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European climate—energy security nexus: A model based scenario analysis ☆

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ABSTRACT

In this research, we provide an overview of the climate-security nexus in the European energy sector, through a model based analysis of scenarios produced with the POLES model. The scenarios describe the consequences of different degrees of GHG emission constraint, at world level, but also for a case where Europe adopts an ambitious climate policy, while the rest of the world sticks to much more modest abatement policies. The analysis shows that under such stringent climate policies, Europe may benefit of a significant double dividend, first in its capacity to develop a new cleaner and climate-friendlier energy model, and second in a lower vulnerability to potential price or supply shocks on the international energy markets.

1. Introduction

It is usually considered that the development of national or regional energy policies should be based on three pillars: energy security, environmental sustainability and economic competitiveness. This is particularly true for Europe, where each one of these pillars is brought forward by one dedicated institution, respectively, the Directorates General for Energy and Transport, for Environment and for Competition. But this is also true for other countries or regions of the world, as the development of sound energy policies is often considered as based on trade-offs, aiming at the right balance between potentially conflicting goals. The key argument of this paper is to demonstrate that these targets may be put into convergence, according to the taking into account of global constraints and to the policy hypotheses retained at the global and regional level. In particular, the adoption and implementation of strong climate change and greenhouse gases abatement policies may be considered as the most effective way to enhance energy security through a lower degree of dependence of the European energy system on fossil fuels (Zecca and Chiari, 2010).

Energy security "is ubiquitous to contemporary discussion about energy issues and climate change. The term is commonly found embedded in discussions framed around a handful of notions, which denote unimpeded access or no planned interruptions to sources of energy, not relying on a limited number of energy sources, not being tied to a particular geographic region for energy sources, abundant energy resources, an energy supply which can withstand external shocks, and/or some form of energy self-sufficiency" (Chester, 2010). The 2001 European Commission Green Paper "Towards a European Strategy for the Security of Energy Supply" claims: "The European Union's long-term strategy for energy supply security must be geared to ensuring, for the well-being of its citizens and the proper functioning of the economy, the un interrupted physical availability of energy products on the markets, at a price which is affordable for all consumers (private and industrial)" (European Commission, 2001, pp. 3). Vivoda (2010) shows how energy security cuts across different areas, involving geological, economic and environmental aspects. Increasing concerns over both energy security and the environmental impact of anthropogenic energy emissions feeds the necessity to enhance our understanding of the climate and energy security nexus.

In this perspective, we explore the "energy security and climate policy nexus", using the POLES world energy model, initially developed at EDDEN-LEPII.[1] This model is a well established model of the world energy system and is commonly used by different European institutions. One of its characteristics is that it provides a detailed description of future energy demand and supply in more than fourteen countries. The consistency of the long term projections is ensured by the taking into account of the energy technologies that are available in the long term and of the future expected improvements in their costs and performances. Data on future technologies are gathered and updated in a dedicated database that is associated to the model (Knopf et al.,

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[1] Economie du Développement Durable et de l'Energie - Laboratoire d'Economie de la Production et de l'Intégration Internationale, Grenoble: http://webu2.upmf-grenoble.fr/LEPII/spip/spip.php?rubrique76.

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2010). The results for the energy sector in the medium term are comparable to those of other world energy models projections, such as those of International Energy Agency or Energy Information Administration. However, unlike the POLES model, these projections do not cover the 2050 horizon (International Energy Agency, 2010; US Energy Information Administration, 2010; BP 2011). The model's behavior for the long term has been studied and compared with the one of other large scale European world economy and energy models in preceding foresight exercises. These exercises aimed at studying the costs of mitigation strategies and low emission scenarios (Edenhofer et al., 2010).

We describe here a family of scenarios based on consistent sets of exogenous hypotheses on economic growth, energy resources, technology performances and climate policies, with a particular focus on the "environment and energy security nexus", according to the aims of the SECURE research project.[2] The POLES model is not a General Equilibrium Model, but a Partial Equilibrium Model aimed at describing the energy sector, within a year by year dynamic recursive simulation framework. In this paper, we describe the results of four scenarios in order to illustrate the consequences of different settings concerning climate policies on the fundamentals of the energy markets, both at global and regional level.

The first one is called *Muddling Through* and illustrates the consequences of relatively low intensity and non-coordinated climate policies in the different world regions. This scenario can be used as a reference case, to which stronger policy cases can be compared. The second case, *Europe goes Alone,* describe a situation in which Europe implements gradually stronger climate policies than in the mere *Muddling Through* case, while the rest of the world sticks to low intensity climate policies. Finally, the *Global Regime* scenario illustrates the consequences of coordinated and ambitious climate policy, shared at world level.

The exercise shows that energy policies in the *Muddling Through* case result in a noticeable limitation of emissions compared to *Business As Usual* case. However the global emission level reached in 2050 far exceeds the one that is considered as reasonable in IPCC's AR4.[3] The *Europe Alone* scenario helps to show that in a world with low policy coordination there might still be strong advantages in pursuing an ambitious regional climate policy as it may considerably limit the vulnerability of Europe to events occurring in an otherwise very unstable energy world. The *Global Regime* case not only helps to constrain climate change in an acceptable range but also changes the whole picture of the world energy system in the first half of the century. In particular, the long term sustainability of the oil and gas production profile is significantly improved. Two variants are developed for this case: *Global Regime with two carbon markets* (GR-2M) and *Global Regime with full trade* for carbon (GR-FT) in order to test the consequences of a differentiated or a unified carbon emissions market.

Section 1 of this paper briefly presents the POLES model and the *Muddling Through* scenario, which, although it contains some elements of emission reduction, represents a state of the world that is maybe probable, but surely not desirable from the climate change perspective. Section 2 is dedicated to the presentation of the climate policy alternative scenarios and to the comparative analysis of their results in terms of emission performances and impacts on the world and European energy system to 2050. Section 3 discusses the consequences for the international energy markets and for the energy import profiles of Europe. Section 4 translates the conclusions of this study in terms of risks and vulnerability; it also points to the double dividend that may be associated with a change in the European energy paradigm and the resulting reduced vulnerability.

2. The POLES model and the *Muddling Through* projection

The *Muddling Through* projection provides an image of the energy scene up to 2050, resulting from the continuation of ongoing trends and structural changes in the world economy, with only low intensity and non-coordinated climate policies in the different world regions.

Through the identification of the drivers and constraints in the energy system, the model used in this exercise allows the description of the pathways for energy development, fuel supply, greenhouse gas emissions, international and end-user prices, on a year by year basis from today to 2050. The approach combines a high degree of detail in the key components of the energy systems and a strong economic consistency, as all changes in these key components are largely determined by relative price changes at sectoral level. The model identifies 47 regions for the world, with 22 energy demand sectors and about 40 energy technologies—now including generic "high energy efficiency" end-use technologies. Therefore, each scenario can be described as the set of economically consistent transformations of the initial *Business As Usual* projection that is induced by the introduction of policy constraints.

2.1. The POLES model

The POLES model is a partial equilibrium model of the world's energy system that provides a detailed year-by-year projection until 2050 (or in some studies 2100), for the different regions of the world. The model simulates the energy demand for each economic sector, the supply and prices for the primary energy sources on the international markets, and the impacts of innovation, experience effects and R&D in new and renewable energy technologies and major energy conversion systems (electricity or hydrogen-based for the longer term).

The central role of price mechanisms in the model allows simulating the impacts of emission abatement policies through the introduction of a carbon price. This induces lower energy consumption through price elasticities and accelerated diffusion of highly efficient devices (low-emission electric or hydrogen cars or low-energy buildings). Although the adjustment mechanisms are mostly based on economic factors, simulations have to account, when necessary, for the role of other factors such as political restrictions or public acceptability. This is for instance the case for nuclear energy, for which constraints may be exogenously introduced.

The model therefore provides a consistent framework for studying the interconnected dynamics of energy development and environmental impacts. Projections are made on the basis of exogenous economic growth and demographic projections for each region. It takes into account the resource constraints for both oil and natural gas and enables the calculation of greenhouse gas emissions from the burning of fossil fuels and, further on, of the costs (marginal and total) of reducing emissions in the various countries or regions (Fig. 1).

It thus makes possible the simulation of various emission constraint scenarios and the identification of the consequences of introducing a carbon tax or emission quotas systems. The main limitation of this modeling system is probably that it does not account for macro-economic feedbacks. However, this also allows the production of a relatively robust estimate of the impacts of climate policies on the sole energy sector, while the macro

[2] SECURE Security of energy Considering its Uncertainty, Risks and Economic implications: Project no. 213744 under the European FP7 research project, http://www.secure-ec.eu/.

[3] Intergovernmental Panel on Climate Change, Fourth Assessment Report.