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Impact of the regulatory framework for transmission investments on the cost of renewable energy in the EU

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ABSTRACT

Under the current regulatory frame in the EU, transmission planning is done at the national level to maximize national welfare, rather than European welfare. In this paper, we develop a competitive equilibrium model that calculates the impact of this imperfect regulatory framework on the cost of renewable energy. We apply the model to a power system with two interconnected zones, and find that the impact is case specific, but significant. We also find that the negative impact of national transmission planning on the cost of renewable energy is more significant in a state of the world in which Member States trade renewable energy, but that this negative effect is much smaller than the positive effect of renewable energy trade between Member States. We conclude that the imperfect regulatory framework for transmission investment is a significant cost for renewable energy in the EU, but that it should not stop Member States from trading renewable energy.

1. Introduction

The EU objective is to rely on renewable energy sources for 20% of the energy consumed in 2020, and the efforts to achieve this objective have been shared among Member States with binding national targets (EU, 2009). The burden sharing agreement has been partly based on the renewable energy potential of the different countries, and partly based on their economic power. This implies that there are opportunities to trade renewable energy to reduce the cost of achieving the national targets (Amundsen and Nese, 2009), which is also allowed by the regulatory framework: Norway and Sweden are the first to organize cross-border renewable energy trade using a common market for green certificates. Aune et al. (2012) found that the cost of achieving the national renewable energy targets for 2020 could be reduced by almost 70%, and EC (2008), Capros et al. (2008) and Ecofys et al. (2011) consider that the annual savings could be up to €10 billion.

However, these studies assume that the transmission investments that are required to enable this generation cost reduction will follow. The importance of transmission investments to avoid spilling renewable energy and to reduce the cost of backup capacity in a power system with increasing share of renewable energy has also been underlined in the recent debate around the EU Roadmap 2050 (Meeus et al., 2012). The electricity industry association (Eurelectric, 2010) for instance envisages an electricity generation mix with 40% renewable energy in 2050. The study considers 241 interconnections between countries, concluding that the desired increase of interconnection capacity would be 40% by 2030 (from 179 to 253 GW), after which the grid capacity would remain stable until 2050. The European Climate Foundation (ECF, 2010) considers electricity generation mixes with up to 80% renewable energy in 2050. Their energy system analysis focuses on 15 corridors, and calculates the desired increase of the total capacity of these corridors by 2050 with different demand flexibility assumptions. The desired increase of the corridors is 388% (from 34 GW to 166 GW) in the 80% renewable energy scenarios without improvement in demand flexibility, which reduces to 274% in scenario with 20% improvement of demand flexibility.

The problem is that these transmission investments will not necessarily materialize under the current regulatory framework in the EU. Transmission planning in Europe is mainly done at the national level to maximize national welfare. The National Regulatory Authorities that have to approve the investments are indeed mandated to take

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care of national interests. This can result in suboptimal transmission investments because cross-border projects that are beneficial for Europe, but not for all the involved Member States, can be blocked as Member States can veto or delay projects that are partly developed on their territories.

The main contribution of this paper is to propose a model that can analyze the relevance of this problem in the EU context. Building on the work of Buijs et al. (2011), Buijs and Belmans (2011), Drondorf et al. (2010), and especially Sauma and Oren (2006, 2009), we develop a competitive equilibrium model that captures the four states of the world that are relevant in this context: a situation with no trade versus perfect trade of renewable energy across borders in combination with national versus international transmission planning. We apply the model to a power system with two interconnected zones to illustrate the relevance of suboptimal transmission investments for the cost of renewable energy. The example also provides insights into the sensitivities of the results to the differences between the zones in terms of their access to renewable energy sources.

The paper is organized into 3 sections. Section 1 details the four states of the world that are analyzed in the paper. Section 2 explains how the four states of the world have been modeled. Section 3 presents the results of the numerical example. The paper finally concludes with the main insights that we take away from this modeling exercise.

1.1. States of the world

Electricity wholesale market integration across national borders is an ongoing process in the EU (Glachant and Lévêque, 2009). The process is driven by cooperation among market operators, which is referred to as the coupling of markets (Meeus, 2011a, 2011b; Meeus et al., 2005). For the purpose of this paper, we will assume the market is already perfectly integrated so that we can focus on comparing two states of the world for renewable trade and transmission planning (Table 1).[1]

Table 1
Matrix representation of the four states of the world considered in this paper.

		Renewable energy trade	
		No trade	Perfect trade
Transmission planning	National	1 (Current state of the world)	2
	International	3	4

1.2. Renewable energy trade

Every country in Europe has a binding national renewable energy target, which have been set at EU level to share the burden of achieving the EU objective that 20% of the energy consumption in 2020 should be based on renewable energy. The EU framework for renewable energy support schemes includes the possibility for member states to trade renewable energy to comply with their national targets, but they can also choose to develop their domestic renewable energy sources. We consider two extreme states of the world for renewable energy trade: no trade and perfect trade.

In the first state of the world, there is no renewable energy trade. This is the current situation between most EU Member States, as indicated in the recently submitted National Renewable Energy Action Plans (EC, 2011). Only Italy and Luxembourg intend to import a small share of the renewable energy they need to comply with their binding national targets. In the second state of the world, there is perfect renewable energy trade. This is the current situation between Sweden and Norway, who decided to implement a common mechanism, a unified green certificates market.

Note that the current situation with almost no trade in renewable energy in Europe can be explained by the existence of local benefits for the development of renewable energy technologies and non-harmonized national support schemes. Renewable development policies are indeed about proving public support to renewable energy technologies. Some of the benefits are global, such as the reduction in greenhouse gas emissions; other benefits are more local, such as the reduced dependence on imported fossil fuels and the creation of green jobs and technology industries (Lund, 2009). Various instruments are being used, from so-called feed-in tariffs to green certificate systems and mandatory obligations regarding the share of renewables in the energy production sectors (Aune et al., 2008; Haas et al., 2011; IEA, 2009). To be able to trade renewable energy, Member States need to harmonize their support schemes, or at least make them compatible.

1.3. Transmission planning

We consider two extreme states of the world for transmission planning: national planning and international planning. As discussed in the introduction, the current state of the world in EU is national transmission planning. The third energy liberalization package and the energy infrastructure package include first steps towards a more international perspective for transmission planning in the EU. The third energy liberalization package, for instance, introduced the Ten Year Network Development Plan that tries to improve the coordination between the different national transmission plans (ENTSO-E, 2012). The energy infrastructure package goes a step further by encouraging Member States to design innovative cross-border cost allocation agreements that can potentially unblock some projects with a benefit for Europe, but without a strong national interest for all involved parties (EU, 2013). However, without additional intervention, planning will continue to aim at maximizing national rather than European welfare (Buijs and Belmans, 2011; Buijs et al., 2011).

2. Modeling the states of the world

We model a three-stage decision process, as in the work of Sauma and Oren (2006, 2009). In the first stage, the transmission capacity is decided, followed by the generation investments in the second stage, and the production and consumption schedules in the third stage. At each stage, the reaction of the next stage is anticipated. A first novelty of the model is that it also includes a two-zone system managed by two different transmission system operators regulated by a different national regulatory authority that jointly decide on the capacity of the interconnector between them. Buijs et al. (2011), Buijs and Belmans (2011) and Drondorf et al. (2010) already studied multi-zone systems with different transmission planning objectives, but they did it in a two-stage decision process without generation investment. A second novelty of the model is that it includes the possibility to integrate renewable energy support schemes. Linares et al (2008) already studied this type of schemes, but they did it in a single zone system, without considering transmission investments.

In order to focus on imperfections in transmission and renewable policies, we assume a competitive behavior of electricity generators. This introduces a supplementary difference with respect to the Sauma and Oren (2006, 2009) framework, which includes oligopolistic (Cournot) behavior for electricity generators. We could have represented the model as an optimization program, but we have instead chosen for a competitive equilibrium representation as it is closer to the functioning of electricity markets, and it can easily be extended.

[1] Note that we do not model climate change policies, such as the European Emission Trading Scheme: it would not modify our main results; including this scheme would imply studying other policy interactions that are out of the scope of this paper, but have already been treated by, for instance, Linares et al (2008).