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Analysis of Technical and Economic Feasibility for the Implementation of a Power Generation System Using Wind Energy in the Paraguayan Chaco

Felipe Mitjans[1], Jean Pulfer[2]
[1] Engineer,Universidad Nacional De Asunción, Paraguay; Master Of Science, Universidad Politécnica De Cataluña, España
2 Engineer, Swiss Federal Institute Of Technology Lausanne, Switzerland; Master Of Science, Swiss Federal Institute Of Technology Zurich, Switzerland
Corresponding Author: Felipe Mitjans

Abstract: This Article Aims To Present A New And Sustainable Approach Focused On Power Generation From Wind In Paraguay, Specifically In The Western Region. In This Context Is Presented An Analysis Of Technical And Economic Feasibility, Whose Results Are Based On A Study Of The Wind Resource Available In The Region, Using For This Purpose A Weather Station Mounted In The Location La Patria. The Wind Data Measured At A Height Of 10 M Above The Ground Were Then Extrapolated To A Height Of 80 M Using Mathematical Models Available In Literature. Finally, These Data Were Correlated With Those From The Weather Station Of The Location 15 De Agosto Obtained By Baez (2011), Considering A Frequency Of 30 Min. Between The Measurements. The Results Of The Assessment Have Demonstrated The Feasibility Of Installing A System Of Wind Generators Able To Produce An Electric Output Of 46 MW, Operating With A Capacity Factor Of 25%. The Results Have Been Consistent With Studies That Support The Future Wind Farm Of 49 MW Projected In The Department Of Tarija (Bolivia), Located At The Same Geographic Latitude As La Patria, Even Considering That The Wind Resource In The Last Location Has Been Measured Only During A Four Months Period (November 2012 To February 2013), Which Corresponds To A Period Of Year With Relatively Low Wind Speeds. In Order To Conduct A More Comprehensive Analysis Of Technical And Economic Feasibility, This Paper Presents A Technical Study Using The Computer Simulation Tool Matlab/Simulink And The Retscreen Software. The Analysis By Simulations Considered A Realistic Scenario Assuming That The Wind Generator System Is Connected To The National Grid (SIN), After The Construction Of A 220 Kv Transmission Line From The Place Of Generation To The Transformer Station Of Loma Plata. For The Economic Analyses Have Been Taken Into Account The Benefits And Incentives Associated To Such Generation Projects Regarding To Carbon Credits For CDM Projects (Clean Development Mechanism). As An Alternative Has Also Been Discussed The Negotiation Of Certified Emission Reductions CER And Finally Has Been Considered The Possibility Of A Governmental Contribution For Implementing This Kind Of Projects.

Keywords: Wind Power Generation- Renewable Energy - Matlab/Simulink - Retscreen.

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I. INTRODUCTION

We Are Observing Growing Global Climate Problems Due To The Excess Of Emitted Greenhouse Gases To The Atmosphere And The Lack Of Commitment By The Developed Countries To Comply With The Kyoto Protocol. Therefore, The Search For Energy Alternatives, Like The Renewable Energies, Can Help To Mitigate These Problems. Countries Like China, The USA And Some European Countries Are Currently Developing The Use Of Technologies Based On Renewable Energy Resources. Currently, Only 13.5% Of Primary Energy Supplies Worldwide And 22.2% Of Electricity Generation Is From Renewable Sources (IEA, 2014). In South America Brazil Stands Out As One Of The Countries With The Greatest Innovation In Technologies Associated With Renewable Energy, Followed By Argentina And Uruguay. Latin America Invested In Renewable Energy In 2013 US$ 15.5 Billion, A Small Amount Compared To The USA, China And Europe Which Invested US$ 35.8, 56.3 And 48.4 Billion Respectively. Paraguay's Energy Matrix Is Characterized By A High Primary Supply Of Renewable And Local Sources, Particularly Hydropower And Biomass. According To The National Energy Balance Of 2014, 57% Of The Energy Offer Corresponded To Hydro, 27% To Biomass And The Remaining 16% To Hydrocarbons, Which Are 100% Imported (VMME, 2015). Recent Prefeasibility Studies Have Shown That The Energy Matrix Of Paraguay Could Be Diversified With Other Methods Of Generating Electricity. Even Decentralized And Distributed Generation Could Be

Viable Getting A Decrease Of Losses In The Transmission Lines, As Generation Would Be Closer To Load Demand. One Of These Viable Alternatives Is Wind Power. The Zones Of The Highest Wind Potential In Paraguay Are The North Of The Chaco, As Well As The Northeast, Center-West And Southeast Of The Oriental Region. However, There Is Still No Reliable Evaluation Of This Potential, Such As A Wind Map Based On Quality Measurements. National Authorities Are Currently Promoting Projects For Studies In This Area. On The Other Hand In Paraguay There Are Considerable Limitations For The Installation Of Large-Scale Wind Power Systems With High Profitability Due To A Lack Of Energy Policies That Would Strengthen The Act No. 3009/06 About "Independent Production And Transport Of Electric Power", Especially Regarding Differentiated Tariffs For Generated Electricity. In Order To Remedy This Situation Was Recently Submitted To Congress A Bill On Renewable Energy, Which Should Create Favorable Legal And Economic Conditions For The Development Of All Types Of Renewable Energies In Paraguay. Between A Possible Strength That Raise This Paper It Exists A New Macro-Energetic Scenario, Which Inserts Innovation To The Current Energy Matrix, Promoting Decentralization Of The Load Demand, Improving The Quality Of Life Of The Population Of The Department Of Boquerón, The Area That Has Been Considered For The Feasibility Study Of The Integration Of Wind Technology. Taking Into Account The Natural Growth Of The Area Of The Mennonite Colonies In The Central Chaco, Future Implementation Of Wind Power Systems Proposed In This Paper Would Generate A Positive Impact To The Paraguayan Power System Through A Considerable Power Relief In The Northern Transmission Line System.

II. WIND POTENTIAL IN PARAGUAY

Paraguay Winds Are Characterized By Three Main Phenomena, Namely:1. The Flow From High Pressure Centers On The Western Edge Is Controlled By The South Pacific Anticyclone And The Eastern Part Is Controlled By The South Atlantic Anticyclone. 2. The Andes And The Altiplano Are Acting As A Barrier, Suppressing Winds From The West Throughout The Country. 3. The Generated Wind Is Depending On The Intensity Of The Quasi-Stationary Low-Pressure Center In The Chaco (Brizuela Et Al., 1997). As A Result Of The Convergence Of The Phenomena Mentioned Above There Are Generally Low Wind Speeds Throughout The Year Mainly In The Eastern Part Of Paraguay, Belonging To The High Pressure Zone. On The Paraguayan And Argentinian Chaco And The Pampa Lands Is Located An Almost Stationary Low Pressure System. In Winter, When The Low Pressure Zone Is Located On The Paraguayan Chaco, Winds Are Blowing From The Eastern Sector Rotating To Northeast In The Center Of Paraguay, As Can Be Seen In Fig.1.

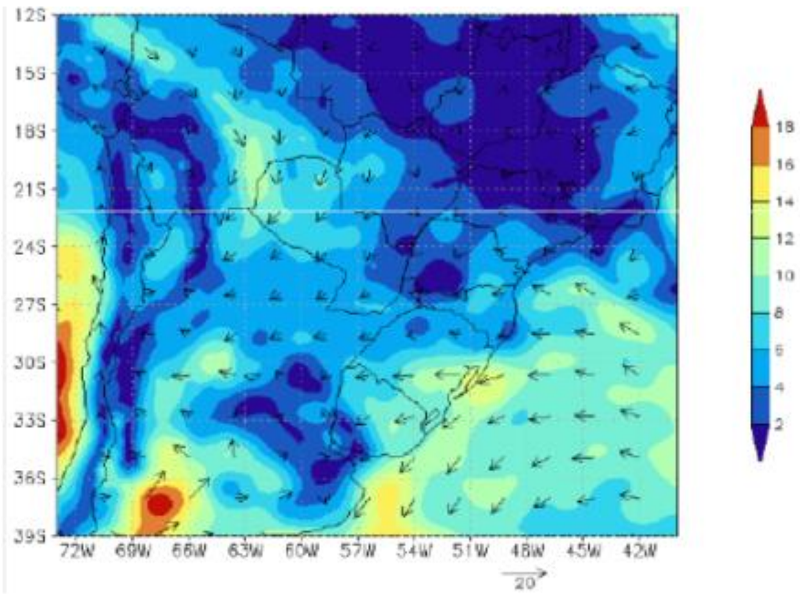


Fig. 1: Wind Speed In The Center Of South America At A Height Of 30 M Above The Ground In M/S, Source: DINAC, 2013.

Fig. 2: Location Of The Main Weather Stations In The Measurement Area, Source: Google Earth And Own.

In Summer, The Southernmost Location Of The Depression Centered Over The Mountainous Pampa Area Produces Northern And Northeastern Winds In The Paraguayan Chaco. There Is A Huge Seasonal Variation Of The Wind In This Area. Peaks Are Expected During The Months Of August To December Due To The Rapid Heating Of The Area (Brizuela Et Al., 1997).

Weather Station Of La Patria

The Weather Station Of *La Patria* Was Installed In November 2012. It Is Located In The Western Region, Specifically In The Department Of Boquerón At A Distance Of Approximately 130 Km Northwest Of The City Of *Mariscal Estigarribia* And About 500 Km Northwest Of The Capital Asuncion (See Fig. 2) .The Instruments Have Been Provided By The Center For Appropriate Technology (CTA) Of The Catholic University Of Asuncion (UCA).

Both The Anemometer And The Wind Vane Were Calibrated And Synchronized For A Measurement Range Of An Average Speed And An Average Wind Direction With Measuring Frequency Of 30 Min. Both Instruments Have Been Installed By The Staff Of The National Direction Of Civil Aeronautics (DINAC) On A Mast 10 M Above Ground. Data Have Been Stored In A Data Logger And Then Processed In A Computer.

The Wind Speed Data Have Been Transmitted Per GPRS To A Central Database (FECOPROD, 2012). To Get The Values Of Wind Speed At A Height Of 80 M The Measured Values Were Extrapolated Using Equation (1) Taken From Villarrubia, 2014.

$$v_{80} = v_{10}\frac{ln(^{80}/_{z_0})}{ln(^{10}/_{z_0})}$$

(1)

V_{80} And V_{10} Represent The Wind Speed At A Height Of 80 M And 10 M Above Ground Respectively (In M/S), And Z_0 The Roughness Length Downwind Considering In This Case A Value Of 0.28 M (Villarrubia, 2014).

Fig. 3 Shows The Wind Rose Of The *La Patria* Weather Station During The Measurement Period. It Can Be Seen That The Prevailing Winds Are Blowing From The Northeastern Sector (NE) To East- Northeast (ENE), Which Occurred In Daytime With A Weight Of 21 And 25% Respectively For The Total Of All Measurements Processed During The Four Months Measured. In The Schedule Nocturne Los Prevailing Winds Are From The West (W) South-Southwest (SSW) With A Weight Ranging Between 5% And 7%. This Abrupt Change In Wind Direction Is Due To Pressure Changes Atmospheric Entre Day And Night Generated By Temperature Changes. During The Day The Room Temperature Is Increasing Together With An Increase In Wind Speed. At Night The Reverse Process Occurs.

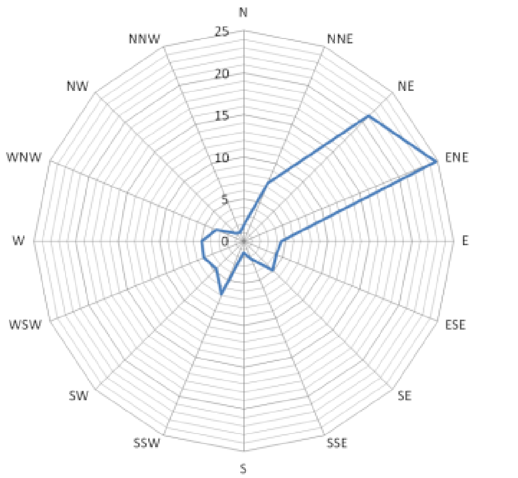


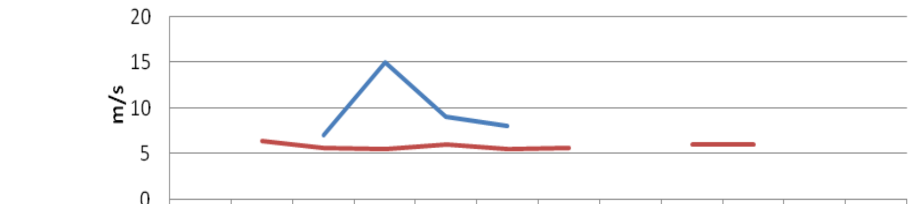
Fig. 3: Wind Rose Of La Patria. Source: Mitjans, 2013

Fig. 4 Shows That The Average Hourly Wind Speed During The Measurement Period Increases During The Day From 7 A.M. Reaching Its Maximum Value Of 16 M/S At Around 4 P.M. And Decreasing Sharply Overnight Reaching Minimum Of 7 M/S. The Average Speed For The Four Months Of Measurement Extrapolated To A Height Of 80 M Was 11.2 M/S. However, It Is Worthy To Mention That The Measurements Were Performed During The Year Period With The Lowest Wind Speeds. The Annual Average Would Then Be Higher Than The Mentioned Value.

Comparing The Results Of The *15 De Agosto* Weather Station Made By Baez (2011) (See Fig. 5) With The Ones Of *La Patria*, It Can Clearly Be Seen That The Average Wind Speed In *La Patria* Is Higher Than In *15 De Agosto* Throughout The Whole Measurement Period. This Confirms That There Is A Higher Wind Potential In The Northwestern Chaco Than In Its Central Part Making It Very Likely The Feasibility To Install A Large Scale Wind Generation System.

Fig. 4: Average Hourly Wind Speed Between November 16th, 2012 And February 16th, 2013 In *La Patria*. Source: Mitjans, 2013

However, There Is Some Uncertainty As Wind Speed Data Along A One Year Period Are Not Available For None Of The Weather Stations Of The Studied Area. So, Mathematical Models Had To Be Used To Be Able To Get A Clearer View. In Bolivia, Specifically In The Department Of Tarija, Located On The Same Latitude As *La Patria*, After The Recently Concluded Yearlong Wind Measurement Campaign At A Height Of 80 M, It Is Planned To Install A 49.5 MW Wind Farm, What Reinforces The Hypothesis Of The Trend, That Wind Speed Increases In The Area Of The Department Of Boquerón From East To West (Evwind, 2013).



	Set	Oct	Nov	Dic	Ene	Feb	Mar	Abr	May	Jun	Jul	Ago
La Patria			7,0	15,0	9,0	8,0						
15 de Agosto		6,4	5,6	5,5	6,0	5,5	5,6		6,0	6,0		7,1

Fig. 5: Comparison Of Monthly Average Wind Speeds In *La Patria* And *15 De Agosto*. Source: Baez, 2011 And Mitjans, 2013.

In Order To Develop A Mathematical Model To Estimate The Nonlinear Behavior Of The Average Wind Speed Between The Two Stations, Have Been Processed Separately The Monthly Data Of The *La Patria* Weather Station Measured Between November 16th, 2012 And February 16th, 2013 And Of The *15 De Agosto* Weather Station Measured Between December 10th, 2008 And October 24th, 2010. Data Are Missing For Several Months To Complete One Year Due To Faulty Measuring Equipment (See Fig. 5). However, The Results Obtained By Mathematical And Statistical Models Help To Confirm, That The Minimum Annual Average Wind Speed At A Height Of 80 M Above The Ground Is About 7 M/S, Representing An Annual Average Power Of 325 W/M^2. The Correlation Rate Between The Two Stations Is 77% With A Standard Deviation Of 5.13% And A Variance Of 26.36%.The Sudden Change Of Wind Speeds Due To The Change Of Atmospheric Pressure And Temperature Between Day And Night Forms Ridges In The Frequency Distribution Of Wind Speeds, A Behavior That Is Outside The Weibull Distribution (See Fig. 6).

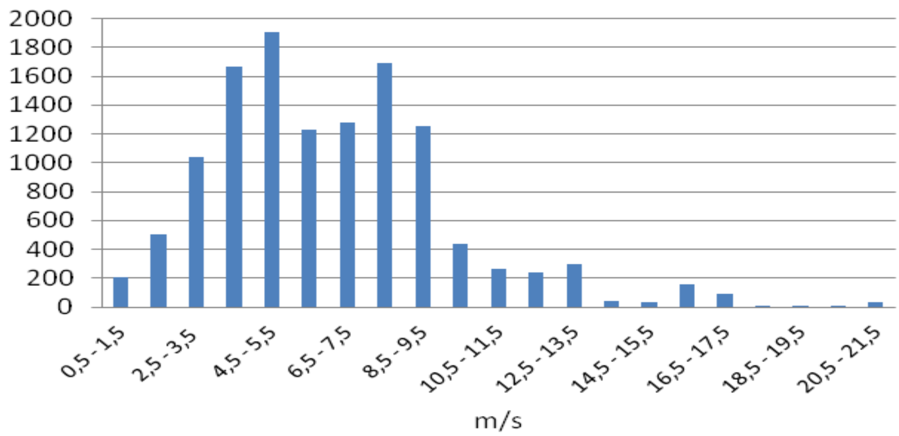


Fig. 6: Absolute Frequency Distribution Of Wind Speed At *La Patria*. Source: Mitjans, 2013

The Asymmetry Factor K Of The Weibull Function Is Obtained By The Empirical Equation (2), Where N Is The Annual Average Wind Speed

$$k = 0.73\, v^{0.5} \qquad (2)$$

The Scale Factor C Of This Function Is Obtained By Equation (3):

$$c = \frac{v}{\Gamma\left(1+\frac{1}{k}\right)} \qquad (3)$$

Fig. 7 Shows The Weibull Distribution Density P(N) From Equation (4) For Different Typical Asymmetry Factors K Comparing Them With The Distribution Of The Processed Measured Values Of *La Patria*.

$$p(v) = \frac{k}{c}\left(\frac{v}{c}\right)^{k-1} e^{\left(-\frac{v}{c}\right)^{k}} \qquad (4)$$

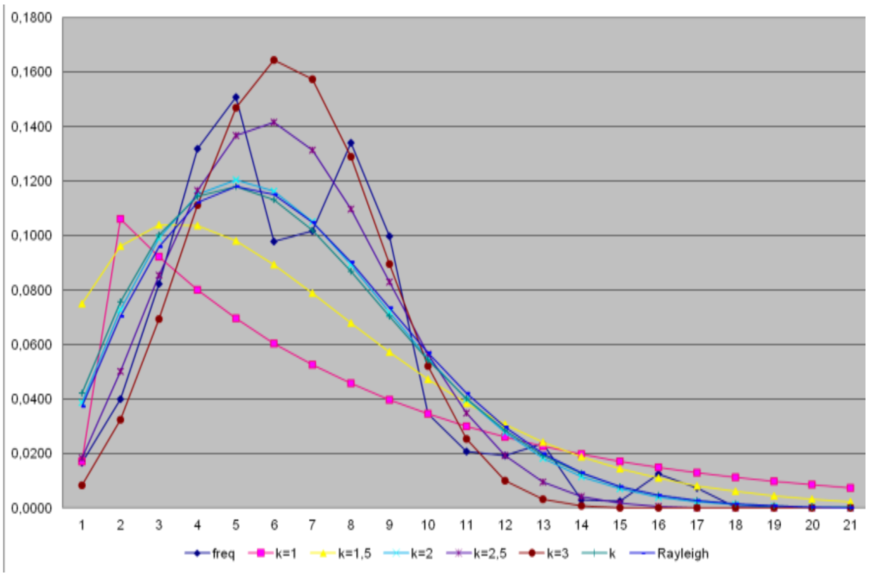


Fig. 7: Weibull Distribution For Different K Factors And The Wind Speeds Distribution Measured In *La Patria*. Source: Mitjans, 2013

Based On The Analysis Performed With The Retscreen Software Has Been Selected A Three-Bladed Variable Pitch Wind Generator With A Power Rating Of 2.3 Mwe, A Cut-In Speed Wind Of 3 M/S And A Rated Wind Speed Of 9 M/S. These Data Are Consistent With The Wind Profile Measured By The Different Meteorological Stations Used As A Starting Point For The Development Of The Present Study. The Wind Farm Will Have An Installed Capacity Of Around 46 MW Composed Of 20 Turbines Mounted On 80 M High Towers. It Would Have A Capacity Factor Of 25% And An Annual Generation Capacity Of 100.5 Gwh. Inside Each Wind Turbine The Voltage Level Is Lifted From 0,69 To 30 Kv. When Operating Off The National Grid, They Will Be Connected By Autrotransformers To A 30/23 Kv Station To Be Installed At A 30 Km Distance From The Point Of Generation. When Operating Connected To The National Grid (SIN), The Voltage Levels Of The Single-Phase Transformers Would Be 30/220 Kv. In This Case A 130 Km Long Overhead Transmission Line Of 220 Kv Single Circuit Will Be Necessary From The Site Of The Wind Farm To The Existing Transformer Station Of *Mariscal Estigarribia*, Which Will Have To Be Modified To Operate At A Voltage Level Of 220 Kv (Ande, 2013 And Mitjans, 2013).

III. WESTERN SYSTEM OF THE PARAGUAYAN GRID

Noting The Extensive Length Between The Points Of Generation And Consumption Of Energy, Specifically In The Western Region, This Paper Aims To Propose A New Macro-Energy Scenario With Regard To The Implementation Of Emerging Technologies For Power Systems. By This Mean Could Be Solved Partially The Problems That Might Arise In A Not Too Distant Future, Considering The Rate Of Annual Growth And The Imminent Use Of All Available Energy From The 2 Bi-National Hydropower Plants By 2030 (GIZ, 2013) .

Fig. 8 Shows The Projections Of The Energy Demand Of The Western System In A Medium Term (2013-2022), Seen From The *Loma Plata* 220 Kv Station, Which Supplies The Whole Central Chaco Area, With The Cities Of *Loma Plata, Filadelfia, Neuland* And *Mariscal Estigarribia* Having Actually A Load Factor Close To 70% And An Annual Growth Rate Of 10% (Ande, 2013). This Projection Demonstrates The Limits To Cover The Estimated Demand, Considering That The Amount Of Energy To Be Generated By The Wind Farm Represents 67% Of The Amount Of Energy Needed To Cover The Entire Energy Demand In 2013 (See Fig. 8). Based On This Premise This Paper Raises Two Possible Scenario. The First Is Based On The Operation Of The Wind Farm As A Generation System Isolated From The Distribution Grid. The Second Presents An Wind Power System Connected To The National Grid (SIN), Given That The Construction Of A Second 220 Kv Overhead Transmission Line To The *Loma Plata* Station Is Planned Only For 2021, After Terminating Of Two Overhead 500 Kv Transmission Lines To The *Villa Hayes* Station, One From Yacyreta And Another From Itaipu (Ande, 2013).

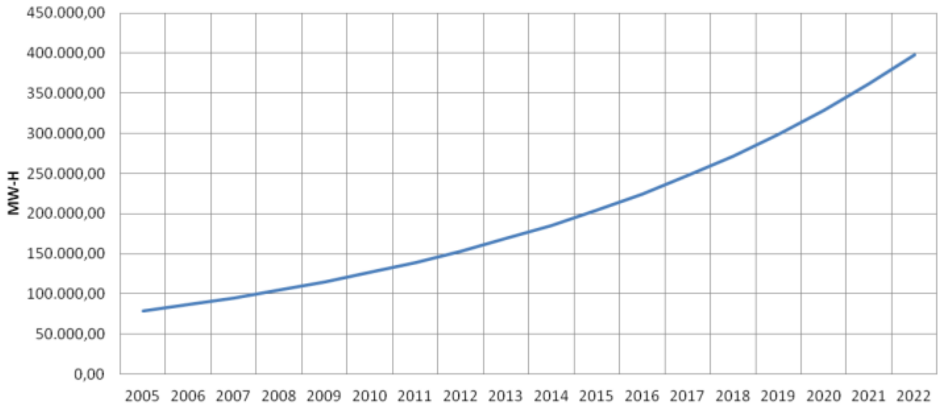


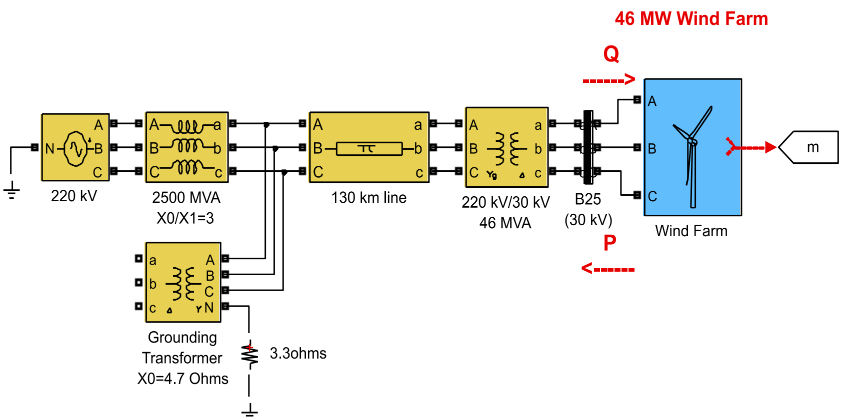
Fig.8:Annual Energy Demand Of The Western System. Source: Ande, 2013 And Mitjans, 2013.

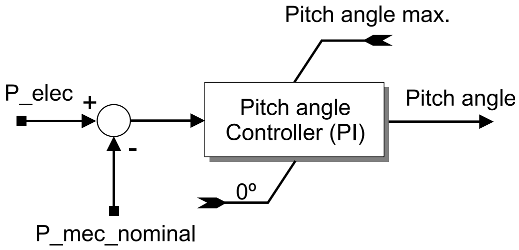
The Main Advantage Associated To The Implementation Of Such Emerging Technologies For Power Systems Is, That The Power Transformer At The 220 Kv *Loma Plata* Station Will Operate With Less Load. This Will Benefit The Voltage Profile At The Bars Of The Northern System And Will Reduce The Technical Energy Losses Of The 220 Kv Transmission Line Between *Vallemí* And *Loma Plata*, Given The Extensive Length Of 200 Km Between Both Stations And The High Impedance On This Line (Ande, 2013).

IV. ANALYSIS BY SIMULATIONS

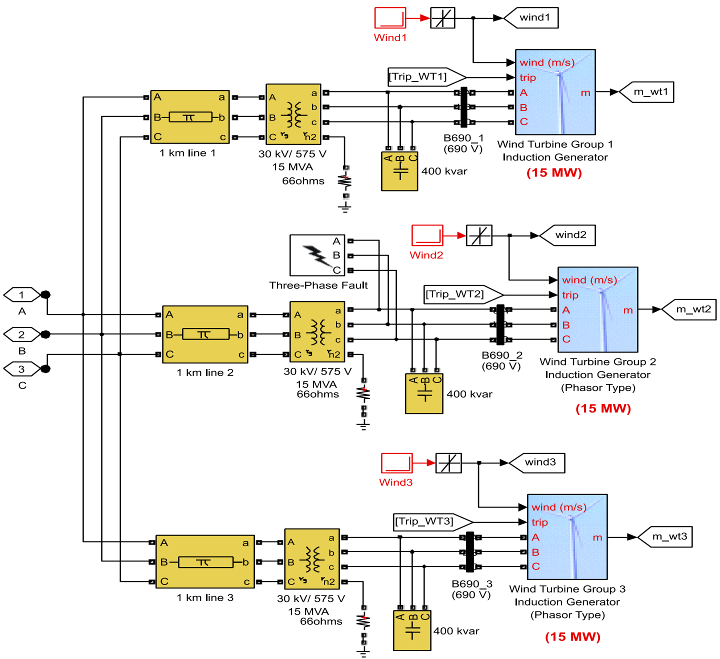
Using Data Obtained By The Analysis Performed With The Retscreen Software Has Been Developed An Analysis By Simulation Using The Matlab/Simulink Software Tool. In This Simulation Environment Results Are Obtained Using A Variable-Step Simulation Considering The Integration Method Based On Implicit Runge-Kutta Formula (Ode23tb). The Block Diagram Represents The Wind Farm Interconnected To The National Grid (See Fig. 9 (A)). To Simplify The Analysis By Simulations Were Considered The Installation Of Three Groups Of Wind Turbines Of 15 MW Each Providing A Total Power Source Close To The 46 MW Calculated With The Retscreen Software. These Are Connected To A 30 Kv Output Bar To Make Possible The Power Export On A 220 Kv Line Of 130 Km From The Wind Farm Installed In *La Patria* To The *Mariscal Estigarribia* Station.

The Wind Turbines Use Squirrel Cage Induction Generators And The Reactive Power Absorbed By Each Induction Generator Is Compensated By A Capacitor Bank (400 Kvar By Each Group Of 15 MW) Connected To A Low Voltage Bar (B690) (See Fig. 9 (B)). The Generator Stator Is Connected Directly To The Mains Of 50 Hz. The Generator Rotor Is Coupled To The Variable Speed Wind Turbine. A Proportional-Integral (PI) Controller Is Used To Control The Pitch Angle Of The Blades Of The Wind Turbines To Limit The Power Output At The Rated Mechanical Power. The Block Diagram Of The PI Controller Is Shown At The Bottom Of Fig. 9 (A).



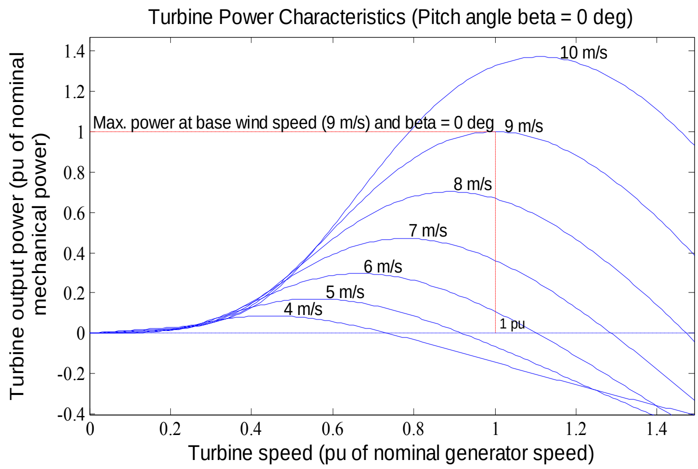


(A) Above: General Scheme.
Below: Diagram Of The Blades' Pitch Angle Control

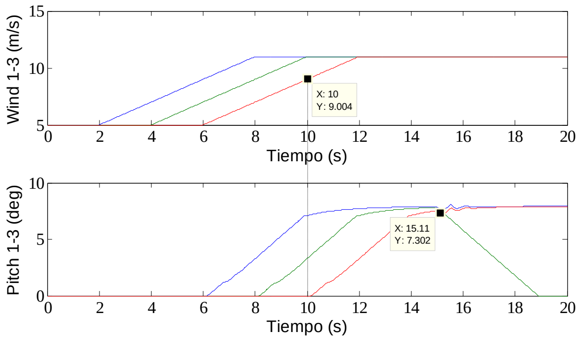


(B) Wind Turbines Grouped Into Three Groups Of 15 MW.
Fig. 9: Block Diagram Of Wind Farm Interconnected To The National Grid (SIN). Source: Own Elaboration

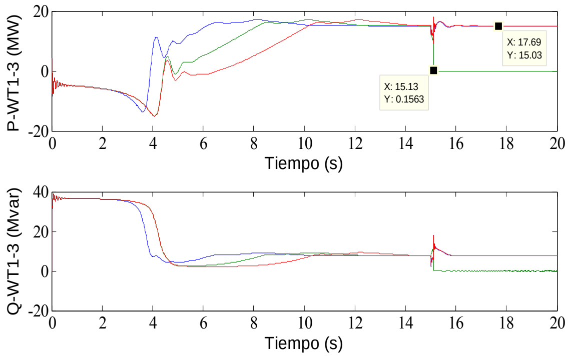
The Characteristic Curves Describing The Variation Of The Mechanical Power As A Function Of Turbine Speed For Wind Speeds Within A Range Of 4 To 10 M/S Is Shown In Fig. 10(A). It Shows, That The Wind Speed To Obtain The Nominal Mechanical Power (1 Pu = 15 MW) Is 9 M/S.



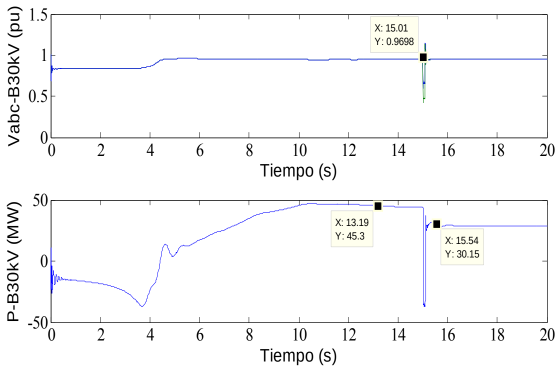
(A) Characteristic Curve Of The Wind Turbine Blade Angle Of 0 °.



(B) Changes In Wind Speed And Their Effect On The Pitch Angle Of The Blades.



(C) Active And Reactive Power Of The Three Groups Of 15 Mwe Wind Turbines.



(D) Voltage And Active Power Variations At The 30 Kv Bar.

Fig. 10: Analysis Of The Proposed Scheme By Simulations Interconnected To The SIN. Source: Own Elaboration

In Order To Verify The Results When Considering A Realistic Scenario Of Variable Wind Speeds Fluctuating Around The Average Speed Measured In *La Patria* (Equivalent To 7 M/S), Was Simulated The Response Of The Wind Power System By Checking The Stresses On The 30 Kv Bar Under Variable Wind Conditions. Initially, The Wind Speed Applied To Each Group Of Turbines Was Fixed To 5 M/S. Then, From A Time Equal To 2 S (For The Particular Case Of Group 1) The Wind Speed Was Increased From 5 M/S To 11 M/S In A Time Interval Of 3 S. The Same Wind Gust Is Applied To The Wind Turbines Of Group 2 And 3 With A Delay Of 2 And 4 S Respectively (See Fig. 10(B)). In This Figure Can Also Be Seen That The Blades Are Held Constant At An Angle Of Zero Degrees, When The Electrical Power Output Is Far Below Its Nominal Value. When The Output Power Is Increased Above Its Nominal Value As A Result Of An Increase In Wind Speed, The PI Controller Acts On The Control Variable (Angle Of The Blades Of The Turbines) In Order To Compensate The Increased Power Maintaining The Output Power Controlled On Its Nominal Value (15 MW By Group, See Fig.10(C)).

To Verify The Effect That Introduces A Temporary Malfunction Of One Group Of Turbines, It Has Also Been Simulated The Effect Of A Fault On The Low Voltage Terminals Of Turbine Group 2 (See Fig. 10(B) Block Three-Phase Fault), Applied To A Time Of 15 S. It Can Be Seen In Fig. 10(C), That Under These Operating Conditions The Group 2 Automatically Protects Itself Leaving To Provide Active And Reactive

Power To The 30 Kv Bar. Finally, Fig. 10(D) Shows The Voltage Changes In The On The 30 Kv Bar, Where Can Be Seen That Under Normal Operating Conditions The Bus Voltage Is Close To 0.97 Pu. The Evolution Of The Total Power Of The 30 Kv Bar Can Also Be Observed, Which Reaches The Maximum Value (Close To 46 MW) After 10 S And That When Registering The Temporary Power Failure Is Reduced To Approximately 30 MW By Effect Of The Protection Of The Wind Turbines, That Make Up The Group 2.

V. ECONOMIC CONSIDERATIONS

Assuming The Considerations That Have Been Brought Out In This Paper, With Respect To The Installed Power Of 46 MW And The Amount Of 20 2.3 MW Wind Turbines, A Total Investment Of About US$ 110,000,000 Is Estimated. Considering An Own Contribution By ANDE Of About US$ 20,000,000, An External Financing Of About US$ 90,000,000 Would Be Required. In The Amount Of The Investments Mentioned Above, Have Been Considered The Benefits Provided By Law Nº: 60/90 On The Promotion Of Investments. For This Type Of Projects Based On Renewable Energies And Energy Efficiency There Are Available Funds With Very Low Interest Rates And Flexible Repayment Periods. For The Profitability Calculations An Interest Rate Of 1% Per Annum And A Grace Period Of 2 Years Was Considered.

The Economic Analysis Shows, That The Investment Required For The Commissioning Of The 46 MW Wind Farm Would Be Repaid By An Energy Sales Selling Price Of 200 US$/Mwh, The Equivalent Of US$ 21,000,000 Annually. On The Other Hand, Being A Renewable Energy Project It Could Benefit From The Clean Development Mechanism (CDM). However, Since It Is Currently Paralyzed By The Countries Which Signed The Kyoto Treaty, Until The Agreements Of DOHA 2012 Will Be Ratified, It Will Not Be Possible To Issue And Sale Of Certified Emission Reductions CER (Mitjans, 2013). Taking This Point As Background, The Economic Viability Could Be Supported By The Voluntary Carbon Market, Which Has Actually A Value Of 3 US$/ Tco_2 (EU.ETS Carbon Price, 2013). Considering As Baseline A Natural Gas Power Station With The Same Power Using 75% Of The Generated Energy To Be Equivalent To The Amount Of Carbon Dioxide Not Emitted Into The Atmosphere, It Could Be Generated An Additional Annual Income Of About US$ 235,000 (Olade, 2003).

Additionally, In The International Market For This Kind Of Projects Are Considered Governmental Subsidies Of Around 15 US$/Mwh, What Represents An Additional Income, That Could Eventually Repay The Investment Within A Reasonable Period, Reaching Thus A Total Annual Income Of US$ 23,000,000. For A Plant Factor Of 25% Investments Could Be Amortized Within 10 Years Resulting In An IRR Of 8.23% And A NPV Of US$ 89,000,000. Taking The Same Criteria Mentioned Above With A Plant Factor Of 50% A Total Annual Income Of US$ 44,000,000 Would Be Generated And Investments Could Be Amortized Over A Period Of 4 Years Resulting In An IRR Of 26.08% And A NPV Of US$ 396,000,000. This Analysis Demonstrates The Feasibility Of The Project.

VI. CONCLUSIONS AND RECOMMENDATIONS

Despite The Incomplete Data On Wind Speed At The Site Of Measurement In La Patria It Was Found By The Present Study That The Installation Of A 46 MW Wind Farm Is Technically And Economically Viable. To Prove It In A More Forceful Way, It Would Be Necessary The Realization Of A Full Year Lasting Measurement Campaign, Preferably At 80 M Height. Besides, The Enactment Of The Law Of Renewable Energy Currently Under Consideration In Congress Would Create A Legal Framework And Favorable Economic Conditions For This Endeavor.

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