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Coordinated Reactive Compensation in a Wind Park

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***Abstract*— In wind energy, an incentive payment related to the reactive power compensation is applied. In the past, the maximum incentive was achieved when the cos φ, that was calculated as a monthly mean, was almost unitary (cos φ = 1.00). The payment is a percentage of the average reference tariff (ART).**

Since the 1st of January 2007, the Spanish regulation RD436/2004 has modified the incentive payment. Nowadays, it is calculated each 15 minutes from the energy during this period, and its maximum value depends on the achievement of a objective power factor (cos φ) which is defined in three time frames: peak hours (cos φ < 0,95 cap.), valley hours (cos φ < 0.95 ind.) and flat hours (cos φ = 1.00).

To maximize the incentive payment, in the Sotavento Experimental Wind Park (Spain) a configuration with a central controller that coordinates the actuation over all the capacitor steps in the wind park has been installed. In this article, a central controller algorithm which is based on a dynamic programming is proposed. Its main objectives are: to maximize the incentive payment, or achieve the equivalent objective PF, and to minimize the number of connection operations over the capacitor steps (especially those in substation). At the present time, the algorithm is being tested in the wind park.

Keywords-component; Wind park, power factor correction, dynamic programming

I. INTRODUCTION

The reactive compensation in wind parks is typically done by means of capacitors banks, these are divided in steps, installed in the LV side of wind turbines and in the MV side of substation [1]. Each set of capacitors is controlled by means of its own Power Factor Controller (PFC) which could be incorporated in the control circuits of wind turbines or as a separated device. In each PFC, the set-point cos φ was unitary and it was calculated from monthly energy. An incentive or penalty complement depending on the achievement of unitary cos φ, the complement was a percentage of ART. In most of the cases, it was enough to achieve the unitary objective power factor (cos φ) so that all PFC have the same unitary cos φ set-point.

The Spanish regulation Royal Decree (RD) 436/2004 [2] has modified the strategy of power factor correction in wind farms from 1st of January 2007. Nowadays, the cos φ, and so the incentive payment, is calculated every 15 minutes and its required value depends on the time of the day (see TABLE I).

TABLE I INCENTIVE PAYMENT FOR REACTIVE COMPENSATION IN WIND PARKS (RD 436/2004)

	cos φ	Incentive (%)		
		Peak	Flat	Valley
Inductive	<0.95	-4	-4	8
	<0.96 and ≥0.95	-3	0	6
	<0.97 and ≥0.96	-2	0	4
	<0.98 and ≥0.97	-1	0	2
	<1.00 and ≥0.98	0	2	0
	1.00	0	4	0
Capacitive	<1.00 and ≥0.98	0	2	0
	<0.98 and ≥0.97	2	0	-1
	<0.97 and ≥0.96	4	0	-2
	<0.96 and ≥0.95	6	0	-3
	<0.95	8	-4	-4

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In the reactive compensation scheme depicted above, the maximum incentive payment is not achievable most of the time. The simplest solution to overcome this problem is to install PFC's, whose cos φ set-point is controlled by a timer. In this configuration the behaviour of capacitors in substation is fundamental to achieve the desired cos φ. However, the number of capacitor steps in substation is usually reduced, besides, these capacitors have a high discharge time and they cannot be frequently connected. As a consequence, it could be very difficult to get the required cos φ by means of the local actuation of the controllers.

A more sophisticated and expensive solution is installing FACTS (e.g. STATCOM) that allow the wind park working at the desired cos φ at any moment, only if there is enough reactive power installed [3].

An intermediate solution can be developed; it consists in coordinating the actuation of all the PFC installed in the wind park by means of a central controller [4][5]. In this way, actuation of each PFC can be adjusted in real time and independently in order to achieve a wind park cos φ as close as possible to the maximum incentive payment value (see Figure 1). It must be designed a central controller algorithm with the ability to coordinate the actuation over all capacitor steps.

In this study, a control algorithm for the central controller is proposed. Through simulations, the behavior of this system is compared with the one of simplest configuration shown above.

This scheme is installed in the Sotavento Experimental Wind Park (http://www.sotaventogalicia.com) located in Galicia (northwest of Spain) [6]. At present, the algorithm has already been implemented in the Central Controler and it is being tested.

II. THE ALGORITHM FOR THE CENTRAL CONTROLLER

The system shown in Figure 1 is a centralized one, in which actions of PFC's (located at wind turbines and substation) are coordinated by means of a central controller. The proposed algorithm for this controller works following these steps:

A. In each moment, the amount of reactive power necessary to achieve the desired cos φ is calculated.

B. This amount of reactive must be distributed between the capacitor banks of the substation and the ones of the wind turbines. This must be done by minimizing the number of operations over the substation capacitor banks.

C. In this step, the total amount of reactive power that must be generated in all the capacitor banks of all wind turbines, is distributed between each wind turbine. An optimization function that takes into account the available capacitors and the active power generated in each wind turbine is used.

D. Finally, the required states of the capacitor steps must be sent to the PFC's.

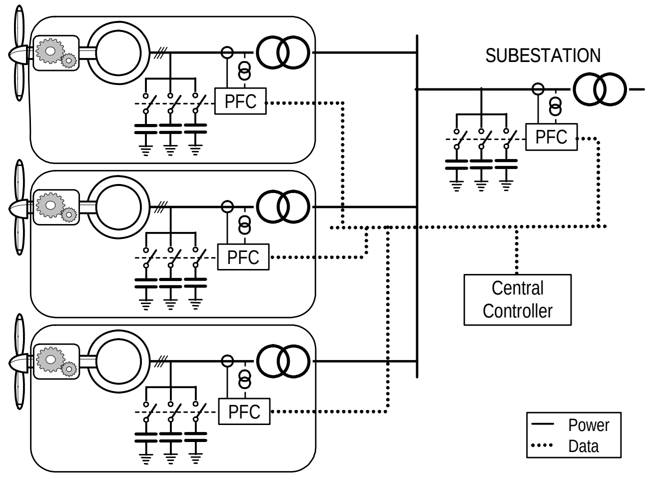

Figure 1 Wind park with a central controller for reactive compensation

A. *Capacite reactive power calculation*

As shown before, the cos φ is calculated every 15 minutes as a mean value from the active and reactive energy during this period. For the sake of achieving as much incentive payment as possible, the cos φ must be as close as possible to the values shown in TABLE I.

Each 15 minutes period has been divided in shorter time segments in order to have a fast system response. The value of these fixed duration segments has been optimized so as to get a balance between achieved cos φ and the number of capacitor steps connections. The response of PFC's and the frequency of measurements also have a strong influence on its value.

The number of time segments (N_s) in each period is the relationship between the duration of a period (T = 15 min) and the duration of a segment (T_s): $N_s = T/T_s$.

At the end of each segment, a reactive power increment obtained from the difference between the actual cos φ and its objective value is calculated by using the equation:

$$\Delta Q_c^{(s+1} = P^{(s} \cdot \tan\left(\arccos\left(\cos\varphi_{obj}\right)\right) - Q^{(s} \qquad (1)$$

where cos φ_{obj} is the objective cos φ, $P^{(s}$ and $Q^{(s}$ are the mean active and reactive power during the segment s, and $\Delta Q_c^{(s+1}$ is the reactive power deviation for achieving the cos φ_{obj}.

The capacitive reactive power to be connected at the beginning following segment is:

$$Q_c^{(s+1} = Q_c^{(s} + \Delta Q_c^{(s+1} \qquad (2)$$

where $Q_c^{(s}$ and $Q_c^{(s+1}$ are the capacitive reactive powers injected in the wind park (in wind turbines and substation) during the segments "s" and "s+1", respectively.

With this compensation strategy, the maximum reactive deviation from the required value in each period is:

$$\sum_{s=1}^{n} Q^{(s} = Q^{(0} - Q^{(N_s-1} \quad (3)$$

where $Q^{(0}$ is the uncompensated reactive power for the first segment and $Q^{(Ns-1}$ is the uncompensated reactive for the last segment in the 15 minutes period.

B. Capacitive reactive power in substation and wind turbines

In the previous paragraph, the amount of capacitive reactive power $Q_c^{(s}$ that must be injected in the whole wind park at the beginning of each segment "s" has been calculated. The next step is to allocate this power between the substation and the wind turbines capacitors, so:

$$Q_c^{(s} = Q_{Csub} + Q_{Cwt} \quad (4)$$

where Q_{Csub} is capacitive reactive power in the substation and Q_{Cwt} is the total for the wind turbines.

Usually, substation capacitors are installed in the MV side, this fact reduces the number of connection operations of their steps, besides, their discharge can last several minutes. As a consequence, the wind turbine steps, normally installed in the LV side, must be used more dynamically in order to fulfill (4).

Taking into account this restriction, the reactive sharing between substation and wind turbines is done by means of a hysteresis process, as can be seen in Figure 2, where:

- $Q_{Csub,min}$, is the reactive power for minimum step of substation capacitors battery.
- $0\times Q_{Csub,min}$, $1\times Q_{Csub,min}$, $2\times Q_{Csub,min}$ and $3\times Q_{Csub,min}$ represent the achievable reactive power values with the substation capacitor steps
- Q_{CwtL} and Q_{CwtH}, are the low and high limits for the reactive to be generated by the wind turbines
- $Q_{Cwt,max}$ is the total reactive power that could be generated by connecting all the capacitor steps in all the wind turbines

A possible situation to consider is that some wind turbines of the wind park could not be able to communicate with the central controller. These wind turbines would not take part in the coordination of reactive compensation. Only the wind turbines that participate in the coordinated strategy are taken into account in this process, thus:

$$Q_{Cwt,max} = \sum_{n=1}^{N_{wt}} Q_{total,i} \quad (5)$$

where, N_{wt} is the number of wind turbines that participate in the coordinated reactive compensation and $Q_{total,i}$ is total capacitive reactive power installed in the wind turbine "i".

With the aim of getting a solution for the allocation with the hysteresis process shown in Figure 2, the next rules must be followed:

- Operations over the substations capacitor steps are only done when the total wind turbine reactive is out of the limits Q_{CwtL} and Q_{CwtH}
- When a change in the state of substation steps is necessary, the new values for substation reactive power Q_{Csub} and total wind turbine reactive power Q_{Cwt} are those whose solution is as far as possible from the limits Q_{CwtL} and Q_{CwtH}
- The central controller must estimate the time left to accomplish the complete capacitor discharge. So, only discharged steps will be considered when the solution to (4) is calculated.
- When a solution to the allocation is not found (e.g. when some capacitors are discharging), the closest one is chosen.

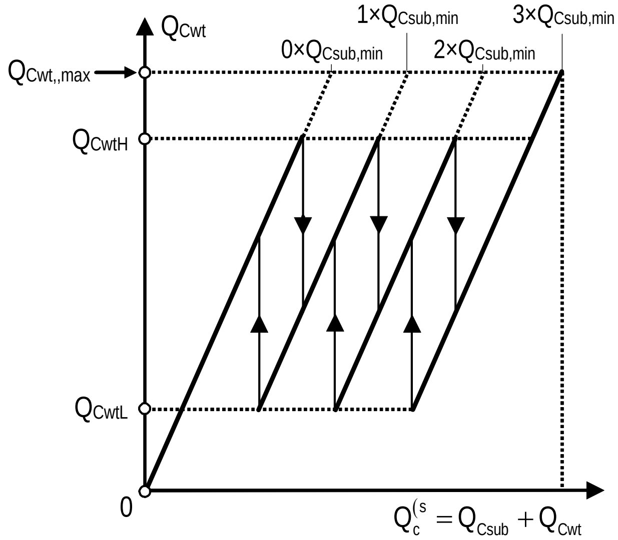

Figure 2 Hysteresis process to allocate the required reactive power between substation and wind turbines

C. Wind turbine reactive allocation

In the previous paragraphs, it has been calculated the amount of reactive power to be generated by all the capacitor steps installed in wind turbines. Now, it is necessary to distribute this reactive power between each wind turbine using an optimization algorithm. Dynamic programming has been used in the optimization process, its associated cost function takes into account the number of capacitor steps to be connected or disconnected and the power delivered by the wind turbine [7][8]. In this way, the desired reactive power is achieved with a minimum of capacitor step operations.

1) Discretization and cost function

Once the total capacitive reactive power (Q_{Cwt}) is calculated, as shown above, the next step is to distribute it between the capacitor steps of each wind turbine.

In a wind turbine, the capacitive reactive power generated depends on the state of the capacitor steps. So, there are 2^N possible step combinations for a wind turbine with N steps, although, there are only N different reactive power values if all the steps have the same size. The number of step combinations exponentially increase with the number of steps, especially if all the capacitors of each wind turbines are treated as a whole set of capacitor steps. In this way, for a certain Q_{Cwt} value could exist a great deal of step states of wind turbines combinations which generate this reactive power. This makes difficult to calculate an optimal step states for the entire wind park. To cope with this problem, an optimization method based on dynamic programming is proposed in following paragraphs.

In order to decrease the number of operations to calculate an allocation solution, the space of possible values of Q_{Cwt} is discretized. Thus, any value of Q_{cwt} is expressed as:

$$Q_{Cwt} = \text{round}\left\{\frac{Q_{Cwt}}{Q_{min}}\right\} \times Q_{min} \qquad (6)$$

where Q_{min} is a reactive value used to discretizing, it could be the maximum common divider for all the capacitor steps in all wind park.

For each wind turbine a vector ($\mathbf{Q_{Cwt,i}}$) with Nc_i +1 elements is calculated, and:

$$Nc_i \approx \frac{Q_{total,i}}{Q_{min}} + 1 \qquad (7)$$

where subindex "i" is used to refer to the wind turbine "i" and $Q_{total,i}$ is the maximum reactive power that can be generated by all the capacitors installed on the wind turbine "i".

Each vector element, from 0 to N_{Ci}, has associated a reactive power calculated as $k \times Q_{min}$, where k is the position of the vector element. The value for a k-element is calculated by means of a cost function, defined below, only the reactive associate can be reached with any step states, so:

$$\mathbf{Q_{Cwt,i}}(k) = \begin{cases} \Psi_{k,i} & \text{if } \exists j \in \{1,\dots,2^{N_i}\} \mid \sum_{r=1}^{N_i} \mathbf{E_{i,j}}(r) Qs_{i,r} = kQ_{min} \\ \text{null} & \text{otherwise} \end{cases} \qquad (8)$$

where:

- N_i is number of capacitor steps in the wind turbine "i"
- $\mathbf{E}_{i,j}$ is a $N_i \times 1$ vector whose elements represent the state of the capacitor step in the wind turbine "i". Its values are "0" if the corresponding capacitor step is disconnected and "1" if it is connected.
- $Qs_{i,r}$ is the capacitive reactive power for the step "r"
- $\Psi_{k,i}$ is a cost function that will be defined below.

The cost function is the value to be optimized and it is defined as:

$$\Psi_{k,i} = NOp_{min,k} + 10^{-3} \cdot \left(k \cdot Q_{min} - T_i \cdot \frac{P_i^{(s} - P_{Ni}}{P_{Ni}}\right)^2 \qquad (9)$$

where:

- T_i is a constant
- P_{Ni} is nominal power for the wind turbine "i"
- $P_i^{(s}$ is the mean power generated by wind turbine "i" during the segment "s"
- $NOp_{min,k}$ represents the minimum step states changes to achieve the reactive $k \times Q_{min}$, thus:

$$NOp_k = \min\left\{\text{sum}\left(\text{xor}\left\{\mathbf{E_i^{(s}}, \mathbf{E_{i,j}}\right\}\right)\right\}_{j \in \{1,\dots,2^{N_i}\}} \qquad (10)$$

where $\mathbf{E_i^{(s}}$ represents the step states at the end of segment "s"

The cost function has two terms, as shown in (9). One related to the operations number, so the optimization of this function will guarantee that the number of operations over the capacitor steps will be minimized. The second term has been intended to achieve that those wind turbines that are generating more active power can also be the ones generating more capacitive reactive power.

2) Optimization process

In former paragraphs, a set of vector $\mathbf{Q_{Cwt,i}}$ for each wind turbine has been calculated. These vectors will be used for the optimization process that calculates the allocation of the total wind turbine reactive power Q_{Cwt} between all the capacitor steps in wind turbines.

Owing to a dynamic programming method a set of cumulated vectors is created (see Figure 3). The first cumulated vector is equal to $\mathbf{Q_{Cwt,1}}$, and the next ones are calculated following these steps:

- The elements of the new cumulated vector are calculated from the combination between the no-null elements of previous cumulated vector and the next $\mathbf{Q_{Cwt,i}}$ vector. The position in the vector is associated to capacitive reactive power, so, the new element's position is obtained summing the previous cumulated vector plus the wind turbine vector's positions.
- The new element's cost is calculated summing the costs of the elements that generate it.
- The final cost of the new element is the minimum value of the costs calculated in the previous point.
- The final cumulated vector has no-null values related to all the possible capacitive reactive power values, that can be obtained by any combination of all capacitor steps installed in wind turbines. The size of this vector can be calculated with:

$$Nc \approx 1 + \sum_{i=1}^{N_{wt}} Q_{total,i} \Big/ Q_{min} \qquad (11)$$

The value of each no-null element of the final cumulated vector is the optimum cost for associated reactive power. Hence, for any reactive power value or element in the final vector the related step states in each wind turbine can be calculated, and they will be the ones that optimize the capacitor operation number and the sharing of capacitive reactive power.

As a conclusion, for total wind turbine reactive power value (Q_{Cwt}) the element (k_{sel}) that must be selected in the final vector is:

$$k_{sel} \approx \frac{Q_{Cwt}}{Q_{min}} \qquad (12)$$

Then, the step states in each wind turbine that generates the optimum value for this element must be calculated, and the following equation must be fulfilled:

$$Q_{Cwt} = \sum_{i=1}^{N_{wt}} Q_{wt,i}^{opt} = \sum_{i=1}^{N_{wt}} \left[\sum_{r=1}^{N_i} \mathbf{E_i^{opt}}(r) Qs_{i,r} \right] \qquad (13)$$

where $Q_{wt,i}^{opt}$ represents the optimum value for the capacitive reactive power to be generated in wind turbine "i" and $\mathbf{E_i^{opt}}$ the step state vector that generates this reactive power.

Each optimum value $Q_{wt,i}^{opt}$ could have associated more than one step state vector $\mathbf{E_i^{opt}}$. In the following paragraphs a selection method is presented with the aim of eventually deciding the required state for the steps in each wind turbine.

3) Optimun step states

The central controller must send the desired step states to each PFC, installed in substation and wind turbines, in order to achieve the required reactive compensation.

In the preceding paragraphs, the capacitive reactive power Q_{Csub} required in the substation and the reactive capacitive power to be generated in each wind turbine $Q_{wt,i}^{opt}$ have been calculated. The next step is to calculate the states of capacitor steps so as to get the mentioned reactive power.

In the substation the number of capacitor steps is usually low, e.g. in the Sotavento wind park there are 2 steps. In this case, the required state for them can be easily calculated, nevertheless, the capacitors discharge time must be respected when deciding the steps that must be connected.

In the case of wind turbine capacitors, since the typical discharge time for LV capacitors is lower than 1 minute, estimation of discharge state could be overcome if the duration of the segment (T_s) was large enough.

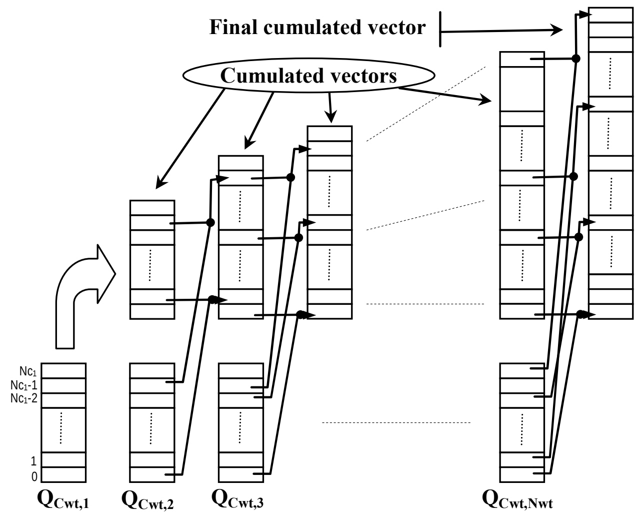

Figure 3 Optimization process

Lastly, it is necessary to calculate the step states vector for each wind turbine. As shown in previous paragraphs, an optimum wind turbine reactive power $Q_{wt,i}^{opt}$ could have several step state vectors with the same reactive power. With a selection process, the accumulated number of connection step operations will be balanced between the capacitor steps of the same size in each wind turbine.

III. SIMULATION

The behavior of reactive compensation configuration shown in Figure 1, and the central controller introduced in this article are evaluated through simulation. A wind park model and a PFC model are needed and, therefore, presented in the next paragraphs.

A. Wind park model

Wind park has been modelled from the measurement data given by the Sotavento experimental wind park. The active and reactive curves for each wind turbines have been calculated from these measurements. In addition, the losses in lines and transformer have also been modelled as a function of the power generated by the wind park.

B. PFC model

In the Sotavento experimental wind park a commercial PFC device has been installed in the substation and in all the wind turbines that will participate in the centralized reactive compensation. A model for this device has been done by means of laboratory tests.

IV. RESULTS

In former sections the central controller algorithm for the system depicted in Figure 1 has been introduced. In order to evaluate the benefits of this centralized configuration, a comparison against a local controlled system is done. In this scheme, the reactive compensation is locally done with the PFC installed in each wind turbine and in the substation. The cos φ set-point for all PFC's is the same, and it is controlled by a timer, the set-points are adjusted to the maximum payment values shown in TABLE I.

The data for simulation, active and reactive power in substation and wind turbines, is obtained from measurements given by the Sotavento experimental wind park. The simulation results can be observed in Figure 4. Results for the proposed central system are called Central, and those for the local controlled system are known as Local.

For the sake of easily understanding the results, during the simulation the objective cos φ has been considered constant, so different simulations have been done for flat, valley and peak situations.

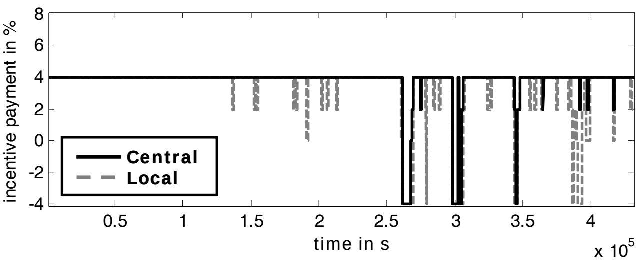

Figure 4 Incentive payment and cos φ for each 15 minutes period (flat)

A summary of simulation results is presented in TABLE II, where the total incentive payments during the simulation period and the total number of connection operations for all the steps in the wind park are displayed. As can be seen, the reduction of operation number for the central system is higher than a 70% when compared to the local system. Furthermore, the incentive payment has been at least increased a 0.15%.

TABLE II SIMULATION RESULTS

Incentive Payment (%)	Operation Number	Reg.	Period
3,99	5147	Central	Flat
3,84	25593	Local	
7,27	9169	Central	Peak
7,55	33749	Local	
8,00	4828	Central	Valley
7,50	34415	Local	

It must be noticed that the achievement of a cos φ in low generation situations is influenced by the stops of wind turbines at low wind conditions. Moreover, in peak periods with high generation the amount of installed capacitive power limits the achievable cos φ.

V. CONCLUSIONS

In this study a scheme for reactive compensation in wind parks is depicted. The system is based on the coordination of all capacitor steps in wind turbines and in substation by means of a central controller. All local PFC's continuously receive the desired state for its capacitor steps from the central controller.

The algorithm for the central controller is here presented. Its main objective is to achieve the cos φ that maximizes the incentive payment with the minimum number of capacitor steps operations. Furthermore, the operations in substation capacitor steps are specially taken into account with a pre-selection process.

The main conclusions of this article are:

- The behavior of the central system is compared to a local one by means of simulation.
- Modelling of PFC's and wind park has been done through real measurements and laboratory tests.
- With the central controller algorithm, the achievement of a specific cos φ is higher than that achieved with a local scheme. Besides, the number of operations over the capacitor steps is highly reduced.
- The number of operations in substation has been specially reduced with the central system.
- The accumulated steps operation in a wind turbine has been balanced so that capacitor steps of same size have a similar number of operations.

The central scheme for reactive compensation as shown in Figure 1 has alredy been implemented in the Sotavento Experimental Wind Park; at the present time, the algorithm for the central controller is being tested.

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It is our honour and pleasure to invite you to the 9th International Conference on Electrical Power Quality and Utilisation, taking place this time in Barcelona, Spain.

As a consequence of the technical quality and especial social atmosphere that has always characterized this series of conferences, the number of submitted papers shows a steady trend to increase. On this occasion, over 350 papers have been reviewed by the Scientific Committee, of which only 227 have been accepted for oral presentation. Many good papers had to be rejected because of the upper limit imposed by the number of parallel sessions. Apart from regular papers, the technical programme is completed with several tutorials, plenary sessions and a panel session that closes the conference.

The present 9th EPQU Conference is the continuation and development of previous conferences on the same or similar subject-matter, which have been organized in Poland by Electrical Power Engineering Institute of Technical University in Lodz and Institute of Electrical Drive and Industrial Equipment Control of AGH-University of Science and Technology in Krakow (since 1997) in collaboration with Azov Technical University of Mariupol (Ukraine) and Ukrainian National Academy of Sciences (Institute of Electrodynamics).

The first one entitled Electrical Power Quality in National Electrical Power System took place in Lodz in 1987. The next one entitled Electrical Energy Quality was organized in Spala (Poland) in 1991, and was followed by the third one named Efficiency and Quality of Electrical Power Supply for Industrial Plants, which was held in Mariupol (Ukraine) in 1994.

Since 1997 all conferences have been organized in Krakow with the same name: ELECTRICAL POWER QUALITY AND UTILISATION - 1997, 1999, 2001, 2003, 2005.

In 2005 the members of EPQU Conference scientific committee decided to change the place of the next – 9th EPQU Conference – to Spain and organize it in collaboration with CITCEA-UPC (www.citcea.upc.edu). We are sure that it was very good decision!

Thanks to our several sponsors, particularly ENDESA, the registration fee for the EPQU'07 is similar to past editions. We believe the social programme, traditionally composed of a reception, excursions and a gala dinner, is quite attractive and will satisfy the most exigent attendant.

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The Barcelona of the 21st century is a city shaped by the '92 Olympics, a city transformed for and by the need to do justice to that great international event. The Barcelona we see around us now, the Barcelona we enjoy today, is a new Barcelona, Mediterranean in keeping with its traditions, with its face to the sea and its arms open to other cultures and peoples, giving and receiving, happy to make and to share its riches.

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Yours sincerely,

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Isabelle Heriakian	*European Copper Institute*	*Belgium*
Bill Howe	*EPRI Solutions*	*USA*

EPQU'07 Organizing Committee

In alphabetical order

Mireia Berenguer	*CITCEA - Technical University of Catalonia*	*Spain*
Samuel Galceran	*CITCEA - Technical University of Catalonia*	*Spain*
Oriol Gomis	*CITCEA - Technical University of Catalonia*	*Spain*
Daniel Montesinos	*CITCEA - Technical University of Catalonia*	*Spain*
Joan Peracaula	*CITCEA - Technical University of Catalonia*	*Spain*
Michal Ramczykowski	*Polish Copper Promotion Centre*	*Poland*
Rodrigo Ramírez	*CITCEA - Technical University of Catalonia*	*Spain*
Antoni Sudrià	*CITCEA - Technical University of Catalonia*	*Spain*
Andreas Sumper	*CITCEA - Technical University of Catalonia*	*Spain*
Roberto Villafáfila	*CITCEA - Technical University of Catalonia*	*Spain*

EPQU'07 Scientific Committee

In alphabetical order

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Detmar Arlt	*University of Applied Sciences Duesseldorf*	*Germany*
Carlos Arroyo	*EDELNOR S.A.A*	*Perú*
Salvador Baille	*Schneider Electric España*	*Spain*
Birgitte Bak-Jensen	*Aalborg University*	*Denmark*
Hans-Peter Beck	*Clausthal University of Technology (CUT)*	*Germany*
Oriol Boix	*Technical University of Catalonia*	*Spain*
Franco Bua	*Engineering Consulting & Design*	*Italy*
David Chapman	*Copper Development Association*	*United Kingdom*

Mircea Chindris	Technical University Cluj	Romania
Leszek S. Czarnecki	Louisiana State University	USA
J. Policarpo G. De Abreu	Itajubá Federal University	Brazil
Anibal T. De Almeida	University of Coimbra	Portugal
Emmanuel De Jaeger	LABORELEC	Belgium
Jan Desmet	Hogeschool West-Vlaanderen	Belgium
Johan Driesen	Katholieke Universiteit Leuven	Belgium
Stefan Fassbinder	German Copper Institute	Germany
Joan Frau	ENDESA	Spain
Aurelio García Cerrada	Comillas-ICAI	Spain
Julio García Mayordomo	Universidad Politécnica de Madrid	Spain
Walter Giménez	Universidad Tecnológica Nacional	Argentina
Emanuel Gluskin	Holon Institute of Technology	Israel
Dusan Graovac	Infineon Technologies AG	Germany
Jan H. Griffioen	INNOMET	Netherlands
José Luis Gutiérrez Iglesias	UNESA	Spain
Marek Hartman	Gdynia Maritime University	Poland
Bill Howe	EPRI Solutions	USA
Tahir Kapetanovic	E-Control Austrian Energy Regulatory Authority	Austria
Vladimir Katic	University of Novi Sad	Serbia
Włodzimierz Koczara	Warsaw University of Technology	Poland
Victor Levi	United Utilities PLC	United Kingdom
Ricardo López	Instituto de Investigaciones Electricas	México
Natasa Markovska	Macedonian Academy of Sciences and Arts	Macedonia
Christine Materazzi-Wagner	Pöyry Energy GmbH	Austria
José M. Maza Ortega	University of Sevilla	Spain
Alex McEachern	Power Standards Laboratori	USA
Mark MacGranaghan	EPRI Solutions	USA
Władysław Mielczarski	Technical University of Lodz	Poland
Rozmyslaw Mienski	Tecnical University of Lodz	Poland
Jovica Milanovic	The University of Manchester	United Kingdom
Janusz Mindykowski	Gdynia Maritime University	Poland
Dave Openshaw	EDF Energy Networks Branch	UK
Pere Palacín	Ramon Llull University	Spain
Igor Papič	University of Ljubljana	Slovenia
Estrella E. Parra	Universidad Nacional	Colombia
Maciej Pawlik	Technical University of Lodz	Poland
Francisco José Pazos	Iberdrola	Spain
Ángel Alberto Pérez	MGE UPS Systems	Spain
Paulo Ribeiro	Calvin Collegue Michigan	USA
Renato Rizzo	University of Naples Federico II	Italy
Alain Robert	Université Catholique de Louvain	Belgium
José M. Romero	Endesa	Spain
José A. Rosendo Macías	University of Sevilla	Spain
Josep M. Rovira	Col·legi Oficial d'Enginyers Industrials de Catalunya	Spain
Hugh Rudnick	Pontificia Universidad Católica de Chile	Chile
Knut Samdal	Sintef Energy Research	Norway
Marek Samotyj	Electrical Power Research Institute	Poland
Pavel Santarius	Technical University of Ostrava	Czech Republic
Jurij Sayenko	Pryazovskyi State Technical University of Mariupol	Ukraine
Gerd Schauer	VERBUND-Austrian Hydro Power AG	Austria
Marian Sobierajski	Wroclaw University of Technology	Poland
Zbigniew Styczynski	Otto-von-Guericke-Universität Magdeburg	Germany
Alfredo Testa	Seconda Universitá di Napoli	Italy
Julio Usaola García	Universidad Carlos III de Madrid	Spain
Fanica Vatra	Society of Power Engineers in Romania	Romania
Paola Verde	Università degli studi di Cassino	Italy
Yuriy Varetsky	LVIV Polytechnic National University	Ukraine
Eduardo Zabala	Fundación LABEIN	Spain
Dario Zaninelli	Politecnico di Milano	Italy
Ahmed Zobaa	Cairo University	Egyp

PROGRAMME AT GLANCE

PROGRAMME AT GLANCE
MONDAY, OCTOBER 8th

09:30 - 13:00 **TUTORIALS**	
T1: Practical Power Quality at World-wide Industrial and Commercial Sites	**MoT01** **Room: CosmoCaixa**
T3: Energy Storage for Power Quality and Reliability	**MoT03** **Room: CosmoCaixa**
15:00 - 18:30 **TUTORIALS**	
T2: Cost of Power Quality	**MoT02** **Room: CosmoCaixa**
T4: Understanding Power Quality Measurements Results and Fault Disturbances	**MoT04** **Room: CosmoCaixa**
17:00 - 19:00 **Conference Pre-registration**	

TUESDAY, OCTOBER 9 th

08:00 - 09:00 **Conference Registration**	
09:00 - 11:00 **Opening Session and Plenary: DSP Techniques for Power System Applications** **A.Gómez-Expósito, J.A. Rosendo**	**TuMP** **Room: Auditorium**
11:00 - 11:30 **Coffee Break**	
11:30 - 13:30 **TECHNICAL SESSIONS**	
1A-PARAMETERS OF PQ	**TuM01** **Room: Auditorium** **Chair: to be confirmed**
1B-MODELING AND SIMULATION	**TuM02** **Room: A1** **Chair: to be confirmed**
1C-PQ MEASUREMENTS	**TuM03** **Room: A2+A3** **Chair: Francisco Pazos Filgueira**
1D-PQ IMPROVEMENT	**TuM04** **Room: A4** **Chair: Igor Papic**
13:30 - 15:00 **Lunch**	
15:00 - 17:00 **TECHNICAL SESSIONS**	
2A-MARKETS	**TuA01** **Room: Auditorium** **Chair: William Howe**

2B-MODELING AND SIMULATION	TuA02 Room: A1 Chair: Marek Hartman
2C-PQ MEASUREMENTS	TuA03 Room: A2+A3 Chair: Birgitte Bak-Jensen
2D-PQ IMPROVEMENT	TuA04 Room: 2D Chair: Fanica Vatra
17:00 - 17:30 **Coffee Break**	
17:30 - 19:30 **TECHNICAL SESSIONS**	
3A-EMC	TuE01 Room: Auditorium Chair: Oriol Boix
3B-MODELING AND SIMULATION	TuE02 Room: A1 Chair: Irena Wasiak
3C-PQ MEASUREMENTS	TuE03 Room: A2+A3 Chair: Pavel Santarius
3D-PQ IMPROVEMENT	TuE04 Room: A4 Chair: to be confirmed
20:00 - 23:00 **Welcome Party**	

WEDNESDAY, OCTOBER 10 th

09:00 - 10:00 **Plenary Session: LPQI vision:The future of Power Quality** **Quality of Electricity Supply: The initiatives of CEER/ERGEG**	WeMP Room: Auditorium
10:00 - 11:00 **Plenary Session: Power Quality Measurements Methods,Analyzers and Costs**	WeMP Room: Auditorium
11:00 - 11:30 **Coffee Break**	
11:30 - 13:30 **TECHNICAL SESSIONS**	
4A-EMC, LOADS AND CONVERTERS	WeM01 Room: Auditorium Chair: Eduardo Zabala
4B-MODELING AND SIMULATION	WeM02 Room: A1 Chair: Jovica Milanovic
4C-DISTRIBUTED GENERATION AND RENEWABLE ENERGIES	WeM03 Room: A2+A3 Chair: Koen Van Reusel
4D-IMPROVEMENT AND DISTURBING LOADS	WeM04 Room: A4 Chair: to be confirmed

13:30 - 15:00 Lunch	
15:00 - 17:00 TECHNICAL SESSIONS	
5A-ECONOMIC ASPECTS	WeA01 Room: Auditorium Chair: Paola Verde
5B-MODELING AND SIMULATION	WeA02 Room: A1 Chair: Antoni Sudrià
5C-RELIABILITY OF SUPPLY AND DISTRIBUTED GENERATION	WeA03 Room: A2+A3 Chair: Mircea Chindris
5D-SENSIBILITY OF LOADS	WeA04 Room: A4 Chair: Oriol Boix-Aragonès
17:00 - 17:30 Coffee Break	
17:30 - 19:30 TECHNICAL SESSIONS	
6A-LOADS AND CONVERTERS	WeE01 Room: Auditorium Chair: Zbigniew Hanzelka
6B-RELIABILITY AND CONTINUITY OF SUPPLY	WeE02 Room: A1 Chair: Salvador Baille
6C-DISTRIBUTED GENERATION AND RENEWABLE ENERGY	WeE03 Room: A2+A3 Chair: Samuel Galceran
6D-PQ MEASUREMENTS	WeE04 Room: A4 Chair: Emmanuel De Jaeger
21:00 - 23:00 Gala Dinner	

THURSDAY, OCTOBER 11 th

09:00 - 11:00 TECHNICAL SESSIONS	
7A-HARMONICS	ThM01 Room: Auditorium Chair: Jose Antonio Rosendo Macias
7B-RELIABILITY AND CONTINUITY OF SUPPLY	ThM02 Room: 7B Chair: to be confirmed
7C-DISTRIBUTED GENERATION AND RENEWABLE ENERGY	ThM03 Room: A2+A3 Chair: Maciej Tondos
7D-PQ MEASUREMENTS	ThM04 Room: A4 Chair: to be confirmed
11:00 - 11:30 Coffee Break	
11:30 - 13:30 TECHNICAL SESSIONS	
P.Session 8A-Voltage dips in installations:Ongoing activities in	ThA01

international organizations	Room: Auditorium Chair: Math Bollen
P.Session 8B-Energy Efficiency	ThA02 Room: A1 Chair: Franco Bua
P.Session 8C:Distributed Generation and Renewable Energy+Reliability and Continuity of Supply	ThA03 Room: A2+A3 Chair: Rodrigo Ramírez
P.Session 8D-Education	ThA04 Room: A4 Chair: to be confirmed

13:30 - 14:00

Closing Session

TECHNICAL PROGRAMME

MONDAY, OCTOBER 8th

TECHNICAL PROGRAMME

MONDAY, OCTOBER 8th

09:30 - 13:00

TUTORIALS

T1: Practical Power Quality at World-wide Industrial and Commercial Sites	**MoT01** **Room: CosmoCaixa**
T3: Energy Storage for Power Quality and Reliability	**MoT03** **Room: CosmoCaixa**

15:00 - 18:30

TUTORIALS

T2: Cost of Power Quality	**MoT02** **Room: CosmoCaixa**
T4: Understanding Power Quality Measurements Results and Fault Disturbances	**MoT04** **Room: CosmoCaixa**

17:00 - 19:00

Conference Pre-registration

TUESDAY, OCTOBER 9th

TUESDAY, OCTOBER 9 th

08:00 - 09:00 **Conference Registration**	
09:00 - 11:00 **Opening Session and Plenary: DSP Techniques for Power System Applications**	**TuMP** **Room: Auditorium**
11:00 - 11:30 **Coffee Break**	
11:30 - 13:30 **TECHNICAL SESSIONS**	
1A-PARAMETERS OF PQ	**TuM01** **Room: Auditorium** **Chair: to be confirmed**

Obtaining Patterns for Classification of Power Quality Disturbances Using Biorthogonal Wavelets, RMS value and Support Vector Machines
V. Vega, C. Duarte, G. Ordóñez

A Simplified Implementation of the Test Protocol for the IEC Flickermeter
J.J. Gutiérrez, J. Ruíz, L.A. Leturiondo, A. Lazkano, I. Azpiri

Examples of International Flicker Requirements in High Voltage Networks and Real World Measurements
D. Arlt, M. Stark, C. Eberlein

Power Quality Problems in Regional Distribution Networks in the Czech Republic
P. Santarius, P. Krejčí, D. Spáčil, P. Vašenka

MPCA Approach for Localization of Electrical Sags
A. Khosravi, J. Meléndez, J. Colomer, J. Sánchez

Study of the Voltage Unbalance Conditions Based on the Behavior of the Voltage Unbalance Factor (CVUF)
A. Ferreira Filho, D. Garcia, F. Nascimento, M. Oliveira

On Global Index for Discrete Voltage Disturbances
G. Carpinelli, P. Varilone, P. Verde, P. Caramia, R. Chiumeo, I. Mastrandrea, F. Tarsia, O. Ornago

1B-MODELING AND SIMULATION	**TuM02** **Room: A1** **Chair: to be confirmed**

Database Development for Power Quality in PEA's Distribution System
W. Phongphat, S. Trin

Hybrid Time/frequency Domain Modelling of Nonlinear Components
W. Wiechowski, B. Bak-Jensen, C. Leth Bak, J. Lykkegaard

Network Reconfiguration in Radial Disrtibution System: Tabu Search
J. Dhiman, T. Thakur

Digital Simulation of Voltage Dip Characteristics of Wind Turbine Systems
A. Junyent, O. Gomis, M. Martinez, A. Sumper, M. Sala, M. Mata

Voltage Collapse Proximity Indicators for Radial Distribution Networks
S. Mangione, A. Augugliaro, L. Dusonchet

The Application of Fortescue's Transformation to describe Power States in Multi-phase Circuits with Non-sinusoidal Voltage and Currents
M.T. Hartman

1C-PQ MEASUREMENTS

TuM03
Room: A2+A3
Chair: Francisco Pazos Filgueira

Development of a Photovoltaic Array Emulator System based on a Full-bridge Structure
G. Martín, J. López, M. Teixidó, A. Sudrià

An Assessment of Distortion of Supply Voltage Waveform in All-Electric Ship Power Network - Case Study
M. Szweda, T. Tarasiuk

Influence of Power Factor Compensating Capacitors on Estimation of Harmonic Distortion
F.M. Fernández, P.S. Nair

Power Quality Monitoring System – Voltage Dips and Short Interruptions
D. Kottick, J. Furman

A New Approach to Reactive Power Calculation of the Static VAr Compensator
A. Osnach

New Developments in Power Quality Immunity and Voltage Sag Standards
A. Eberhard, A. McEachern

A New, Ultra-low-cost Power Quality Measurement Technology
A. McEachern

1D-PQ IMPROVEMENT

TuM04
Room: A4
Chair: Igor Papic

Harmonic Emission of Electronic Power Converters for Auxiliary Services in Electric Trains
M. Brenna, F. Foiadelli, M. Roscia, D. Zaninelli

Matrix Converter for reducing Harmonics in Micro-turbine Generation System
F. Jurado, M. Ortega, A. Cano

Photovoltaic-inverters as Active Filters to improve Power Quality in the Grid. What can State-of-the-art Equipment Achieve?
C. Mayr, R. Bründlinger, B. Bletterie

Inductive Decoupling of Low Voltage Sub-Networks
J. Jahn, A. Engler

Voltage Sag Cost Reduction With Optimally Placed FACTS Devices
J. Milanovic, Y. Zhang

Techno-economic Improvement of Voltage Sag Performance with FACTS Devices
Y. Zhang, J. Milanovic

Power Supply System for AC Contactor Ride-trough
P. Andrada, G. Navarro, J.I. Perat

13:30 - 15:00	
Lunch	

15:00 - 17:00	
TECHNICAL SESSIONS	
2A-MARKETS	TuA01 Room: Auditorium Chair: William Howe

Electrical Power Delivery Improvement in Portugal through Quality Function Deployment
J. Delgado, P. Saraiva, A. Traça de Almeida

Power Quality in Romanian Electricity Market
C. Stanescu, V. Fanica, A. Poida, P. Postolache

Need of Voltage Quality Regulation in the Future Electricity Infrastructure
S. Bhattacharyya, J. Myrzik, J. Cobben, M. Lumig, M. Didden, W. Kling

Voltage Quality Issues in a Competitive Electricity Market
H.S. Bronzeado

Analysis of the Main Norms (standards) and Laws on Electrical Energy
A. Constantinescu, D. Constantinescu, D. Grigorescu, M. Covrig

2B-MODELING AND SIMULATION	TuA02 Room: A1 Chair: Marek Hartman

Using Complex Adaline for the Direct Symmetrical Components Estimation
S. Mortazavi, M. Joorabian, M. Mohseni

Monitoring Harmonic Sources in Distribution System By Neural Network Estimator
Y. Varetsky, T. Nakonechny

Harmonic Current Vector Method with Reference Impedances - Field Measurement Verification.
T. Pfajfar, B. Blažič, I. Papič

Fast Varying Loads
V. Bohorquez

CPC Power Theory as Control Algorithm of Switching Compensators
L.S. Czarnecki

Limitations of the IRP p-q Theory as Control Algorith
L.S. Czarnecki

Visual Management of Sags and Incidents Gathered in Distribution Substations for Power Quality Management
D. Macaya, J. Meléndez, J. Sánchez, M. Castro

2C-PQ MEASUREMENTS	TuA03 Room: A2+A3 Chair: Birgitte Bak-Jensen

The Impact of FIFA World Cup 2006 on Power Quality in the Electric Distribution systems
J. Rubens Macedo Jr., A. G. Martins, M. Jovita ,V. Siqueira, J. Renato ,V. Carneiro

System of Monitoring Power Quality Parameters in Real Time
V. Tukhas

An Experimental Evaluation of Short-Time Flicker Index
J. Klepacki

Metrological Supervision of Energy Meters in Power Distribution Plants up to 35kV.
S. Skundric, D. Naumovic Vukovic, A. Nikolic, D. Kovacevic

A New Approach to Voltage Measurements in Power System
D. Comic, S. Milovancev, V. Vujicic

The importance of IEC 61000-4-30 Class A for the Coordination of Power Quality Levels
R. Neumann

Power Quality Monitoring in the Romanian High Voltage Grid
D. Ilisiu

Building Permanent PQ Monitoring System on MV Network in Elektra Zagreb, Croatia
I. Klaric, G. Sagovac

2D-PQ IMPROVEMENT	TuA04 Room: 2D Chair: Fanica Vatra

Dynamic Voltage Restorer (DVR) Using Three Dimensional PWM Control Algorithm
Z.L. Liew, A.K. Ramasamy, V.K. Ramachandaramurthy, R.K Iyer

Optimization of Compensation of Meshed MV Network by Modified Genetic Algorithm
M. Paar, P. Toman, H. Nielsen

Control of Dynamic Voltage Restorer using TMS320F2812
A.K. Ramasamy, R.K. Iyer, V.K. Ramachandaramurthy, Z.L. Liew

Central Control System Based on Genetic Algorithms to Improve Power Quality
R. Klempka, M. Tondos

Voltage Phase Controller for Power Systems
T. Sieńko, J. Szczepanik, T.J. Sobczyk

A Control Algorithm for Hybrid Compensation of Fast Varying Loads
V. Bohorquez

Active Earthing System to Optimise Power Quality in MV Networks
A. Amezua, F.J. Pazos, G. Santamaría, J.M. García, G. Buigues, I. Gutierrez

17:00 - 17:30
Coffee Break

17:30 - 19:30

TECHNICAL SESSIONS

3A-EMC	TuE01 Room: Auditorium Chair: Oriol Boix

Flicker Impact on 150 W Lamps of Different Ages
M. Manana, A. Ortiz, F.J. Azcondo, F. Diaz, F. Gonzalez, C. Renedo

Effects of voltage sags on different types of ballasts for 150-W HPS lamps
F. Ortiz, A. Ortiz, M. Manana, C. Renedo , F.J. Díaz, F.J. Azcondo

Human Exposure to Power Frequency Electric and Magnetic Fields inside a Very High Voltage Power Station
C. Munteanu, I. T Pop, C. Diaconu, M. Ilia

Earthing Systems Design in Presence of Nonuniform Soil
G. Zizzo, A. Campoccia, E. Riva Sanseverino

Magnetic Losses Simulation in PM SM Drive by FE: Harmonic Superposition by Method of Locked Rotor
R. Kaczmarek, W.Y. Huang, J.C. Vannier

Numerical Methods for Induced Voltage Evaluation in Electromagnetic Interference Problems.
D.D. Micu, E. Simion, D. Micu, A. Ceclan

Magnetic Field Reduction Study for Low Voltage Distribution Panels located in MV/LV Substations
H. Beltran San Segundo, C. Cervelló García, V. Fuster Roig, T. Yebra Vega

3B-MODELING AND SIMULATION	TuE02 Room: A1 Chair: Irena Wasiak

Application for Fault Location in Electrical Power Distribution Systems
S. Herraiz, J. Meléndez, G. Ribugent, J. Sánchez, M. Castro

Harmonic Sources Localization: Comparison of Methods Utilizing the Voltage Rate or the Current Rate
K. Wilkosz

Dynamic Modeling of Induction Motor Loads For Transient Voltage Stability Studies
T. Aboul-Seoud

Modeling and Adaptive Control of an Electric Arc Furnace
R. Balan, O. Hancu, S. Stan, H. Balan

Harmonic Components Identification through the Adaline with Fuzzy Learning Parameter
M. Mohseni, M.A. Zamani

Search for Network Parameters preventing Ferroresonance Occurrence
J. Wisniewski, E. Anderson, J. Karolak

Designing Industrial Processes for PQ Resiliency
B. Fortenbery

3C-PQ MEASUREMENTS

TuE03
Room: A2+A3
Chair: Pavel Santarius

Flickermeter used for Different Type of Lamps
R. Cai, J. Cobben, J. Myrzik, W. Kling, J. Blom

The DFT Algorithms Analysis in Low-cost Power Quality Measurement System based on DSP Processor.
M. Szmajda, K. Gorecki, J. Mroczka

Power Quality effects on the Measurement of Reactive Power in Three-Phase Power Systems in the Light of the IEEE Standard 1459-2000.
V. Leon-Martinez, J. Montañana-Romeu, J. Giner-Garcia, A. Cazorla-Navarro, J. Roger-Folch, M.A. Graña-López

Data System for the Monitoring of Power Quality in the Transmission Substations Supplying Big Consumers
F. Vatra, A. Poida, C. Stanescu

Adaptive digital synchronization of measuring window in low-cost DSP power quality measurement systems
K. Gorecki, M. Szmajda, J. Mroczka

Estimation of Power System Parameters based on Load Variance Observations – Laboratory Studies
A. Bień, D. Borkowski, A. Wetula

Needs and Experiences for Acquiring the Experimental Capabilities fot the New Liberalized Framework of the Electricity Network
E. Perea, A. Gil de Muro, E. Zabala

3D-PQ IMPROVEMENT

TuE04
Room: Cosmocaixa
Chair: to be confirmed

PFC Units Sizing in Steel Factory Harmonics Environment: A Case Study
A. Baggini, F. Bua, F. Buratti, A. Ascolari

Improving the Voltage Regulation of Secondary Feeders by Applying Solid-state Tap Chagers to MV/LV Transformers
D. Monroy, A. Gómez-Expósito, E. Romero-Ramos

Problems of Passive Filters Application in System with Varying Frequency
J. Mindykowski, P. Rupnik, T. Tarasiuk

Recursive Control for Active Power Filters
R. Magureanu, D. Creanga, V. Bostan, M. Priboianu

Electrical Power Quality Improvement using a DSP Controlled Active Power Filter
C. Patrascu, D. Popescu, A. Iacob

Modeling for passive hybrid filter performance analysis.
L.L. Ravagnani, L.C. Oliveira, D.L. Milanese
F. Schorr

Application of DSTATCOMCompensators for Mitigation of Power Quality Deviations in Low Voltage Grid with Distributed Generation
P. Gburczyk, R. Mienski, R. Pawelek, I. Wasiak

20:00 - 23:00
Welcome Party **Room: BCN World**

WEDNESDAY, OCTOBER 10th

WEDNESDAY, OCTOBER 10 th

09:00 - 10:00 **Plenary Session: LPQI vision: The future of Power Quality** **Isabelle Herikian** **Quality of Electricity Supply: The initiatives of CEER/ERGEG** **Luca LoSchiavo**	**WeMP** **Room: Auditorium**

10:00 - 11:00 **Plenary Session: Power Quality Measurements Methods,Analyzers and Costs** **Juan Martínez**	**WeMP** **Room: Auditorium**

11:00 - 11:30

Coffee Break

11:30 - 13:30

TECHNICAL SESSIONS

4A-EMC, LOADS AND CONVERTERS	**WeM01** **Room: Auditorium** **Chair: Eduardo Zabala**

Feasibility Study of Advancing and Sitting up Power Line Communication (PLC) System under Circumstances of Electromagnetic Compatibility (EMC) on the Ships
M. Bakkali, C. Mascareñas, F. Sánchez de la Campa, C. Martín, F.J. Abad, M. Barea, J.M. Valverde, J. Valencia, J.E. Chover

Possible Design of Bus Bar Construction for Matrix Converter
I. Galkin, A. Sokolovs

Evaluation of PLL's Technologies for the Calculation of the Electrical Network Frequency in Single Phase Systems
H. Rivas, J. Bergas

Assessment of Electromagnetic Disturbances Transfer between Networks
P. Gburczyk, R. Mienski, R. Pawelek, I. Wasiak, W. Kepinski

Virtual Synchronous Machine
R. Hesse, H.P. Beck, D. Turschner

Frequency Converters as Sources of Interharmonics
I. Zhezhelenko, Y. Sayenko, T. Baranenko

High Voltage Auxiliary Power Supply with the Simplified Power Circuit Topology for the DC Trains
D. Vinnikov, J. Laugis

4B-MODELING AND SIMULATION

WeM02
Room: A1
Chair: Jovica Milanovic

Analysis of Voltage Profile And Its Improvement In Harmonic Included Distribution Systems
S. Galvani, H. Hosseinian, S.H. Hosseini, F. Shahnia

Analysis of HV and MV networks faults effect on short drops
G. Nicolau, J.R. Regué, R. Bosch

Voltage Quality Improvement in Distribution Networks
C. Zúñiga

Voltage Estimation in Electrical Distribution Systems
J.O. Pinto, R.B. Godoy, L. Galotto

Multiple Signal Processing Techniques Based Power Quality Disturbance Detection, Classification, and Diagnostic Software
J.O. Pinto, R.B. Godoy, L. Galotto

Case Studies of Harmonic Problems, Analysis, and Solutions on Transmission Systems
D. Mueller

4C-DISTRIBUTED GENERATION AND RENEWABLE ENERGIES

WeM03
Room: A2+A3
Chair: Koen Van Reusel

A Study of Electric Power Quality using Storage System in Distributed Generation
K. Yukita, Y. Goto, K. Ichiyanagi, K. Hirose

Impact of Embedded Generation on the Voltage Quality of Distribution Networks
G. Esposito, N. Golovanov, C. Lazaroiu, D. Zaninelli

Comparison between Solar and Wind Energy in Lebanon
A. El-Ali, N. Moubayed, R. Outbib

Innovative Training Techniques to Account for Power Quality Issues when Deploying Distributed Energy Resources
C. Coujard, S. Galant, A. Vafeas, S. Grenard, M. Bollen, R. Rodriguez

Distributed Generation Impact on Voltage Sags in Distribution Networks
J.A. Martinez-Velasco, J. Martin-Arnedo

Grid Connected Wind Turbine-Fuel Cell Power System Having Power Quality Issues
M. Gaiceanu, G. Fetecau

4D-IMPROVEMENT AND DISTURBING LOADS

WeM04
Room: A4
Chair: to be confirmed

LC Coupled Shunt Active Power Filter (APF): New Topology and Control Methods
J. Balcells, M. Lamich, D. González, J. Gago

Damped-Type Double Tuned Filters Design for HVDC Systems
M.A. Zamani, M. Mohseni

Paper Ref: 203 Title: Active Compensation of Harmonics in Industrial Applications

S. Kalaschnikow, S. Hansen, L. Asiminoaei, H. Gedde Moos

Electric Arc Furnace Modelling from a "Power Quality" Point of View
I. Vervenne, K. Van Reusel, R. Belmans

Propagation of Unbalance in Electric Power Systems
M. Chindris, A. Sudrià, A. Cziker, A. Miron, H. Balan, A. Iacob

Integrated Approach for Power Quality requirements at the Point of Connection
J. Cobben, S. Bhattacharyya, J. Myrzik, W. Kling

Dynamic Harmonic Mitigation and Power Factor Correction

C. Chavez, J. Houdek

13:30 - 15:00
Lunch

15:00 - 17:00
TECHNICAL SESSIONS

5A-ECONOMIC ASPECTS	**WeA01** **Room: Auditorium** **Chair: Paola Verde**

Economical Damage due to Low Power Quality
I. Zhezhelenko, Y. Sayenko, A. Gorpinich

Creating a Regulatory Framework for Voltage Quality
B. Franken, V. Ajodhia, K. Keller, K. Petrov, C. Müller

Overview of Electricity Deregulation, Power Quality and Energy Efficiency Studies in Turkey
Ö. Gül

Planning for "High Quality" Distribution Networks
F. Pilo, G. Pisano, G.G. Soma

The Costs of Keeping Reliability of Electrical Devices in Power Enterprise.
W. Kopterski

Methodology for Assessment of Financial Losses due to Voltage Sags and Short Interruptions
J. Chan, J. Milanovic

Pan-European Power Quality Survey - a study of the impact of poor power quality on electrical energy critical industrial sectors
R. Targosz, J. Manson

5B-MODELING AND SIMULATION	**WeA02** **Room: A1** **Chair: Antoni Sudrià**

Flashover Rate Due Lightning in Overhead Distribution Lines
C. Vásquez, C. Blanco, W. Osal

Simulation of Electric Quantities in Lighting Networks
E. Konečná

Time-Series Load Modelling and Load Forecasting Using Neuro-Fuzzy Techniques
Z. Haydari, A. Mohammadi , F. Kavehnia, M. Ghanbarian, M. Askari

Computer Aided Online Fault Diagnosis of Induction Motors
Suri Sathya Prashant S.Shyam Sunder K.SatyaKrishna S.A.Sharma

S.A. Sharma, S. Sathya Prashant, S. Shyam Sunder, K. Satya Krishna

Impedance Measurement of a Fuel Cell on Load
E. Aglzim, A. Rouane, B. Kraemer, R. El Moznine

ANETO: A tool for the Automatic Generation of Base-case Theoretical Network Models
A. Gómez, G. Tévar, M. Rodríguez, J.A. García

Evaluation and Trends of Power Quality Indices in Distribution System
E. Mertens, L. Dias, F. Fernandes, B. Bonatto, J. Abreu, H. Arango

5C-RELIABILITY OF SUPPLY AND DISTRIBUTED GENERATION

WeA03
Room: A2+A3
Chair: Mircea Chindris

Reliability of Large Power Units in Probabilistic Approach
J. Buchta, A. Oziemski

Assessing Fault Tolerant Power Infrastructures : An approach using Operating Dependability Study Methods
J.F. Christin, A.A. Pérez, J. Sallent

Micro storage in distributed PV grid-connected installations and Demand Side Management
X. Vallvé, A. Graillot, S. Gual, H. Colin

Steady State Model of 100kWe SOFC Power Conditioning System
M. Gaiceanu, G. Orsello

Impact of Distributed Generation over Power Losses on Distribution System
F. Gonzalez-Longatt

Mitigating Voltage Sag By Optimal Allocation of Distributed Generation Using Genetic Algorithm
M. Jenabali Jahromi, E. Farjah, M. Zolghadri

Distributed generation and renewable energy sources in Poland.
J. Paska

5D-SENSIBILITY OF LOADS

WeA04
Room: A4
Chair: Oriol Boix-Aragonès

Electrical Quality Requirements for Scientific Applications. The ALBA Synchrotron Light Source Case.
M. Cusidó, LL. Miralles

Affect of Voltage Sags on Electro-magnetic Contactor
I. Iyoda, M. Hirata, N. Shigei, S. Pounyakhet, K. Ota, T. Ise

PWM Inverters for Stand-alone Single-phase High Quality Power Generation.
R. Lima, A. Mendes, A. Almeida, A. Cardoso

Contributions to Analysis of Energetical Performances of Auxiliary Equipments of Luminaries
S. Diga, D. Rusinaru, F. Ivan

Characterisation of Centralized CSS supplied Emergency Lighting Equipment Behaviour
M. Granziero, M. Cappellari, F. Bua, A. Baggini

A Study of Voltage Sags in Electric Motors. Development of a sag generator
J. Perez, C. Cortes, A. Gomez

CIGRE/CIRED/UIE JWG C4.110 Voltage dip immunity of equipment in installations

M. Bollen, M. Stephens, K. Stockman, S. Djokic, A. McEachern, J. Gordon

17:00 - 17:30
Coffee Break

17:30 - 19:30
TECHNICAL SESSIONS

6A-LOADS AND CONVERTERS	**WeE01** **Room: Auditorium** **Chair: Zbigniew Hanzelka**

Power Quality Problems in Unbalanced Operations of Fault Tolerant H-bridge Multilevel Active Front-ends
G. Brando, A. Dannier, A. Del Pizzo, R. Rizzo

Methodology for Assessing the Impact of Short-Term Voltage Variations (Sags) on Power Electronic Equipment
C. Trujillo, H. Torres, A. Pavas, J. Guacaneme

Switching Power Supplies: Experimental Analysis of Absorbed Powers
R. Langella, A. Testa

Influence of Modulation Frequency on the Properties of the Induction Motor, which is supplied from Frequency Converter.
J. Kubin, E. Konecna

An Innovative Approach for Condition Monitoring and Fault Diagnosis of Induction Motor by estimation of Rotor Time constant using Extended Kalman Filter
P. Parthasaradhy, S. Sathya Prashant, S. Shyam Sunder, K. Satya Krishna

Series-Connected DC-DC Power Converters for Low-Voltage DC Source in Distributed Generation
C. Pica, R. Bojoi, G. Griva, A. Tenconi

Static Switches for their use on Capacitors Batteries connection
R. Camell, Q. López, M. Teixidó, H. Rivas, A. Sudrià

6B-RELIABILITY AND CONTINUITY OF SUPPLY	**WeE02** **Room: A1** **Chair: Salvador Baille**

New Power Quality Solutions Especially Designed For Industrial Applications
F. Ferrandis, A. Barona, J. Olarte, J.L. Iribarren

Design of Emergency Power Systems For Reliable Uninterrupted High Power Applications.
D. Sarussi, C. Kornfeld

Electrical Power, Quality Improvement in the Eastern European Reagion
D. Fita, L. Muresan, R. Borz

Reliability analysis of distribution networks.
R. Gono, M. Kratky, S. Rusek

Energy Sustainability in Sub-Saharan Africa
D. Nchelatebe Nkwetta, V. Van Thong, J. Driesen, R. Belmans

Regulation of the Electricity Supply Continuity and Decision making of Distribution Companies about Measures to be undertaken in the Network.
V. Detrich, P. Skala, Z. Spacek, V. Blazek

Reliability Centered Maintenance
E. Mascarell

INCA: A Tool for Assessment and Improvement of Supply Reliability Indices
J.A. Rosendo, A. Gomez, J.L Martínez, G. Tévar, M. Rodríguez

6C-DISTRIBUTED GENERATION AND RENEWABLE ENERGY

WeE03
Room: A2+A3
Chair: Samuel Galceran

Estimation of the Energy Losses in a Wind Park
E. Diaz-Dorado, C.J. Carrillo, J. Cidrás, E. Albo

Harmonics Effect caused by Large Scale PV Installations in a LV Network
M.C Benhabib, J.M Myrzik , J.L. Duarte

Compensation of Fast Changing Loads - Application Example Wind Turbines
P. Goldstrass, A. Kartal

Analyzing the Quality of Supply under the Insight of the DC Networks
F.J. Santiago, A. Gil de Muro, J. Anduaga

An Anti-islanding Control System for Distributed Generation Plants with Synchronous Machines
L. Piegari, R. Rizzo, P. Tricoli

Development of a Tool for Calculating the Effects of PV-systems connected to a Low Voltage GRID
C. Gonzalez, A. Sumper, R. Ramirez, R. Villafáfila, O. Boix, M. Chindris

Field Demonstration on Multiple Power Quality Supply System in Sendai, Japan
K. Hirose, T. Takeda, A. Fukui

6D-PQ MEASUREMENTS

WeE04
Room: A4
Chair: Emmanuel De Jaeger

Validation techniques of network harmonic models based on switching of a series linear component and measuring resultant harmonic increments
W. Wiechowski, B. Bak Jensen, C. Leth Bak, J. Lykkegaard

GPS-synchronized harmonic measurements performed on a 400 kV transmission network
W. Wiechowski, B. Bak Jensen, C. Leth Bak, J. Lykkegaard, J. Wasilewski

Single-Point Strategies for the Detection of Harmonic Sources in Power Systems
A. Cataliotti, V. Cosentino, M.G. Ippolito, G. Morana, S. Nuccio

Monitoring Power Quality beyond EN 50160 and IEC 61000-4-30
A. Broshi

Observability of Power System Behaviour by Optimal Located Phasor Measurement Units
P. Komarnicki, C. Dzienis, Z.A. Styczynski, G. Müller, I. Gollub, J. Blumschein

The Design and Construction of Power Quality Parameters Recorder
M. Rogóż, Z. Hanzelka

Field Measurements on Wind Turbines: a Voltage Dip Characterization under the Spanish Grid Code
E. Gomez, M. Cañas, J.A. Fuentes, A. Molina, F. Jimenez

21:00 - 23:00
Gala Dinner **Room: Auditorium**

THURSDAY, OCTOBER 11th

THURSDAY, OCTOBER 11 th

09:00 - 11:00 TECHNICAL SESSIONS	
7A-HARMONICS	ThM01 Room: Auditorium Chair: Jose Antonio Rosendo Macias

Harmonics Consideration of a RSFCL in a 11kV Distribution System
H. Heydari, H. Hooshyar, M. Savaghebi, R. Sharifi

The Practical Application of the Method Enabling to determine the Participation of the Customer and Utility in the Harmonic Distortions at the PCC.
K. Kuryło

Choice of Harmonic Filters for a High Voltage Network with Distributed Non-linear Load
L. Kovernikova

Power System Harmonic Estimation using Neural Networks
B. Swiatek, M. Rogoz, Z. Hanzelka

Application Examples of Broadband Active Harmonic Filter Systems in Four Specific Industries
J. Johnson, I. Evans

Reducing Heat in a Transformer and increasing its Loading Capacity, by decreasing the Percentage of Harmonics and Reactive Power within the Distribution Network of an Industrial Consumer
M. Duta, A. Iacob, S. Popescu, M. Serb, M. Bernea

Harmonic Analysis in Ideal and Nonideal
F.N. Belchior, J.P Abreu, H. Arango

7B-RELIABILITY AND CONTINUITY OF SUPPLY	ThM02 Room: A1 Chair: to be confirmed

Development of Search Space Establishment-less Type High Speed Genetic Algorithm Considering Mutation Rate and Using Parallel Computer
T. Ujiie, Y. Mizutani, K. Mizutani, M. Leelajindakrairerk

Methodologies and Tools for Electric Power System Reliability Assessment on HL I and HL II Levels.
J. Paska

Problems of Deployment of RC Switching Elements in Distribution MV Networks for Improving Reliability of Power Supply
P. Moldřík, J. Gurecký, P. Krejčí, L. Paszek

Decentralized Control of a Different Rated Parallel UPS Systems
R. Strzelecki, D. Wojciechowski

Reactive Power Control in Transmission Network as a Tool for Reliable Supply
G. Blajszczak

Selection of High-power Static UPS
R. Villafáfila, A. Sumper, D. Montesinos, A. Sudrià

Reliability Evaluation of Photovoltaic and Mini Wind Plant interconnected with UPS
A. Burgio, D. Menniti, A. Pinnarelli, N. Sorrentino

7C-DISTRIBUTED GENERATION AND RENEWABLE ENERGY

ThM03
Room: A2+A3
Chair: Maciej Tondos

Improving Power Quality with coordinated Voltage Control in Networks with Dispersed Generation.
T. Pfajfar, I. Papič, B. Bletterie, H. Brunner

Control of a DFIG-based Wind System in presence of Large Grid Faults: Analysis of Voltage Ride through Capability
J. Arbi, I. Slama-Belkhodja, S. Arnalte

Exploitation of Renewable Power Sources for Local consumers' Reservation
J. Rozenkrons, A. Staltmanis

The Load Flow Calculation in Unbalanced Radial Electric Networks with Distributed Generation
M. Chindris, A. Sudria, B. Tomoiaga, C. Bud

The Load Flow Calculation in Harmonic Polluted Radial Electric Networks with Distributed Generation
C. Bud, B. Tomoiaga, M. Chindris, A. Sudria

Improving Power Quality in Remote Wind Energy Systems Using Battery Storage
T. Aboul-Seoud

Pace of Tower Shadow Fluctuations in a Wind Farm (Speaker: ***A.A. Bayod-Rujula)***
J. Mur-Amada, A.A. Bayod-Rujula

Wind Power Variability Model. Part III – Validation of the model (Speaker: ***A.A. Bayod-Rujula)***
J. Mur-Amada, A.A. Bayod-Rujula

Characterization of Spectral Density of Wind Farm Power Output (Speaker: ***A.A. Bayod-Rujula)***
J. Mur-Amada, A.A. Bayod-Rujula

7D-PQ MEASUREMENTS	ThM04 Room: A4 Chair: to be confirmed

Optimal Measurement Devices Allocation for Harmonic State Estimation Considering Parameters Uncertainty in Distribution Networks
C. Muscas, F. Pilo, G. Pisano, S. Sulis

Methods for Power Quality Analysis according to EN 50160.
A. Nikolic, D. Naumovic Vukovic, S. Skundric, D. Kovacevic, V. Milenkovic

Modular System For Distributed Power Quality Monitoring.
P. Bilik, L. Koval, J. Hula

PEA's Premium Power Service: Baseline and Risk Assessment
Ch. Madtharad, Ch. Sorndit, S. Premrudeepreechacharn, M. MacGranaghan

Evolution of processing signal techniques in power quality
T. Yebra, V. Fuster, H. Beltrán

Method for Characterizing Measured Three-phase Unbalanced Voltage Sags
M. Madrigal, B.H. Rocha

Power Quality Measurements at an Automobile Factory.Conclusion
M. Pérez Donsión

Automatic System for Distance Reading of Static
G. Nakov

11:00 - 11:30
Coffee Break

11:30 - 13:30
TECHNICAL SESSIONS

P.Session 8A-Voltage dips in installations:Ongoing activities in international organizations	ThA01 Room: Auditorium Chair: Math Bollen

Immunity of Voltage Dips in Installations
M. Bollen

Equipment and Process Behaviour during Voltage Dips
K. Stockman

Statistical and Economical Data on Voltage Dips
A. McEachern

Economic Framework for Power Quality, Joint Working Group C4.107
J. Milanovic

Other Power Quality Activities within International Organisations
M. Bollen

8B-Energy Efficiency	ThA02 Room: A1 Chair: Franco Bua

Utilization of the Standard-voltage-range in Low-voltage Networks for the usage of Local-Energy-Controllers without affecting the Powerquality
P. Kadel

Standby Power Consumption in Belgium
K. Clement-Nyns, I. Pardon, J. Driesen

Total Reliable Efficiency (TRE). A Global Approach for Continuous Energy Improvement
J. Daura, R. Steinbauer

Energy Efficiency of Distribution Transformers in Europe
R. Targosz, F. Topalis, W. Irrek, J. Frau, A. Baginski, A. Klimowicz, A. Rialhe, J.O. Budin, J. Szkutnik

Energy Efficient Transformer Selection Implementing Life Cycle Costs and Environmental Externalities
E. Amoiralis, M. Tsili, P. Georgilakis, A. Kladas

Ant Colony Solution to Optimal Transformer Sizing Problem
E. Amoiralis, M. Tsili, P. Georgilakis, A. Kladas

The High-Frequency Interferences Produced in Systems what Includes the Pulse Width Modulation Inverter and AC Motors
E. Darie

8C:Distributed Generation and Renewable Energy+Reliability and Continuity of Supply

ThA03
Room: A2+A3
Chair: Rodrigo Ramírez

Study of Power Fluctuation from Dispersed Generations and loads and its impact on a Distribution Network through a Probabilistic Approach.
P. Chen, Z. Chen, B. Bak-Jensen, R. Villafáfila, S. Sörensen

Coordinated Reactive Compensation in a Wind Park
E. Diaz-Dorado, C.J. Carrillo, J. Cidrás

A New Heuristic Network Reconfiguration Algorithm for Radial Distribution System
J. Dhiman, T. Thakur

Reliability and Continuity of Supply
C. Musonda, K. Kasonkomona

Study on Adaptive Power System Stabilizing Control calculated by "Search Space Establishment-less Type Genetic Algorithm Considering Mutation Rate (MSSELGA)"
Y. Hirabayasi, Y. Mizutani, K. Mizutani, M. Leelajindakrairerk

Development and implementation of a Condition Monitoring System in a Substation
J. Velásquez, R. Villafáfila, P. Lloret, Ll. Molas, S. Galceran, A. Sumper

IEC 61850 as a Flexible Tool for Electrical Systems Monitoring
P. Lloret, J.L. Velásquez, L. Molas, R. Villafáfila, S. Galceran, A. Sumper

8D-Education and Economical Aspects

ThA04
Room: A4
Chair: Anibal de Almeida

A Free Simulator Program for Teaching Power Quality Concepts
A. McEachern

Power Quality between Necessity and Tradition in Master Courses Curricula of Romanian Electrical Engineering Faculties
D. Rusinaru, I. Mircea, S. Diga, F. Ivan

A New Vision of PQ Research for the Next 10 Years-Revised
W. Howe

Power quality education using a remote monitoring laboratory
A. Sumper, R. Villafáfila, L. Molas, O. Gomis, S. Lopez, R. Ambrona

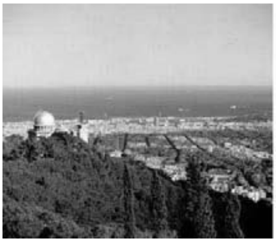
DERLab – Distributed Generation Test Facility
P. Gburczyk, R. Mienski, R. Pawelek, I. Wasiak

Cardinal fusses and barriers of the transition in the energy sector of Republic Bulgaria
J. Angelova

Analysis of Electrical Power Sale Costs by the Use of "Sensitivity Analysis" Method
J. Angelova

13:30 - 14:00
Closing Session **Room: Auditorium**

SOCIAL TOUR



PANORAMIC BARCELONA

From the mountains to the sea

9th October - morning

A panoramic tour of the city, from the mountain to the sea, passing through some of the most representative avenues and buildings: Montjuïc Mountain, stop to admire a panoramic view of the city and the Port, the Ramblas, the Paseo de Gracia, the Diagonal, the Sagrada Família and the Olympic Port.

Price per person: **45 €**



HISTORICAL BARCELONA

Stories and legends of the Gothic Quarter

9th October - afternoon

A walk through the old quarter of the city, where plentiful remains of the old Roman Walls and constructions can be seen, and the great Gothic buildings, witness to the ascendancy of the city and its culture in the Middle Ages. The trip goes via the Ramblas, the Mercado de la Boqueria, Plaza Sant Jaume, where the Palau de la Generalitat and the City Hall are situated, the Cathedral and its cloister, and the Plaza del Pi.

Price per person: **50 €**

WINE CELLARS AND MONTSERRAT

Magic day in the Catalonian Holy mountain and the Codorniu cellars

10th October - all day

An outing to the Codorniu cellars, in the Penedés area, about 30 Kilometres from Barcelona. The Penedés is the wine-growing region which created the "cava", a sparkling wine vintage of worldwide renown. During the trip you will visit the cellars and see the winemaking process. Then we shall go to Montserrat, the holy mountain of Catalonia, a majestic mountain about 60 kilometres from Barcelona. It name comes from its special silhouette, cut by erosion into a saw shape. The Royal Basilica houses the picture of the legendary "Virgen Morena", patron saint of Catalonia. Catalan lunch not far from Montserrat.

Price per person: **100 €**



GALA DINNER

Maremagnum Convention Centre

10^{th} October - night

The Sala Maremagnum, a hall with a total indoor surface area of 900 sq.m. and a private terrace measuring some 550 sq. m. with exclusive direct access through the gall itself. From the sala Maremagnum, one can see the city's skyline from the sea, the Columbus monument, Montjuïc mountain, the Port of Barcelona, etc…

Price per person: **80 €**



BARCELONA GAUDÍ TOUR

Modernist designs and Colours

11^{th} October - morning

The Modernist movement is reflected in the architecture of the "Eixample" district. A central sector of the Eixample is the Quadrat d'Or (Golden Square) because of its concentration of Modernist Buildings. A trip through the Catalan Modernism - Art Deco, Modern Style - an artistic current which manifested in Europe around the turn of the century whose main features are the variety of forms and the richness of its decorative elements. A large proportion of the masterpieces of modernist architects such as Gaudí, Domènech i Montaner and Puig i Cadafalch are concentrated in the "Eixample" quarter. A visit to the Templo de la Sagrada Família (Holy Temple), probably the most famous of Gaudi's works, is still being built according to his initial project. The catalogue of constructions by Gaudí does not end here, we can visit the masterpiece of his work: the Parque Güell, now UNESCO heritage, where nature and art coexist in a same place. This fantasy garden is also one of the best spots from which the city can be seen.

Price per person: 45 €