Available online at www.sciencedirect.com
SCIENCE DIRECT
Electric Power Systems Research 76 (2006) 557–566
ELECTRIC POWER SYSTEMS RESEARCH
www.elsevier.com/locate/epsr

Demand elasticity increase for reducing social welfare losses due to transfer capacity restriction: A test case on Italian cross-border imports

Sergio Bruno [a,*], Michele De Benedictis [a], Massimo La Scala [a], Ivar Wangensteen [b]

[a] *Dipartimento di Elettrotecnica ed Elettronica, Politecnico di Bari, Bari, Italy*
[b] *Department of Electrical Power Engineering, NTNU, Trondheim, Norway*

Received 16 February 2005; received in revised form 22 July 2005; accepted 9 October 2005
Available online 21 November 2005

Abstract

The paper is aimed at showing how demand-side policies for increasing inner demand elasticity could help in reducing market inefficiencies generated by transfer limits on interconnections, with a special regard to energy imports dependent countries. In order to develop the studies in a realistic environment, a model for the Italian electricity market has been developed. Test results show effects of variations in demand elasticity on the national social surplus and congestion costs. It will be shown how an increase of demand elasticity can counterbalance the need of additional transfer capacity in reducing cross-border congestions.

Keywords: Power markets; Energy imports; Transmission capacity; Demand elasticity

1. Introduction

The restructuring process of electric power industry in the European community is partly a result of the European Parliament Directive 96/92/EC, December 1996 [1] supplemented by Directive 2003/54/EC, June 2003 [2]. Prior to these initiatives, competitive electricity markets had already been developed in England and Wales, Norway, Sweden.

The Directives suggested the necessity of developing individual deregulated electricity markets for all Member States of the Union, and defined basic common rules. Achieving a European competitive environment, where electricity can be traded freely in the Internal Energy Market, is one of the main goals the Directives were aiming at.

In the EU, free movement of goods, persons, services and capital is ensured, and, since electricity must be considered a common good, the directive appliance would give any energy supply company the right to participate in the clearing process of any Member State's energy market. Therefore, energy would naturally flow from the lower marginal cost areas to the higher marginal cost ones, prices would be leveled, competition and open access would lead to an overall increase of social surplus for all Member States.

Presently, some States have already developed common energy markets (Nord-Pool for Scandinavian countries, for example) and energy exchange agreements between Member States, already existing even before 1996, are ordinary tools for a better use of generation resources. Nevertheless, pure competition in European electricity markets seems to be quite a hard target to achieve. Although progresses to overcome regulatory barriers have been made by the definition of new rules for cross-border trading [3], still a common market seems to be a far away objective.

Moreover, limits on transfer capacity and violations of security constrains cannot allow energy to follow any path. In some cases, intensive energy flows can generate congestion and security violations, especially if we consider that interconnection systems were built in order to allow mutual help between the national power systems and not for commercial purposes. Since technical infeasibility, for instance due to transfer limits, congestions, static and dynamic security constraints, can be causes for lower market efficiency, the European Parliament already

* Corresponding author.
E-mail address: bruno@deemail.poliba.it (S. Bruno).

0378-7796/$ – see front matter © 2005 Elsevier B.V. All rights reserved.
doi:10.1016/j.epsr.2005.10.004

approved a recent proposal made by the Council of the European Union, concerning the expansions of the trans-European network (1229/2003/EC) [4].

Even though the increase of transfer capacity on interconnections is a highly sought-after objective, other policies can help in enhancing European electricity market efficiency. In the last 10 years, wholesale electricity markets have developed successfully, but active demand-side participation is still very low. The issue of how to increase the elasticity of the demand offers many possible solutions, exhaustively described in [5] along with the thorniest obstacles. In [6], Price Responsive Load programs, actually implemented by the New York Independent System Operator (NYISO) for studying the actual responsiveness of loads to prices, have been described.

An improvement of demand elasticity is highly desirable since it would yield a reduction of price volatility, an overall reduction of prices and spikes, and, more generally, an improvement of market behaviour and efficiency [5]. Regarding the effects on security related issues, in [7], it has been shown how demand flexibility can also help in solving the problem of long-term availability of peaking capacity, whereas in [8], the authors investigate the role that demand responsiveness to prices can play in the presence of congestions. Results show that congestion effects are alleviated as the demand elasticity increases. In the limit case (lossless system with infinite demand elasticity) congestions are removed with no concern to which constraint has been considered.

In the following, this paper shows how demand-side policies aimed to increase the elasticity of inner demand can help in reducing the market inefficiency generated by transfer limits on interconnections (i.e. social welfare losses are reduced), with a special regard to energy-import dependent countries. For these countries, the increase of demand elasticity would also help in overcoming scarcity periods, reducing the cost of energy and the dependence on imports. Results obtained through the development of a realistic model for the Italian electricity industry are presented.

2. Overview on the Italian interconnection system and energy imports

The diverse distribution of production technologies in Europe, derived by different energy policies, is reflected in the amount of electricity exchanged between different countries. Consequently, congestion costs play an important role in the cross-border electricity market. Italy is characterized by the highest imported volumes of electrical energy in Europe.

The Italian grid is interconnected to external systems by 15 circuits as follows:

- to France by three circuits operated at 380 kV and one circuit at 220 kV;
- to Switzerland by two circuits operated at 380 kV and six circuits at 220 kV;
- to Austria by one circuits operated at 220 kV;
- to Slovenia by one circuit operated at 380 kV and one circuit at 220 kV.

In the year 2002, these transmission lines permitted the exchange of 51.52 TWh. In the Italian case, the amount of imported energy is constrained by the Net Transfer Capacity (NTC) since marginal cost are always lower abroad, due to the strong dependence on thermoelectric plants and the lack of nuclear power in Italy. NTC during years 1999–2003 steadily increased from 5400 to 6400 MW due to limited improvements in the existing equipment and recalculation of limits on the basis of joint studies by GRTN, RTE and Swiss operators. After the Italian blackout in September 28th 2003, maximum NTC values were lowered to 6050 MW.

NTC on the Italian border is shared between pluriannual contracts (44% in 2001 and 43% in 2002) and annual contracts. Annual contracts were shared evenly by Italian and foreign operators in 2001 whereas in 2002 they were distributed according to a 35% and 22% share for national and foreign operators, respectively.

In the short term, GRTN (the Italian System Operator) planned the implementation of two new links at 380 kV with Switzerland (S. Fiorano-Robbia) and Austria (Cordignano-Lienz) which can increase the NTC of 1500 and 800 MW, respectively. In the medium term, GRTN is also considering the possibility of adopting phase shifting transformers to increase NTC of at least 400 MW on the Italian border.

In Italy, the rotating outages in June 2003 and the largest blackout of the EU history, experienced on September 28th, pulled the attention of political decision makers on the dramatic lack of generation resources, the dependence on foreign supply and the total exploitation of transmission capacity on the interconnection [9]. Although it is recommendable to increase the availability of inner resources and renew the old-technology steam power generation plants, characterized by low efficiency and higher marginal costs, it is also clear that low-priced energy from the neighbourhoods (i.e. nuclear from France) will always be characterized by lower marginal prices. Therefore, importing less expensive energy would necessarily results in an increase of the inner social surplus. From an economic viewpoint, an optimal solution will always maximize the overall imports, whereas limitations on exchanges are mainly due to security and reliability reasons. In [10], it has been shown that NTC should be increased by additional 10,000 MW for yielding a perfect integration (i.e. equal marginal prices) of the Italian market with the French and Swiss ones.

The NTC value on the interconnection can be increased only by means of new investments on transmission (new transmission lines, advanced transmission technology and special protection schemes) because, without investments, higher NTC would just result in a reduction of security margins. This study is aimed at showing how, in the Italian electricity industry, a reduction of congestion costs and a consequent improvement of social welfare can be achieved also by developing demand-side policies for increasing the responsiveness of loads to prices.

In Italy, attempts to flatten the load curve have been recently made, for example, by developing time-varying tariffs. Initial results have been not very satisfactory because householders are usually characterized by a very inelastic behaviour. This is due to