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ElectroWhat: A platform for territorial analysis of electricity consumption

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Abstract

In the canton of Geneva, the per capita electricity consumption of private households increased by 12.1% between 2000 and 2010. The electricity efficiency program ECO21 conducted by the *Services Industriels de Genève* (SIG) was initiated with the goal of reducing the demand. A territorial characterization of electricity demand permits designing such programs and making ex-ante estimations of savings potentials. To extend this approach to the whole Swiss territory, a collaboration was initiated with SIG to develop the *ElectroWhat* platform that decomposes the yearly electricity consumption of every Swiss municipality into estimated load curves per activity and per electric appliance.

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1. Introduction

According to [1] in 2013 40% of the total final energy consumed in Switzerland was used for space heating and domestic hot water production. Two thirds of this energy is made up of fossil resources generating important CO2 emissions. The use of heat pumps could increase the share of renewable heat production. Consequently, the electricity demand would rise, especially in winter when PV based production is low. Today the Swiss electricity mix is mostly based on nuclear and hydro power plants. The moratorium on the construction of new nuclear power plants following

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the Fukushima accident will progressively phase-out nuclear electricity from the Swiss electricity mix. Hydropower capacity is close to its maximum and the electricity demand, which had continuously been increasing until 2010, has stabilized at approximately 59 TWh/year [2]. The future vision is to combine the following: a phasing-out of nuclear production, an increase in the share of renewable heat production and the development of electric mobility. This objective represents a challenging task. Efficient use of electricity is an important driver for the transition of the electric supply, required to achieve the energy strategy 2050 goals of the Swiss Federal council. At the regional scale, Geneva achieved a decrease in the consumption of private households of 4.6% per capita between 2010 and 2015.

The design of large scale electricity efficiency programs requires a detailed knowledge of how the electricity demand of a territory breaks down into various activities and electric appliances. This is illustrated by the study of [3] that makes a detailed analysis of how electric consumption evolved in the Canton of Geneva. This study served as basis to redesign in 2009 the large scale electricity savings program ECO21 launched in 2007 by the *Services Industriels de Genève* (SIG). Such a study allows for example to make ex-ante estimations of savings achievable by large scale electric device replacement, as for example efficient lighting in the common parts of collective residential buildings. Expected versus real savings for two ECO21 sub-programs are compared in [4] using three different approaches.

The increasing share of renewable electric production that is often subject to temporal constraints, raises the question of how demand side management could reduce demand peaks as well as the need of storage. Active storage being expensive, a forecast of the electric load curve is useful input helping to make optimal use of the battery [5]. On the other hand indirect storage can be implemented by shifting part of the load (e.g. electric hot water boilers) to a more suitable time when renewable excess electricity is available. Local micro grids connecting producers, consumers and storage units should include efficient real time communication. A multi-scale communication protocol is defined in [6] and tested in [7] in a 0.4 kV network. The estimation of load curves by usage type is valuable input to estimate the potential of such smart grids.

There are numerous methods to simulate load curves. The review paper [8] classifies the most relevant algorithms into five groups, including both deterministic (replicating average behavior) and random models (replicating the diversity of consecutive days). Considering a larger territory including all energy service companies (ESCO) of the EOS holding group, the report [9] describes the bottom-up model behind the *ElectroWhat* platform. The chosen approach combines top-down deterministic statistical disaggregation in sections 2.1, 2.2 and bottom-up time of use models in section 2.3. *ElectroWhat* seeks to answer the question who consumes where, when and for what use at the national level.

This project is the result of a collaboration between the academic project SCCER FEEB&D [10] and the industrial partner SIG. Since this collaboration is subject to a confidentiality agreement, section 2 therefore does not give all the details behind the model. The article focus is on the outcomes and validation of the model as well as potential applications.

2. Electric demand model

The yearly demand of a municipality is split into three main sectors, each one with its own estimation algorithm as described in the following three sub-sections. The yearly consumption is split into 36 activities and 18 electric appliances such as lighting, fridges, TV, etc. A further step consists in transforming the yearly demand into estimated load curves using a library of load curve shapes.

2.1. Industry & services

For each municipality, the estimation of the yearly consumption of the industry & services sector is based on the number of working places per NOGA activity code available in the STATENT database [11]. This statistic is combined with unitary average consumption per working places and NOGA code. Considering the territory of Geneva and that of the EOSh group, these unitary consumptions are estimated using the total billed electricity per activity. For the remaining Swiss municipalities, the average unitary consumptions are calculated using a yearly national survey conducted for approximately 12’000 companies [12]. For each activity code the total yearly demand is decomposed into different appliances as for example lighting, motor power, heat, etc.