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Energyscope – An Interactive Online Information Platform on the Energy Transition

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ABSTRACT

Many countries are undergoing an energy transition to reduce their carbon emission and increase their level of energy autonomy. This generates numerous policy, technology, economic and environmental challenges. This multi-dimensionality calls for an integrative approach, which requires appropriate decision making and communication tools, based on objective and rigorous information, enabling for a rapid appraisal of pros and cons of different strategic options for this energy transition. To this end, a web platform, Energyscope, has been developed for the specific case of Switzerland to help the general public and the decision makers to understand the challenges and opportunities related to the Swiss energy transition, and help them forge their own opinion. This web-platform includes a MOOC (Massive Open Online Course) for the general public, which is a first-of-a-kind, synthetic answers to 100 frequently asked questions about the energy transition, as well as an energy calculator. Unlike most existing energy modelling approaches the Energyscope calculator enables the user to build in an intuitive and user-friendly way its own energy scenarios and to directly visualize and compare their socio-economic and environmental impacts at national level, without compromising on scientific rigour. Furthermore all assumptions and references used are clearly quoted in an on-line wiki making it transparent for all users. In addition, this calculator possesses some unique features such as a monthly resolution, which is paramount in countries that experience significant climatic variations throughout the year. This seasonal aspect is often overlooked in similar existing tools. Energyscope is a generic tool that can be adapted to any country.

Keywords: Energy transition, energy planning, decision-making support, web-platform, energy calculator

1. Introduction

Impact of CO_2 emissions on climate, increasing competition over finite fossil resources, the nuclear accident of Fukushima and increasing geopolitical risks have forced many countries to engage into an energy transition. Switzerland is amongst them and wishes to reduce significantly its carbon emissions, while progressively phasing out nuclear power generation, which accounts for almost 40% of its electricity supply, without affecting its prosperity and supply security.

There is no single pathway for such an energy transition. Each option will bear pros and cons. Hence it is paramount to provide decisions makers with clear and objective information regarding the overall impact of the different energy scenarios that can be envisaged.

This information must also reach the citizens who cannot be left aside from this discussion.

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This is particularly true in Switzerland, which benefits from a direct democratic system, which means the Swiss population will be voting on many topics related to the energy transition in the coming decades. But information to the general public is necessary in any country undergoing a profound energy transition, since a transformation towards a more efficient and decentralized energy system requires the proactive participation of the end users, which goes beyond a simple public acceptance for novel technologies.

Several studies reveal the potential to improve publics' understanding of energy use and saving (DeWaters and Powers, 2009; Attari *et al*., 2010). Well-designed efforts to improve citizens energy literacy can play an important role on the energy transition. Thus there is a need both for basic education of the population at large about energy questions, as well as a tool that enables decision makers and voters to test their own convictions. The Energyscope ("Swiss-Energyscope", 2015) is a multi-dimensional platform that responds to these needs. The MOOC (Massive Open Online Course) and the 100 Q&As have for objective to increase the energy literacy of the larger population, while the online energy calculator gives a hands-on view of the energy system since it allows users to develop and compare different possible energy systems for the future.

2. Limitations of existing platforms and calculators

In the last years several efforts have been done in many mature and transition economies to wide spread energy literacy amongst both decision makers and the wider public. However no multi-dimensional politically and technologically neutral platform has been developed so far. While many governments, NGOs and industry players have published online information about the benefits and risks related to this technology or that energy strategy, this information can often be proved biased and cannot a priori be considered objective. Many associations throughout the world tend to develop websites with the aim to bring neutral information to the general public. These however often lack the global perspective, authoritativeness and scientific credentials which limits their acceptance and hence their impacts.

To the best of our knowledge no other multidimensional transparent, neutral, scientifically rigorous platform exists that covers the needs for basic education of the population about energy questions, while offering a tool in support to decision making on energy related issues. Most of the efforts at national level that can be considered neutral are articulated around online- and computer-aided tools that allow users to design their own energy scenarios based on scientific input data, considering both physical and technical restrictions of the energy systems. In this way, users can test their ideas and convictions regarding the energy transition while they get insights into the problematic. However, all the tools developed to date suffer some shortcomings, and either lack scientific rigour to allow for pertinent decision making or lack simplicity for being accessible to decision makers.

The DECC (Department of Energy and Climate Change of UK) is a pioneer in the development of online energy calculators. It developed the "The 2050 Calculator" (UK Department of Energy and Climate Change, 2014), which lets users to create their own CO_2 emissions reductions pathways. It lets the user build its own energy scenario based on 42 discrete input parameters related to technology, efficiency and demand evolution, within a predefined reasonable range. Once the input choices have been entered by the user, the calculator delivers the output in the form of eight indicators: Energy supply/demand, electricity supply/demand and greenhouse gas emissions display the annual values from 2010 to 2050. The other indicators (energy security, footprint, cost and air quality) focus on the year 2050.

Apart from Switzerland, several other countries and regions have since built their own energy calculators mostly for year 2050, amongst which Wallonia (Belgium), China, South Korea, India, Taiwan and Australia. Furthermore, a global energy calculator has also been developed ("A Prosperous World for Everyone in 2050", 2015), whereby the users have to design pathways to 2050 that remain below the 2°C global temperature increase threshold.

All these calculators are built on a logic very similar to "The 2050 calculator" of DECC, while some cover additionally some non-energy issues such access to food, land use, crop yield or urbanization level.

All the above-mentioned calculators display only annual data, thus overlooking the issues of seasonal variation of supply and demand. This is a key aspect to be shown when the integration of renewable energy sources is studied due to their stochastic character. Furthermore, the use of annual data does not allow studying the role of technologies for seasonal storage or the required back-up power for electricity production.

3. Presentations of the Energyscope Platform

The Energyscope information platform is composed of three main elements: an online energy calculator, a Massive Open Online Course (MOOC) and a 100 Q&As about the energy transition. These three elements are jointly meant to fulfill the following two goals:

- Increase the knowledge of citizens on energy with a focus on the prospects, risks and challenges regarding the energy transition.
- Provide decision makers and citizens with a tool to develop their own energy scenarios in order to test their convictions respecting the structural and technical constraints.

The platform is online and available to users since April 2015. It is also directly accessible from the official website of the Swiss Ministry of Energy.

3.1 100 questions and answers (Q&As)

This book provides 100 synthetic and popularized answers to 100 basic questions that citizens may ask themselves about how the current energy system works and about options regarding the energy future of Switzerland. Its goal is to help understanding the national energy problematic and help them to define their position for the next votes, whose results will shape the energy transition (in Switzerland every law can be challenged by a referendum)

These 100 Q&A are available online, as well as an eBook format (Vuille *et al*., 2015b). The eBook, which contains about 70'000 words, has been further synthetized into a 40'000 word pocket book (Vuille *et al*., 2015a), which has been distributed by bookshops throughout the country.

The 100 questions are grouped into the following eleven chapters:

1. Challenges of the Swiss energy transition
2. Electrification of the energy demand
3. Ensuring future supply security

4. The untapped potential for energy efficiency
5. Merits and drawbacks of renewable energies
6. The need to adapt the electricity grid to the new energy system
7. The need for energy storage
8. Swiss energy policy system between taxes and subsidies
9. Strategies for phasing-out nuclear energy
10. Effects of the energy transition on the citizen
11. Towards a sustainable energy system for Switzerland

More than 30 experts from the different energy sectors from the academic and private sectors have reviewed its content, which guarantees both credentials and objectivity. It has been co-authored by a scientific journalist, who is an expert in popularizing science, which guarantees that its content is appealing and accessible to the larger public.

3.2 The Massive Open Online Course (MOOC)

As many other countries, Switzerland is re-designing its energy strategy thinking of an energy transition towards a more efficient use of energy, an expansion of renewable energy sources and a progressive phase-out of nuclear energy. In a direct democracy system as Switzerland, such a process must be based on a good understanding of the problematic and the issues related to technology and policy related decisions. Thus, this MOOC is open to citizens willing to increase their awareness in the field in order to knowingly decide.

The MOOC is accessible both on the Energyscope platform, as well as on the global online edX platform for free academic courses ("Swiss-Energyscope", 2015). It contains 27 topics related to the energy system in general, to the energy technologies and to the challenges of the energy transitions. Each topic is based on a 10-15 minutes video lesson followed by a short multiple-choice questionnaire so that the participants can test their newly acquired knowledge. The content is available both in French and German, which are the two main official languages in Switzerland.

The MOOC is a perfect complement to the 100 Q&As since it is addressed to a younger public familiar with online learning environment.

3.3 The Energyscope Online Calculator

3.3.1 General description

The online calculator ("Swiss-Energyscope Calculator", 2015) is the heart of the Energyscope platform. It has been designed to help users visualize, compare and create different energy scenarios. The tool shows which would be the impacts on the energy situation in respectively 2035 and 2050 from predefined choices (input parameters) made by the user regarding energy technologies and socio-economic situation of tomorrow. The users are offered the possibility to save, export and share the scenarios they create.

Predefined scenarios, such as those defined by the Swiss government in its *Energy Strategy 2050*, are made available to the users so that they can visualize, compare or modify these by adjusting the input parameters to match their own convictions. The current energy situation can also be visualized and serves as a reference baseline for measuring the impact of future scenarios with respect today's situation. The online calculator is however not a forecasting tool, as it does not calculate any evolution pathway from today baseline. It is a purely scenario-based tool that assesses the impact of hypothetical, but nonetheless realistic, future scenarios shaped by the users with the current energy situation of the country considered.

The calculator is available in two levels of complexity: simplified and advanced version. The simplified version contains a limited number of input parameters and output indicators in comparison with the advanced version to make it more accessible to non-energy specialists. Furthermore a quiz built in the form of an interactive tutorial is available. Its goal is to show to the users the functionalities of the calculator while they try to answer energy related question in an interactive way using the information supplied by the calculator.

The input parameters and output indicators of the calculator have been chosen in order to offer the best possible tradeoff between scientific rigour and user-friendliness. The main targeted users of the calculator are non-specialist citizens and decision makers who have an interest for the energy domain. Thus, the Energyscope calculator follows the premise of "learning by doing". The impacts of users' choices must be directly visible and easy to understand. For fulfilling these requirement specifications, an adequate modeling strategy is required. In this regard, the response time of the Energyscope model is below one second. A detailed description of the model is available in (Codina Gironès *et al.*, 2015).

Finally, all the assumptions and literature references used by the calculators (e.g. calculation approach, conversion efficiency of technologies, potential of renewable energy sources, price evolution of equipment and fuels, etc.) are clearly quoted in an on-line wiki making the tool absolutely transparent for all users.

3.3.2 The 6 Outputs indicators

The output of the calculator is provided in the form of six indicators: "Final energy consumption", "Electricity generation & consumption", "Energy sources", "CO_2-equivalent emissions", "Deposited waste" and "Cost of the energy system" ("d" in Figure 1). For each indicator, the calculator provides a graphical output in the form of a bar chart (Figure 1).

The six indicators can be displayed with annual, seasonal or monthly granularity ("f" in Figure 1), which is a key differentiator compared to similar online energy calculators. The seasonal and monthly resolution allows highlighting the variations of supply and demand along the year. Furthermore the role of seasonal storage technologies and/or the need for back-up installed power can be analyzed. The seasonal component is a key aspect in the study of energy systems with a high percentage of renewable energy sources due to its variability along the year.

Although the monthly resolution offers a critically more accurate view of the energy system than an annual approach, it does not fully reconcile the macro-situation with the hourly or minute timescale that characterizes the functioning of the electricity grid. In particular, it does not specifically address the issues of the production capacity needed to cover peak power supply, the standing reserves needed to cover shortage of intermittent renewables in periods of low production, or the daily storage capacity needed to absorb excess electricity from these intermittent sources. In the case of Switzerland, this possibly discrepancy between the results yielded by the calculator in a monthly resolution and the needs is expected to be limited as the existing pumped-storage capacity offers sufficient capacity to absorb the hourly to daily variations due to the intermittence of renewable sources. This discrepancy would have to be addressed specifically in case the Energyscope calculator is adapted to other countries or regions.

Figure 1. (Swiss-Energyscope Calculator) Screenshot of the Energyscope online calculator: (a) Complexity menu for simplified or advanced version, (b) Scenarios selection menu, (c) Inputs menu: Socio-economic group is open for showing the sliders design, (d) Indicators tabs, "All" tab shows the annual values of the six indicators, (e) Units menu, (f) Time granularity menu, (g) Language (choice of 4 languages including English).

It is also possible to choose among different units ("e" in Figure 1) for the indicators such as GWh or kWh/inhabitant, the latter unit offering for a more tangible information to the citizen and also comparison with other countries as well.

The final energy consumption is allocated into heating, electricity and transport, which renders the competition between electricity and fuels explicit, mainly for covering transport and heating needs. Another key aspect of this indicator is the addition of the waste heat from power generation, although the indicator is defined as the final energy consumption. By extending the system boundary to include the power production plants, the use of more efficient technologies for electricity production, such as cogeneration, directly reduces the final energy consumption indicator. Although incomplete, this is a simple first order approach to consider the exegetic performance of the energy system.

The environmental indicators ("CO2-equivalent emissions" and "Deposited waste") are calculated with a LCA (Life Cycle Assessment) approach. The "CO2-equivalent emissions" takes into account the emissions of all gases contributing to the greenhouse effect. The "Deposited waste" quantifies the volume needed for disposal of solid waste (mainly radioactive) and the amount of TOC (total organic carbon) dumped into the water. This indicator has been limited to the impact of wastes as this is the most important environmental impact in the Swiss context. It could be easily extended to a more comprehensive definition of environmental impact by including additional LCA pollution categories.

The last indicator is the "Cost", which gives the annual cost of the energy system. It takes into account the energy (fuels and imported electricity), O&M (operation and maintenance) and investment costs. The investment costs are calculated for each year (2011, 2035 and 2050) by assuming that the complete energy system is entirely replaced during the selected year, taking into account the relative prices and technology development status. This assumption allows comparing the investment cost of the reference year 2011 with those for 2035 and 2050, without having to consider any installation/decommissioning pathway.

3.3.3 The 49 input parameters

The online calculator is based on 49 inputs parameters on which the user can play using sliders. These sliders are bound by reasonable minimum and maximum values as defined by authoritative literature or combined expert judgment, which ensures that the scenarios created by the users reflect truly realistic futures ("c" in Figure 1). They are grouped in six categories: Socio-economic, Energy efficiency, Transport, Heating, Electricity and Costs. There are dependent and independent sliders. As example, in the Transport category users find both types: the percentage of the different types of vehicles in the car fleet are defined by five sliders each representing a vehicle type. The sum of the positions of these five sliders always need to be 100%, hence the calculator considers them as bound. The user has the possibility to lock values to avoid self-adjustment by the calculator. Independent sliders are used for input parameters, such as the use of public transport.

The heating category is the one with the higher number of sliders. It is possible to define the combination of technologies that supply heat in the industry sector and for the buildings. In addition there is a differentiation between centralized (district heating) and decentralized heating technologies for buildings.

In the electricity category, the sliders represent the installed power for each technology, except two sliders: CCS (CO2 capture and storage) and Seasonal Storage. These two sliders go from 0 to 1, where 0 means no use of the technology and 1 represents the full deployment of the technology. It is also necessary to mention that the model does not automatically balance the electricity supply and demand. Users can define a system with overproduction or deficit of electricity.

4. Conclusions

The Energyscope platform is a tool-box that has been developed with the aim to inform policy makers and the public at large about the challenges of the Swiss energy transition and pros and cons of realistic future energy scenarios. Its strength resides in its multi-dimensional approach and its neutrality towards different technology options. Thanks to its scientific rigor, online accessibility and, most importantly, its transparency with respect assumptions made and data sources used, the Energyscope platform can be considered as both an educative and an inclusive decision making tools for both policy makers and the wider public.

The key components of the Energyscope platform have been structured in a way that can be easily replicated and adapted to any country or region in the world, whether this is about the 100 questions and answers, the MOOC or the calculator. For instance, a new version of the calculator is being developed for the Canton of Vaud (Switzerland).

The platform is online and available to users since 14th April 2015. The community of users of Energyscope is still growing both amongst policy makers and the wider public thanks to both word of mouth and specific marketing and dissemination efforts. How impactful and useful the Energyscope platform is will be the object for future work, together with adapting the platform to other regions/countries and studying potential applications of the national energy model behind the calculator.

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EnergyScope－針對能源轉變過程的使用者交互型線上資訊系統

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摘　要

許多國家正在經歷一個能源轉變階段，以減少能源生產和利用過程的碳排放，同時提高自身的能源自主性。該轉變過程將受到大量來自政策、技術、經濟和環境方面的挑戰，因此需要建立一個合理的基於客觀嚴謹資訊的決策方法和交流機制，從而針對該轉變階段之不同策略的做出快速高效評估，並確定不同策略的優劣。針對以上的考量和瑞士的具體情況，公眾和決策者可以參考energyscope.ch來瞭解瑞士能源轉變所涉及的機遇和挑戰，並標明他們自身的意見或想法。 該平台為公眾準備了一個大規模開放性的網路課程，這些課程集中回答了能源轉變過程最受關注的100個熱點問題。該平台也具有與能源相關的計算功能。 與大多數現有的能源建模方法不同，EnergyScope的計算功能提供了一個直觀、友好的介面，以視覺化和比較自己的能源方案，從而確認具體方案對國家社會經濟和環境的影響。該過程無需具備嚴謹的科學知識。更重要的是，平台的線上百科清楚地標明了所有涉及的假設和引用，並且向所有用戶開放。另外，計算器具備一些獨特的功能，比如按月顯示所考慮方案的情況，這對那些全面氣候變化顯著的國家非常重要；然而，該季節性變化大多被同類工具所忽略。簡而言之，EnergyScope是一個可以應用於任何國家之一般性的能源計算工具。

關鍵詞：能源轉變、能源規劃、決策支持、線上平臺、能源計算

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