (simple and advanced) and in 4 languages (English, German, French and Italian). The book and the MOOC are only available in French and German since the major focus was on the Swiss population. The structure of the underlying system model is described in [6, 7].

1.1 – Basic choices

Targeting a broad spectrum of voters imposed a number of choices to simplify the message while addressing the key questions addressed in the public debate about the energy transition of the country.

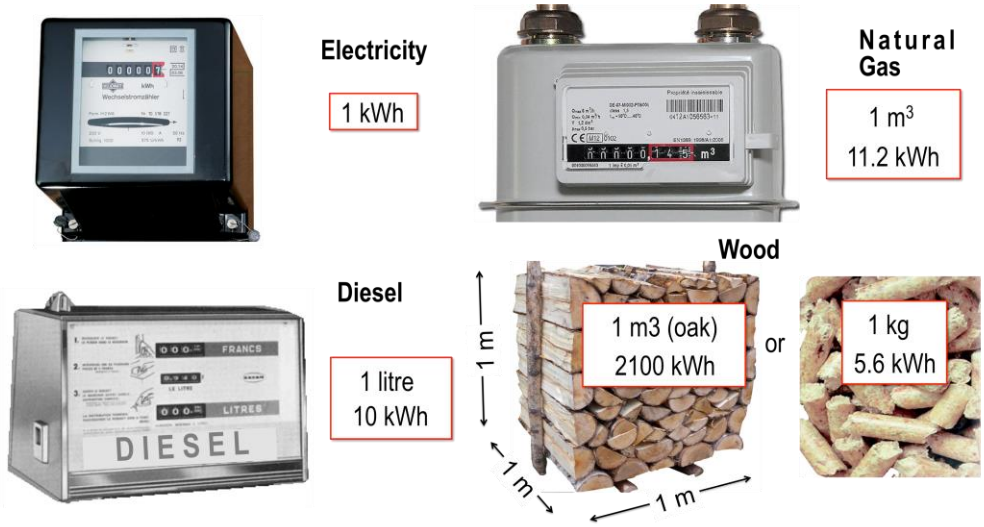

Fig. 1. Energyscope MOOC 1: Using the same unit for different final energies [5].

The calculator presents the results of scenarios using the following 6 indicators:

a) **Final energy** demand plus waste heat from power plants. Final energy is the name given by economists to any energy that can be purchased by people. One question is why add the waste heat from power plants to the final energies. Earlier attempts of introducing the exergy concepts in a cantonal Law on energy [8] showed that this could be valid for energy experts or especially interested politicians but was fairly difficult for the average man in the street. Therefore this was avoided and it was circumvented somehow, by adding the waste heat from power plants to the final energy demand. Doing so artificially expands the system boundary to include the final energy acquired by the power plant operators and allows a graphical visualization of the positive effects of combined heat and power (cogeneration). The choice of energy unit was also made to be closer to common people mainly used to paying their electricity bill in kWh. Figure 1 shows the slide used in the first lesson of the MOOC to show the correspondence between the main final energies. Furthermore three different scales are offered: GWh for nationwide figures, kWh/capita that has the merit to allow a comparison between countries and Wyear/(year.cap) that makes the link with the concept of a 2 kW society that is often quoted as a target proposed in Switzerland [9]. Figure 2 shows the reference final energy of Switzerland in 2011 that illustrates the strong seasonal pattern of consumption that is typical of countries of central to northern Europe. Two major sectors for energy demand and CO_2 emissions are the heating and transportation sectors that are still for a large part satisfied by fossil fuels.

b) **Electricity demand and supply.** Here the choice was made to illustrate in a single graph the electricity demand and supply for two situations, either the comparison between the reference year and a new scenario or a comparison between two scenarios (Fig 3). The calculator offers an initial choice with the six proposed governmental scenarios (3 for 2035 and 3 for 2050). The electricity demand being known it is convenient to show on the same graph the proposed supply from various sources. Figure 3 shows in a monthly representation for 2050 the comparison between the most optimistic scenario (2050 low) and the scenario Business As Usual (2050 high).

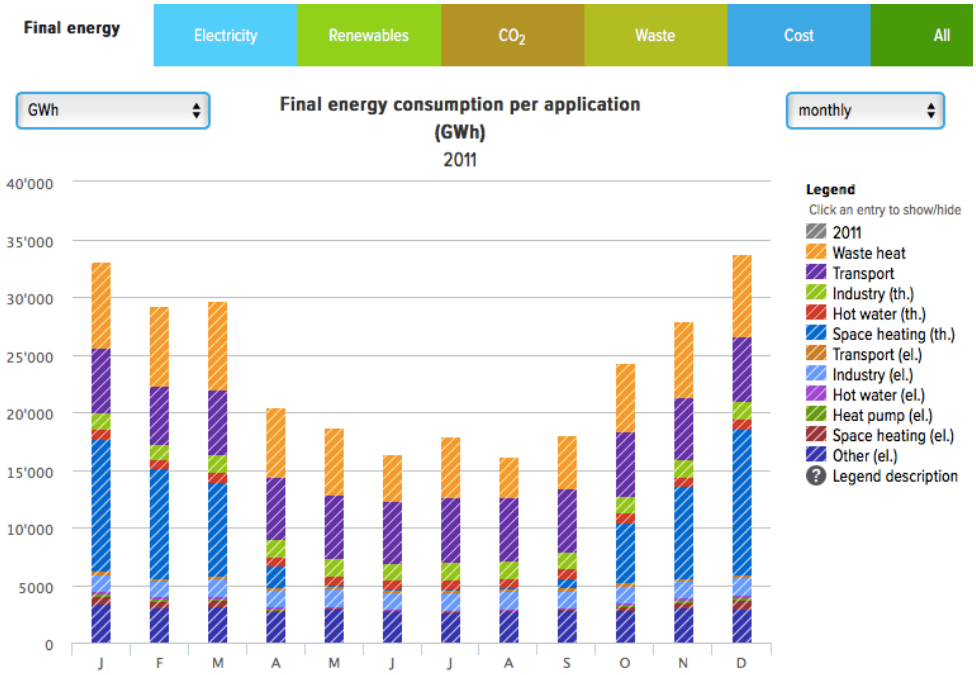

Fig. 2. Energyscope MOOC lesson 2: Final energy of Switzerland in 2011 [5].

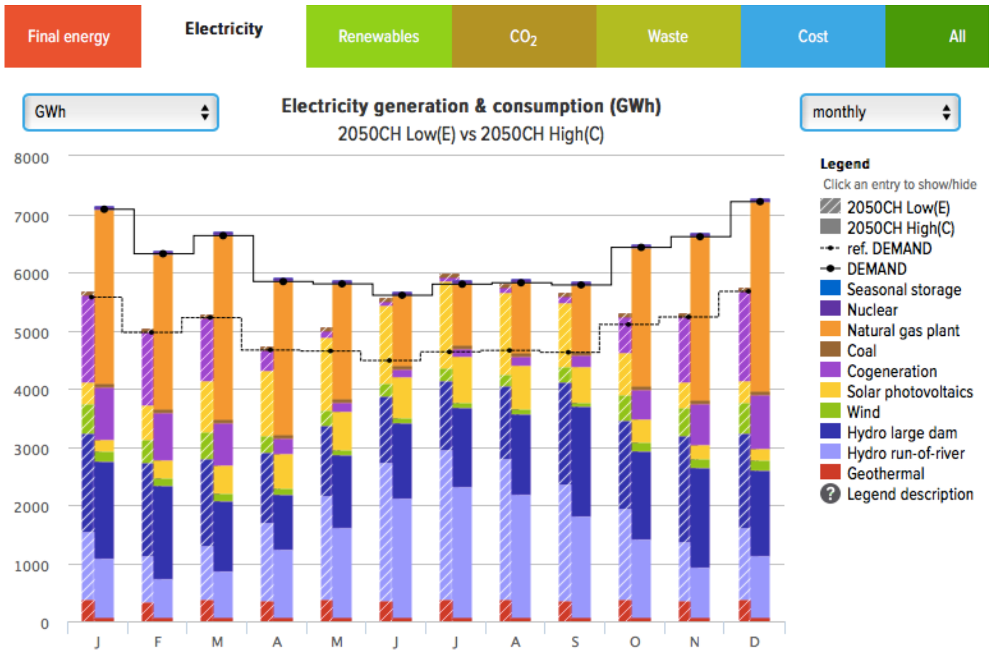

Fig. 3. Comparison between two extreme Swiss governmental electricity scenarios for 2050 [5].

c) **Contribution of renewable.** This indicator refers to the various sources of primary energy supplied to the national energy system, both in detailed form in the monthly or seasonal representation and in overall percentage in annual representation.

d) **CO_2 emissions.** This indicator is particularly pertinent in a time where the fight to prevent global warming is taking place. In this particular case the emissions linked to the imported electricity are also considered assuming a European mix. Therefore in case of import the emissions are not strictly linked to the country itself.

e) **Wastes**. This indicator considers the long-term wastes resulting from the energy system construction and operation. It concerns primarily the nuclear wastes but also includes other wastes like the solid residues from the waste incineration plants that need to be disposed of in controlled landfills. Emissions and wastes for each technology are calculated with the database Ecoinvent [10]

f) **Costs**. The public discussion frequently includes this indicator, people being often afraid of the potential economic penalties perceived with the development of the new renewable. The calculation of this indicator does not account for the continuous transition from now to the targeted year. It is based on the costs of the national energy system if the main changes would occur at the targeted year.

Figure 4 shows a comparison of the summary of the 6 indicators for the scenario (2050 high-business as usual) and (2050 low with a more rational use of energy). This is, of course, done on an annual basis. As can be seen the business as usual scenario (2050 high) shows a higher final energy demand (but still - 30% compared to 2011), a higher electricity demand (+19% compared to 2011), a lower percentage of renewable (but still a progress from 18 to 37% compared to 2011), higher CO_2 emissions (but still -17% compared to 2011), lower long term wastes (but - 96% compared to 2011) and a higher annual cost (+21% compared to 2011). The increase of long-term wastes is due to the use of more equipment for a more rational use of energy. All scenarios do not include the use of nuclear power, since they are proposed by the government, which decided in 2011 not to renew the present nuclear plants.

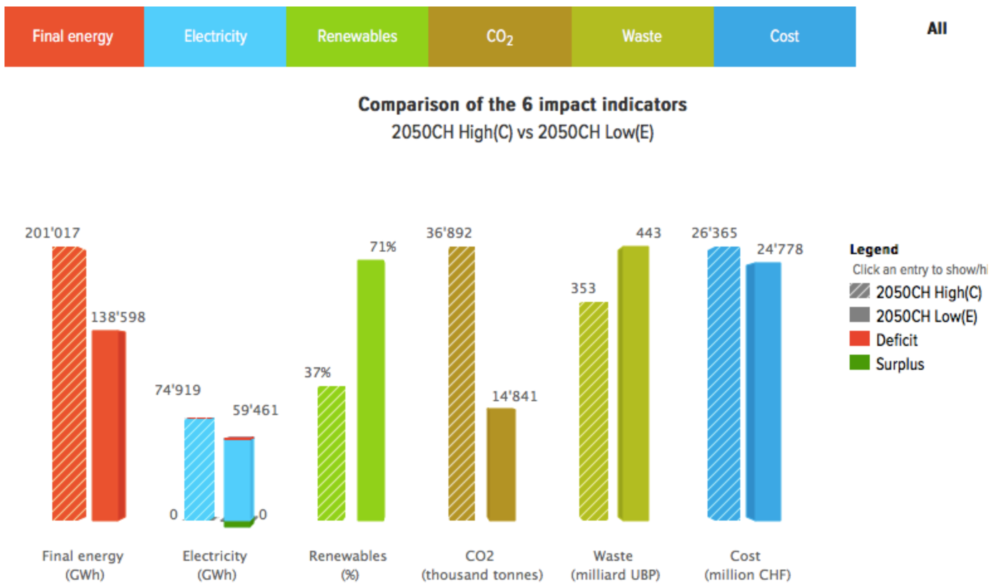

Fig. 4. Summary comparison between two extreme Swiss governmental scenarios for 2050 [5].

Let also note that in order to the possibility to the early users to familiarize themselves the calculator also offers a simplified version where only final energy, electricity and CO_2 emissions are available.

1.2 – Input parameters

The input parameters that the user can change using cursors are grouped into the following 6 sets of parameters:

a) **Socioeconomic**. This is limited for the moment to 2 elements, the population growth (assumed to grow from 8.1 to 9 million in 2050 but choice given up to 10.7) and the GDP growth (0.79%/year but choice given up to 3%/year)

b) **Energy efficiency**. This includes 4 assessments including the building specific demand, the energy intensity in industry, the appliance average consumption per household and the average consumption for lighting.
c) **Transport**. Choices there are made in two steps. First the percentages of public transport, freight transport and biofuels. Then a choice is provided between various road vehicles including hybrid and electric vehicles, natural gas and hydrogen vehicles,…
d) **Heating**. Here again a procedure in 2 steps is proposed with menus considering the heat for industry, the level of centralisation, the district heating and the distributed heating technologies and finally the type of heating fuels. Cogeneration is included in these choices.
e) **Electricity supply**. Again 2 sets of menus are available, one for renewable and one for non renewable. The possibility of introducing seasonal storage based on the use of synthetic fuels made from renewable excess electricity in the summer is offered. The introduction of CO_2 capture and storage is also made possible.
f) **Costs**. This includes the general energy prices, the investment costs and the interest rates. To simplify the model assumption is made that the parts of the energy system that changes is built at the targeted year and considering of course the amortization over the expected lifetime of the equipment.

1.2– Transparency

One critic that is often made is the lack of transparency in the scenario models, and in particular in the assumptions made regarding the evolution of the technologies and their specific cost. Care was therefore made to introduce a wiki describing the main assumptions and references taken in the model. Those cannot be changed by the user. Furthermore the book one hundred questions and answers and the MOOC provide complementary information.

1.3– Philosophy

The calculator available so far does not show other scenarios than the official scenarios of the government in order not to influence the users in their choices with our own pre-optimised scenarios. The government scenarios are based on a report from Prognos [11]. This would be the case if we provided our best scenarios that would inevitably be biased by our own evaluation of parameters and technologies. The user can then modify the scenarios according to his own choices in a self-learning exercise since he can visualize the results on the six main indicators following each curser change.

2. Results

2.1. Early reactions from users

A few hours following the release of the platform in April 2013, consisting mainly of the calculator and the book since the course is provided at the pace of one lesson per week, we received a number of negative comments along the following lines:

a) Ultra-pro-nuclear groups were offended by the fact that the scenarios presented did not consider the renewal of the 5 Swiss nuclear reactors. These reactions occurred in spite of the fact that we clearly stated that we presented the scenarios proposed by the government. The latter decided, following the Fukushima accident, to pull out from nuclear at the end of life of the actual reactors and that decision was later endorsed by the two legislative chambers. The fact that the calculator provides the possibility for users to introduce nuclear power in their own scenarios was just overlooked by these early protesters. Furthermore the scope of considering the complete energy system with all energy requirements and not only electricity confused this group that tended to be mainly concerned about keeping a CO_2 free electricity only (in 2011 Switzerland electricity production was for 39% nuclear, 56% hydro and 5% from thermal plants mainly). At the time the conflicting evaluation of the future cost of nuclear power was not an issue in these early reactions. The latter remains a difficult topic but we tried to account for recent cost assessments from the French “cour des comptes” [12] showing a unit cost increase of nuclear from 49.6 €/MWh to 59.8 €/MWh as a result of the modification of existing plants recommended following the Fukushima accident. The other element is the price mentioned during the negotiation between the UK government and EDFenergy of 92.5 £/ MWh to be guaranteed for 30 years [13]. As a compromise the maximum investment cost chosen for 3rd generation nuclear power plant was 80% of the current estimates of the EPR plants in construction in Finland and France. This results in a maximum cost close to 90€/MWh.

b) Anti-wind power groups. Switzerland has by far the lowest production of wind power per capita as compared to the neighboring countries [9: MOOC lesson 18] . This is in part due to the lower wind potential of the country but also to the strong resistance of some groups to the implementation of wind farms. Project opposition is also favoured in numerous ways by the Swiss legal framework. However, regarding the calculator, the protests were mainly based on the fact that the capacity factor was judged as being too high (0.25) and we did correct this number that was mainly based on extremely well-located wind turbines in windy mountain valleys. In the mean time we reduced this number. The adapted capacity factor is 0.22. Nevertheless protest kept coming on all the traditional questions about noise, projections of ice, threats to bird life,… . This is however the possibility in the calculator to set to zero the wind energy and to find ways to replace it by other resources.

c) Climate change deniers that contest the role of human activities on global warming or ocean acidification and therefore the need to reduce CO_2 emissions. For those groups quoting the need to limit the CO_2 to 450 ppm is extravagant!!

d) Rigorous scientific users regretting the fact of not using SI units like Joules. As explained before this was a deliberate choice to reach a broad range of users and no attempt were made to modify that.

e) Some of the same group contesting the reliability of a calculator based on monthly average as the smallest time scale. Developing a calculator with monthly average is already a challenge in terms of simplicity of use, but the authors of this platform consider that it is already an excellent indicator scale for assessing long-term scenarios. It is however clear that all the present efforts towards smart grids and daily storage will be an important part of the success of future energy systems. The strategy for future development of the calculator is to provide an add-on capability to run an hourly simulation program for the one or two best scenarios of each user. This however would also mean to model the predictive control strategy of the devices and microgrids.

Some of the above groups are extremely reactive but still represent a minority and the overall comments were generally positive. Among the request for improvements let us cite the wish for additional windows where the impacts from a given user change resulting from a move of the cursor of one parameter, would be instantly visualized in several indicator window views. This would correspond to the initial philosophy that is to suggest for the user to act sequentially to allow a better feeling of the implication of one action, rather than providing a black box optimized answer. However the concept of a multi-window on top of the two existing windows is considered as an over-complication of an interface that is already complex for laymen.

2.2. Example of scenario

One frequent question is how could we further improve the scenario 2050low, which, as can be seen in figure 4, provides already a significant step forward of most indicators compared to the 2050 high scenario which corresponds to business as usual. Figure 3 shows that with the planned solar PV (11.2 GW), wind (2 GW) and deep geothermal (0.6 GW) and the absence of chemical seasonal storage, the country would have an excess of supply in summer. One approach is to try to introduce seasonal storage to convert the excess of electricity of the summer into chemical fuels used to produce back electricity in the winter months considering a round trip efficiency. However the way it is structured at present imposes to reduce first some of the cogeneration to make the provision for new electricity from seasonal storage. This is due to the fact that at present cogeneration is adapted initially to satisfy the entire electrical demand without import and seasonal storage is only effective if there is some deficit of electricity production.

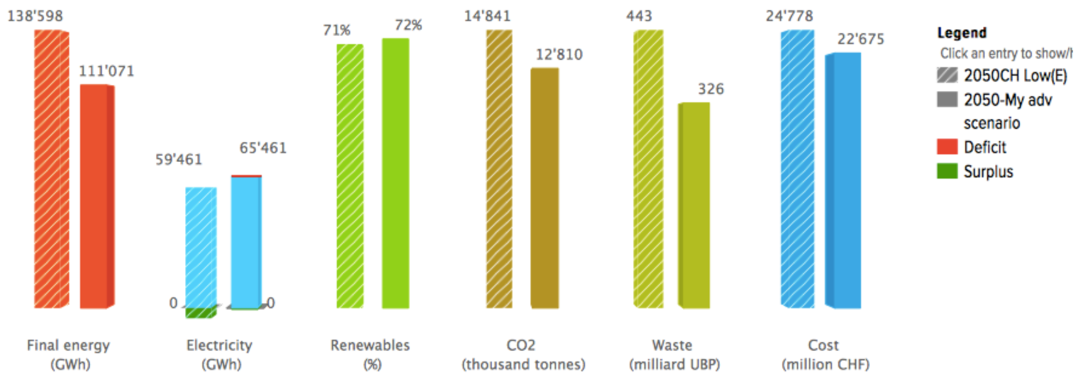

Fig. 5 Results of the scenario 2050 Low A with some seasonal storage [5].

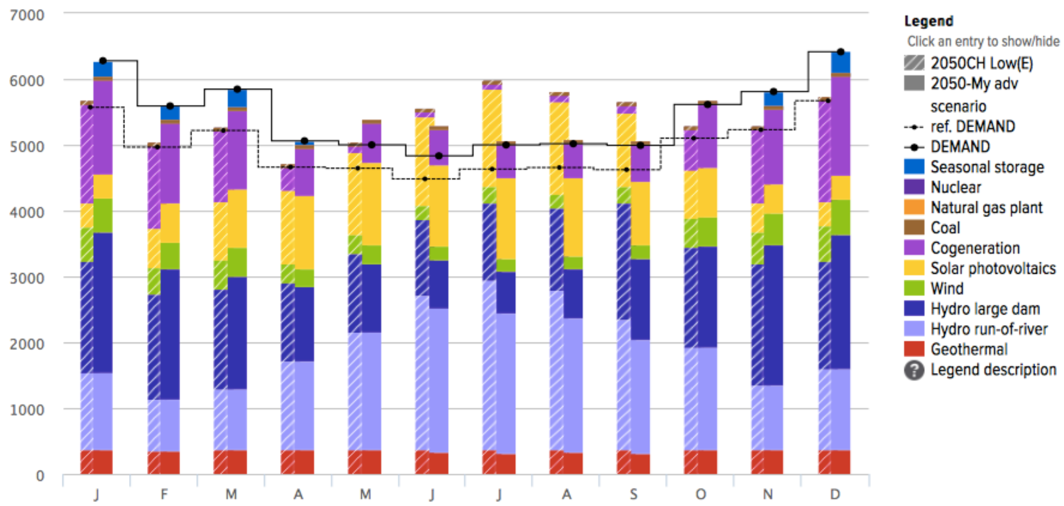

Fig.6. Electricity of scenario 2050 Low A with seasonal storage in blue [5].

This new scenario as shown in figure 5 includes an increase of electricity consumption due, in particular to a boost of electric heat pump decentralized heating to 70%, an increase of battery vehicle to 80% of the private fleet. Decentralized cogeneration is done with 3 % of advanced cogeneration with fuel cells and thermal heat pumps are used for 22% of the heat supply.

Direct electric conversion from solar or fuels via fuel cells is explained in the MOOC lesson [9, lesson 20] using Figure 7 in particular. While direct conversion with solar photovoltaics is generally well-known, direct conversion for example of natural gas or biogas using fuel cells is still embryonic. The calculator includes two choices for decentralized cogeneration either standard cogeneration with engines or advanced cogeneration with fuel cells, the latter being primarily used in scenario 2050Low A of figure 6.

Conclusions

The Web-based platform allowing a general public to understand and modify energy scenarios has generally been well received except for minority but very active groups focussing on a few specific energy technologies or affected in their emotional convictions. Transparency in the hypotheses made is particularly appreciated. The calculator shows in particular that all official scenarios for a

2050 horizon in Switzerland result in costs that are within a 10 % range and some 10 to 20 % higher than the costs of the reference year 2011. The most optimistic official scenario with significant improvement of most indicators appears to be even slightly cheaper that a business as usual scenario. Further work to allow a simulation at an hourly time scale for the most promising scenario is envisaged.

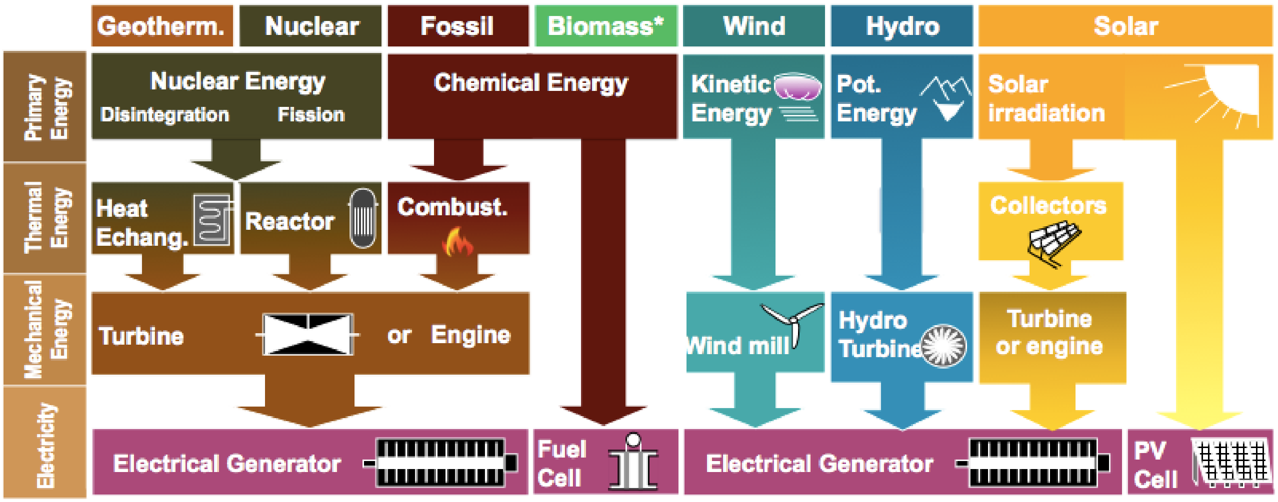

Fig. 7 Energy conversion paths to electricity [5, lesson 20].

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