Long-term implications of global shale gas development regarding growth and energy markets.

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Introduction

The sudden start of shale gas production in the United States (U.S.) a decade ago is a piece of evidence of the uncertainty about the future availability of fossil fuel resources. Indeed the U.S. gas production was declining and the country was building regasification plants to secure liquefied natural gas (LNG) importations. Nobody were expected an unconventional resource like shale gas to become a new game changer in the U.S. energy mix, policy and strategy [1]. However, from 2005 to 2014, shale gas stopped the decline of U.S. production and raised it by nearly 30%, taking a share of 35% of total gas production. Even if the first basins set under production are already declining (like the Barnett shale) the start of drilling activity in new giant fields like the Marcellus still raises the overall shale gas output.

This sharp increase of unconventional gas production induced several significant macroeconomics impacts. First the U.S. natural well-head gas price decreased from 6.73$/MBtu in 2006 to 3.73$/MBtu in 2013 (U.S. Energy Information Administration, 2014). This drop disconnected the U.S. gas price from other gas market of the world, benefited the U.S. consumers and attracts many investment in gas intensive industries, such as in the petrochemical industry [2] becomming more competitive in the international market. The electricity market also benefited from a low gas price and 15% of coal-fired were directly substituted to gas-fired power plant (Energy Department, 2014a, fig. 15), which reduced U.S. greenhouse gas (GHG) emissions [3]. This helped the electricity price for the industries which remained stable unlike the other part of the world, being now half of the European price (IEA, 2013, fig. 5.18) . Finally, shale gas activity contributed in 2010 for $76 billion of the U.S. Growth Domestic Product (GDP) and the creation of 600000 jobs. Those figures are expected to reach respectively $231 billion and 1.6 million by 2035 (IHS, 2011) [4].

Other regions of the world which are hypothetically rich in shale gas resources are looking to reproduce the U.S. shale gas success story, like Europe. Besides a relatively small european shale gas production at the moment, the U.S. production has already had several consequences on the European market. First, regarding gas markets, Qatar's LNG gas production capacities build under contract for the U.S. are now shipped partly to Europe, disturbing the European gas spot

[1] As en example, the International Energy Agency (IEA) published a special issue concerning unconventional gas resources only in 2009 in its World Energy Outlook (WEO) (IEA, 2009) and used the expression "a golden age of gas" in 2011 (IEA, 2011a, special report) (IEA, 2012a, special report) .

[2] According to the American Chemistry Council (ACC), $71.7 billion of investment projects were planned in 2013 (American Chemistry Council, 2013).

[3] This is without taking into account the ongoing controversy about methane fugitive emissions, which are proportional to the number of well drilled, this one being much larger in the case of shale gas extraction. For discussions on the subject and studies which are assessing the fugitive emissions related to shale gas activity, see Howarth (2014); Heath et al. (2014); Jackson et al. (2013); Osborn et al. (2011); Wigley (2011); Jenner and Lamadrid (2013).

[4] See (Kinnaman, 2011) for a review of studies on the economical impact of shale gas extraction.

price. Also, the European petrochemical industry suffers the U.S. increased competitiveness. Finally, cheap U.S. coal substituted by gas is shipped overseas, disturbing European energy policy choices (coal-fired plants are re-opened in Germany when the country build policy incentive towards renewables).

In this context, whether or not highly energy intensive economies should exploit shale gas resource is an issue that requires to be assessed in the long-run. In fact, if shale gas is abundant in Europe, the question of exploiting new fossil fuel resources should be taken in the context of an energy system transition regarding climate constraints. Fossil fuels will remain to be a significant part of the global energy mix (63% by 2035 for the low carbon scenario in the 2013 WEO[5]). Their availability to reduce short-term tensions on energy markets and favorise low-carbon futures is a controversial issue. Recent studies suggested that because of shale gas production, the U.S. energy transition objectives could be delayed(Energy Modeling Forum, 2013). Regarding fossil fuels and climate policies, gas is a key resource as it produces less GHG emissions per thermal units than fuel and coal. The worldwide availability of shale gas could then determine our ability to cope with constraints on emissions without affecting the economy deeply. Comparing the IEA prospective scenarios gives an idea about how hypothesis on shale gas availability shapes the vision of the future energy content of the economy [6].

This technical report disentangles the issues of the long-term implications of global shale gas development with a computable general equilibrium (CGE) model, by first modelling development of the shale gas production sector, and secondly looking-forward scenarios analysis within this modelling framework.

Features and stylized facts of the shale gas economic and dynamic of production are analysed and modelled together with the conventional gas production sector in section 1.2. The later constitutes then a single module embarked within the framework of IMACLIM-R, a model described in section 2, which provides an innovative framework to organize the dialogue between economics (to capture the general interdependences between sectors, issues and policy decisions), and engineering sciences (to capture the technical constraints and margins of freedom). It provides a multi-sectoral, dynamic modelling approach for thinking the link between growth and energy constraints given the limited availability of fossil resources and carbon mitigation policies.

We first in section 2.1 build contrasted scenarios concerning the start of shale gas production in other parts of the world and the U.S. strategy in term of gas LNG exportation. Section 2.2 analyses benefits of lower energy price in the U.S. economy, with a deeper study of the occuring structural change in section 2.4. Section 2.3 proposes to contrast those conlusions by looking at the role of shale gas within U.S. in transition to a low carbon pathway under a climate policy. We then look at the impact of changes within the U.S. economy on the global welfare through tensions created on global markets (Section 2.5). We finally take a look at energy markets, with the consequences for main gas producers facing U.S. as a new exporter (section 2.6), and secondly by the study of indirect impacts of Middle East oil and gas profits together (section 2.7).

[5] IEA, 2013 .

[6] Based on the author's analysis, the differences in the 'new policy' scenarios in the three last WEOs in term of volume of gas produced in 2035 is strongly correlated to the considered amount of global shale gas resource (IEA, 2012b, 2011b, 2010)

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