Real-time carbon-emissions and consumer responsibility - a marginal approach for an open economy: the case of the Swiss electricity consumption

Romano, Elliot; Hollmuller, Pierre; Patel, Martin

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the energy transition

Current and Future Challenges to Energy Security

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INTRODUCTION:

CURRENT AND FUTURE CHELLENGES TO ENERGY SECURITY

- the energy transition -

The AIEE - Italian Association of Energy Economists (Italian affiliate of the IAEE - The International Association for Energy Economics) has organized this international conference in cooperation with the Bocconi University - GREEN (Centre for Geography, Resources, Environment, Energy and Networks), of Milan to bring together energy experts engaged in academic, business, government, international organizations for an exchange of ideas and experiences on the present and future landscape of energy security.

The first two editions of the AIEE Symposium on Energy Security - Milan 2016 and Rome 2017, were an opportunity to explore new energy trends, challenges and creative solutions for the energy security, the availability of new technologies, the emergence of new market conditions and of new market operators.

Following up on the success of the past editions this third AIEE Energy Symposium to provided a fresh look on the major forthcoming issues offering an excellent occasion to continue the dialogue and to share best practice and experience with delegates from all over the world.

The energy situation is evolving in Europe as well as in the rest of the world, where new actors, the emerging economies, are taking the leading role. Political developments in several areas of the globe (North Africa and Middle East, the Caspian region, ASEAN countries) are reshaping the geopolitical situation, generating some worries about the security of supply in the EU countries.

The concept of energy security is undergoing a rapid transformation. In the past, geopolitics and the supply of oil and gas were the dominant factors determining energy security.

Today, a broader and more complex spectrum of elements are interacting to both stabilize and threaten energy security. The availability of energy sources, when we consider both fossil fuels and renewables, is increasing. In particular, a major source of change is the strong growth in the production and integration of renewable and distributed energy, which offers opportunities to diversify the energy mix and thus improve energy security by reducing physical reliance and price exposure to only a few sources and countries. At the same time, this paradigm of a new energy system has strong implications both on petroleum-producing countries and companies, with knock-on effects on geo-economic balance of powers and energy markets and on the security and reliability of the transmission and distribution networks.

The new challenges of the digital revolution that on one hand offers opportunities to improve efficiency, to have lower costs but on the other hand raises a whole new set of challenges and creates vulnerabilities we have never seen before so that energy is being viewed as a key part of national security.

While in the past the supply side was the dominant factor in energy security, with the critical element being the possibility of sourcing the products to produce electricity and provide mobility, now the energy security balance is changing.

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Eliot Romano, Pierre Hollmuller, Martin K. Patel

REAL-TIME CARBON-EMISSIONS AND CONSUMER RESPONSIBILITY - A MARGINAL APPROACH FOR AN OPEN ECONOMY: THE CASE OF THE SWISS ELECTRICITY CONSUMPTION

Elliot Romano – Energy system group – Faculty of Science - University of Geneva – 66 Bld Carl-Vogt, CH-1211 Genève 4
Pierre Hollmuller – Energy system group – Faculty of Science - University of Geneva – 66 Bld Carl-Vogt, CH-1211 Genève 4
Prof. Martin K. Patel – Energy department – Faculty of Science - University of Geneva – 66 Bld Carl-Vogt, CH-1211 Genève 4

Overview

Electricity generation is a major source of the global greenhouse gas emissions [CHG]. At the European level, the sector contributed to approximately 25.8% of the global CHG emissions during the year 2015. In Switzerland, over the same period, the share of GHG emissions emanating from electricity generation represented 1.4 % of the country's global emissions, as most of his electricity generation is issued from hydro and nuclear plants. However, as an open economy at the heart of the electricity system, the total bi-directional energy exchanges, with his European neighbors raised to 85.6 Terawatt hours (TWh) for that period, higher than the total national generation, 58.3 TWh.

Electricity trade over power grids makes the measurement of greenhouse gas emissions complex. To bypass the obstacle, accounting methods usually follow the United Nations Framework Convention on Climate Change (UNFCCC), under which the GHG emissions are allocated according to the territorial and issuer principle. According to the latter principle, the CO_2 emission factor from the generation mix amounts to approximatively 26 g CO_2/kWh. As far as energy exchanges and market integration should be considered, a consumer responsibility method is a preferred approach to estimate the CO_2 emissions from electricity consumption at a country level. The aim of the current paper is to provide an accounting framework for GHG emission factors of power consumption in an open economy, such as Switzerland.

Method

In Switzerland and his surrounding countries, different technologies generate electricity. They differ by their variable costs (€/MWh) and their exhausted CO_2 emissions. Following international trade theory, as long as low marginal cost equipment is available in some countries, and outside congestion situation, the global welfare and benefits for market actors will increase through exchanges opportunities. In response to the demand by the importing country, the demand curve in the exporting country will shift to the right of the supply/demand equilibrium, which means that some equipment with higher marginal cost, and likely more emitting plants, will be required to satisfy the domestic demand and exports. Market integration therefore provokes an upward shift of the hourly demand curve in countries with a dominance of low variable cost equipment during most of the year. The number of hours during which those technologies are run increases and does not correspond to that when standing alone from other markets. Consequently, it also leads to different carbon emissions.

Our method adopts a marginal approach and allows to measure the real-time impact of the domestic consumption on greenhouse gas emissions, by considering the electricity flows.

The impact is measured through the marginal effect of Swiss cross-border exchanges and demand on the generation merit-order of neighboring countries. This analysis will be carried out on an hourly basis. The data, referring to the year 2017, are issued from the ENTSO-E transparency platform, published as part of the market transparency directives to which all market stakeholders are subject.

Results

Results can be summarized into four main findings. First, the method describes the environmental quality of the imported energy flows from the surrounding countries. It also determines the marginal technologies which are run to comply with the demand issued by cross-border flows. German fossils fuels technologies appear to be marginal more than 45000 hours, when they come to satisfy the incremental demand due to the Swiss imports. Second, the direct emissions footprint from electricity consumption in Switzerland can be estimated. The level of emission amounts to around 130 g CO_2/kWh, a figure which is five time higher than the estimated footprint under the territoriality principle. Third, results also show the temporal pattern of emissions associated with the Swiss electricity consumption for 2017. Finally, the method provides a pattern of the estimate of the CO_2 emissions cutback due to the saving of a kilowatt-hour of imported electricity all over the year.

Conclusions

As reality of cross-border flows should be considered, the consumer responsibility method is preferred to estimate the CO_2 factors from electricity consumption when electricity markets are integrated. A significative increase in the emission factor estimated through the marginal approach can be observed. The marginal method could be adopted at a national level, as it sensitizes individuals over their real-time carbon footprint. Consumers are also therefore responsible for their CO_2 emissions, regardless of whether the power is produced inland or outland.

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