ENERGY FLOWS MONITORING AT THE CANTONAL LEVEL

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ABSTRACT

As an increased number of measures (Swiss or European level) aim at developing more sustainable policies for energy management and reduction of CO_2 emissions in particular (for example, the 3x20 policy), very few tools currently exist at the regional/cantonal level to monitor the multiple existing energy flows. Energy issues at local and territorial level have become considerably more complex in the last twenty years for a number of reasons. First, new technologies penetrated the market and now compete with fossil-based conversion systems. In addition, energy systems are evolving to systematically become multi-fluid and multi-services. Finally, local and state authorities have taken up a stronger and broader role in terms of energy policy and have committed to ambitious goals in terms of both increased energy efficiency and implementation of renewables.

Within this project, a decision-support and monitoring tool for policy makers has been developed, which includes thorough information on the most prominent energy aspects of the Canton of Vaud, and paves the way for establishing more indicators covering environmental and economic aspects. The development of a web-based tool aimed at visualizing the entire energy chain, from energy sources to end-use sectors at the level of a whole Swiss Canton is thus presented here. This tool provides a unifying structure for all the useful information on energy sources, vectors and final consumptions, this approach thereby giving access to a global overview, understanding and monitoring of the energy supply and demand characteristics of any given Canton (or any equivalent subnational territorial entity).

The final goal of this approach is to give access to the direct visualization of all energy flows on the platform, thus translating and broadening the national statistics on the energy chain up to the cantonal (territorial) level. Therefore, this innovative tool will allow quantifying energy profiles, modelling conversion nodes along the energy chain, as well as assessing the overall energy balance per end-use sector.

This very innovative platform constitutes a centralized energy data repository as well as a quantitative evaluation tool, encompassing most useful energy sources.

Keywords: monitoring, Canton, energy flows, web-based tool, decision support

INTRODUCTION

Switzerland has recently committed to phase-out nuclear power contribution to the electricity production mix, while reducing greenhouse gas emissions. While many regulations have already been put in place at the cantonal level to this end, the need to follow the evolution of energy-related data appears of crucial importance. With this goal in mind, a tool has been developed allowing various institutional as well as private entities to visualize the most pertinent energy data necessary. In particular, at the Canton governmental level, the web-based tool shall represent an extremely useful support to thoroughly monitor the effects of policy decisions.

The project has been entirely financed by the Canton of Vaud (Switzerland).

WEB-BASED ARCHITECTURE

The web-service oriented architecture aims at visualizing on a single platform all the relevant energy data that could later be used for both the purposes of communication and decision-making. The main goals are to achieve a maximum flexibility, robustness and security: in fact, the whole development of the platform has been oriented towards adopting widely spread technologies and architecture, thus ensuring overall robustness and replicability, while guaranteeing at the same time an enforced security of all the data.

The platform comprises of two main parts: first, the server handles the requests made by a user and thereafter consults all the relevant data in the database. The second part is the "data management tool" that is used to manage the integration of new data. Both parts are integrated within the same web-service, but are fundamentally different in their usefulness and can be accessed independently. In other words, a user can have access to the server (to consult or make a query), the data management tool (to insert new data on the platform), or even both - depending on the user rights and accreditations.

Server architecture

The basic architecture of the platform is depicted in Figure 1, and comprises:

- the *interface*, developed in Groovy/Grails;
- the *service layer*, which processes all the requests from the user, and invoke the data access layer so that it can get all the useful data needed for further calculations. This layer is also responsible for all the communication between interface and data processing;
- the *data access layer*, which defines the means of accessing data from the database. This module allows to develop a large number of queries of any type (production, consumption and gross final consumption and import/export);
- the *database*, for all the relevant energy data and user accounts.

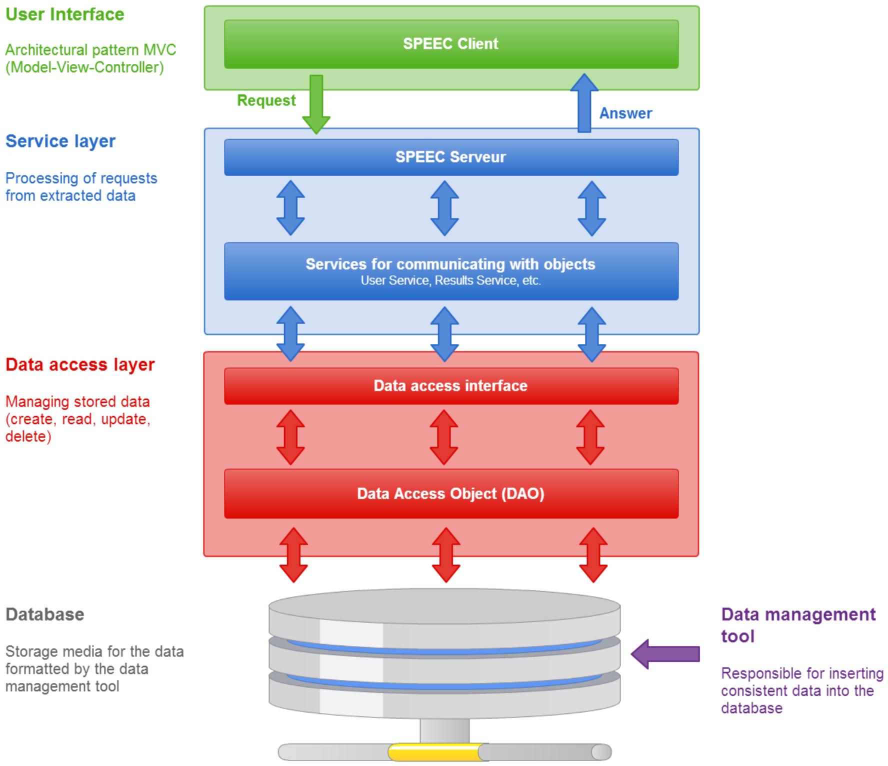

Figure 1 – Three-tier architecture of the tool: the front-end webserver, data processing and data management are fully separated

User management: rights and roles

Different user profiles can be precisely defined with specific data access rights. Three roles have been implemented, namely Administrator, User and Data provider. While the user can only consult the database and make queries, the Data provider can only submit new data. The administrator can do both, and in addition can review the pending data from the data provider, and manually validate them. This double-step process for the data validation is detailed later (see § Data tool management). All the roles are additives.

Granularity of the data

Sub-entities of the considered territory (i.e. either a municipality or a district) cannot be easily considered since most data become sensitive either because of issues related to the commercial nature of energy consumption data or because of privacy protection rights (especially when the granularity decreases down to the urban zone/neighborhood level). Therefore, and despite a construction and implementation of the tool initially designed to accept different granularity levels (municipality, district, canton), only the Canton level has been ultimately considered.

MAIN FUNCTIONALITIES AND DISPLAY OF THE PLATFORM

Two basic visualization modes are currently implemented within the platform: the pie chart and line chart (see Figure 2).

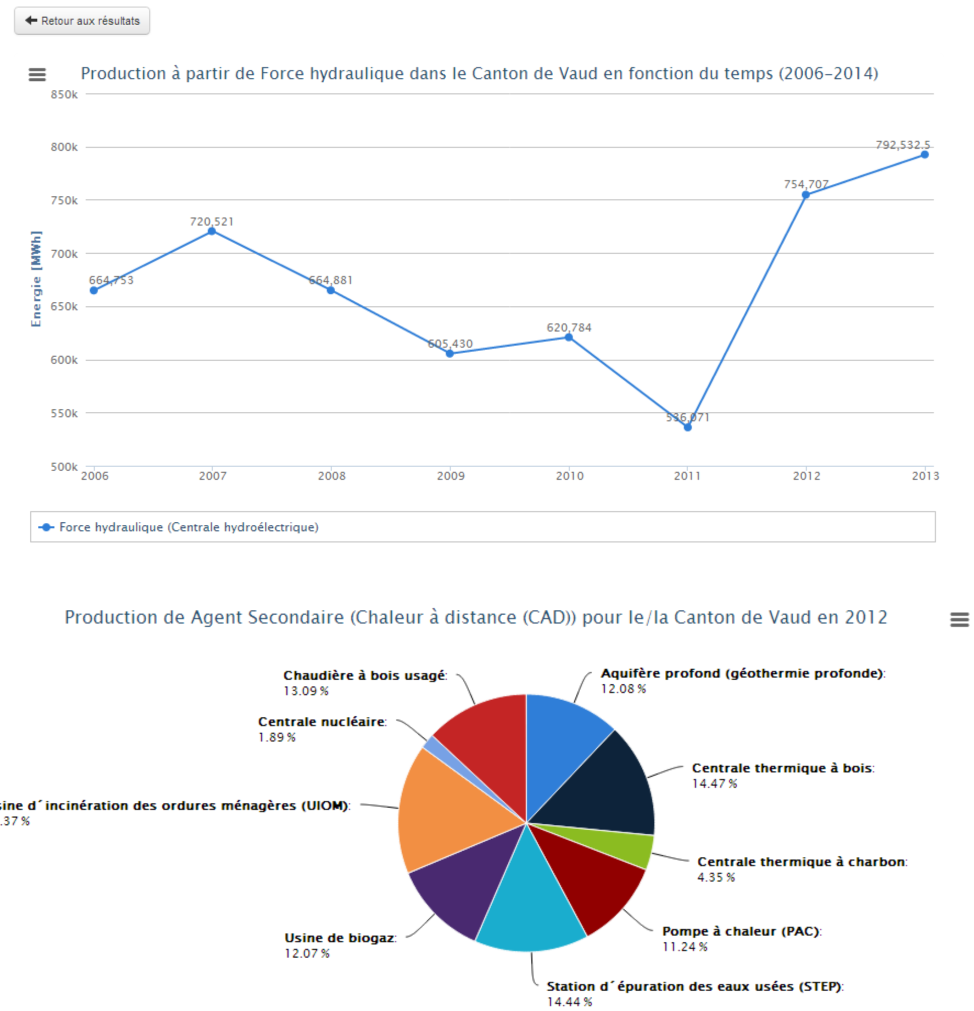

Figure 2 – Possible visualisations: 1) Line chart, 2) Pie chart, legend in French. For confidentiality reasons, the data presented here has been altered.

The viewable data comprises production, raw and final consumption of all energy carriers mentioned in the Swiss Energy Statistics from SFOE (electricity, natural gas, coal, wood, renewables, waste, crude oil, petroleum products…).

DATA MANAGEMENT TOOL

Process

A two-step process has been specifically designed to ensure a complete accuracy of the data inserted in the database. While many automatic tests are being performed as soon as a data provider inserts new data, manual intervention has been deemed necessary to validate the last part of the process. Therefore, a first step of the process concerns the insertion of new data from the data provider: when all the possible errors, typos and numerous checks have been identified and corrected, all the data is then inserted in a temporary database. The data cannot be consulted at this stage by a user with basic rights, but only by an administrator.

During the second step of this process, an administrator will review all the data, aided again by a battery of different tests to help with the validation. Those two steps are detailed in the two following paragraphs, as well as in Figure 3.

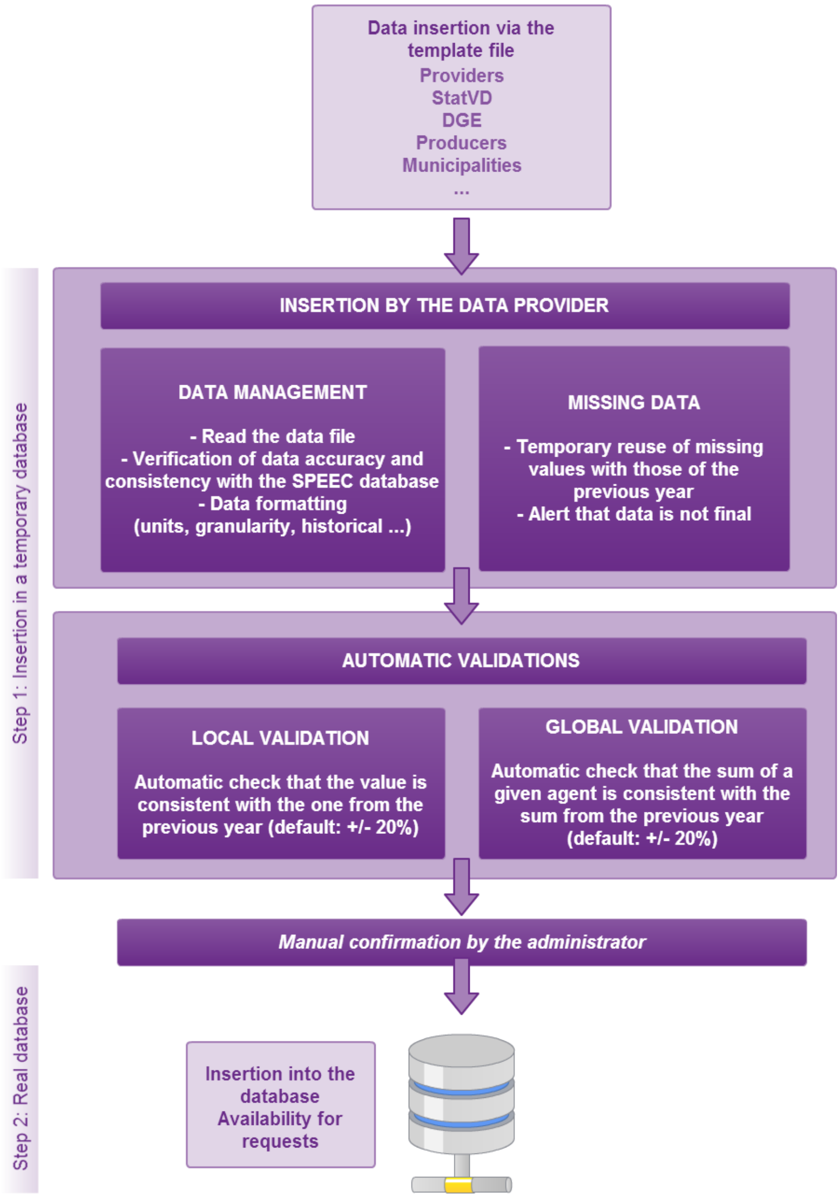

Figure 3 – Two-step process for the data management tool

Insertion

When a user has the specific rights to feed the database (i.e. administrator or data provider), a special menu is unlocked: the *Import Data* menu. The insertion is achieved thanks to specific templates, readily prepared for the type of data to be inserted (production, sales, consumption…). This facilitates the insertion for data providers and ensures readability.

Once the file is imported, the tool checks the consistency of data entries with the database model and sends warnings if something is improper. The occurrences are often typos or a designation not recognized by the database such as acronyms (e.g. “CAD” instead of “district heating”, or 6.3k instead of 6’300 [MWh]). Everything can be easily corrected thanks to dropdown menus should it be necessary. Another issue can be that these exact values (for example the electricity production for Vaud in 2012) have already been inserted, with possibly a different value: in this case, the model needs to recognize it and ask whether the user want to replace the existing values or keep the old ones.

When everything has been corrected directly by the data provider, the data is inserted in a temporary database, ready to be validated by an administrator.

Validation

To facilitate the administrator’s work, several warnings are implemented so that potentially problematic errors can be readily seen at a glance. These are either focused on the value by itself (local warning, e.g. electricity production of a single company), or on the total value of the energetic agent (global warning, e.g. total electricity production over the whole Canton).

For the local warning, a test checks if the value entered by a data provider is not too different from the years before. While not always a good indication since some energies are bound to explode (e.g. PV or wind, which are very small currently but expected to expand drastically in the years to come), most other energy agents such as electricity, gas, district heating will stay within a fixed boundaries (depending on the weather, the energy policies, the incentives etc.). Therefore, a threshold is assumed at 20% by default, but can be changed thanks to a button to trigger stricter or looser warnings.

The global warning adds all the same agents over the whole Canton, independently of the provider, in other words, it sums the whole production/consumption without singling out the producers. Like in the previous case, a comparison is drawn with the previous years, and a warning is issued if the difference is too important.

Finally, it has been estimated that about 80% of the data can be (relatively) easily found and inserted in the database, while the remaining 20% will be obtained at the price of more effort (much more time will need to be invested to gather it). In the case where some data is missing, a catching routine has been set-up to insert a temporary value in the database, while waiting for the real one. This allows freeing the temporary database much earlier than waiting, and giving access to a number that will not be too far from the reality. For example, in the fictitious case of five electricity producers with one of them not having inserted its data yet, the values of the latter stemming from the previous year are temporarily inserted in the database instead, and added to the total with the five others, along with a clear mention that the value given is not definitive. This is done thanks to the auto-insertion button.

DISCUSSION

Many projects are currently developed in the field of energy management and planning of urban zones. This is the case of widely diverse projects such as the MEU platform (meu.epfl.ch) [1][2], which is a web-based platform serving as a decision support system for decision makers at municipal level, or the PlanETer tool which allows for an energy audit at a territorial level [3]. Additionally, for example the Swiss-Energyscope web platform allows (thanks to its energy calculator) viewing the current energy situation and create a scenario for 2035/2050, and thus visualize the implications of energy choices for Switzerland [4]. However, to our knowledge, no other Swiss tool allows a specific representation of the energy flows at a cantonal level.

As far as the authors are aware, this is the largest and most comprehensive database for a given year, at a cantonal level. However, the critical mass of data needed to keep the tool updated implies a huge effort. The most recent reports made to comprehensively evaluate the full range of energies flows on a cantonal level date back to 2009 [5], while the perspectives for 2035 date from the beginning of 2010 [6]. This underlines the difficulty to gather useful data, and to keep it up to date. This is especially striking for energy agents such as oil products, which are extremely easy to find at a national level thanks to custom agencies [7], but extremely difficult to estimate at a cantonal level without real borders. Wood would also be such an extremely difficult energy vector to evaluate precisely: it is currently either extensively studied and analysed once every 5-10 years via comprehensive studies such as the Rapport Bois-Eau [8], or either estimated, with a wide range of possible errors.

Nevertheless, populating such a database is greatly dependent on data availability. An appropriate regulatory framework should therefore be consolidated in order to convince the data providers to share the data needed for such a tool.

CONCLUSION

By way of a relatively complex web-based tool, different energy flows at a regional/cantonal level can be readily displayed at various detail levels, while guaranteeing a very robust and secure service for the different types of users. This innovative platform is thus an important database for energy-related data all the while being a useful tool for decision-making and follow-up of policy regulations initiated at regional/cantonal level.

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