Interconnection of Small Power Systems

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Abstract **– Direct current was the first type of transmission system used in very early days of electrical engineering. The ever increasing progress of semiconductor technology continues to have a significant impact on the development of advanced power electronic apparatus used to support operations. This apparatus is also used to provide an efficient management of electrical grids, turning this kind of transmission into a reliable alternative regarding to the traditional system.**

This paperwork is intended to study the possibility to use this technology in the interconnection of the central bloc of the Azores Islands. The purpose is to improve its energetic efficiency. Taking the three islands situation into account, the most important aspects in an interconnected network, as well as the most important variables for the working of the whole equipment were analysed.

In this technical-economical analysis, the financial component is extremely relevant in this study's decision's tree. It is therefore many times put into the shot light.

Key-Words **– Energy Quality – Direct Current – Converter – IGBT – Cable Transmission.**

I. INTRODUCTION

In the last few years there has been a great evolution in DC technology, which has allowed it to become more competitive when comparing to the alternative system. This development has a positive effect on the reliability of the whole system and on its costs, the most important points are:

- Increase of the semiconductor's capacity that comprise the converter;
- Evolution on the different semiconductors connection's architecture;
- Use of the forced commutation;
- Digital electronic application and optical fiber on the converter's control.

As one can see, the growing of this technology has been almost exponential. Therefore its advantages will be further on presented. Thus the option of using this technology on the interconnection of this case and its viability will be one of the most important purposes of this paperwork.

The calculation of variation as far as this study's production costs are concerned were analysed, specifically the costs related to the combustible as well as the fixed costs for the working of the centrals. In addition the cost of the non-supplied energy, due to long interruptions was considered. The values of the power to reallocate are relevant when dimensioning the equipment to use. Its estimative is done for a value of a reasonable time.

The main aspects in a connection of direct current are studied as well as the advantages in relation to the AC system. The components that constitute the connection as well as the functioning of the converter is analysed, starting from the command and working principle.

The different elements that make up the cables to use in this interconnection are examined as well as the conductor, conductor screen, insulation, tensile armour and outer cover. The approximate dimension of three possible paths and two possible scenarios is also calculated.

In the early years the islands in study are showing a significant growth on the energy's consume. Hence in the future its interconnect is an hypothesis to be analysed due to the enlargement of the energy's quality, withdrawing of costs and other advantages to be explained further on.

II. IMPORTANT ASPECTS IN AN INTERCONNECTED ELECTRIC NETWORK

The functioning of an interconnected electric network is based on the principle of the frequency-power regulation. This means that in an AC network all centrals work in parallel maintaining the frequency within the previously fixed limits. Thus the equality between the consumed and supplied power is to be seen instantaneously. An eventual interconnection among the three islands of the Central Bloc of Azores would bring several benefits for the consumers especially in the quality of the consumed energy.

The specific characteristics of small energy systems together with the small dimension of networks, create some difficulties to maintain higher levels in the quality of service, from the technical and human point of view. The small dimension of the networks has as consequence a weak capacity to absorb the handicaps that come up or affect them. Thus, there are other advantages in linking this three small systems of energy:

- Reducing the investment in centrals of production's storage;
- Acquiring a greater security in what is planned;
- Power demand problems;
- Frequency's stability;
- Delaying of investment in new generators unities and investment bigger generators unities;

▪ Using, with mutual interest the differences of production costs, namely of the fossil combustibles.

III. ASPECTS TO ANALYSE IN THE PROJECT

This kind of project demands the analysis of several questions. Among them the motivating cost factor, the great consumer and the access to energy, and finally the evolution of the connection's characteristics. But its decision is mainly determined by economical aspects, involving the study of cost-benefit.

In this particular case there are some special technical conditionings and these determine the need to apply a solution with some specific characteristics. Hence, there will be aspects to take into account at the conception, implementation and functioning of this type of interconnection:

▪ The first point of connection of the future system to each island's network should be localized, preferentially in the region of bigger electrical density of the same network (gravity charges' centre), at least when the predominance of energy's injection is forecast.

▪ This interconnection system should have characteristics that can minimize the environmental impact caused by its existence.

▪ As far as the electrical characteristics are concerned , when comparing to its equivalent solutions, it should guarantee minor losses in the electric energy transportation. It should also allow the inversion and the control of electric energy's flux on the most favorable conditions.

▪ The proposed system of interconnection should minimize the investments to be made on the existing electric network, namely the investments related to the implementation of new generation unities as well as the recovering or demobilization existing unities.

▪ It is important to point out the question of the storage's generation. As a matter of fact, the main purpose will be the one to have in each island's network a significant number of generator's unities and use them in the best possible way .

The flux of electric energy among small energy systems, might in many case act as a natural trend and its working should be based on the following principles:

- Security in supplying;
- Protection of the environment;
- Small consumers protection;
- Recognition of the existing diversity among the islands system.

IV. COST IN STUDIED CENTRALS

The total cost of an electro producer centre is constituted by two main parcels:

$$C_F + C_V$$

The fixed cost, C_F, shows a fixed amount as well as the amortization and income of the investment, human resources, insurance, taxes, maintenance costs at the thermal central of St. Jorge Island, among others. The variable cost, C_V, depicts the the cost of the combustible consumed during the energy production. The variable cost is the products of the motors consume (g/kWh) for the cost of the combustibles and for the produced energy. This charge is determined by the price of the combustibles in the international market. Taking the year 2005 into account it is essential to be acquainted with the total amount of the produced energy during that year. The purpose is to obtain the cost of the combustibles.

The thermal production through diesel is very expensive. Hence there might be significant gains if its usage diminishes. In the scenery of the interconnection among the three islands the diesel thermal production may be put aside and compensated through the fuel oil production, which would implicate excessive profits. The resulting 23 832 MWh of the diesel production would be then distributed for the two fuel oil centrals of the Fail and Pico Islands.

This production transfer implies that only in the year of 2005 **1,04144 millions of euros (-17%)** in combustibles would have been spared. The interconnection would have had a huge impact in this particular case.

For the calculation of the C_F one should take into account the investment's initial (I_{ini}) and remaining value (I_{res}). In this case, the remaining value will not be considered due to the central's characteristics. The price of the fixed cost is established through the following equation:

$$C_F = \frac{I_{ini} - I_{res}}{n} + \left(I_{ini} - j\,\frac{I_{ini} - I_{res}}{n} \right) r$$

Equation 1

The number of the years for the investment's amortization (n) may vary from 20 to 20 years and will be considered as 30 years. The factor (j) corresponds to the mentioned year and will vary from 0 to n. Finally the capital income tax (r) will be 11%, which comes from the 8,5% of duty and 2,5% of the inflation tax.

In this study, the diesel thermal production would not be necessary. Therefore, the groups nourished by this combustible represent an unnecessary charge. Based on the EDA data the following values may be achieved.

Table 1 – Fixed cost in studied centrals.

	St. Jorge	Faial	Pico
Number of diesel groups	9	2	0
Average cost of each diesel group (considered value)	300.000€[1]		--
I_{ini} (€)	3.240.000€	600.000€	--

[1] One is about an approached value, after consulting some companies who sell such equipment. References: http://www.dieselserviceandsupply.com/Used-Generators/Katolight-2000-11286.aspx http://www.peakpowertools.com/Diesel-Generator-Cummins-2000-kW-Electric-Gen-Set-p/gtr558023.htm

j factor	23 (Entered to the service in 1984)	26 (Entered to the service in 1982)	--
C_F (€)	191.160	28.800	0
Total (€)	219.960		

The St. Jorge's central's initial cost will consist of the value of its 9 diesel groups, plus 20% due the building of the central and its equipments. However at the Faial island the expected initial cost will the one of the diesel groups. The reason is because only these have relevance for the study of this central. Thus two diesel groups and four fuel oil groups make part of it.

Once the accounts of 2005 were made, the fixed costs of the diesel thermal production were approximately 220.000€. Besides this value, the amounts spent with human resources, insurances, taxes and central's maintenance expenses on St. Jorge's island.

The today's interconnection of the islands would not alter this charge since the investment was done in the past. But through this manner, one becomes aware of the fixed expenses resulting from this type of production. On the other hand, it remains the idea of how much one could save just in the year of 2005 if the interconnection should be made at the beginning of the exploration.

The non-supplied energy (ENF) is part of the EDA's Distribution and Transportation's Network Characterization's Report. The data that were obtained correspond to the year of 2006 and depict considerable values, namely dozens of MWh. For this particular case only the values whose origin is at the shipment and production will be taken into account. The non-supplied energy motivated by the distribution depends on the variables that overcome the purpose of this paperwork.

Table 2 – Non-Supplied Energy (MWh).

	Accidentally		Foreseen	
	Production	Transport	Production	Transport
St. Jorge	1,55	0	8,09	0
Pico	68,6	18,96	15,14	0
Faial	41,63	0	0,01	0
Total	153,98			

By making a pondered average of the energy's average cost is placed at the 0,14185€/kWh. By multiplying this cost for the non-supplied energy and considering only the long interruptions, one would get 22.000€, which would be no longer earned by EDA. This costs could be easily reduced through the interconnection of the three islands.

This was a company's calculus but the valuation of this energy by the consumers, would be at least 10 times higher. For example, the costs related to an interruption during the working time of a factory, can be very high.

V. ANALYSIS OF THE POWER TO RELLOCATE

The analysis of the maximum demand values of each island's electric energy consume will be important for the correct dimensioning of the equipment to be installed in the three island's interconnection. Knowing the growing patterns of the islands is vital since the installed equipment would need to be prepared for this growth. The useful life of the different components that allow the interconnection is placed between the 30 to 40 years. Despite this high value, the connection will be dimensioned to support a consumer's increase in the next 10 years. Taking the described growths into account, one can consider that these are constant over the following 10 years.

By applying them in the power's increase of the maximum demand, Pico island will register a power near the 16 MW in 10 years time. In St. Jorge's island the maximum demand will consist of about 8 MW. Finally in Faial it will be approximately 20MW. The formula used for this calculation was the following:

$$Demand_{future} = Demand_{present}(1 + growth\_tax)^{number\_of\_years}$$

Equation 2

VI. CONNECTION IN DIRECT CURRENT

Once these purposes are studied, the next step is to analyse another crucial aspect: the type of connection in direct current. The HVDC applications (High Voltage Direct Current) consist essentially of three types: Monopolar Link; Bipolar Link and Homopolar Link.

In this particular case the most consensual option seemed to be the bipolar link. This choice could be on one hand explained by the inconvenient of the ground return through the homopolar link, despite the fact that this one does not require so many isolating costs. The inversion of the course of the power's transfer is viable in the bipolar configuration, which is obtained through the converters control. The big majority of the direct current transmission systems is bipolar. Thus the monopolar operation is merely allowed if one of the poles should be non reachable.

Main components

Two converters in series will be used in order to obtain a tension of about 15kV from the direct side between both conductors, which is typical from the bipolar link. As far as the voltage between the conductors is concerned, the considered value is reasonable, since the current is not too high for the aspired power values. Besides that the value is not very high for this kind of transmission, which makes the converters construction not problematic.

In a simple way, the following picture represents the most basic components that, together with the converters will provide the connections among the islands. In both limits, their constitution will be very similar, since the power's traffic is bidirectional. AC filters, DC filters and transformers will be fundamental for the power's transmission.

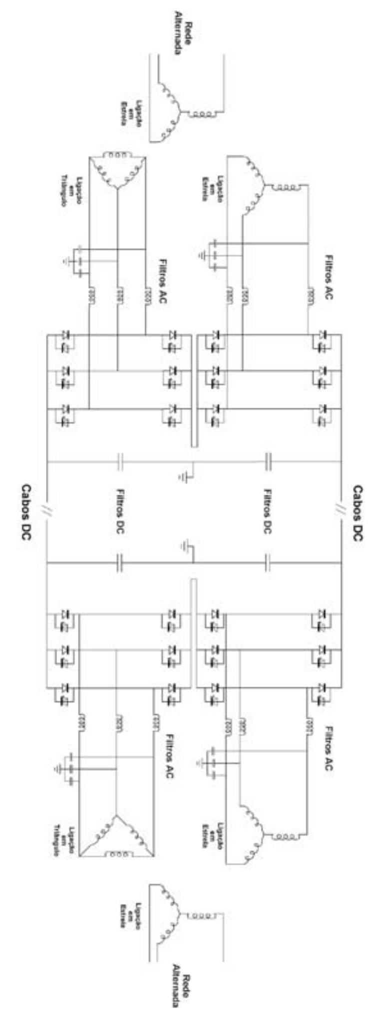

Figure 1 – Most important components in the interconnection.

The primary winding should have star-connected. The secondary will have two windings: one star-connected and other in triangle. On the direct side, both converters of each terminal work in one of six pulses. However its command should depict a delay between itself of about 30º, so that in the way out a 12 pulsation index could be obtained. This delay results from the transformers windings.

On the grid's side, the secondary's windings in star-connected and in triangle, originate the 5th harmonic that comes in the star's winding to annul itself with 5th harmonic that comes from triangle winding. The same happens with the 7th harmonic but only if the converters present the same command and the 30º delay.

It is important to emphasize that the converter's pulsation index increase facilitates the elimination of harmonics through low impedance condensers. This happens because its frequency raises. For example, with a 10 pulsation index one has k=1 (fundamental), k=9 and k=11, k=7 and K=13, etc.

$$u = V_M \sin(t) + V_{M_{11}} \sin(11wt) + V_{M_9} \sin(9wt) + V_{M\,7} \sin(7wt) + V_{M_{13}} \sin(13wt) + \ldots$$

$w = 314$ (frequency of the network)

Equation 3

If the pulsation index should be equal to 100, one would have k=1 (fundamental), k=99 and K=101, k=97 and K=103, etc.

$$u = V_M \sin(t) + V_{M_{101}} \sin(11wt) + V_{M_{99}} \sin(9wt) + V_{M\,97} \sin(7wt) + V_{M_{103}} \sin(13wt) + \ldots$$

$w = 314$ (frequency of the network)

Equation 4

The higher the harmonics' frequency is the easier they can be filtered. Thus, the pulsation index should be as higher as possible so that the harmonics may have a frequency far from the fundamental. For this particular potency the reasonable frequency for the carrier should be a thousand Hz's, which results in a pulsation index of dozens. However the carrier's frequency is bounded by the high potency.

In a direct current interconnection, there are other important components for the effective functioning, such as overcurrent protections, high frequency filters and the so-called DC reactor. This one is used on the direct current side in order to soften the current and to protect the converter from unpredicted oscillations. Its typical value is placed around the 300-600 mH.

The potency semi-conductors with MOS- Bipolar technology, in this case the Insulated Gate Bipolar Transistors (IGBT) will be the more indicated one for this specific study. This semi-conductor may support s 3300V tension and a 1200A current, high values that make sense in this case. The converter almost does not require command or commutation especially in comparison with other semi-conductors such as the GTO. Its operation's frequency may reach 20Hz in high power applications. This value is very superior to the 1000Hz, which is considered reasonable for the working of this converter.

As far as the converter's architecture is concerned its semi--arms are made up of a module and submodules. Each module is composed of three submodules placed in serial and these are composed by three already specified semiconductors in parallel (IGBT 3300V/1200A). The outlook of the submodules in serial allows to obtain high tensions. The placement of the semiconductors in parallel permits the operation with high currents. The following picture illustrates this situation:

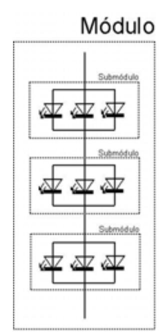

Figure 2 - Constitution of a module of the converter.

Placing semiconductors in serial and in parallel is a delicate problem. However it is fundamental in an assembly like this. It is important that the IGBT stay in conduction at the same instant in order to guarantee the correct voltage distribution through the module as well as the uniform division of the current. One should have some concerns on the assembly of the IGBT, namely the utilization of the individual port's attack circuits in order to get balanced and reduced commutation times, avoiding the parasite oscillations. These could be avoided, by assembling in serial with each port a resistance or a small inductance with a ferrite core, if the commutation times are not critic.

The IGBT can illustrate great variations at the value of conduction's threshold tension and this may damage its association in parallel in this particular case. Hence, it is important to use inductances in serial where the IGBT are simultaneously put in conduction and in cut, with the uniform division of the currents made by the inductances. The use of these connected inductances is useful, since the current's increase on one of the components inducts tensions by magnetic connection and these tend to reestablish the balance. It is a more expensive solution in comparison to the low cost in serial resistances. Nonetheless it is better in case of losses.

By placing a IGBT in serial or parallel one is still confronted with the existence of several command circuits that should guarantee that all mechanisms shoot at he same time. The outlook of the IGBT should also be symmetric at least one symmetric axle.

VII. CONVERTER'S WORKING / FUNCTIONING ANALYSIS

As far as the converter's functioning is concerned it is considered that in it's command the adopted modulation should be by Pulse Width Modulation, PWM. To be more precise, it should be the three-level synchronous modulation (sinusoidal). When the intention is to generate a three-phase AC voltages, delay ð, of the three-phase's system network, senses that indicate in each stage the instantaneous position of the network or its angle' position, are required. The next picture describes the converter's command circuit.

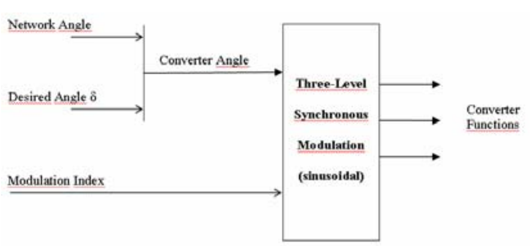

Figure 3 - Simple circuit of Command.

The control circuit will have three entries: the position of the energy's network tensions in each instant, the intended delay angle and the modulation index (reason between the maximal amplitudes of the modulating (sinusoidal wave) and carrier (triangular wave)). On the way out there will be three converter functions, one for each converter's arm.

The converter's potency is based on two main variables: the potency's angle (ð) and the converter tension's amplitude. For each potency's angle there will be an active potency's value.

The reactive potency switched with network may be controlled through the tension's amplitude of the converter's way out, more precisely through the difference between the network's tension amplitude and the converter's exit.

The fundamental's amplitude regulation of the converter's AC tensions will be performed through the modulation's index. By doing this regulation it becomes possible to perform a continuous and rapid control of the reactive potency. It is then possible to do a complete scanning, which includes negative values.

VIII. CONNECTION IN DIRECT CURRENT ADVANTAGES

The decision of the type of connection between the islands was made considering many aspects of electrical engineering. Following, many of these aspects will be explained.

When transmitting using direct current, reactive power control is independent of active power, what brings stability and quality to the energy. The converter can change from maximum capacitive to maximum inductive reactive power within a couple of milliseconds. The limitations for how fast the reactive power can be controlled are set by the surrounding AC system. The speed of this change depends on the command of the converter. The PWM control, brings a faster dynamic response to the system which reduces the need of high capacity filters.

However, transmitting in a AC network brings some problems. One of them is the capacitive effect that cables cause, like submarine cables. They generate much reactive power. In this particular case, with a tension next to 15kv, this problem does not apply.

A DC transmission system will be a valuable asset during a grid restoration. It will be available almost instantly after the blackout and does not need any short circuit capacity in order to become connected to the grid. The benefits will differ if one or both ends are exposed to the blackout. Black start capability if equipped with a small synchronous generator feeding auxiliary power (or power from another grid).

Adding an AC circuit to any network makes its short-circuit power increase, caused by its low reactance. This system has the advantage of not contributing to the short circuit currents in the connecting system, thus there will be no need for upgrading circuit breakers. However, this has to be addressed when discussing protection coordination. Thus, this can bring a big advantage in our study.

The losses in a DC transmission are reduced about 2/3[2], when compared with an AC system. This happens because due to the reduction not only of the losses in the dielectric of the cables,

[2] Reference in Muhammad H. Rashid, "Power Electronics" chapter 5.

but also in the corona effect, despite having a bigger effect in high voltage. However, in this case, this aspect has a minor importance. The absence of skin effect, very common in AC systems, also helps to decreasing the losses.

This power system engineer offers a number of additional benefits such as:

- Less of logistic during its construction;
- High availability – 98,5/99% [3];
- Little maintenance and reduced operation costs;
- Reduced visual impact.

IX. INTERCONNECTION CABLES

The transmission of energy using underground cables brings some advantages considering the air transportation and the visual impact. This last one is very important in various cases, like touristic areas where the scenery impact is relevant. Using the cables to transmit direct current also brings advantages when compared with AC because there are almost no electromagnetic fields and ground current is none.

Considering the constitution of the cables, it can be pointed out the 500mm^2 section of the conductor, that allows currents about 1000A. Further more, the conductor has to be water-tight. Considering the insulator material, the most used and the one with the best technical features, is polyethylene. Thus, it is widely recommended. To the armour, the use of steel cables is recommended as it is required to force it in submarine areas. Further more, in the interconnection areas, where a high depth is achieved, it is recommended the use of two layers of armour, with the respective swelling tape.

Comparing the different scenarios

The length of the cables used in this transportation is about 160km, if three connections are built among the islands. These connections can be made in two different ways, that differ in the existence or not of the path number 3. The relation between these two scenarios is related with the amount of wasted energy, this value is about 193,95 MWh. What represents a monetary worth of 27511,77€ per year, considering the rate of 0,14185€/kWh, if the three paths are built.

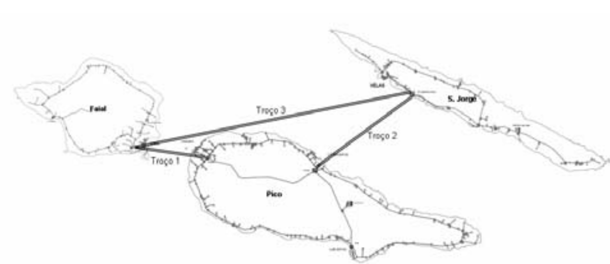

Figure 4 – Positioning of the different paths of the interconnection.

[3]Value related for the experience of the ABB relatively to this system, [ABB_HVDC].

At first it is important to know the potency in charge to determinate the maximum demand supported by the interconnection cables. That are presented in the chapter IV, in which the diesel thermal central of S. Jorge would be inactivated, and this island would have to be compensated.

Its energy production related to diesel of 2004 it's about 22434 MWh, that if dividing for the hours of the year (8760), we would have a average power of 2,56 MW. Observing the year of 2006, that grew up 8% (characteristic in this case), we can obtain about 3 MW.

To these results it is needed to add the average power transferred between islands in case of interruption, in order of dividing the total non-supplied energy caused by interruptions by the number of hours in the year of 2006.

The non provided energy calculated has its origins in the system of production and transportation, which is also assumed as the main cause of the long interruptions, and this would take us to 17,6 kW as average power of 2006.

At last, the average power supported by the interconnection is approximately 3,0176 MW, which will be very useful to calculate energy losses. In these calculations it has to consider:

- The average power calculated goes to S. Jorge island the most by the second and third paths, which path has about 3/2 MW;

- The average power that results from the interruptions, 17,6 kW, will be equally divided by the 3 paths.

After this, it is important to know the cables resistance, with a 500 mm2 section – information given by Cabelte, at 20ºC the resistance is close to 0,0605 Ω/km. With the length values of the calculated paths, there are sufficient information to calculate losses and rounds about 142,51kW.

Table 3 - Calculation of the losses in the paths.

	Path 1	Path 2	Path 3
Average Power (MW)	$\frac{0,0176MW}{3} \simeq 0,0059MW$	$\frac{3MW}{2} + \frac{0,0176MW}{3} \simeq 1,51MW$	$\frac{3MW}{2} + \frac{0,0176MW}{3} \simeq 1,51MW$
Average Current (A)	$\frac{0,0059MW}{15KV} = 0,39A$	$\frac{1,51MW}{15KV} = 100,67A$	$\frac{1,51MW}{15KV} = 100,67A$
Length of the Path (km)	11,83	21,92	44,93
Resistence (Ω)	1,43	2,65	5,44
Losses in the cables (W) $P = R \times I^2$	0,22	26856,29	55131,4
Converter Losses (W)	118	30200	30200
Total Losses (kW)		142,51 (4,72%)	

The previous value shows up that the total losses value is about 4,72%, by adding the losses in the converters and cables. In what the total power is concerned, was considered 1%[4] of losses per converter, having always in mind that each path has two converters.

The third path will be the most expensive of all the interconnection, because is two times bigger than the second one and four times than the first, because of this, the calculation of the losses without this path must be studied. For these calculations, it has to consider:

- The calculated average power that goes to S. Jorge island, it would only be possible by the second path – with about 3 MW;

- The production that goes to S. Jorge island is divided between the two remainder islands, so in the first path we'll have 1,5MW as average power (Faial's production);

- The average power that results from the interruptions of 17,6 kW, will be divided equally by the two paths.

With these scenario, the lack of the third path increases losses in 2,29%, that actually represents 7,01% of power flow. With the triangle connection, the interconnection become more stable, but the costs/efficiency determinates a connection of this kind. By the previous values it is possible to know the saved costs per year, in this case the 2006. The difference between losses in these two scenarios is about 605,23 MWh, based on 0,14185€/kMh, which is the weighted mean charged by EDA, reaching the saved costs of 85851,65€ per year.

It is important to notice that the losses has it's variations influenced by the square of the current, which signifies it is not stable working with mean values. In order that one should not calculate the mean losses throw the mean current, but from the current integral, which in this case it's not possible because we cannot obtain the current formula. The correct values would be higher in what the losses are concerned. One should attend to the maximum values instead of the mean values to be aware of the errors caused by the approximated values.

X. CONCLUSIONS

In this document the main issue is the technical/economical analysis of the different interconnection aspects. We have to consider two important questions: "Does the interconnection brings benefits that returns the investments?"; "Should be direct current transmission?".

The cost of such a connection goes around the 310 – 400 k€/MW[5], a quite expensive investment if the three connections are made. The interconnection was dimensioned to support a consume growth for the next 10 years, this way one can know for each path the power to install.

The path 1 connects Pico and Faial islands, as Faial island can eventually have a peak power in the order of the 20 MW, the equipment of this path must be prepared for this power, in case of failure of the path 3. The path 2 connects Pico and St. Jorge islands, as Pico island can eventually have a peak power in the order of the 16MW, the equipment must be ready for this power in case of failure of the path 1. The path 3 connects St. Jorge and Faial islands, as Faial can eventually have a peak power in the order of the 20 MW, the equipment of this path must be prepared for this power, in case of failure of path 1.

At the end of counts, the some of the three connections rounds about the 17,36 – 22,4 million euros were considered the construction prices between 310 - 400 k€/MW, seen that the interconnection in study has a low capacity of transport, considering the most part of the ABB constructions.

With the removal of path 3, the construction price of the interconnection decreased to the 11,16 – 14,4 million euros, a much lower value than the initial one, that must be considered, once the annual spare with this path is of 85851,65€/year concerning the losses, in the year 2006. So the construction of the path 3 isn't considered viable, even tough being important for the net reliability growth.

In what the first question is concerned, the analyzing only economically shows us that the interconnection is worth. Based on Account Report of EDA of 2005 from 09/08/2006, the investment results in reserve power generation were about 9,5 millions euros. With the interconnection in study, these investments would be reduced or even indispensable, as we have in every island reserve power generation. Besides that, it is demonstrated here that the interconnection would lead to an economize of 1,24 million euros. Being the cost of the interconnection placed between the 11,16 million euros and the 14,4 million euros, one can easily conclude that this investment would have a fast replace.

The interconnection of the three islands, would bring certain significant improvements concerning the energy quality of a 40 000 inhabitants population, that undergo long dozens of interruptions every years. The islands have been having a strong growth of energy consume, therefore, their connection is a possibility that must be seriously considered, moved by the quality energy growth and the decrease of costs.

As far as the DC transmission choice, the evolution of this technology, has become this system more and more competitive concerning the AC system, namely in the control of the power flow, reduced transmission losses, less equipments in the reactive power compensation and the absence of the short circuit power increase. Therefore, this option is, nowadays, totally trusted and appropriate for the case.

Another point that was also referred was the fact that the losses using direct current in a transmission are about 2/3 less. Therefore, without path 3, the energy that would be lost with an AC system, would increase 1.37MWh in the year considered, what means that a transmission using direct current has gains of about 195000€ per year, considering the rate of 0,14185€/kWh.

[4]According to data supplied for the ABB, www.abb.com
[5] According to the data granted by the ABB, www.abb.com

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