SUMMARY
The current offer of wind turbine models is large and rapidly growing. The technical information available is diversified, disperse and thus difficult to compare. Actually only few simple turbine reviews are known, making difficult to keep the pace of wind turbine growth.

The present work has as main goal to collect, in a simple and compact way, a wide range of this disperse data related with wind turbines generators and raise the interest among wind industry for studies like this one.

The purpose was neither to elect the best wind turbine models, nor to select the worst ones. Rather, to give simple comparison and ranking tools, capable of giving simple indicators and being rapidly update in the future.

With the quality and quantity of information supplied and keeping in mind the practical sense of this study all wind turbines models considered were analysed as follows:

- Overall number of wind turbines installed and per continent;
- Overall installed power;
- Year of first installation for each turbine model;
- Capacity factor based on generic wind (Weibull) distribution ($A=8\ m/s;\ k=2,\ V_{avg}=7\ m/s$);
- Capacity factor based for different wind (Weibull) distributions.

INTRODUCTION
In recent years all of us are attending a rapid growth of renewable energy, especially wind energy. The rapid growth of wind energy implementation exploits this industry to improve WEC’S performance and its features.

With worldwide implementation of wind farms different wind conditions could be found. For each different site, the best performance WT should be selected in order to maximise the wind farm performance.

With wide range of WT suppliers in market and all of technical information available for each WEC’S, selecting a WT is always an attractive and hard challenge. A wide range of parameters could be compared in order to preview what is the best wind turbine that fits in wind farm conditions.

METHODOLOGY
The study tries to incorporate the most representative set of turbine models and suppliers available today in the market. However, for practical reasons, the range of study had to be limited. Based on the authors empirical approach five wind turbines suppliers were chosen. Taking in consideration the actual technology state of the art, only the wind turbines that fits range of 2.0 MW to 3.0 MW were considered. Additionally, only models that have at least 50 machines implanted were considered.

The wind turbine suppliers selected were:

- Enercon;
- Nordex;
• Repower;
• Siemens;
• Vestas.

The results obtained are represented by graphs enabling a rapid approach of indicators. The performance results were obtained for air density of 1.225 kg m\(^{-3}\).

RESULTS

The wind turbine market and technology could be analysed taking into consideration a wide range of parameters. Taking into consideration the information available, the three most representatives parameters were considered together (capacity factor, year of 1\(^{st}\) installation and number of wind turbines installed) to enable a rapid comparison. The results show a performance ranging from 0.3 to 0.46. The presence in market of each model is too wide, ranging from 70 to 2128 WEC’S. This graph also shows the year of installation of 1\(^{st}\) each WT model. The oldest one is Vestas V80 2.0 and the younger is the higher capacity factor Repower MM92 Evolution.

Accordingly with Weibull distribution considered (A=8 m/s; k=2), Repower MM92 Evolution is the WT that has the better capacity factor (0.45) followed by Vestas V90 2.0MW (0.43). The results show that the capacity factor could vary significantly. It’s important to realise that from 1997 to 2005 the capacity factor of WT vary significantly (from 0.30 to 0.43) and from 2005 the capacity factors are above 0.37 and ranging between 0.37 and 0.45. Capacity factors of recent WT are higher than the oldest ones. This factor could be an indicator of growth of WEC’S technology, though these analyses should be taking with care. Bellow follows the representativeness of each WT model in overall models considered for this study. Two parameters were considered (number of wind turbines installed and installed capacity).
Figure 2 – Installed capacity.

Figure 3 – Ratio of installed capacity.

Figure 4 - Ratio of overall WT installed.
Following the graph analysis (from figure 2 to 3) the first conclusion should be done in respect to WT installed. Enercon E70 is the major representative (2128 WTs) followed closely by Vestas V80. These WT models represent around 46% of total WTs installed and around 42% of total installed capacity, for all models considered. The three less representative WT models only represents around 3% of the models considered.

In accordance with latest graph the main market of all WEC’S is the Europe, except Siemens SWT93. The European market represent at least for each model more than 60%, 11% for Siemens SWT93. It’s interesting to see that there are three models (Nordex N90 2.3MW, Nordex N90 2.5MW and Siemens SWT 82 VS) that only are implemented in Europe. Actually the European market is significantly forward from others markets in world.

The last analysis follows in set of graphs bellow. Here are represented the variation of WT performance in accordance with Weibull parameters k and v. For each model it’s possible to estimate the WT performance taking into consideration the wind conditions in site. As stated above, the Repower MM92 Evolution is the WT with better performance followed by Vestas V90 2.0MW.

Figure 5 – The global market of each wind turbine.
Figure 6 - Capacity factor variation for a wide range of Weibull parameters $k$ and $v$ (Enercon E70 2.0MW).

Figure 7 - Capacity factor variation for a wide range of Weibull parameters $k$ and $v$ (Enercon E70 2.3MW).

Figure 8 - Capacity factor variation for a wide range of Weibull parameters $k$ and $v$ (Enercon E82 2.0MW).
Figure 9 - Capacity factor variation for a wide range of Weibull parameters $k$ and $v$ (Nordex N80 2.0MW).

Figure 10 - Capacity factor variation for a wide range of Weibull parameters $k$ and $v$ (Nordex N90 2.3MW).

Figure 11 - Capacity factor variation for a wide range of Weibull parameters $k$ and $v$ (Nordex N90 2.5MW).
Figure 12 - Capacity factor variation for a wide range of Weibull parameters $k$ and $v$ (Repower MM70 2.0MW).

Figure 13 - Capacity factor variation for a wide range of Weibull parameters $k$ and $v$ (Repower MM82 Evo 2.0MW).

Figure 14 - Capacity factor variation for a wide range of Weibull parameters $k$ and $v$ (Repower MM92 Evo 2.0MW).
Figure 15 - Capacity factor variation for a wide range of Weibull parameters k and v (Siemens SWT82 VS 2.0MW).

Figure 16 - Capacity factor variation for a wide range of Weibull parameters k and v (Siemens SWT93 2.3MW).

Figure 17 - Capacity factor variation for a wide range of Weibull parameters k and v (Vestas V80 2.0MW).
FINAL REMARKS

It’s important to refer that all information considered was supplied by WT suppliers and some criteria imposed probably took apart some WTG that also could be interesting to analyse and should be take into consideration in future work. In accordance with information available it’s important to state that the track record supplied does not refers to the time period (ends of 2008) for all WT models, and in this sense the analysis of first set of graphs (from figure1 to figure5) should be tanking with care.

With the growth of wind industry, updating this study with new models and more parameters is an attractive challenge. The operational problems, supplying time, inherent technology, noise and turbulent levels, IEC classes are parameters that should be considered in WT analyses in future works and were not considered at this study.

REFERENCES

ENERCON

Global_Experience_Sept_.2008.pdf

ct_E70_E4_2000kW_calculated.pdf

SA-001-ct_E70_2_3MWRev1_0ger-por.pdf

SA-001-ct_E82-Rev1.0ger-eng.pdf
NORDEX
Reference list N80-N90-N100_09-07-2008.pdf
N80 curvas de potencia (100103).pdf
N90-1-power-curve-en.pdf
N90H-1-power-curve-en.pdf

REPOWER
Power Curve MM70.pdf
SD-2.2-WT.PC-1-E-EN_MM82_Evolution_Power_Curve.pdf
SD-2.9-WT.PC-1-C-EN_MM92_Evolution_Power_Curve.pdf

SIEMENS
ref_total_011008.pdf
PP 2.3 MW VS 1.225 kgm3.pdf
SWT-2.3-93 Sales Power Curve rev 1.pdf

VESTAS
Vestas Track Record - full version 30062005.pdf
944407.pdf
950019.pdf
0000-5450.pdf