UCTE IPSUPS study

Feasibility Study:

Synchronous Interconnection of the IPS/UPS with the UCTE

Summary of Investigations and Conclusions

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Introduction

At the beginning of 2002, the Electric Power Council of the Commonwealth of Independent States (EPC CIS) expressed its interest in a synchronous interconnection with the power systems of the CIS countries and the Baltic States (IPS/UPS) to the power systems of the members of the Union for the Co-ordination of Transmission of Electricity (UCTE).

Therefore, the UCTE decided to conduct a pre-feasibility study in order to analyse the steady state load-flow [1]. After this was completed in 2003, the UCTE and the EPC CIS's Commission on Operational and Technological Coordination (COTC) agreed to launch a detailed feasibility study on the synchronous interconnection of the power systems concerned.

The project was carried out in close cooperation with a UCTE consortium and a group of companies from the IPS/UPS. A geographical overview and some key figures on the different synchronous systems in Europe is given in Figure 1.

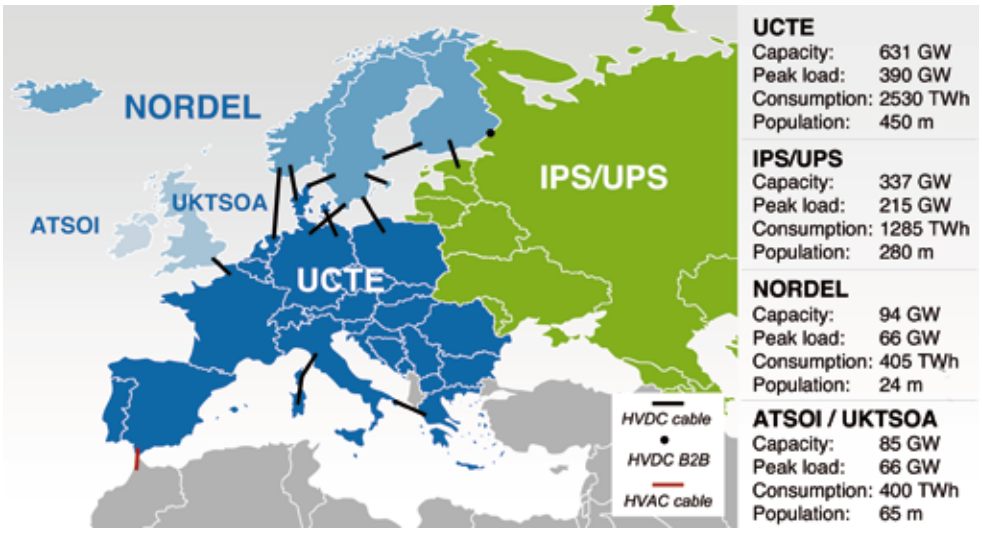


Figure 1:
Synchronous systems in Europe

The Feasibility Study is designed to answer three major questions:

- Is a synchronous interconnection of the IPS/UPS and the UCTE possible?
- What measures have to be taken in both systems?
- What are the associated costs?

The study is unique in its ambitions and scope. There is not an existing electricity system anywhere in the world at present which spans more than 10 time zones and that has different network structures, load characteristics and various generation patterns. More than 700 million people on two continents are served by the systems under investigation.

Although endeavours have previously been undertaken to examine the feasibility of an interconnection, the present study is unprecedented in regard to the resources employed and the advanced investigation methods and technologies applied. It is the first time that the dynamic behaviour of synchronously coupled systems has been investigated by using a merged dynamic study model of the UCTE and the IPS/UPS.

The Final Report provides an overview of the work performed during the period from April 2005 to April 2008, as well as presenting the findings and results of this study. A number of recommendations on further possible activities are also given in the report. The results of the project can be used as a basis for any further decision making by the stakeholders concerned in system development on either side.

Scope of Work

The main objectives of the study were to investigate the technical, operational, organisational and legal feasibility for an East-West synchronous interconnection of the transmission systems. It was also charged with identifying the necessary measures and associated costs involved in the implementation of the entire systems. The project work is a combination of analyses and power system simulations for two synchronously coupled systems without

enforcing regulations and standards of one system on the other. The initial priority for investigation was and is to maintain the current level of system security and reliability in the systems concerned. This presented a major challenge for the experts from both the IPS/UPS and the UCTE.

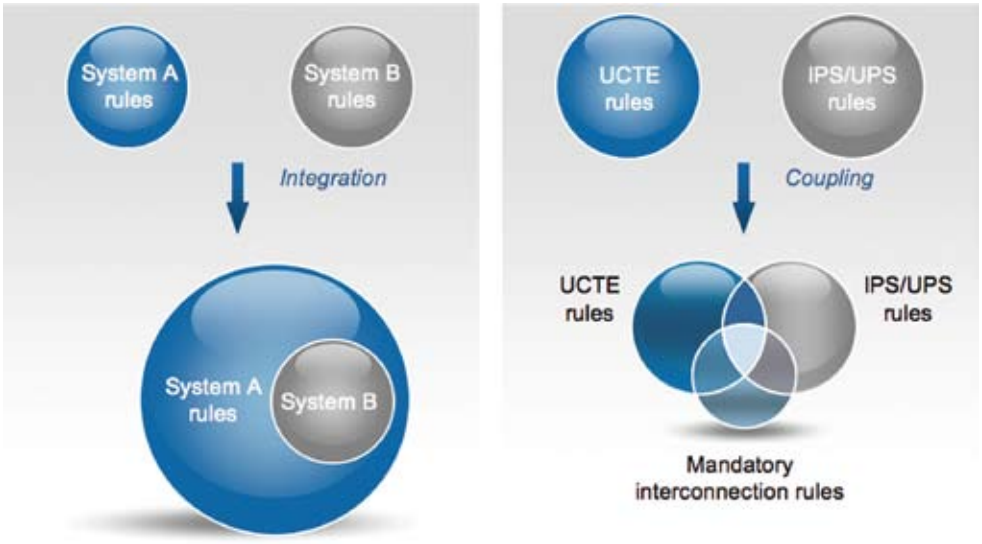


Figure 2:
Principles of system integration and system coupling

All power system extensions in the UCTE grid have up to now been based on two principles. The individual Transmission System Operators (TSOs) are committed to these. They require the adherence to a common set of standards for operating the interconnection and its development, as well as upholding the rules of the common electricity market. In applying these principles, relatively small power systems were connected to the UCTE in a step by step procedure by adopting the UCTE standards in their entirety for the operation and reliability of such systems.

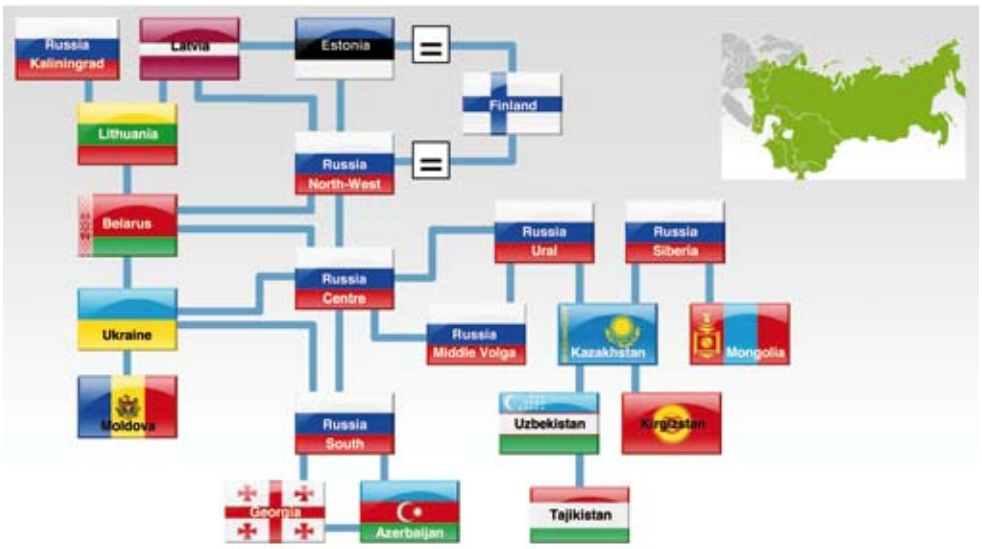
However, the marginal conditions for the present feasibility study are quite different from those applied to all former system interconnections. Contrary to the standardised UCTE *system integration* analysis procedures, this study has investigated the *system coupling* of two large electrical power systems, both having different regulations, standards and operating philosophies. Figure 2 illustrates the different principles of system integration and system coupling.

The two synchronous areas have been operated independently using different operating procedures and regulations for some considerable length of time. Therefore, the feasibility of the synchronous interconnection has not only to be defined in terms of the compatibility of technical performance, but also that of organisation and management within a consistent legal framework in order to ensure a secure and reliable interconnection. A mandatory set of technical, organisational and legal requirements needs to be defined in order to avoid any negative influence of one system on the other. However, the technical standards and internal regulating of each system will, as far as possible, remain unchanged providing that they do not have any negative impact on system security.

Project Organisation

Two consortia were established in order to carry out the study:
The UCTE-Consortium responsible for the project consisted of 11 TSOs from 9 countries, namely: E.ON Netz GmbH (Germany) – acting as the Consortium leader, ELIA System Operator S.A. (Belgium), MAVIR Hungarian Power System Operator Company (Hungary), Electroenergien Sistemen Operator EAD (Bulgaria), PSE-Operator S.A. (Poland), Red Electrica de Espana S.A. (Spain), Reseau de Transport d'Electricite (France), RWE Transportnetz Strom GmbH (Germany), Slovenska elektrizacna prenosova sustava, a.s. (Slovak Republic), National Power Grid Company "Transelectrica" (Romania) and Vattenfall Europe Transmission GmbH (Germany).

Figure 3:
Structure and member countries of the IPS/UPS



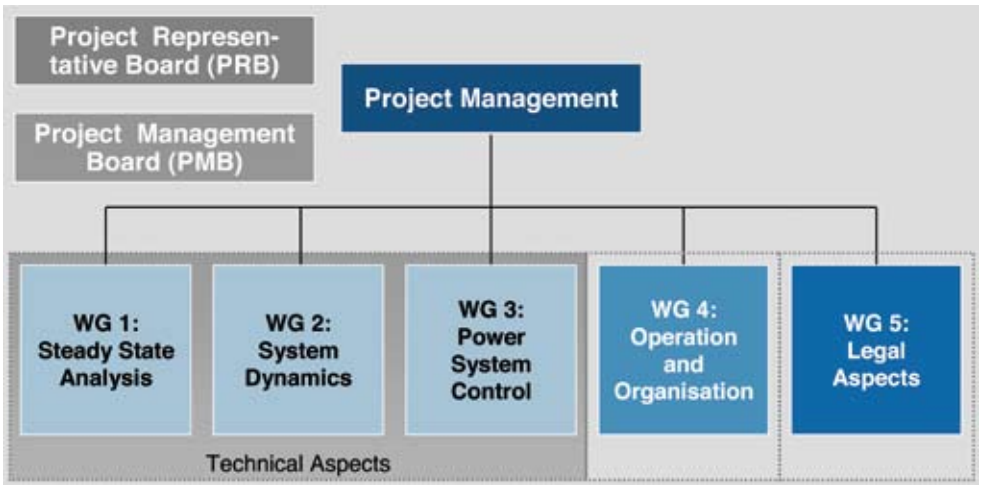
On the IPS/UPS-side, a group of 8 companies established a joint agreement for the project: Belenergo (Belarus), Eesti Energia (Estonia), KEGOC (Kazakhstan), Latvenergo (Latvia), Lietuvos Energija AB (Lithuania), Ukrenergo (Ukraine), Moldelectrica (Moldova) and the System Operator - Central Dispatch Organisation for the Unified Energy System of Russia (RAO UES). The latter had the leading function for the Eastern European partners. An overview of the structure and the IPS/UPS member countries is given in Figure 3.

The 3-year investigation was inaugurated in April 2005 by the signing of a Cooperation Agreement between both parties. The project is of significant importance in furthering progress on electricity issues. The European Commission, whose policy is to promote the creation of an open electricity market in Europe, is displaying considerable interest in the results of the study. The work of the UCTE consortium is co-financed by the Trans European Network (DG-TREN) programme run by the European Commission.

The Terms of Reference (ToR), prepared before the actual start of the project, included a detailed description of the scope of work and the study procedure. The project work was generally divided into three phases:

1. Data acquisition and system modelling;
2. Verification and simulation;
3. Assessment and results.

Figure 4:
Organisational structure of the Feasibility Study



The organisational structure of the project is shown in Figure 4. The study was performed at a working level by a group of experts from the UCTE and the IPS/UPS. Five working groups dealt with the sub-tasks of steady state analyses, system dynamics, power system control, operation and organisation, as well as the legal aspects. All internal and external UCTE activities were coordinated by the project management.

Further project entities were:

- A Project Representative Board (PRB) was responsible for the political communication and lobbying, and consisted of representatives from the European Parliament, European Commission, UCTE, EPC CIS, the Baltics, TSOs and IPS/UPS companies;
- A Project Management Board (PMB) was responsible for the steering of the project and deciding on major steps during the study. It also approved the progress and reports of the working groups. This joint board consisted of representatives from the UCTE and the IPS/UPS.

Allocation of Information, Data and Modelling

In order to deliver qualified results from the analysis work, the data allocation and modelling were the key prerequisites for the power system simulations within the study. In this respect, the obligations of both sides for the provision of data and models were stipulated in the Cooperation Agreement signed by the UCTE and the IPS/UPS: It was a common understanding that the quality of the simulation results truly depended on the quality of the input data. Therefore, providing the necessary data and information was a sine qua non condition for the successful completion of this comprehensive study.

The initial activities that followed the beginning of the project in April 2005, involved analysing the then current technical, organisational and legal status of the IPS/UPS. The *Questionnaire on Data Acquisition for the IPS/UPS* was agreed among the parties in June 2005. The questionnaire was based on earlier data allocation procedures that had been used in similar UCTE investigations. It consisted of a specification for the necessary input data on steady state and dynamic system simulations, as well as data for power system control, system operation and organisational aspects. A similar acquisition procedure for network data was applied within the UCTE. These procedures were so determined to ensure that the analyses were carried out under the required quality standards. The legal marginal conditions were issued in a separate legal questionnaire.

It evolved during the study procedure that the acquisition of data was the most complex matter entailed in this work. Although a certain amount of information was provided, it did not entirely meet the volume of the information required. Consequently, a compromise was arrived at that enabled the necessary input and accuracy of data to be supplied in time for the analyses to be carried out. However, for the purpose of achieving the provisions laid down in the ToR, the UCTE and the IPS/UPS made plausible assumptions where necessary or used data gained by experience or information from relevant literature.

Based on the current separate synchronous areas, models for the power system simulations were prepared by the UCTE and the IPS/UPS, respectively. Both parties were responsible for their respective model preparation and for their individual validation procedures. These were carried out by an interactive comparison of real measurements and system simulations. After the setting up of the individual models, they were merged in order to create joint simulation models for evaluating the impact of a possible synchronous coupling. The UCTE and the IPS/UPS focussed their analyses on their individual synchronous systems in line with their knowledge and skills.

The simulation models were prepared using the best available information that could provide a detailed representation of the system structure in the interface area. In cases where data was not available or not permitted due to (e.g. legal restrictions) equivalent models were subsequently used and validated.

Analysis, Findings and Results

A review of existing transmission system studies [1, 2, 3, 4, 5] was performed in each of the individual working groups as an initial step prior to the technical and organisational investigations. The IPS/UPS gave a general overview of their principle structure, key figures and the global operational control behaviour. This was presented in an *IPS/UPS System Survey* which was finalised in February 2006.

In parallel to the data acquisition process, the installation of a Wide Area Measurement System (WAMS) – similar to the one operating in the UCTE – was initiated in the IPS/UPS synchronous area [6]. This transient measurement system was a prerequisite for the validation of the dynamic simulation models. One was able from early 2007, to observe the dynamic system behaviour of the whole synchronous IPS/UPS area and receive measurements, for example, following disturbances in the grid. Some 26 measurement devices had been installed in the IPS/UPS up to April 2008. Around 50 measurement devices are currently installed in the UCTE synchronously operating systems.

In order to define the necessary technical specifications, a *Technical Glossary* was prepared which was also used as a basis for common communication within the study.

Figure 5:
Interface tie lines under consideration

The nine tie lines (three of 750 kV, four of 400 kV and two of 220 kV) considered as being available for the coupling itself are shown in Figure 5: Eight links connect Ukraine with its Western neighbours and one 400 kV line links the transmission system of Moldova with Romania.

The transmission lines and the "MIR" power system were operated as an integral part of the IPS/UPS up to 1995, prior to Poland, Hungary, Slovakia and the Czech Republic being synchronously interconnected to the UCTE. These lines need to be refurbished and partly reconstructed in order to have a synchronous coupling between the UCTE and the IPS/UPS.

Due to their independent development in the past, major differences in the system structure and operation philosophy exist between the UCTE and the IPS/UPS. The UCTE system is developed using the n-1 contingency as the planning criterion, whereas in the IPS/UPS, this criterion is met with the support of a set of operational actions mainly comprising of load and generation shedding.

The findings and results of this study essentially confirm the conclusions arrived at in previous projects. However, this study also enables the previous results to be updated and form a broader context covering the respective organisational and legal tasks, as well as the relevant frameworks. Consequently, an additional value of this project has been

the setting-up of merged simulation models for the steady state and dynamic system simulations. The comprehensive dynamic studies conducted during the project have never previously been performed with such large simulation models. This underlines the fact that dynamic effects reveal the most limiting criteria for system extensions in preference to steady-state load flow limitations.

As to a possible synchronous coupling of the UCTE and the IPS/UPS, the findings and results as well as the impact of a synchronous coupling on the UCTE system can be summarized as follows:

Results from Steady State Analysis

The models for the steady state and load flow analyses reflect the planning status in 2008 for both synchronous areas. The results of the steady state load flow calculations are:

- The parties applied different methodologies and models for the load flow analyses in their particular synchronous areas depending on the variance in the planning and operational criteria. The calculations revealed that in most cases, the admissible power flows in the IPS/UPS are significantly higher than those limits identified in the UCTE.
- As the main load flow paths across the interface run through the Ukraine, the load flow distribution is very sensitive to the generation pattern in Ukraine and its direct Western neighbours.
- In most cases, the power transmission is limited due to the internal congested sections in each synchronous zone. Short distance power transfers between the systems in the interface zone reached a secure power transfer in the East-West direction of about 1000 to 3000 MW. The calculated West-East transfer is limited to 1000 MW.
- The simulations clearly proved that in the synchronously coupled system structure, the capacities for long distance power transmissions are rather limited. In about 50% of the simulated long distance transmissions (e.g. Russia – Germany or Russia – Italy) the transferable capacity across the interface was less than the mandatory transfer capacity for the provision of control reserve. In order to guarantee system security in the UCTE after a synchronous coupling to the IPS/UPS, the UCTE grid must be improved or the present available capacity for the market in the UCTE needs to be reduced. A longterm analysis of market developments needs to be initially carried out in view of the requirement for a realistic allocation of the investments involved.
- The limited inter-system transfer capacities within the UCTE are caused by a high utilisation of the UCTE transmission systems. The available inter-system transfer capacities in the UCTE are also further reduced by the priority for renewable (wind) generation.

Dynamic System Simulations

The dynamic simulation models were individually set-up and validated for each synchronous area based on the load flow models. The UCTE dynamic model has been verified and developed over the last fifteen years and shows a good correspondence between real system measurements and simulation results [7, 8, 9]. The IPS/UPS dynamic model was initially set up for the purpose of this study. This model was verified against recordings of actual disturbances by a Wide Area Measurement System installed in the IPS/UPS during the period 2005-2007.

Both models were merged in order to study the impact of a synchronous coupling on small signal and transient stability.

The results of the model analyses show that the synchronous coupling causes structural based oscillations. Figure 6 shows an example of the generated power oscillations in the synchronous coupled systems after a major disturbance in the North-Western part of the

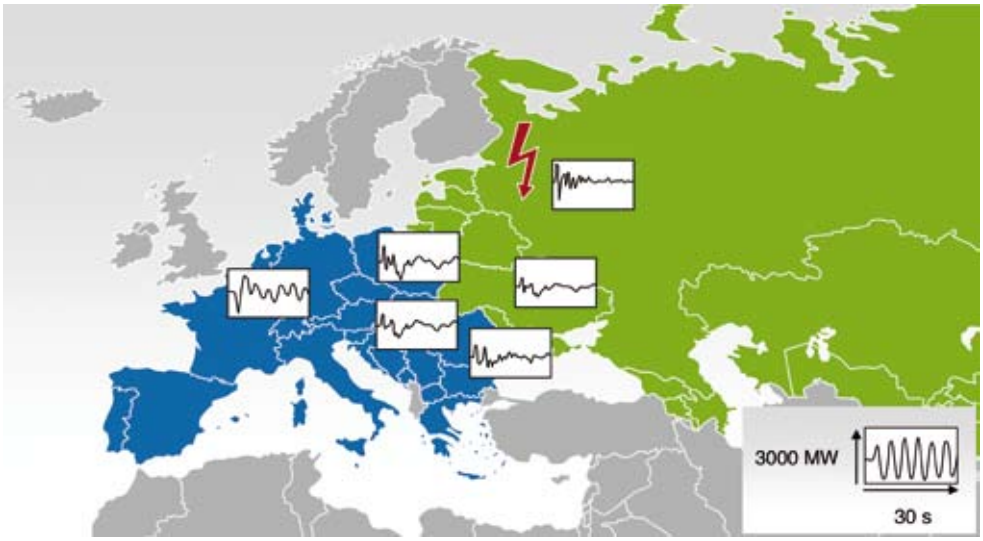


Figure 6:
Profiles of wide-area power oscillations after a severe disturbance in the IPS/UPS

IPS/UPS. These oscillations create a new and poorly damped frequency mode of 0.07 Hz, and thus require special damping measures in the interconnected systems. The oscillations are of electromechanical origin, i.e. the rotors of the machines in the East part of the system oscillate against the rotors of the machines in the West. The final solution to adequate damping measures for the detected low frequency mode (e.g. voltage control or speed governor based) requires further development of the IPS/UPS dynamic model.

The main findings and results of the transient stability analyses are:

- 3-phase short circuits applied in the interface region, which were conceptually cleared, probably do not jeopardize the transient stability of the coupled systems.
- The analyses of more severe events revealed serious potential consequences for the synchronously coupled system of the IPS/UPS and the UCTE. These are in the first instance of a structural nature that needs both sophisticated countermeasures and further research in this respect.

Analyses were carried out following the disturbance in the UCTE on the 4th November, 2006 [10] under conditions of a synchronously coupled IPS/UPS grid. This showed that the coupling of the IPS/UPS and the UCTE might not ensure reliable support between the systems in such emergency situations. Instead, it could worsen the situation due to severe stability risks. The simulation demonstrated the technical drawbacks of large synchronously interconnected systems when considering the survivability of the systems concerned in the event of major incidents.

Economical benefits that are mainly associated with the extension of power systems are to some extent countervailed by technical drawbacks. Priority has to be given to preventing the unabated propagation of disturbances and their consequences throughout the interconnected system.

Power System Control Analysis

The synchronous coupling of the two transmission systems leads to reduced frequency deviations after a large, sudden loss of power. This is a result of the mutual cooperation, which is automatically activated by primary control within the whole synchronous area. The amount and distance of the related power flows increase in proportion to the capacity of the synchronous area and its geographical extension, respectively.

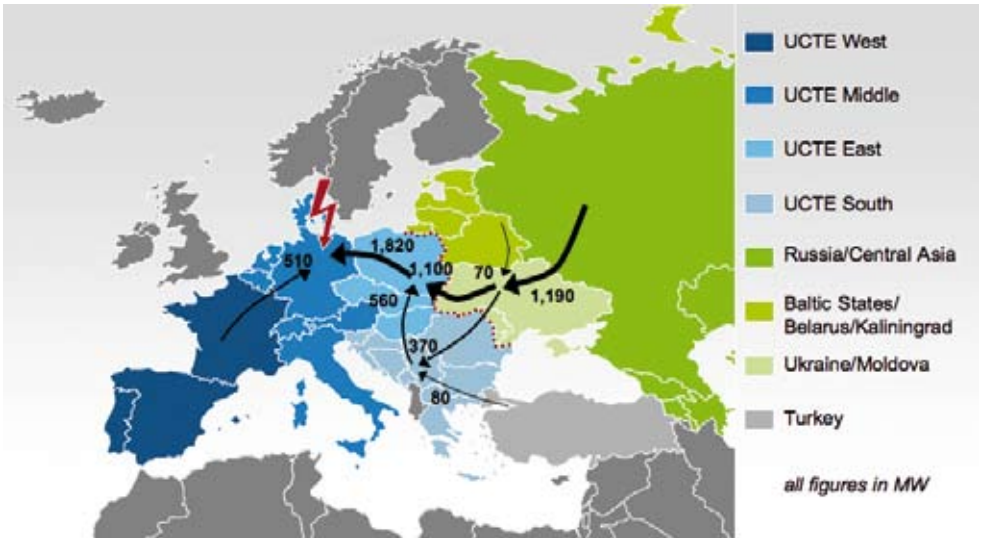


Figure 7:
Control power flow after an outage of 3000 MW in UCTE

The installed power and the control reserve in both systems are in the same range. Figure 7 illustrates the distribution of the control power flow after a loss of 3000 MW generation capacity in Germany. In the case of a 3000 MW outage (the dimensioning amount of reserve power in the UCTE system), a ~1500 MW regulating power flow will cross the interface area.

This flow has to be managed in a secure manner. Hence, free transfer capacity has to be maintained at any time in order to allow this regulating power to flow through the interface in both directions.

Therefore, a synchronous coupling of the UCTE and the IPS/UPS would require the consideration of an additional Control Power Flow Margin (CPFM) for determining the Available Transfer Capacities (ATC). The CPFM is not incorporated in the Transmission Reliability Margin (TRM) according to definitions applied in the UCTE at the present time.

Thus, in order to respect system security, the required amount of CPFM has to be determined and the ATC has to be reduced correspondingly for the market across the IPS/UPS-UCTE interface.

Operation and Organisation

The organisational aspects (i.e. operational procedures at the technical interface, the coordination of strategies and methods among the interface TSOs, etc.) are considered as a bridge between the technical measures and their implementation, as well as for the necessary legal framework.

The IPS/UPS does not have a formal set of common technical standards that can be applied to the entire synchronous area. Hence, the "*UCTE-IPS/UPS Interface Procedures*" were initially based on the UCTE Operation Handbook. This was used as a reference check list for elaborating the interface rules and regulations, as well as for the corresponding EU legislation.

The investigations have considered the present system control structure in the IPS/UPS: The overall frequency control function is currently being carried out by the Russian system operator, while other systems are operated by means of agreed power balances with or without the correction of frequency deviations. The key proposal from the organisational and operational viewpoint is to apply the UCTE control block structure to the IPS/UPS, where the IPS/UPS is wholly acting as one single control block.

There could be changes in the future to the IPS/UPS control block structure (e.g. the IPS in the Ukraine and the Moldavian system could form a separate control block). If changes were made to the present IPS/UPS structure, such changes could not be taken unilaterally and should be mutually agreed upon.

The IPS/UPS control block operator (CBO) is responsible for the coordination of the members in the IPS/UPS. It would act as a control block coordinator with one of the main coordination centres in the UCTE (Brauweiler, Laufenburg, etc.). A decision has to be taken on the control block structure and the responsible CBO for the IPS/UPS synchronous area before the concept of a synchronous coupling can be further developed.

In order to be able to act as CBO, the responsible IPS/UPS company needs to adapt the current secondary controller (pure frequency control) into a power/frequency controller. This implies that the tele-measurement of the real-time power flows must be integrated into the new power-flow secondary controller.

Therefore, legally binding commitments need to be prepared and agreed upon with all operators involved that can provide adequate solutions to these issues. These include such issues as inter-area cooperation agreements with the TSOs, legal rules covering system reserves, as well as specific contracts with generators in regard to power system stability, etcetera.

Legal Aspects and Pre-Conditions

The legal work initially comprised of an analysis and comparison of the legal systems applicable within the UCTE and the IPS/UPS (*Legal Questionnaire*). It appeared from the Legal Questionnaire that there are some quite substantial differences between the two legal systems regarding:

- Harmonisation of rules and regulations;
- Binding nature of rules and regulations;
- Organisation of markets.

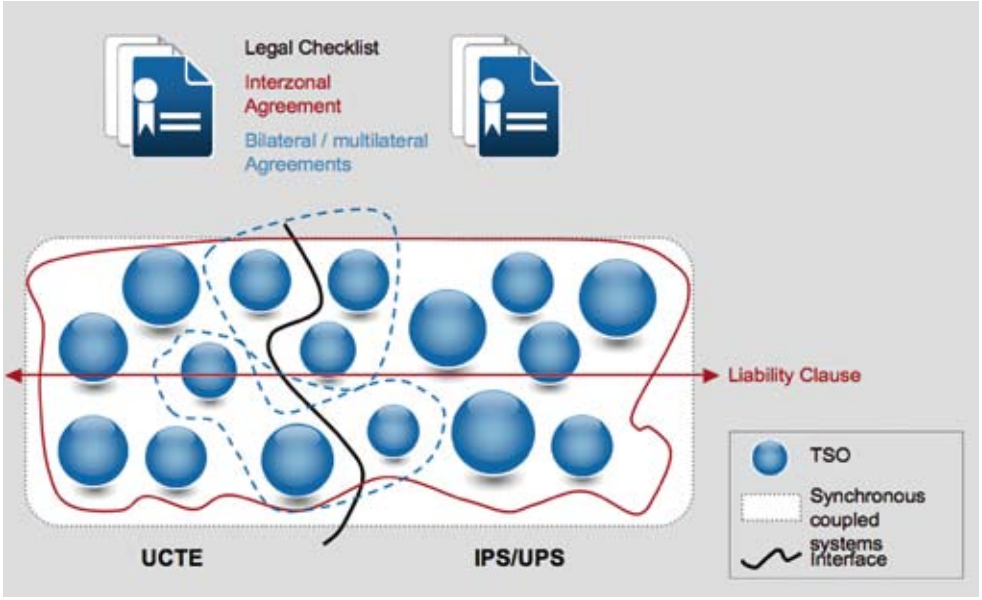


Figure 8:
Legal framework for a synchronous coupling

A tool was developed to take these differences into account, namely, the *Legal Checklist*. This identifies issues that can only be solved by contractual means and those that cannot be solved by purely contractual means, such as, those requiring regulatory or political actions. The Legal Checklist provides a useful list of "To Do's" should the synchronous interconnection actually be realized.

In reality, the so-called "multi layer contractual framework" addresses the legal needs of the study. The principle structure of the legal framework is shown in Figure 8. The proposed contractual framework is "multi layered" as it offers several contractual "layers", namely:

- An "Interzonal Agreement" (IZA) aimed at addressing the needs on a global level for the whole synchronous interconnection; and
- A series of "Bi- and/or Multilateral Agreement" (BLA/MLA) designed to address the legal needs of the interface (e.g. at a local level).

Both types of agreements contain standard clauses that can be found in most contractual relationships. They each cover the standard rules for synchronous interconnections. The BLA/MLA focuses on the interface, whereas the IZA spells out the general principles applicable to the whole synchronous interconnection. The BLA/MLA, while providing rules for the interface, implements the general principles in the IZA. The IZA also contains organisational rules which aim at adapting over a period of time, the contractual structure for developing the synchronous interconnection.

The multi layer contractual framework is headed by the *Liability Clause* that aims at preventing and managing risks/incidents. The Liability Clause contains, among other things:

- A general limitation of damage;
- The creation of a judiciary body (the "Liability Committee") whose function would be to decide upon both technical and legal matters arising from cases of incidents;
- A procedure for submission exchanges.

Finally, the *Case Study* validates the above mentioned legal/contractual framework. It signifies that the framework is coherent and fit to address all types of situations, ranging from a simple incident to a worst-case scenario (e.g. a major incident spreading over the entire synchronous interconnection). Synchronous interconnections imply more complex legal provisions than an asynchronous interconnection, due to the synchronism requirement for the initial method of interconnection. However, taking into account the factors set down in the Legal Checklist, it is evident that the aforementioned framework properly addresses the legal needs of the contemplated synchronous coupling.

Allocation of Investments

As an initial step, the necessary investments for refurbishing the existing equipment and interface lines have been identified. It has to be borne in mind that even if the lines and substations already exist, they have not been in operation for several years since the disconnection of the former CENTREL countries, as well as those in Romania and Bulgaria. The necessary refurbishments of the interface lines are estimated at a total sum of € 280m, of which € 180m is dedicated to the refurbishments in the IPS/UPS interface countries.

In order to improve the congested areas in the UCTE, results from a probabilistic analysis have estimated that the necessary investments in the UCTE amount to € 240m.

Additionally, the synchronous coupling requires an exchange of operational data between both synchronous blocks. Therefore, additional communication equipment has to be installed and the protection schemes have to be partially updated. These measures are estimated to come to some € 14m.

System Coupling by High Voltage Direct Current (HVDC) Technology

The main focus of the project was on the investigation of a synchronous coupling between the IPS/UPS and the UCTE. The study has however also considered the possibility of coupling both systems via High Voltage Direct Current (HVDC) technology. This could provide backing for the creation of a joint electricity market platform between the UCTE and the IPS/UPS. The construction of HVDC back-to-back links between the interface countries might also be considered in the medium term.

HVDC technology has been successfully proved in various specific applications worldwide. The major difference of a DC solution compared to an AC coupling concerns the decoupling character of the link. When system disturbances occur, neither a dynamic interaction between the coupled systems, nor the factor of the CPFM (which reduces the installed interface capacity) has to be considered, as is the case with a synchronous coupling. Additionally, DC links allow the control of the power flow which is used for discharging the grid under overload and emergency situations. Ultimately, due to their technical features, back-to-back links could result in an "easier to realise" perspective. However, in order to assist further decisions relating to a possible DC-coupling of the IPS/UPS and the UCTE, further detailed investigations will be required in addition to any bilateral agreements and studies. Although no specific system simulations were carried out by means of DC coupling of the IPS/UPS with the UCTE, the investments for DC coupling have been determined. The specific investment costs estimated for a back-to-back link are in the region of € 12.5m per 100 MW. Typical unit sizes for conventional HVDC back-to-back links vary between 600 and 1000 MW. Assuming that three back-to-back stations of 600 MW each would be placed at the interface the investment for these stations – not considering costs for network improvements – would amount to € 225m.

Further Studies

The study reveals the need for further investigations into the IPS/UPS in order to refine and endorse the recognized measures and requirements. Major areas identified for further studies are:

- The verification of the IPS/UPS dynamic performance by means of observations being carried out over a longer period. It should be followed by a dynamic model set-up using a parameter identification for the control device models. This allows in-depth simulations on advanced dynamic models that are able to ensure reliable simulation results.
- The analyses of emergency situations in the IPS/UPS caused by severe disturbances that have not been experienced by the system up to now. It is recommended that a simulation model is prepared which sequentially simulates the control automatics and functions after severe disturbances, as well as any necessary restoration measures. The purpose of this would be to adapt and harmonize the current existing operational guidelines, defence and restoration plans for both synchronous areas.
- The analyses of technical and organisational aspects within the IPS/UPS based on the assumption that several control blocks may eventually operate in the IPS/UPS, compared with the single control block status at the present time. As the load flow distribution in the interface area is very sensitive to the generation pattern, the distribution of the control reserve may significantly influence the viable power transfers.

Feasibility Assessment and Conclusions

The conclusions sum up the essential findings of the Feasibility Study, which have been commonly agreed and shared by the study partners. This now allows stakeholders to initiate further activities. Although the conclusions indicate that a synchronous coupling appears technically viable, it must be considered as a long-term option. The findings underline the overall complexity of a synchronous coupling, firstly, in the context of system security and overall reliability, but also from the standpoint of its operability in the underlying electricity markets.

The conclusions of the Study are:

1. The UCTE-IPS/UPS Feasibility Study was completed after a 36 month investigation in accordance with the Cooperation Agreement and the Terms of Reference agreed between both parties.
2. The UCTE-IPS/UPS Feasibility Study investigated the synchronous coupling of the IPS/UPS and the UCTE power systems taking into consideration the key technical, organisational and legal aspects. The project itself is unique in respect to its ambitions, geographical extension and the scope of work. Although endeavours to analyse a synchronous coupling have previously been undertaken, this investigation is unprecedented in regard to the resources employed, the skilled experts involved and methodologies applied. The Study has delivered substantial achievements for the experts and company executives of both systems, in terms of working methods, tools implemented and the building up of mutual understanding.
3. The Study provides verification that a synchronous coupling between the UCTE and the IPS/UPS is feasible. This can be achieved by implementing a number of technical, operational and organisational measures, as well as by establishing the legal framework that was identified during the investigation. As the implementation phase for carrying out the identified measures and conditions is recognized as a long process, a synchronous coupling should be considered as a long term perspective. In order to achieve a joint, world-largest electricity market platform between the UCTE and the IPS/UPS synchronous areas, the construction of asynchronous links may also be considered for system coupling. This certainly deserves further consideration and investigation by the stakeholders concerned.
4. The transfer capacities across the interface in the steady state analyses indicated that the potential power exchanges between the UCTE and the IPS/UPS are limited. This is mainly due to the internal congestions in the systems concerned. Therefore, a synchronous coupling would require investments in the transmission grids on both sides of the interface in order to maintain the transfer capacities available to the present markets in the two synchronous areas. Additional transmission system investment will be necessary to ensure any significant increases in power exchanges.
5. The performed dynamic stability analyses underlined the sensitivity to inter-area power oscillations within the synchronously coupled system structure. While ordinary operational disturbances can be withstood by both the coupled and uncoupled systems, severe disturbances lead to wide-area oscillations in the coupled systems. This could lead to the reduction in system security. The necessary countermeasures require investments both in the generation and transmission sectors.
6. The Study illustrates the overall complexity of the IPS/UPS and the UCTE synchronous interconnection when it comes to key organisational and legal aspects. The realization of any resulting technical solutions for a synchronous coupling within an adequate legal and regulatory framework may only be achieved in the long term. The establishment of the legal basis for a reliable platform in synchronously coupled electricity markets would have to incorporate organisational and operational resolutions that correspond with EU standards. This would imperatively require the implementation of firm interzonal, bilateral and multilateral agreements, which would have to be signed by all companies concerned and approved by their respective stakeholders.

7. The Study reveals the need for further investigations in order to refine and endorse the above mentioned measures and requirements. Major areas identified for further studies are:
   - The verification of the IPS/UPS dynamic performance by means of observations being carried out over a longer period, followed by in-depth dynamic simulations on advanced dynamic models that are able to ensure reliable simulation results.
   - The analyses of emergency situations in the IPS/UPS caused by severe disturbances that have not been experienced by the system up to now. The purpose of this would be to adapt and harmonize the current existing operational guidelines, defence and restoration plans of both synchronous areas.
   - The analyses of technical and organisational aspects for the synchronous operation of a number of control blocks that are being considered in the IPS/UPS.
8. The completion of the Feasibility Study has opened a new era in the cooperation between the Western and Eastern TSOs and the companies responsible for the reliable operation of the transmission systems. This is in the interest of the electricity industry as well as it producing lasting benefits for the citizens in both the EU and the CIS.

References

[1] Union for the Co-ordination of Transmission of Electricity: Pre-Feasibility Study – Load Flow Analysis with Respect to a Possible Synchronous Interconnection of Networks of UCTE and IPS/UPS. Brussels, April 2003.

[2] PreussenElektra, Bayernwerk, EDF, RWE: Technical study of the interface between the extended West European power system and its Eastern neighbours. TACIS and PHARE. Final Report, 1996.

[3] CDU UPS Russia, NDC Ukraine, NDC Belarus, NDC Moldava, IREL: The TACIS and PHARE technical study of the conditions for joint operation of the extended UCPTE system and power systems of Oriental Europe and Central Asia. Final Report 1997

[4] PreussenElektra: Technical study of the conditions for joint operation of the extended UCPTE system and power systems of the Oriental Europe and Central Asia. TACIS and PHARE – IREL. Final Report, 1997.

[5] EDF, CEZ, IVO, RWE and TRACTEBEL: Synchronous Interconnection of the UCTE and UPS Networks – Requirements and Feasibility; Final report. TACIS Programme EREG 96-01, 1999

[6] Ayuev, B., Erokhine, P., Kulikov, Y.: IPS/UPS Wide Area Measuring System. CIGRE, 41st Session, August 2006

[7] Clodius, D., Glaunsinger, W., Lösing, M., Luther, M. et al.: Stability Studies concerning the Integration of CENTREL Network into the Power System of UCPTE. CIGRE 1996, 37-303

[8] Clodius, D., Glaunsinger, W., Grebe, E., Lösing, M., Luther, M.: Parallel Operation of CENTREL and UCPTE Networks under System Dynamics Aspect. Dresden, 12th Power System Computation Conference, August 19th-23rd 1996

[9] Breulmann, H., Grebe, E., Lösing, M., Winter, W., Witzmann, R. et al.: Analysis and Damping of Inter-Area Oscillations in the UCTE/CENTREL Power System. CIGRE 2000, 38-113

[10] Union for the Co-ordination of Transmission of Electricity: System Disturbance on 4 November 2006, Final Report 2007

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Brussels
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On behalf of the IPS/UPS Group of Companies:

Feasibility Study:
Synchronous Interconnection of the IPS/UPS with the UCTE

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