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Needed reduction in mobility energy consumption to meet the goal of a 2000-watt society

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ABSTRACT

Greenhouse gas emissions related to energy production is the main cause of climate change. Transportation accounts for 30% of the total energy consumption, and a reduction in the energy used for mobility is necessary. The 2000-watt society is an environmental concept that fixes a sustainable limit to the energy consumption in different sectors, including mobility. This paper evaluates the energy consumption in several mobility scenarios, and it assesses whether the goal suggested by the 2000-watt society is achievable. We investigate the social characteristics and travel habits of the population living in a case study area. Then, we calculate the modal shift induced by transportation policies such as car-sharing, car-pooling and car-free district. We evaluate the resulting energy consumption, and we compare it with the 2000-watt society limit. We conclude that only a set of measures combining car usage reduction, increase in walking and cycling, and reduction in the total travel distance can achieve the needed energy reduction.

1. Introduction

Climate change is a great risk for the environment, society and economy (Solomon, 2007). The primary cause of climate change is the emission of greenhouse gases (GHG) by combustion of fossil fuel related to energy production for human activities (Pachauri et al., 2014). The transportation sector is responsible for 30% of the total energy consumption and 20% of total GHG emission in the European Union (EC, 2013). Transport policies have direct effects on energy consumption and GHG emission (Poudenx, 2008), and they can lead to a significant modal shift toward more energy efficient modes of transport such as public transport, walking and cycling (Ogilvie et al., 2004). Several public institutions have planned reduction in terms of energy consumption and GHG emission for 2050 (EC, 2011).

A possible goal for energy consumption reduction is given by the concept of 2000-Watt society (2000 W-society) (Notter et al., 2013). Two thousand watts (W) is the continuous energy usage calculated as primary energy for transportation, personal activities, nutrition, household, infrastructure and other common consumption of the society divided by the population. Two thousand watts is the average energy usage of the entire world, and it is considered an environmentally sustainable consumption (Bretschger et al., 2013). Citizens of industrialized nations consume between 5000 and 12000 watts, while, in developing countries, only a fraction is used. The 2000 W-society aims to balance this difference without

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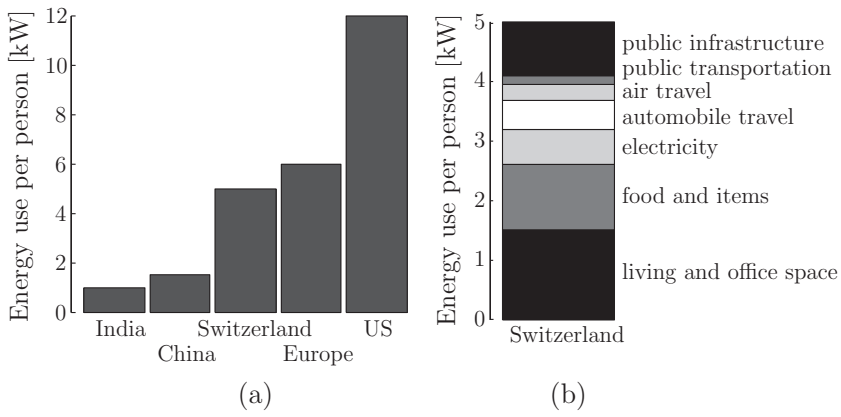

Fig. 1. (a) energy consumption in different nations, and (b) detail of energy consumption in Switzerland divided into "living and office space" (heating, hot water and other consumptions associated to households and offices), "food and items" (food, and consumption and transport of non-durable consumer goods),"electricity" (electricity usage), "automobile travel", "air travel" and "public transportation" (mobility consumption for the different modes of transport) and "public infrastructure" (consumption related to public infrastructure such as public works, water infrastructure, hospitals). Adapted from Notter et al. (2013) and Stulz (2011).

reducing the standard of living in industrialized nations. The energy consumption of some nations is visualized in Fig. 1(a), while, Fig. 1(b) shows the breakdown of the total energy consumption in Switzerland.

In this paper, we investigate the energy consumption related to mobility and discuss whether it is possible to reach the objective set by the 2000 W-society. We analyze the current mobility patterns and energy consumption of the population living in a case study area. We evaluate if existing transport policies, such as car-sharing, car-pooling and car-free district, could induce a modal shift capable of meeting the energy objective.

We use an area in the city of Fribourg, Switzerland, as the case study. This city has been chosen because it is the test case for the Swiss participation to the Solar Decathlon (SD) competition (DoE, 2016). The SD competition aims to design a solar-powered building that incites a sustainable use of energy and resources. Among the different aspects, transportation and mobility are considered.

The Swiss SD team proposes the idea of a network of full-size, solar-powered buildings, referred to as pavilions (EPFL, 2016). These pavilions are catalyst for improving sustainable life styles, including sustainable mobility, of the population living in their proximity. They are multifunctional buildings providing several services and information. We define the study area as the surrounding of the main pavilion, and we refer to this area as the SD district.

We use the following methodology to evaluate whether the adoption of transport policies to the case study area could reduce the energy consumption for mobility and meet the goal of the 2000 W-society. First, we define the boundary of the SD district, we analyze the inhabitants and their mobility patterns using data from the Swiss Federal Statistical Office (FSO, 2016). Secondly, we quantify the objective of the 2000 W-society for mobility, and we compare it to the current energy use. We calculate the maximum modal shift induced by several transport policies. The impact on the mobility is estimated using data of ex-post evaluations of these policies in other cases. Finally, we discuss if the energy consumption goal is reached and what measures should be adopted.

We make a series of assumptions to investigate this aspect.

(a) We do not consider technological advance that could improve the efficiency of transportation systems in the future. Improved combustion engines or fleets of fully electric vehicles are not considered. Therefore, the reduction in energy consumption is achievable only by modifying the modal share or reducing the mobility.
(b) We ignore the way in which the energy is produced and the resulting GHG emission. For example, in the present work, we do not evaluate the different impact and sustainability of electricity produced by fossil fuel or using solar photovoltaic cells.
(c) We do not consider emerging services and in-vehicle technologies which effects on travel behavior are not well assessed in the literature. This includes ride-sourcing and autonomous vehicles.
(d) We evaluate the best possible scenarios for each transport policy. The modal shift induced by transportation policies is influenced by many aspects. However, we simply apply the reduction factors found in the literature to the SD district. This allow us to evaluate a sort of best case scenario. We are indeed interested to know whether it is possible to reach the objective of the 2000 W-society in the best possible case.
(e) The mobility of the inhabitants of the SD district is based on the available information. Data collection is not performed. If statistics are present only for a larger area, we assume that these statistics are representative of the SD district.