ENERGY SECURITY IN A LOW-CARBON WORLD: IDENTIFYING THE MAIN UNCERTAIN DRIVERS OF ENERGY SECURITY IN EUROPE

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Overview

In 2008, the Lisbon Treaty launched new climate and energy policies in the European Union with the aim of significantly decreasing CO2 emissions, while increasing the security of the supply of energy in the Union, at reasonable costs in order to maintain competitiveness. Since then, climate policy and energy security policy have been closely linked in the EU, as developed in the European Energy Roadmap 2050.

Today it is obvious that the two issues are intertwined. They share a common root cause, the demand for energy, but the solutions for improving energy security and reducing greenhouse gases (GHG) are not necessarily the same, and may involve some contradictions. For instance, the deployment of renewable energies led to greater dependency on natural gas for peak load and back-up, especially on Russian gas. Recent geopolitical crises between Russia and Ukraine revealed the European energy vulnerability on this issue.

Energy security does not only refer to geopolitical risks or dependency on primary fuels but is multi-faceted. Several recent contributions proposed an analytical framework to evaluate the concept by incorporating different dimensions or perspectives of the energy security (APERC, 2007; Cherp et al., 2012; Winzer, 2012). In this paper, we use the framework developed by the Global Energy Assessment (Cherp et al., 2012). The starting point of this approach is to work with a definition of the energy security which incorporates the likely radical transformations of energy systems in the long term. Energy security is defined as the low vulnerability of vital energy systems. Even if the security of oil supplies remains important, contemporary energy security policies must address other energy systems as well. This point is crucial in the current context in which many stakeholders call for speeding up energy transition. Vital energy systems thus also refer to different energy carriers (electricity, hydrogen, liquid and synthetic fuels), or to the total energy supply.

Several papers recently used this framework to explore the consequences of climate policies for energy security from a long-term perspective (Jewell et al., 2014; Guivarch et al., 2015). These analyses show that the implementation of ambitious climate policies affects vital energy systems differently. They also emphasize the importance of the time dimension. The objective of this paper is to highlight possible levers that could improve energy security, or limit its degradation, when ambitious climate policies are implemented. For that, we select a series of energy security indicators and analyze their dynamics over the century in a low-carbon world. We aim to identify the main drivers of these dynamics among those of key technologies, the evolution of energy efficiency, fossil fuel resources and markets and economic growth. The positive or negative impact of ambitious energy security policies may depend on the evolution of some uncertain drivers of future energy systems. For instance, the availability and affordability of carbon capture and storage (CCS) technologies would make the use of coal possible in a low-carbon world, while improving energy security for coal-producing countries. Without being sure of succeeding in developing low-carbon technologies, public policies will play a crucial role in their future availability and cost.

Methods

The paper proposes an original methodology to investigate these issues. Using the energy-economy-environment model, Imaclim-R, we created a database of long-term scenarios in which different determinants of the future energy systems, on both the supply and demand side, are considered. Each scenario describes a possible future in terms of economic growth, fossil fuel availability, energy efficiency and the cost of different low-carbon technologies. For each possible future, we imposed a global CO2 emission trajectory leading to the stabilization of the concentration of CO2in the atmosphere at 550 ppm CO2-eq. A set of indicators that capture the multi-faceted aspect of the energy security concept were assessed in each scenario, enabling us to analyze the evolution of the indicators in all possible future worlds, and their dispersion over the course of the century. By focusing on the indicators with the largest dispersion, and by applying a multi-factor analysis of variance (ANOVA), we identified the main explanatory factors. The method identified some levers to improve energy security if ambitious climate policies are implemented.

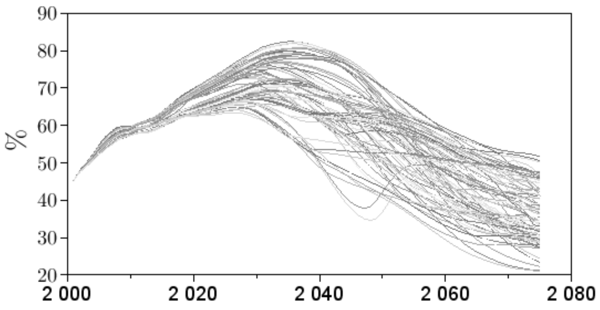
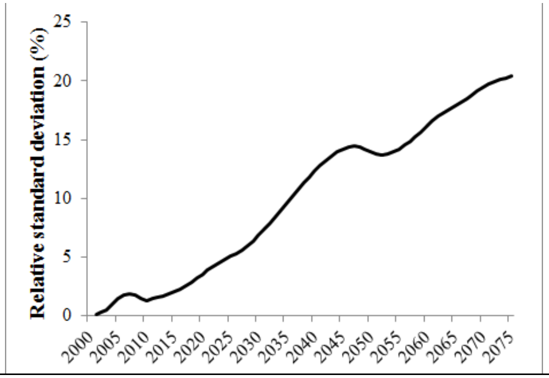
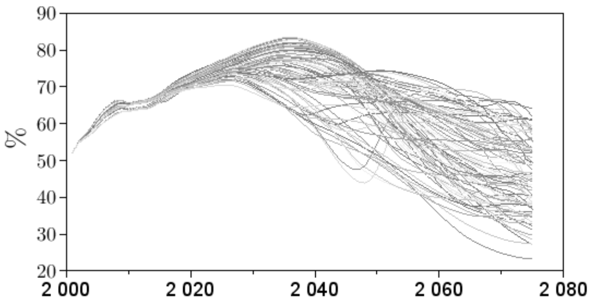
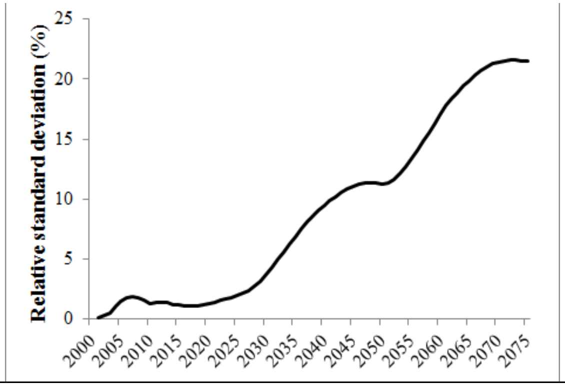
Results

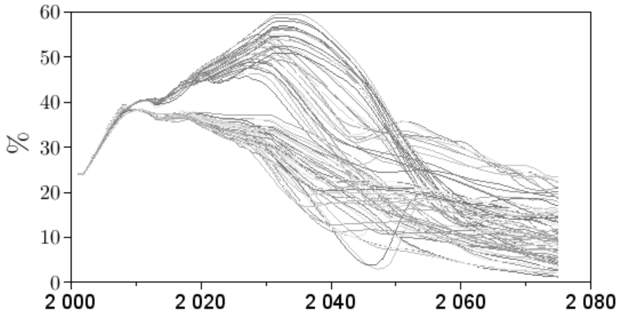
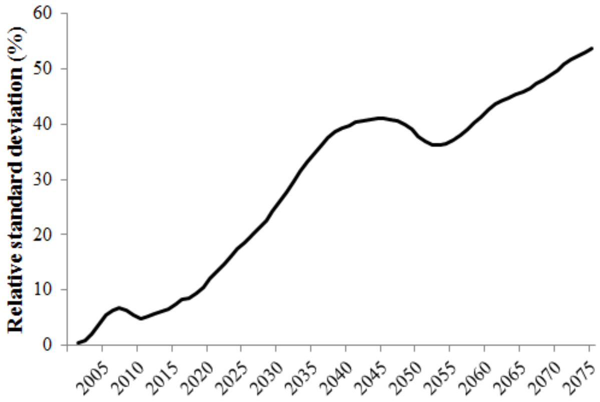
We present results for Europe. First, we describe the evolution of all the indicators over the century. Each line represents one scenario, i.e. one combination of the different assumptions under consideration. The dispersion of each indicator was evaluated by the relative standard deviation (RSD).

The evolution and dispersion of the indicators

Figure 1 presents only the indicators of the sovereignty perspective . All the indicators were calculated such that an increase (respectively a decrease) in their value indicates a worsening (respectively an improvement) in the dimension of energy security they measure. The RSD allowed us to assess whether an indicator varied a lot, or a little in the different scenarios. In other words, it evaluated the degree of uncertainty of the indicator across the scenarios considered.

Figure 1: Evolution and dispersion of the indicators of the sovereignty perspective

Sovereignty perspective		
	Evolution of the indicator	**Relative standard deviations**
TPES: *Share of imports in TPES*		
Primary fuels: *Regional import dependence*		

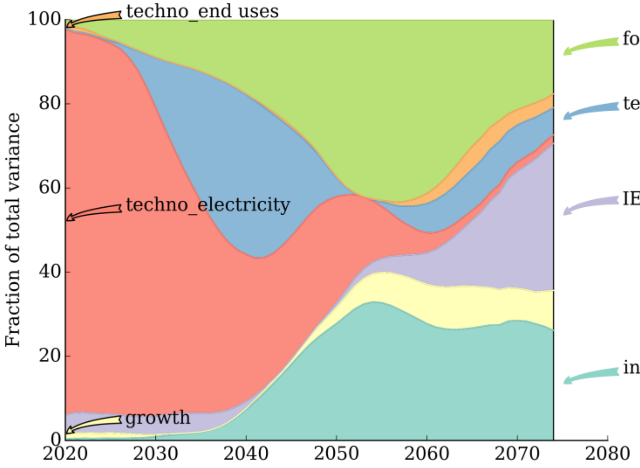
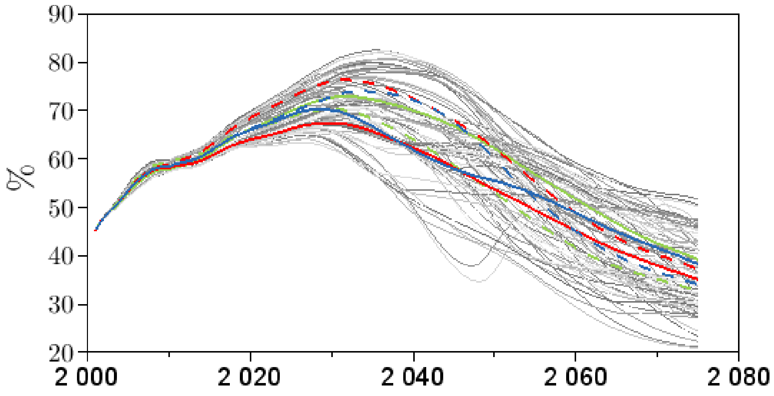
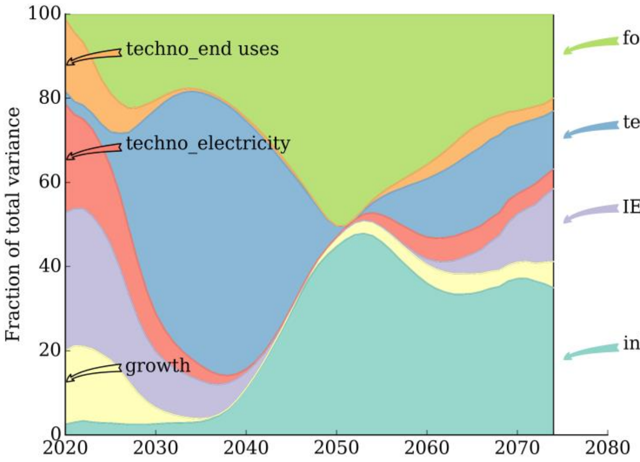
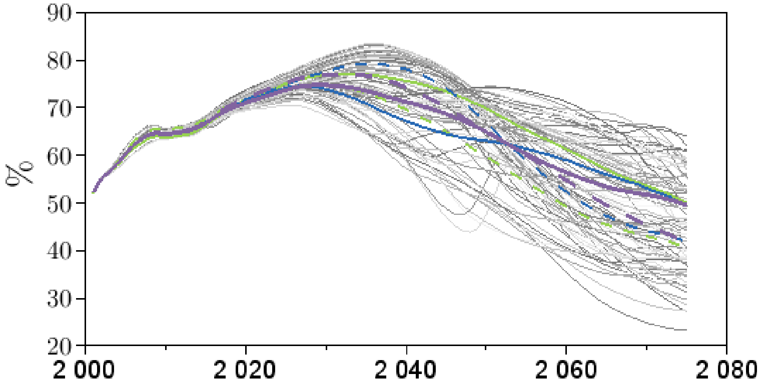
Electricity: *Share of imports for power generation*		

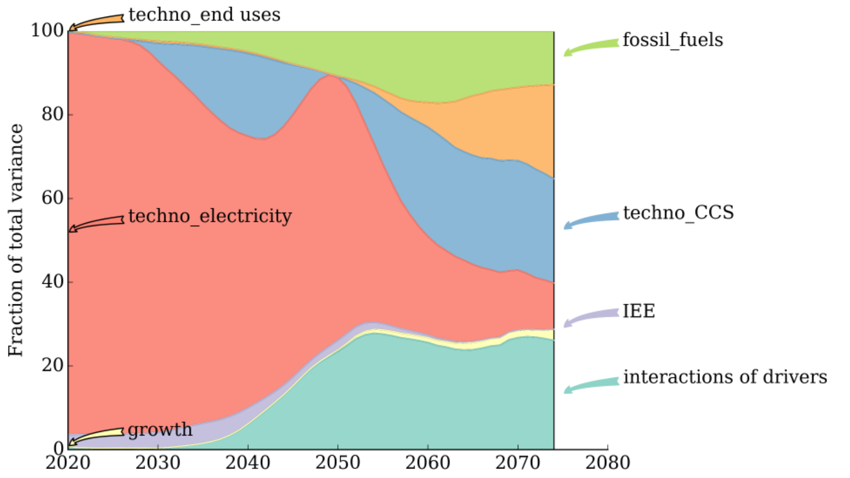
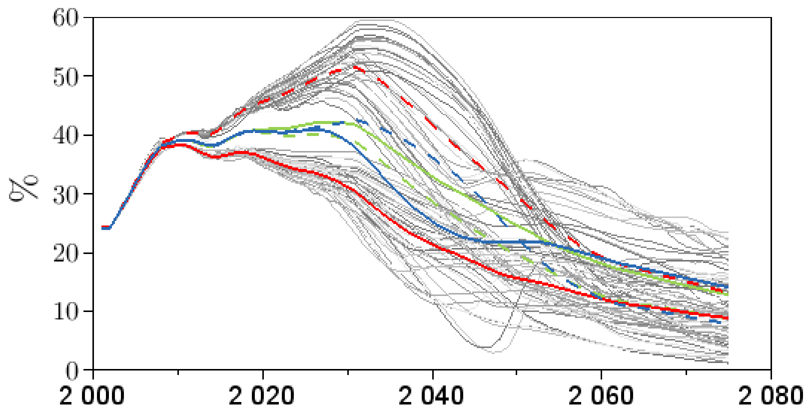
Note: The scale of the y-axis differs among the figures.

Contribution of the different determinants

Our objective is to identify the main factors behind the dispersion of the indicators. Figure 2 presents the contributions of each driver to the total uncertainty surrounding the energy security indicator over time. The evolution of the indicator is shown again in order to show the "direction" of the effect of each determinant. A different color is used for each type of driver: red for low carbon power generation technologies, blue for CCS technologies, orange for low carbon end-use technologies in the transport and residential sectors; purple for induced energy efficiency (IEE), green for fossil fuel resources and markets, and yellow for economic growth. Only the three drivers that contribute most to the variance of the indicator are included. The solid line represents the average of the indicator across the subset of scenarios based on the "high" assumption; the dashed line represents the average of the indicator across the subset of scenarios based on the "low" assumption.

Figure 2: Analysis of the dispersion of the indicators of the sovereignty perspective

	Analysis of variance	Direction of the drivers
TPES		
Primary fuels		

Electricity		

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