

# ACTUAL ISSUES CONCERNING NUCLEAR POWER PLANTS AND INTERCONNECTED GRID

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## ABSTRACT

Nuclear power plants and transmission grid have always been interdependent. In countries and/or regions where nuclear power plants are located they are almost as a rule counted among “strongest” nodes of the grid. Hence, they are treated as such from grid point of view in various aspects (operational, planning ...).

In interconnected high-voltage transmission grid of European mainland, usually called UCTE interconnected system, this importance could be shown in a range of issues and several cases, particularly under present situation in which there are numerous demanding and challenging tasks put on transmission system operators, largely due to the opening of electricity markets in the most of European countries.

Among these issues definitely worth of mentioning is relevant influence to both commercial paths and physical power flows, and also to exchange programmes between control areas and blocks. In this context there is also relation to cross-border transactions and mechanism applied to them.

In respect to security of supply issues and future of nuclear power generation under present regulative framework of most European countries it is necessary to comply with connecting conditions (and other stipulations) from national grid codes where different approaches could be observed.

Furthermore, nuclear issues significantly influence approach to extension of UCTE system. In certain extent this also applies to pending re-connection of present two synchronous zones of UCTE, particularly to area of broader region directly affected with this complex process.

Some of these also reflect to Croatian high-voltage transmission grid as a part of UCTE interconnected system with certain peculiarities.

## 1 INTRODUCTION

Nuclear power plants and transmission grid have always been interdependent. In countries and/or regions where nuclear power plants are located they are almost as a rule counted among “strongest” nodes of the grid. Hence, they are treated as such from grid point of view in various aspects (operational, planning, ...).

In interconnected high-voltage transmission grid of European mainland, usually called UCTE interconnected system, this importance could be shown in a range of issues and several cases, particularly under present situation in which there are numerous demanding and challenging tasks put on transmission system operators, largely due to the opening of electricity markets in the most of European countries.

## **2 UCTE CHALLENGES AND THE IMPACT OF NPP'S**

The Union for the Co-ordination of Transmission of Electricity (UCTE) has been co-ordinating the synchronously interconnected high voltage transmission system (sometimes called TESIS - Trans-European Synchronously Interconnected System) over more than fifty years (until 1999 known as UCPTE what stand for Union for Co-ordination of Production and Transmission of Electricity). Members connected by their interconnections have taken over its share of advantage and problems arising from that fact. In time, from that principles and preconditions, common set of rules were developed as a foundation for reliable operation. Currently their update and assembling into "Operation Handbook" is taking place with the goal to agree upon its legally binding character for all TSO's that are UCTE members.

Since 1991/1992 due to the destruction of several substations with surrounding overhead lines (caused by agressions on Croatia and Bosnia-Herzegovina) this system has been operating in two separate synchronous zones:

1. The main part of UCTE (or so called 1st synchronous zone), since 1996 in synchronous operation with the CENTREL system (Czech Republic, Hungary, Poland, Slovak Republic), since 1997 in synchronous operation with three (Maghreb) countries of North Africa and, since 2002 in trial synchronous operation with the "Burshtyn Island" (the westernmost part of Ukraine).
2. The 2nd synchronous zone (part of Bosnia-Herzegovina, FYROM, Greece and FR Yugoslavia) in synchronous operation with Albania and in the test operation with Bulgaria and Romania.

In the meantime, not only the above mentioned extensions of the UCTE synchronous area took place, but the UCTE system still remains in the focus of the liberalization process of the European electricity markets. Today UCTE members are 37 TSOs from 23 European countries but the UCTE synchronous area(s) cover also three interconnected countries in North Africa with totally more than 200000 km extra high voltage circuit length (above than 200 kV) and approximately 450 million people with consumption of 2700 TWh served by one of the biggest and most secure synchronous system in the world.

### **2.1 UCTE re-connection and post-reconnection phase with specific problems indicated**

During this period the re-connection of both synchronous zones was UCTE's top priority, but despite a declared support, emphasized with the opening of the electricity markets as a major driving force, the realisation of the re-connection was hindered for long years, mostly due to the non availability of a practical international financial support for the implementation of the needed key infrastructure projects. Following favourable external events (as the "first step" securing financial resources for reconstruction of key facilities – in Croatia by domestic funding and in Bosnia-Herzegovina by international funding), the decisive phase of re-connection is under preparation also within UCTE bodies since 2002. This necessity of co-ordination of all actions to be taken along the whole interface (from Adriatic to Ukrainian Carpathian mountains) between both UCTE synchronous zones (including new partners - Bulgaria, Romania and Burshtyn island) is obvious from the extent of the UCTE re-connection process which makes it one of the most challenging and complex processes comparable to significant extensions of synchronous area in the past (see Fig.1).

Several different studies and investigation activities were made in the meantime, trying to assess different scenarios for the re-connection in order to enable smooth realisation of the re-connection process without endangering system reliability or stability (both globally and locally). Following increase of public sensitivity for such issues during last year, this is now more important than ever before.

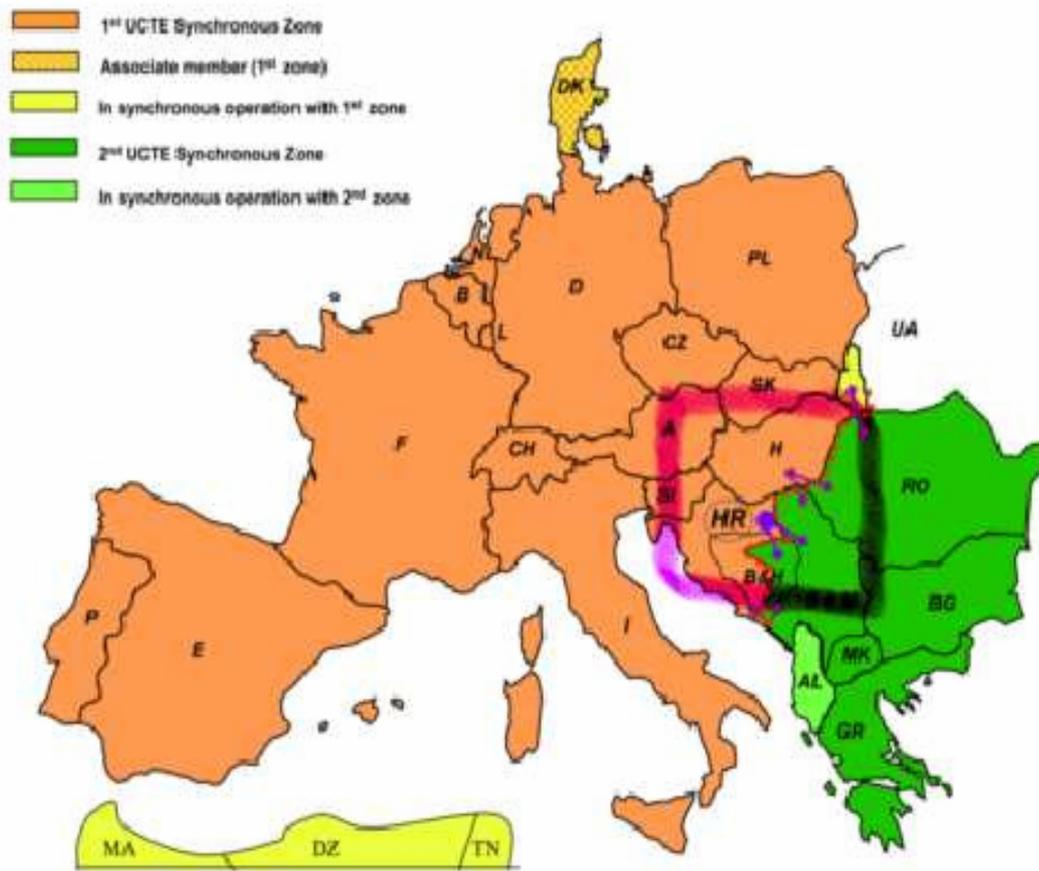


Figure 1 Two synchronous areas of UCTE system (including «interface» between them and main links for re-connection) with marked area represented in Figure 2.

In that respect serious disturbance that occurred in central part of UCTE power system last summer (exactly between the blackout in North-east America and the blackout in Italy) bringing it very close to wide spread blackout (with seven countries involved) pinpointed also one other aspect of NPP role in the grid. Apart of the fact that the initial cause of the disturbance was forced outage of one NPP the most serious problem that aroused during this disturbance was voltage instability that resulted with initial stage of voltage collapse in some parts of the affected grid. Later analysis clearly showed that in a broad area of the UCTE grid there are not enough strong nodes in 400 kV grid between NPP's Krško, Paks and Bochnice/Mochovce. Since the number of long 400 kV lines in rather big area, without sufficiently strong nodes for keeping voltage stability at sufficient level under disturbed operational conditions, will increase even more after the reconnection of present two UCTE synchronous zones (in the east first, and only, NPP's are Kozloduy and Chernavoda) this issue has to be dealt with attention (see Fig. 2). Also during preparation and implementation of multilateral re-synchronisation program appropriate sequence of switching and procedures will be determined to cope with the noticed problem.

This is of particular concern for Croatian grid due to its central geographical and electrical position in the area affected. The fact that Croatian high-voltage grid has extremely interconnected character is in this situation not helpful.

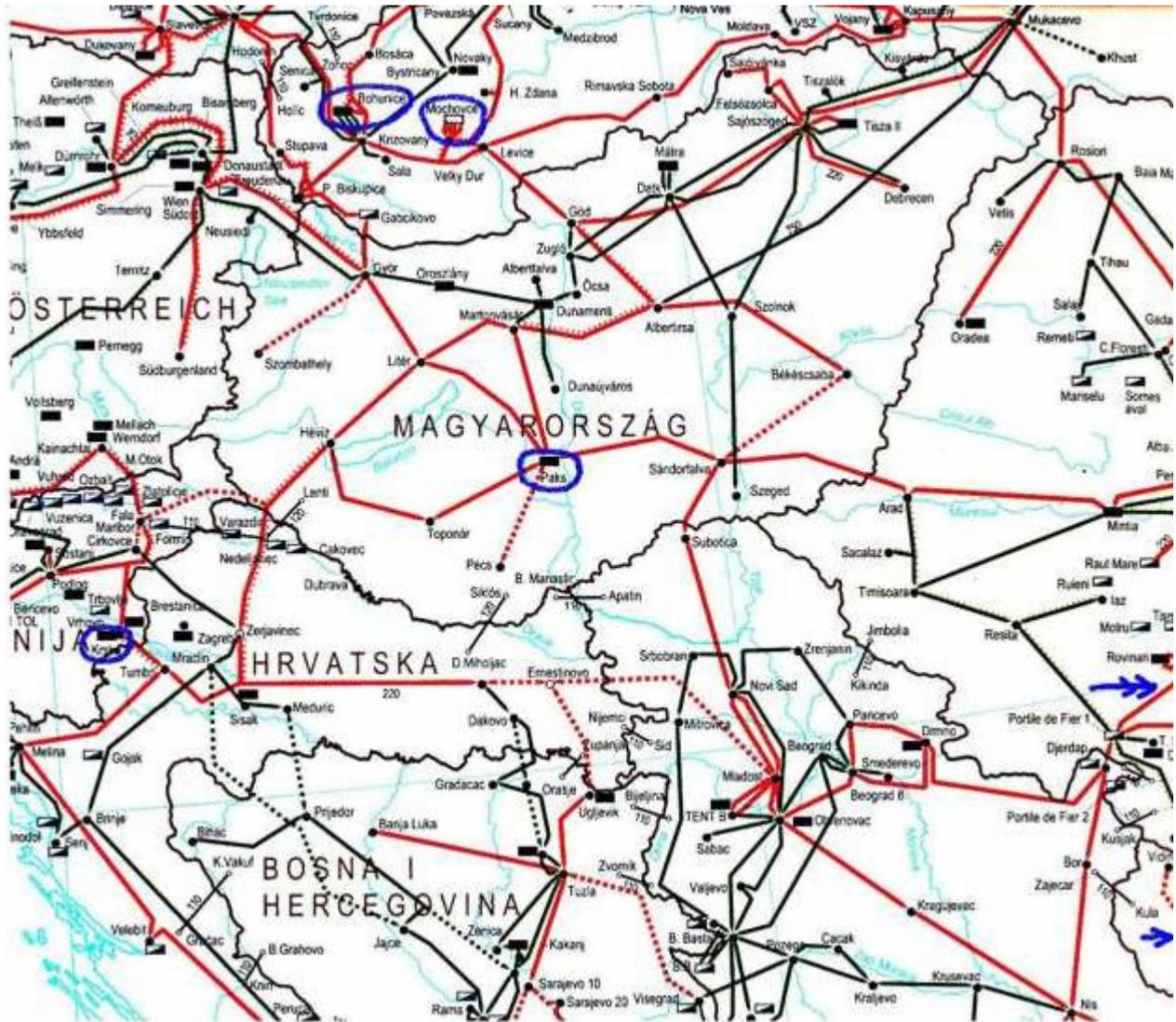


Figure 2 Part of UCTE grid in Central and Southeast Europe with marked NPP's

## 2.2 UCTE system development and nuclear safety

UCTE faces simultaneously several requests for further extension of its synchronous area - from Turkey, North Africa/Near East and interconnected systems of former USSR (UPS/IPS). Due to the different features of these systems and also compared to previous extensions of UCTE, and the fact that UCTE already covers largest synchronous area in the world, redefining of strategies used for previous extensions of UCTE synchronous area is on the agenda.

Nuclear issues significantly influence only one of these potential extensions, but this is the case with the biggest one – UPS/IPS. Although also in other cases UCTE as today (only) TSO organisation cannot take decision on extension of synchronous area completely alone, since it affects also the other stakeholders, UCTE is clearly in “driving seat” of the processes. In the case of UPS/IPS request for synchronous interconnection with UCTE this is very much affected by additional issues arising from *EU-Russia Energy Partnership* where the question of nuclear security plays dominant and very sensitive role. Nevertheless, comprehensive study on the technical (grid) issues of potential synchronous interconnection with UCTE - UPS/IPS will be launched this year according to the agreed Terms of references, but even in the case of positive results it still may not be enough for the implementation due to other preconditions that have to be fulfilled, where to opinion of the most stakeholders involved, exactly the question of demanded nuclear safety will be the hardest one.

### **3 TOWARDS NEW NUCLEAR POWER PLANT'S INVESTMENT DECISIONS**

Future role of nuclear power generation in general and particularly in European “power mix” is a popular topic not only among nuclear experts. One of the rare available tools for assessing future power balance in European grid based on verified data and procedures, “UCTE System Adequacy Forecast” recently extended for the first time to the longer horizon (2004-2010), warns on potential deficit in electricity generation by 2010 unless firm investment decisions are taken soon. Although this publication does not “advertise” any fuel source, still concerns about the impact of environmental demands to the forced closures of significant number of large combustion plants (with relevant Directive coming into force in 2008) and about specific problems arising from increasing share of renewables (predominantly wind power generation) are set out.

As practical proof of relevance for “UCTE System Adequacy Forecast” it can be mentioned that previous edition repeatedly and clearly warned about serious consequences for Italy if the trends in power balance will not change. This case was put on the top of warning (not the only one) also at the presentation made on FF in July 2003.

As it is general knowledge for investment decisions in electricity generation, several preconditions have to be met. Let us briefly address two of them.

#### **3.1 Siting**

Logical consequences of the reasoning set out under 2.1. would be, at least planning of, construction of power plant sufficiently strong to, among primary tasks, support 400 kV grid. Without any doubt, nuclear option will be eligible for such role.

However, it is often objected that construction of new nuclear power plants (NPPs) would be unreasonable, both from technical and economical points of view, for power system with characteristics like Croatian one. However, due to development of wider range of different reactors that make feasible also the construction of (relatively smaller) units, but also due to the changes on (European) electricity markets, that bring new values and opportunities, outdated, such objections could be disputed as old stillish.

The issue of siting for any power plant in respect to high voltage electricity grid is of mutual influence. It is even more emphasised in case of bigger NPP's units. Looking back situation in Croatia, it could be observed that the connection of NPP Krsko to Croatian grid introduced first double circuit 400 kV line in our grid. But also, cancelled NPP Prevlaka left trace in layout of Croatian grid leaving location for future 400 kV switchyard Veleševac (today still only junction point / “crossing” of the internal 400 kV lines). With completion of the reconstruction of high voltage lines under Žerjavinec and Ernestinovo Programs of Reconstruction, Croatian 400 kV grid will be suitable for connection of NPP.

#### **3.2 Legal preconditions**

In respect to security of supply issues and future of nuclear power generation under present regulative framework of most European countries it is needed to comply with connecting conditions (and other stimulations) from national grid codes where different approaches could be observed.

The one of the key documents in the electric power system liberalization is the Grid Code. The document defines relations, behaviour and operation of all entities/users in the electric power system. It creates technical basis for proper electricity market functioning while ensuring sufficient level of both reliability of system operation and security of supply. In practice the national Grid Codes differs partially due to different power system characteristics, tradition, regulatory framework etc. The very important feature of national Grid Codes is possibility for their future improvement, primarily in terms of ensuring of their higher eligibility for use in given area.

Croatian experience in this respect shows also growing high-voltage transmission grid as a part of UCTE interconnected system with certain peculiarities. As such, Croatian Grid Code could be applicable for consideration of NPPs to Croatian transmission grid. Croatia finalised preparation of its national Grid Code without preferring any specific production plants (fuels) (Currently draft version is subject to approval). Some questions were raised to treat wind farms in a specific way by national Grid Code. If this

is to be done, then it is justified to take into account also conditions for connection and operation of NPP in Croatian power system.

#### 4 NUCLEAR POWER PLANTS WITH A VIEW TO CROSS BORDER TRADES

Among these issues definitely worth mentioning is relevant influence to both commercial paths and physical power flows, and also to exchange programmes between control areas and blocks. In this context there is also relation to cross-border transactions and mechanism applied to them. The one of the key issues that determine “free-of-charge” trading of electricity within internal electricity markets in Europe is CBT mechanism (Cross Border Trade).

CBT mechanism was proposed and continuously improved by ETSO (European Transmission System Operators), the Association of TSOs (Transmission System Operators) that deals with Internal Electricity Market issues, where among them CBT was recognised as the one of high importance. The basis for introducing ETSO CBT mechanism principles were related provisions of first EU Electricity Directive 96/92 and conclusions of Florence Forum as well, where the latter gathers all electricity stakeholders (EC, Regulatory Bodies, Ministries, TSOs, traders, consumers etc.) in order to ensure creation of Internal Electricity Market in EU.

CBT mechanism in general tackles with physical electricity exchanges produced in “one country” and delivered to “third country” over the transmission network of transited country. Final aim of establishing of the CBT mechanism is to compensate fairly those TSOs participating in CBT mechanism, whose transmission networks suffer from transits following trading arrangements among them, without distortion to functioning of national electricity markets. Therefore the key elements of CBT mechanism, fully in line with the new Electricity Directive provisions, are as follows: fairness, transparency, non-discriminatory, non-transaction based (the cost of trading is not distance depended) and cost reflectiveness.

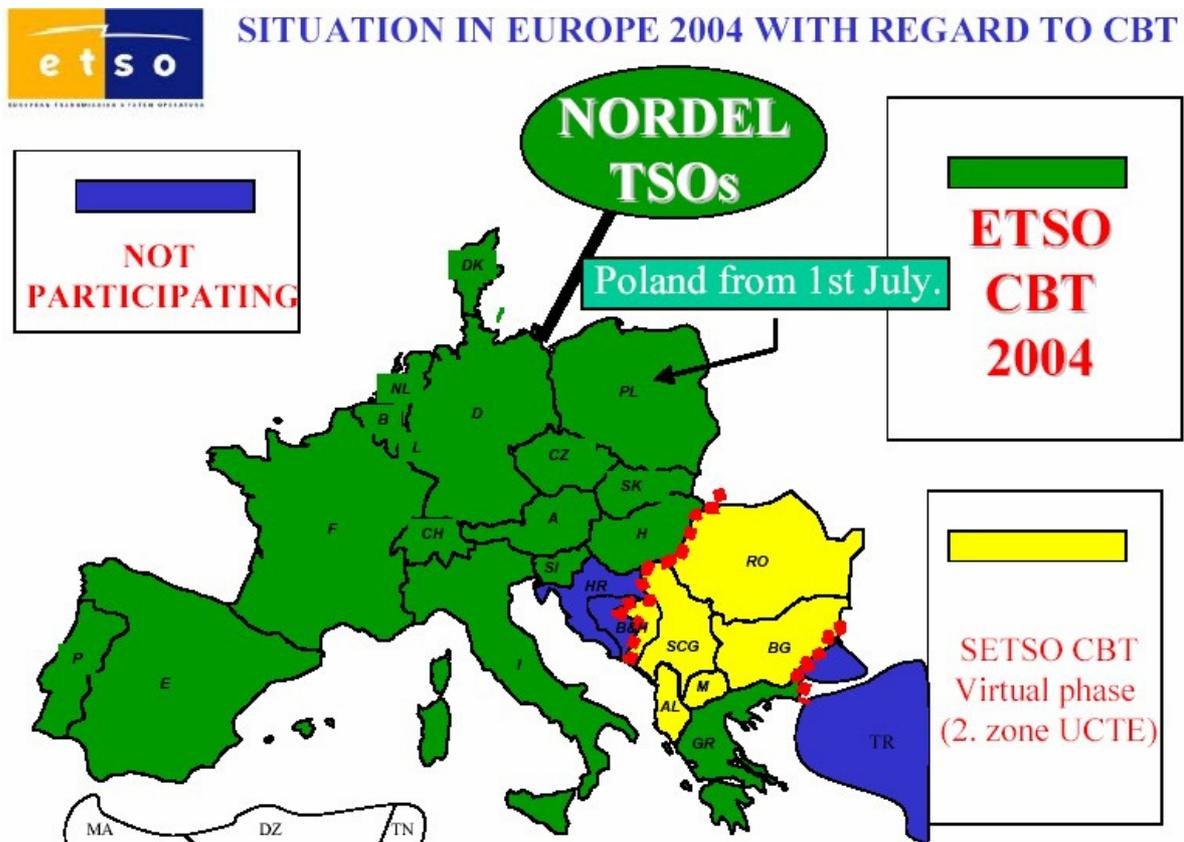


Figure 3 Area covered by ETSO and SETSO CBT mechanism (SETSO CBT from 1<sup>st</sup> July possibly on real basis)

Following intentions to create Regional Electricity Market in SEE (Croatia signed Memorandum of Understanding), taking into account the relevant conclusions of previously held Athens Forums, it is expected that real CBT mechanism is to be introduced in SEE countries from July 1<sup>st</sup> 2004 under the name SETSO CBT. (see Fig. 3). This “regional” SETSO CBT (currently in virtual phase – so called “dry run”) will follow the same principles of ETSO CBT mechanism where applicable due to different level of “unbundling” of power sectors and other difficulties. During 2004, Croatia and most likely entire B&H will not participate in any of CBT mechanisms, due to separated operation of the UCTE transmission networks.

Application of CBT means that electricity is traded as if no borders exist between countries participating within the same CBT mechanism. Although TSOs are interested only to extent of protecting its own interest (to be compensated for increased costs of their transmission networks due to transits), the CBT benefits the present trading companies in terms of decreasing of overall trading costs.

Since two CBT mechanisms are likely to exist after July 1<sup>st</sup> 2004, it is important to consider positions of HEP as power utility which imports its own half of NPP Krsko production in normal operational conditions. Having in mind that Slovenia participates in ETSO CBT mechanism, and that NPP Krsko is located within Slovenian national territory, it is very (apart of political reasons) important to analyse the effects for Croatia (HEP) from CBT points of view. There are two options available: participation of Croatia within either ETSO CBT or SETSO CBT. In first case, nothing will be changed compared to present, but in case Croatia participates in SETSO CBT mechanism, then following CBT mechanism provisions, the peculiarity could be that each imported MWh from NPP Krsko to Croatia should be paid (1 Euro/MWh) to HEP TSO by the entity which imports electricity from NPP Krsko. This will be even doubled in case that ETSO CBT participants agree the idea of introducing new extra 1 Euro/MWh export fee to exported electricity. Therefore there were attempts to treat such exceptional cases specifically (like hydro power plants located in vicinity of borders) but with a lot of problems. Similar is with imports of electricity produced in Hungary and other ETSO CBT countries. To find proper solution for NPP Krsko, special operational Agreement should be signed between Slovenian and Croatian counterparts, that most likely will not be “in spirit” of ETSO CBT mechanism.

Having in mind above, it appears logical to seek for such solutions that will not create any additional financial obligation to Croatia for imports of energy from its own capacity, where NPP Krsko is of biggest importance. Solution could be that Croatia becomes part of ETSO CBT mechanism. Final aim of all traders is to have same CBT mechanism for entire Europe without trading constraint among all countries.

## 5 AS CONCLUSION

The article indicates the new position of NPP facilities in reconnected UCTE grid. The UCTE reconnection will benefit the longterm perspective of NPP new construction, making it more competitive business to other present power production technologies Europe-wide.

The article introduces some broader insight to CBT mechanism. It could be noticed that existence of same CBT mechanism for entire Europe will remove remaining obstacles to free trading of bulk of electricity produced in NPP nowadays. The latter is to be even more important in the longterm.

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