Energy efficiency assessment of an aeolic plant installation in the Livorno harbour: a wind turbine performance comparison based on meteorological model estimations

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Abstract: - Exploiting wind resource is a good alternative in spite of using traditional not renewable and polluting energy sources. However, besides landscape restrictions and administrative practice complexity, it is generally hard to locate a site eligible for aeolic exploitation as well as to assess its related wind resource. As a matter of fact, an expensive wind measuring campaign should be carried out for that, through at least one year long period, at the height aeolic plants typically work (60 to 80 m), or to vertically extrapolate data collected by a 10-m anemometer.
The present paper is the sequel of one previously carried out, which proved the use of meteorological model wind estimations to provide aeolic efficiency performances being comparable with those based on experimental data. In particular, the WRF-NMM prognostic meteorological model has been used to calculate wind estimations, which actually are part of a meteorological archive which was developed at LaMMA laboratory starting from numerical elaborations provided by the weather forecasting service.
A sample application was performed through the installation of an aeolic plant in the industrial harbour of Livorno, Italy. After the wind resource pattern has been analysed by using typical distributions and statistical indicators, a site energy efficiency assessment has been carried out by comparing three different kind of wind turbines basing on rated power: the sizes of 1300, 2000 and 3000 KW have been taken into account. In particular, the comparison has been made between NORDEX N60, ENERCON E82 and ECOTÈCNIA 100 wind turbines.

Key-Words: - Wind resource, Energy efficiency, Aeolic plant, Meteorological model, WRF-NMM, Livorno, wind turbine comparison.

1 Introduction

Exploiting wind resource is a good alternative in spite of using traditional not renewable and polluting energy sources. However, in Italy, and particularly in Tuscany, at the moment such an exploitation by installing aeolic plants is strongly limited because of both all existing landscape restrictions and administrative practice complexity, as stated by local guidelines [1].
From a technical point of view, it is generally hard to locate a site being eligible for aeolic exploitation as well as to assess its related wind resource. In principle an expensive wind measuring campaign should be carried out for that, through at least one year long time period, at the height aeolic plants typically work, i.e. 60 to 80 m a.g.l. To achieve such a goal, an alternative approach is to use vertically extrapolated data measured by surface stations (10-m a.g.l. ones, typically). The present paper is the sequel of one previously carried out [8], which proved the use of meteorological model wind estimations to provide aeolic efficiency performances being comparable with those based on experimental data. As a matter of fact, a choice like that proved to be by far cheaper than that based on measured data. In particular, the WRF-NMM prognostic meteorological model has been used to calculate wind estimations. On the other hand, the use of a local meteorological model for aeolic purposes is supplied with a wide literature, both at an international [15] and a local scale [7], [18]. Actually, WRF model estimations are part of a meteorological archive which was developed by the Air Quality sector of LaMMA laboratory starting from numerical model elaborations provided by the LaMMA weather forecasting service.
Moreover, a sample application was performed through the installation of an aeolic plant in the

industrial harbour of Livorno, Italy.
In the following the study area and reference dataset will be described, as well as main features of the meteorological model providing wind resource estimations. The core of the work is a site energy efficiency assessment carried out by comparing three different kind of wind turbines basing on rated power: in particular the sizes of 1300, 2000 and 3000 KW have been taken into account.

2 Methodological approach

2.1 The LaMMA meteorological archive

The Air Quality sector of LaMMA laboratory built up an archive of meteorological variables which are day-by-day filled as numerical model elaborations by the LaMMA weather forecasting service [12]. The archive is made up by a number of vertical profiles: this allows to get a full 3-D description of the lower atmosphere and is particularly useful for dispersion modelling applications as well as and wind field modelling applications.
Data time step is one hour.

Table 1: Variables stored in the LaMMA meteorological archive.

Variable	Description (unit)
WS	wind speed (m/s)
WD	wind direction (degs from North)
w	wind vertical component (m/s)
T	air temperature (°C)
Pres	pressure (mb)
RelHum	relative humidity (%)
Prec	Precipitation rate (mm/h)
u*	friction velocity (m/s)
Rsw	shortwave solar radiation (W/m^2)
Rlw	longwave solar radiation (W/m^2)
Rswu	outgoing longwave solar radiation (W/m^2)
Ccov	clouds coverage index (tenths)

The archive was based on the RAMS model [13] through the January 2002 to August 2006 time period, whereas the WRF model [4] has been used thereafter.
RAMS model wind estimations for wind resource assessment purposes have been already used [7]. For the present paper purposes, only data extracted from the WRF-based archive has been used.
Basing on these daily WRF-forecast outputs, a meteorological archive has been built up which covers the whole of Italy territory by means of a 10-Km spatial resolution [3]. Meteorological variables are stored according to 12 vertical levels, so that any grid point actually represents a vertical profile.
The parameters stored in the meteorological archive are listed in Table 1.

2.2 The WRF-NMM model configuration implemented at LaMMA

The wind resource dataset the present work is based on are the wind estimations performed by the WRF-NMM prognostic meteorological model [4]. The use of WRF-NMM model for wind resource assessment purposes is currently widely scientifically accepted, e.g., as referred in [15].
WRF-NMM has been developed by NOAA (*National Oceanic and Atmospheric Administration*) and NCEP (*National Centre for Environmental Prediction*) with the aim of becoming the state-of-art in the field of atmospheric numerical modelling. Such a model is currently operative at LaMMA laboratory for the weather forecasting service [14].

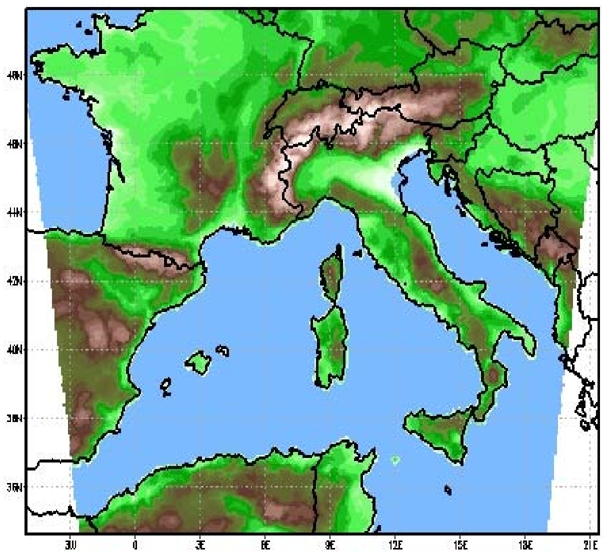

Fig.1: Map of WRF-NMM model configuration implemented at LaMMA for the daily weather forecasting service.

The WRF key features are:

- fluid dynamic equations solver;
- physical models interaction with the NMM solver through a standard interface;
- standard initialization of the boundary layer conditions using global and regional models data;
- data assimilation with "3DVAr" variational scheme.

At the moment the WRF-NMM model runs operationally at a resolution of about 0.1 degrees (12 kilometers at our latitude) and it is directly nested into the NCEP-GFS (T382L64) global model running at 0.5 degrees of resolution and into the ECMWF global model running at 0.25 degrees resolution. GFS and ECMWF data are used to initialize every six hours as boundary conditions the WRF-NMM model.
Each day LAMMA weather forecasting service performs four runs of NMM-GFS and two runs of NMM-ECMWF. Maps availability on the web site is the following.
NMM-GFS:

- 00 UTC run available at 07 UTC
- 06 UTC run available at 13 UTC
- 12 UTC run available at 19 UTC
- 18 UTC run available at 01 UTC

NMM-ECMWF:

- 00 UTC run available at 09 UTC
- 12 UTC run available at 21 UTC

At the moment, for a model run at a 12 Km resolution over the domain shown in Fig. 1, for a 24 hours forecast about 30 minutes of time-machine are necessary. In particular, a PC Linux cluster of 14 1.8 Ghz bi-processor units is used.
Then, 10 more minutes are needed for postprocessing purposes, that is for generating 3-hours step maps.

2.3 Study area and time period

The study domain is given by the coastal city of Livorno, Tuscany, and particularly its industrial harbour area (Fig. 2).
Such a site proved to satisfy a number of requirements: it is affected by quite a strong wind, particularly blowing from western sectors; infrastructures are available for the connection to the existing electric grid; and finally, since of an industrial kind, no landscape restrictions apply.
Data sample used for the present work covers the January 1st to December 31th 2007 time period, so that a full one-year long dataset with a one-hour time resolution is available.

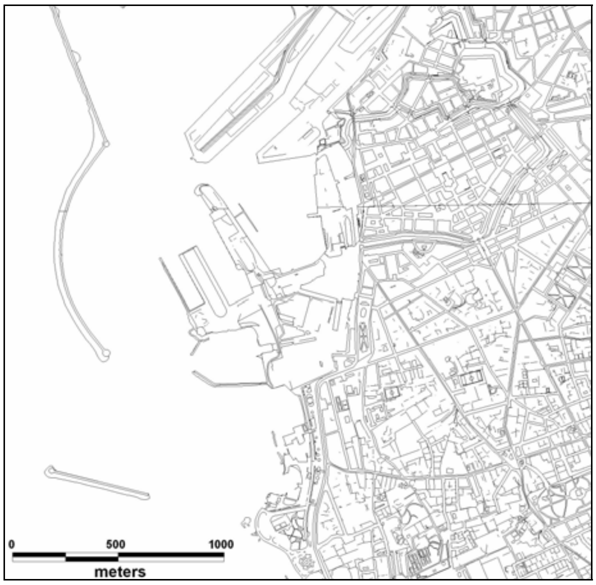

Fig.2: Map of Livorno harbour where possible aeolic site is located.

2.4 WRF model wind estimations

Meteorological data of the archive profile located nearest to the chosen site has been extracted and processed to assess the site aeolic exploitation. Since the model lowest levels are 10, 75 and 135 m a.g.l., wind data at the model's second level (75 m) have been extracted for the purpose of the present paper, particularly if considering the heights of hubs of wind turbines chosen for possible installation in the study area.

3 Site anemological description

The anemological characterization of a given area can be firstly summarized by means of indicators such as wind roses and Joint Frequency Functions (JFF), where occurences are represented per wind speed class and wind direction, both in percentual terms and number of hours.
Analysed wind roses and corresponding JFF referring to the WRF-calculated estimations at 75 m a.g.l. are reported in the following. In particular, they are presented in Fig. 3 and Table 2, respectively.
A preliminary remark resulting from Fig. 3 and Table 2 is the high percentage of valid data affecting the sample being used: as a matter of fact, it is equal to 99.94%, that is the number of valid WRF-related estimations is 8755 hours over 8760.
Wind rose plotted in Fig. 3 shows that predominant wind directions are ENE and NE ones. In particular, percentages of 13% and 9.1% occur for them, respectively.
Moreover, winds bearing from NE and particularly from ENE are affected by high speeds as well. For instance, ENE wind speeds higher than 4 m/s occur

for more than 10% of times, particularly with an amount of 6.5 within the range of 6 to 10 m/s. Similarly, NE wind speeds higher than 4 m/s occur for about 7.3% of times, with an amount of 3.87 within the range of 6 to 10 m/s.

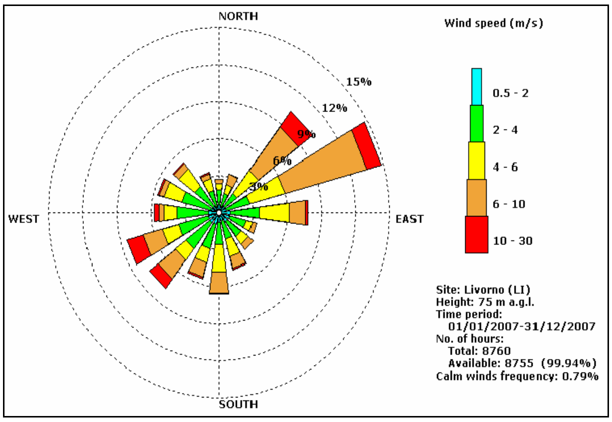

Fig.3: Wind rose of WRF model estimations.

Table 2: JFF of WRF model estimations.

SECTOR	<0.5	0.5 - 2	2 - 4	4 - 6	6 - 10	10 - 30	TOTAL
N		54	109	42	33	3	245
NNE		48	94	64	79	2	292
NE		58	117	206	387	139	911
ENE		60	183	280	653	118	1297
E		87	221	235	128	14	691
ESE		86	131	50	33	0	303
SE		82	133	66	47	0	338
SSE		60	134	128	89	8	422
S		70	154	197	152	6	585
SSW		84	182	103	105	14	495
SW		90	232	102	167	90	685
WSW		85	237	132	156	130	743
W		83	248	98	38	35	503
WNW		62	236	142	37	15	494
NW		59	175	159	45	10	452
NNW		48	117	87	34	9	299
TOTAL	69	1116	2703	2091	2183	593	8755

Secondary predominat wind directions encompass winds blowing from SW and WSW directions. Wind calms, that is winds whose speed is lower than 0.5 m/s, proved to be very rare over the considered time period: in particular wind calms occur 69 hours a year, that is only for 0.79% of times.
The annual wind speed frequency histogram has been plotted according to 25 classes, as shown in Fig. 4. Most frequent winds are those whose speed ranges from 2.5 to 3.5 m/s (16%). Secondly, 1.5 to 2.5 m/s wind speeds and 3.5 to 4.5 m/s ones occur for 13.1 and 15.2% of times, respectively. As a whole, wind speeds higher than 3.5 m/s and 4.5 m/s occur for 63.4 and 48.2%, respectively.
Fig. 5 shows the probability distribution of WRF-calculated wind speeds, which suggests the 3.5 to 4.5 m/s class to be as the one affected by the highest probability (14.7%). Strictly closer values occur for 2.5 to 3.5 (14.2%) and 4.5 to 5.5 m/s (13.6%) classes. As discussed later on, the distribution of wind speed probability throughout the sample time period is a crucial input to calculate the energy annual production of the aeolic plant over the study area.

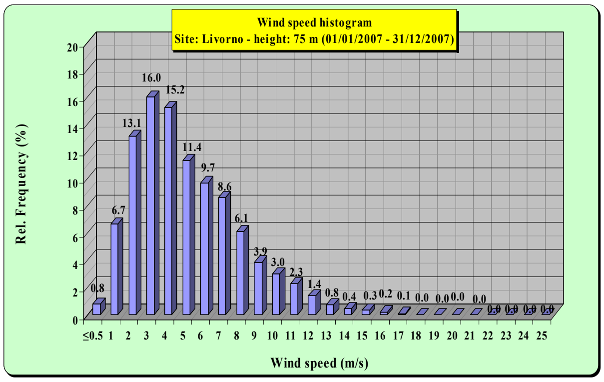

Fig.4: Frequency histogram of WRF wind speed estimations.

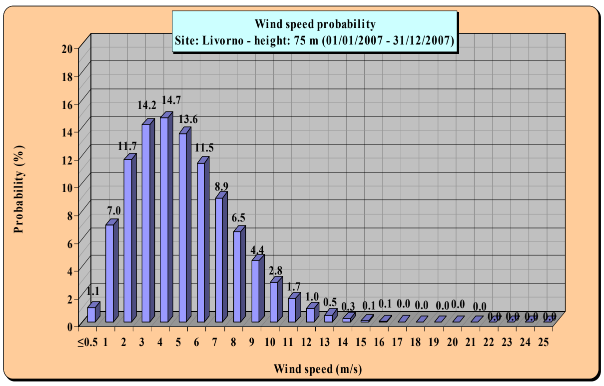

Fig.5: Probability histogram of WRF wind speed estimations.

The Weibull distribution as well as Weibull cumulated probability has been plotted, as shown in Figs. 6 and 7, respectively. The related *A* and *k* parameters are reported as well. In particular, the *A* scale parameter and *k* shape parameter summarize the statistical pattern of wind time series.

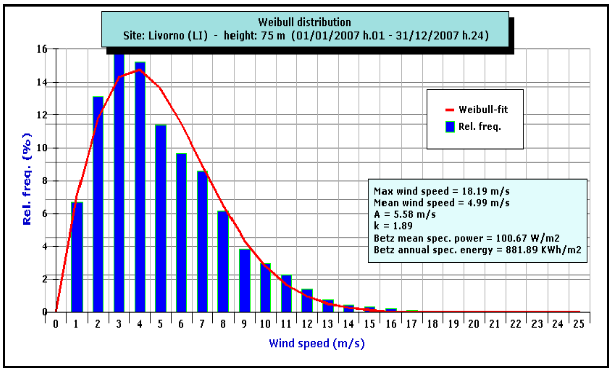

Fig.6: Weibull distribution of WRF wind speed estimations.

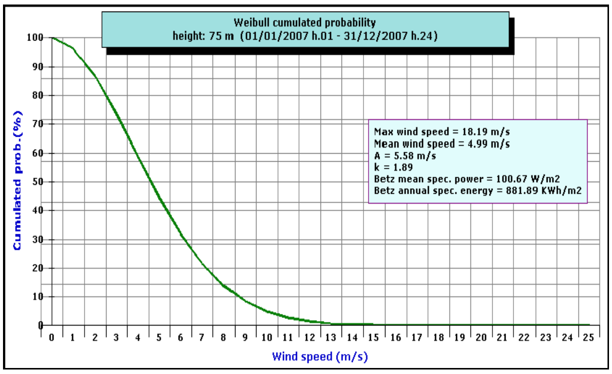

Fig.7: Weibull cumulated probability of WRF wind speed estimations.

Table 3: Site wind parameters.

Anemological parameter	Value
k (Shape Factor)	1.89
A (Scale Factor)	5.58
Maximum Speed (m/s)	18.19
Mean Speed (m/s)	4.99
Betz mean specific power (W/m^2)	100.67
Betz annual specific energy (KWh/m^2)	881.89

By looking at the Weibull curves (Figs. 6 and 7) along with the values of site wind parameters (Tab. 3), a substantial symmetrical pattern resulted, as outlined by the shape parameter value of 1.89. This *k* value is in agreement with those reported within the Italian aeolic atlas carried out by CESI [5], where the overall mean *k* value proved to be equal to 1.4÷1.5, whereas it is equal to 1.5÷2 over coastal sites, which is the case under study. The *A* parameter, which is strictly linked to the wind mean speed, is equal to 5.58.

A further relevant parameter is the Betz annual specific energy [6], which is proportional to the integral of the Weibull cumulated probability (Fig. 7). *A* and *k* parameters, Betz mean specific power and annual specific energy, as well as maximum and mean wind speeds are reported in Table 3, where the whole anemological scenario affecting the aeolic site under study is summarized.

In numerical terms, for the Livorno aeolic site a value of about 5 m/s resulted for mean wind speed, while a value of 18.19 m/s is obtained as maximum. The Betz mean specific power is equal to about 100 W/m^2, while the related annual specific energy is almost 882 KWh/m^2.

4 Energy efficiency of an aeolic plant installation and wind turbine comparison

4.1 Technical features of wind turbines used for comparison

As mentioned above, the energy efficiency assessment of the present work has been carried out by considering the possibility of installing an aeolic plant in the industrial harbour of Livorno (Fig. 2).

With this aim, a comparison has been made by choosing three different kinds of wind turbines basing on rated power: the sizes of 1300, 2000 and 3000 KW have been taken into account. In particular, the comparison has been made between NORDEX N60, ENERCON E82 and ECOTÈCNIA 100 turbines, as listed in Table 4.

In Table 5 main technical features of the three wind turbines chosen for comparison are summarized.

Table 4: Models of compared wind turbines possibly installed over the study site.

No.	Company (Nation)	Model	Rated power (KW)
1	NORDEX (Germany)	N60	1300
2	ENERCON (Germany)	E82	2000
3	ECOTÈCNIA (Spain)	100	3000

Table 5: Technical features of wind turbines used for comparison.

Technical data	NORDEX N60	ENERCON E82	ECOTÈCNIA 100
Number of blades	3	3	3
Rotor speed (prm)	12.8-19.2	6.0-19.5	7.5-14.25
Cut-in wind speed (m/s)	4	2	3
Rated wind speed (m/s)	15	13	15
Cut-out wind speed (m/s)	25	28	25
Hub height (m)	69	70	90
Rotor diameter (m)	60	82	100
Swept area (m^2)	2828	5281	7854
Rated power (KW)	1300	2000	3000

4.2 Compared wind turbines performances over the aeolic site

Once site wind speed frequency and probability distributions have been calculated, technical data of compared wind turbines have been used to assess the aeolic plant energy efficiency provided by any. Moreover, the power curves of each turbine have been merged with wind speed distribution, resulting in the values summarized in the following tables.

In particular, in Table 6 the energy produced over the sample period by the NORDEX N60 wind turbine is presented. Similarly, the related histogram of site energy production compared with the turbine power curve is plotted in Fig. 8.

Table 7 reports the site energy production distribution over the sample period provided by the ENERCON E82 wind turbine, whereas the related histogram of site energy production compared with the turbine power curve is plotted in Fig. 9.

Similarly, the pattern of site energy production due to the ECOTÈCNIA 100 wind turbine is presented in Table 8 and Fig. 10.

Table 6: Site wind speed occurences and probability distribution per wind speed class, along with NORDEX N60 power curve and related energy production over the study site.

WIND SPEED (m/s)	HOURS	PROBABI-LITY (%)	NORDEX N60 POWER (KW)	NORDEX N60 ENERGY (MWh)
0.0 - 0.5	69	1.05	0	0.00
0.5 - 1.5	585	6.98	0	0.00
1.5 - 2.5	1149	11.68	0	0.00
2.5 - 3.5	1401	14.21	0	0.00
3.5 - 4.5	1332	14.69	29	38.63
4.5 - 5.5	994	13.57	73	72.56
5.5 - 6.5	849	11.45	131	111.22
6.5 - 7.5	754	8.93	241	181.71
7.5 - 8.5	536	6.49	376	201.54
8.5 - 9.5	339	4.42	536	181.70
9.5 - 10.5	262	2.83	704	184.45
10.5 - 11.5	199	1.71	871	173.33
11.5 - 12.5	122	0.97	1016	123.95
12.5 - 13.5	66	0.52	1124	74.18
13.5 - 14.5	39	0.27	1247	48.63
14.5 - 15.5	29	0.13	1301	37.73
15.5 - 16.5	18	0.06	1344	24.19
16.5 - 17.5	9	0.03	1364	12.28
17.5 - 18.5	3	0.01	1322	3.97
18.5 - 19.5	0	0.00	1319	0.00
19.5 - 20.5	0	0.00	1314	0.00
20.5 - 21.5	0	0.00	1312	0.00
21.5 - 22.5	0	0.00	1307	0.00
22.5 - 23.5	0	0.00	1299	0.00
23.5 - 24.5	0	0.00	1292	0.00
24.5 - 25.5	0	0.00	1292	0.00
TOTAL	8755	100.00	-	1470.07

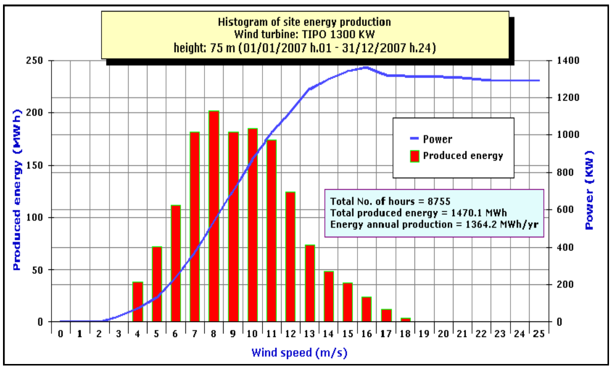

Fig.8: Histogram of site energy production provided by the NORDEX N60 wind turbine at 75 m a.g.l. (01/01/2007-31/12/2007).

Table 7: Site wind speed occurences and probability distribution per wind speed class, along with ENERCON E82 power curve and related energy production over the study site.

WIND SPEED (m/s)	HOURS	PROBABI-LITY (%)	ENERCON E82	
			POWER (KW)	ENERGY (MWh)
0.0 - 0.5	69	1.05	0	0.00
0.5 - 1.5	585	6.98	0	0.00
1.5 - 2.5	1149	11.68	3	3.44
2.5 - 3.5	1401	14.21	25	34.92
3.5 - 4.5	1332	14.69	82	108.89
4.5 - 5.5	994	13.57	174	172.42
5.5 - 6.5	849	11.45	321	271.68
6.5 - 7.5	754	8.93	532	399.88
7.5 - 8.5	536	6.49	815	435.48
8.5 - 9.5	339	4.42	1180	398.78
9.5 - 10.5	262	2.83	1612	421.03
10.5 - 11.5	199	1.71	1890	374.94
11.5 - 12.5	122	0.97	2000	243.24
12.5 - 13.5	66	0.52	2050	134.88
13.5 - 14.5	39	0.27	2050	79.70
14.5 - 15.5	29	0.13	2050	59.27
15.5 - 16.5	18	0.06	2050	36.79
16.5 - 17.5	9	0.03	2050	18.39
17.5 - 18.5	3	0.01	2050	6.13
18.5 - 19.5	0	0.00	2050	0.00
19.5 - 20.5	0	0.00	2050	0.00
20.5 - 21.5	0	0.00	2050	0.00
21.5 - 22.5	0	0.00	2050	0.00
22.5 - 23.5	0	0.00	2050	0.00
23.5 - 24.5	0	0.00	2050	0.00
24.5 - 25.5	0	0.00	2050	0.00
TOTAL	8755	100.00	-	3199.86

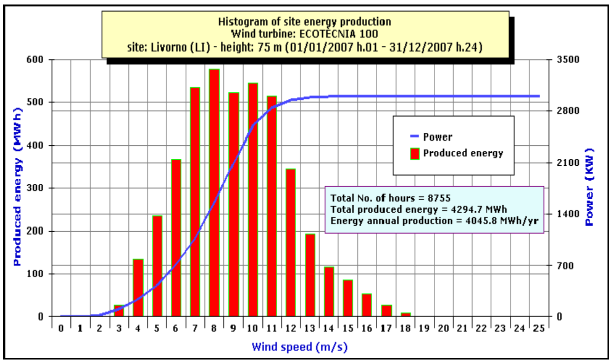

Fig.9: Histogram of site energy production provided by the ENERCON E82 wind turbine at 75 m a.g.l. (01/01/2007-31/12/2007).

Table 8: Site wind speed occurences and probability distribution per wind speed class, along with ECOTÈCNIA 100 power curve and related energy production over the study site.

WIND SPEED (m/s)	HOURS	PROBABI-LITY (%)	ECOTÈCNIA 100	
			POWER (KW)	ENERGY (MWh)
0.0 - 0.5	69	1.05	0	0.00
0.5 - 1.5	585	6.98	0	0.00
1.5 - 2.5	1149	11.68	0	0.00
2.5 - 3.5	1401	14.21	19	26.54
3.5 - 4.5	1332	14.69	102	135.44
4.5 - 5.5	994	13.57	237	234.85
5.5 - 6.5	849	11.45	434	367.32
6.5 - 7.5	754	8.93	712	535.18
7.5 - 8.5	536	6.49	1080	577.08
8.5 - 9.5	339	4.42	1550	523.82
9.5 - 10.5	262	2.83	2091	546.14
10.5 - 11.5	199	1.71	2600	515.79
11.5 - 12.5	122	0.97	2843	345.77
12.5 - 13.5	66	0.52	2950	194.10
13.5 - 14.5	39	0.27	2989	116.21
14.5 - 15.5	29	0.13	3000	86.73
15.5 - 16.5	18	0.06	3000	53.83
16.5 - 17.5	9	0.03	3000	26.92
17.5 - 18.5	3	0.01	3000	8.97
18.5 - 19.5	0	0.00	3000	0.00
19.5 - 20.5	0	0.00	3000	0.00
20.5 - 21.5	0	0.00	3000	0.00
21.5 - 22.5	0	0.00	3000	0.00
22.5 - 23.5	0	0.00	3000	0.00
23.5 - 24.5	0	0.00	3000	0.00
24.5 - 25.5	0	0.00	3000	0.00
TOTAL	8755	100.00	-	4294.69

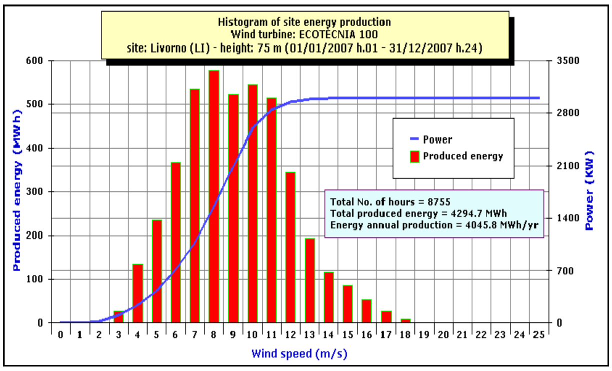

Fig.10: Histogram of site energy production provided by the ECOTÈCNIA 100 wind turbine at 75 m a.g.l. (01/01/2007-31/12/2007).

4.3 Discussion

A number of general working hypotheses has been set for application purposes:

- no wind speed vertical extrapolation has been made: WRF 75-m a.g.l. wind estimations have been used for all wind turbines regardless of their own hub heights;
- no possible energy production loss has been taken into account, that is due to site turbulence, electric grid connection, turbine out of order time, etc.

Along with site energy production performed by any wind turbine per wind speed class, the A_f and C_f site performance parameters have been computed. These parameters, along with total produced energy, energy annual production and full-load hours, are reported in Table 9.

Table 9: Summary of site performance parameters provided by all three wind turbines used for comparison.

Performance Parameters	NORDEX N60	ENERCON E82	ECOTÈCNIA 100
A_f (Availability Factor)	0.59	0.87	0.73
C_f (Capacity Factor)	0.13	0.18	0.16
Full-Load Hours (h/y)	1131	1600	1432
Produced Energy (MWh)	1470.07	3199.86	4294.69
Energy annual production (MWh/y)	1364.17	3031.52	4045.78

The A_f availability factor is the integral of Weibull distribution curve ranging from cut-in and cut-out speeds. The C_f capacity factor is the ratio between the annual energy yield and the product of rated power and 8760 hours. Full-load hours are the number of hours per year turbine works at rated power.

A general difference exists between the meanings of produced energy and annual energy production. As a matter of fact, the former is the total energy produced all over the considered time period, whereas the latter is the estimated energy production in probability terms, that is over a theorical year regardless of an exact historical time period. In other words, produced energy provides an "historical" energy information that is strictly related to the used wind data sample, whereas annual energy production is intended to be as a general prediction of future possible annual energy production basing on wind speed data probability distribution. As a result, the above distinction accounts for these two values may differ even when considering a one-year long time period such as the case of the present application.

Values reported in Table 9 show that the lowest rated power turbine (1300 KW) exhibits the worst performances over the aeolic site, with an availability factor equal to 59%, corresponding to 5168 working hours per year, and a capacity factor of 13%. These two values are the lowest if compared with those performed by the other two wind turbines. This means that the 1300-KW rated power turbine, working for about 5168 hours a year, mostly of time works under a wind speed which is below the rated one.

Analyzing the results performed by the most sized wind turbine (3000 KW), this is affected by an availability factor (73%) which is higher than that performed by the 1300-KW rated power one (59%), in that the range between cut-in and cut-off wind speeds is wider. In particular, cut-in wind speed of 3000-KW turbine (3 m/s) is lower than the one featured by the 1300-KW turbine (4 m/s), implying a higher working time period affecting the former, and then a higher availability factor, which corresponds to a total number of 6395 hours per year.

Moreover, the 3000-KW wind turbine shows higher performances even if taking the capacity factor into account, in that a value of 0.16 is performed against one of 0.13 resulting from the 1300-KW turbine. Thus, the 3000-KW turbine works for 1432 hours a year at the rated power, whereas the 1300-KW one works for 1131 hours per year at rated power. Such a difference of course results in the values of produced energy over the site, whose amount is 1470 MWh for the 1300-KW turbine and almost 4300 MWh for the 3000-KW one.

The analysis of the intermediate powered wind turbine (2000 KW) shows the best performances over the site, in that it exhibits both the highest availability factor (87%) and capacity factor (18%). As a matter of fact, its annual working time period is equal to 7621 hours, while its

annual time period working at rated power is about 1577 hours. Such a best performance results in the site produced energy (3200 MWh), which is more than twice the one produced by the 1300-KW turbine and less than 25% lower than that produced by the 3000-KW turbine.
The choice of an intermediate sized wind turbine features a number of advantages, such as a smaller involved installation area as well as lower plant costs if considering its best rated performances.

4 Conclusions

The present paper is the sequel of one previously carried out, which proved the use of meteorological model wind estimations to provide aeolic efficiency performances being comparable with those based on experimental data. In particular, the WRF-NMM prognostic meteorological model has been used to calculate wind estimations. As a matter of fact, the use of a local meteorological model for wind resource assessment purposes is supplied with a wide literature, both at an international and a local scale. Actually, WRF model estimations are part of a meteorological archive which was developed at LaMMA laboratory starting from numerical elaborations provided by the weather forecasting service.
The site energy efficiency assessment has been carried out by taking as a sample application the installation of an aeolic plant in the industrial harbour of Livorno, Italy.
After the site wind resource pattern has been analysed by using typical distributions and statistical indicators, an energy efficiency assessment has been carried out by comparing three different kind of wind turbines basing on rated power: the sizes of 1300, 2000 and 3000 KW have been taken into account. In particular, the comparison has been made between NORDEX N60, ENERCON E82 and ECOTÈCNIA 100 wind turbines.
A choice like that was not of a random kind. On the contrary, it was suggested by the purpose of detecting a wind turbine model featuring the most suitable power size in order to better exploit an aeolic site like the one under study.
First of all, the site anemological analysis showed the study site to be fairly eligible for the installation of an aeolic plant once the proper wind turbine has been chosen. As a matter of fact, the aim of the present work was to show that the wind speed distribution by wind class suggests the use of a given powered turbine to be preferable regardless of site mean wind speed.
Eventually, the comparison between three different powered turbines possibly installed over the aeolic site showed the choice of the intermediate sized one to be prefereable. As a result, it featured a number of advantages, such as a smaller involved installation area as well as lower plant costs if considering its best rated performances.

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