Bakgrund:
Vindresurser i Somalia

Relevanta mätningar om vindförhållanden och förutsättningar för vindkraft i Somalia går tillbaka till tiden före inbördeskriget kring 1990. Den bifogade studien presenterades 1991 när fortfarande det fanns ett Nationellt universitet i Somalias huvudstad Mogadishu.

Enligt studien lämpar sig 85 procent av det somaliska landområdet för vindproduktion – med dåtidens vindkraftsteknik. Vindförhållandena är mycket intensiva över 10 procent av landet och konstanta och jämna över 70 procent av landet.

Energikonsumtionen per capita ligger på de lägsta i världen. Somalia är glest befolkat, med majoriten av befolkningen boende på landsbygden och i små byar och samhällen med mellan 100 och 5000 invånare. All energiproduktion i landet sker med små dieseldrivna elgeneratorer, som ofta försörjer en enda bygnad, en skola, en verkstad eller ett välbeställt privathem. Eldistribution till flera konsumenter förekommer ibland i städerna, där större företag kan ha generatorer som räcker för flera konsumenter inom ett begränsat område.

Importen av diesel för elproduktion ger höga elkostnader och är ett verksamt hinder för utveckling.

De pålitliga vindförhållandena kopplat till behov av el och möjligheter för att skapa utveckling genom att utnyttja inhemsk förnybar energi gör vindkraften relevant och intressant i Somalia.

Bilaga:
Wind resourses of Somalia, av Rodolfo Pallabazer och Abdulkadi A. Gabor, tidskriften Solar Energy vol 40, 1991.

Solar Energy Vol. 46, No. 5, pp. 313–322, 1991
Printed in the U.S.A.

0038-092X/91 $3.00 + .00

WIND RESOURCES OF SOMALIA

RODOLFO PALLABAZZER* and ABDULKADIR A. GABOW†
Dipartimento di Meccanica, Università della Calabria, 87030 Rende(CS), Italy, †Department of Mechanics, Somali National University, Mogadisho, Somalia

Abstract—The results of wind energy research in Somalia are presented. The wind resource appears to be suitable for power production on 85% of the country, very intense on 10% and uniform on 70%, being regular throughout. Two areas of different wind regimes have been identified and characterized; the wind-distribution characteristics on 11 sites are presented and discussed, together with the territorial maps of the wind intensity and of the wind energy.

1. INTRODUCTION

Somalia is a country that consumes the least amount of energy: 0.27 kW/capita, versus 11 for the United States; the Africa average is 0.4[1,2]. This means that the unsatisfied needs are very high, which restrains the economic development and limits the diffusion of the welfare. Many developing countries are in a similar condition; however, Somalia has some unique properties that can be summarized as follows:

1. Throughout the country, except Mogadisho (1 million inhabitants), the population density is low as most villages have from some hundred to a few thousand inhabitants and most people are not sedentary. Since the consumptions are merely the vital ones, the villages energy needs are very little: some milling, few refrigerators and 4–5 hours/day of lighting, namely 20 to 50 kWh/d for a 200- to 500-inhabitant village can be estimated.
2. Most energy needs are for the water supply, either for drinking or for irrigation and cattle watering. Cattle are still the main Somalian economic resource. However, they are not very remunerative because of fodding poorness and water scarcity. In regard to watering, 7 to 10 Wh/head can be estimated, namely a 7–10 kWh/d well-pumping system could water at least 1000 heads/day.
3. Somalia lacks any chemical and nuclear resources and gets into heavy financial problems when trying to supply oil; fueling of engines in remote areas is difficult and costly. Instead, there are two free and unlimited energy resources: sun and wind. Although not very intense, they are very regular and their typical dilute distribution meets the dilution of the social needs very well. In this situation, solar or wind-power plants are suitable to fulfil durably the primary energy needs, which is an appropriate solution for the *basic welfare*.

On the basis of these considerations a research program on wind energy distribution and exploitation was started in 1983 by the Somali National University (SNU) with the support of the Italian government. The choosing of wind instead of the solar energy was dictated by the economy, the reliability, the local experience and existing data; indeed, no systematic solar radiation measurement has ever been made or reported, while there are some working anemometer stations in the country.

The Fàntoli's climatic study[3] is the only original and recently published source of systematic wind data on Somalia: it collects and discusses wind speed and wind direction data measured during about 20 years with wind-cup anemometers at 2 m of elevation over the ground—in 12 sites well distributed in the country. With regard to the historical data of the aeronautical stations, they are given by the registers of the Somali Ministry of Transport (SMT), usually as 5 or 8 data/day, for periods from 2 to 26 years, depending on the starting of the station. Some of the SMT stations were already considered in ref. 3; however, we had access to more and later data.

Reference 4 collected all the wind data of the SNU research; preliminary results were presented in [5–7].

2. CLIMATIC SURVEY

Somalia is placed in a trade-monsoon area, so climate and seasons are regulated by the monsoons alternation: from December to March the Northeast dry monsoon occur and from May to October the Southwest damp monsoon prevail, two short and irregular calms take place between them. During the monsoon seasons, the winds have a prevailing direction, as it can be seen from the wind-roses of Fig. 1 (from ref.[3]).

Rains are poor: from a few tens (in the North) to some hundreds of mm/year. The rains are irregularly distributed on the territory and concentrated within two periods, May–June and December. There are only two permanent rivers, Shebelle and Juba, both of which run south. In most of the country (except the coastal band), cloudiness is high and water evaporation and seepage is very intense. This causes the Shebelle River to die out in marshes rather than flow into the sea. Temperature is very uniform (on average): there are few degree fluctuations around 27°C.

* ISES member.

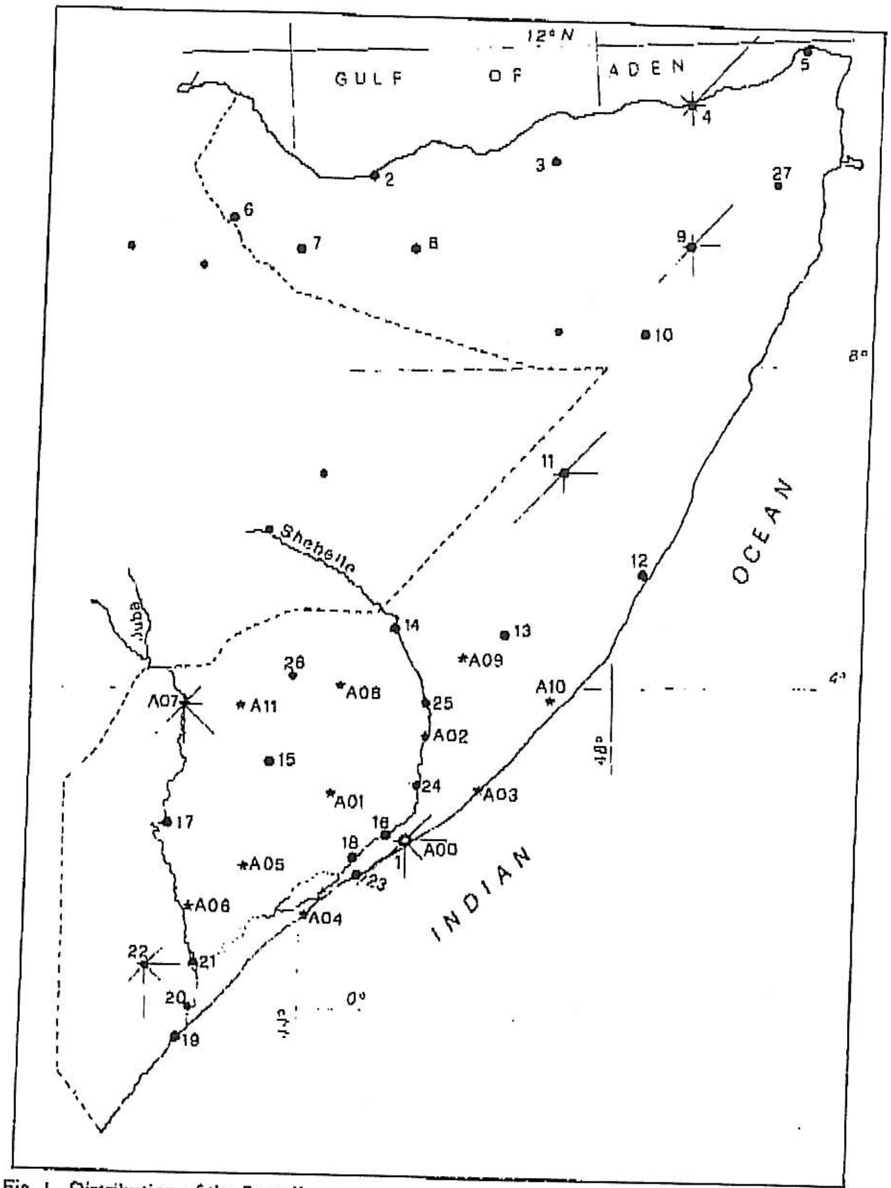

Fig. 1. Distribution of the Somalian anemometer stations. The wind-roses are drawn from ref. 3.

3. THE WIND MEASUREMENT PROGRAM

Table 1 lists the 19 aeronautical (SMT) stations, whose sites are shown in Fig. 1. Although Somalia is largely a flat country where some territorial extrapolation of data is allowed, 19 data points is a small sample to use to get knowledge of the wind energy distribution on a territory more than 600.000 km^2 large.

Some of the SMT data are irregular and/or unreliable, uncertain informations were gotten from other cases about instrument collocation and elevation.

In Table 1 all the main information is given about reliability of the data, type of instrument (usually a counter anemometer or a manual wind-cup instantaneous anemometer), elevation over ground and number of full years of data that are available. The cubic mean wind speed is a reduced value, as it was calculated from 3 hours instead of 10-min data (see later).

Taking into account these limits of the SMT data, 11 new (SNU) anemometer stations were set up in southern Somalia in 1983–84; the sites are listed in Table 2 and shown in Fig. 1. Two wind-cup monthly mechanical anemographes (set up in the sites A00 and A01), one propeller self-generating electric anemograph (used random in A00 and A03) and nine wind-cup counter anemometers have been employed.

The anemographes allow a time resolution up to 10 minutes, which is achieved by manual reading of the recording paper, made by the SNU staff. (There is an error estimate of about ±5%.) This approximation is only accomplished for defined periods; usually, just the hourly averages are read and registered throughout.

Table 1. SMT sites: main informations, with mean wind speeds and cubic mean wind speeds (m/sec)

SMT Anemometer Stations						
N.	Locality	Anem.	h_a	N_h	$\bar{V}$	$\bar{V}_3$
19	KISIMAIO	m	1.5	26	8.5	10.1
18	GENALE	c	2.0	4	2.5	3.9
17	BARDERA	m	1.5	13	4.5	5.5
1	MOGADISHO	c	2/10	26	5.8	6.8
16	AFGOI	c	2.0	3	4.5	6.3
15	BAIDOA	c	10	22	3.6	4.8
14	BELETWEIN	c	15	25	3.6	5.3
13	EL BUR	m	1.5	20	5.3	(*)
12	OBBIA	m	1.5	26	10.2	14.4
11	CALKAIO	c	10	25	4.5	8.1
10	GAROE	m	1.5	-	unreliable	
9	GARDO	m	1.5	21	7.1	8.9
8	BURAO	m	1.5	13	7.7	11.1
7	HARGHEISA	c/m	2/1.5	14	11.6	15.9
6	BORAMA	m	1.5	13	7.0	9.2
5	ALULA	m/c	1.5/10	10	4.6	6.5
4	BOSASO	m	1.5	16	6.4	7.9
3	ERIGAVO °	m	1.5	2	9.3	12.1
2	BERBERA °	m	1.5	13	8.1	12.6

Anemometers: c=counter; m=manual;
c/m=both, subsequently
h_a = anemometer height (meters);
N_h = number of full years of available data
° = poor or irregular data
(*) = only yearly mws are available
All wind speeds are calculated at 10m of elevation

Counter data are registered manually directly from the instrument at 6, 9, 12 a.m. and 3, 6 p.m. by local people. All data are entered into a computer.

Many troubles, failures, social and logistic difficulties were encountered; however, with a few exceptions, continuous data was collected during 4–5 years, which provided an acceptable knowledge of the local wind characteristics and of the territorial distribution of the wind in Somalia.

The program is continuing with some new wind sites in place of the existing ones (the number of anemometer stations that the SNU staff can manage is limited), as more informations are needed in some areas. Unfortunately, there is no possibility at present to extend the investigation to the north.

3. MAIN WIND PARAMETERS

Let $\mathbf{V}$ and $\mathbf{V}_3$ be the mean and the cubic mean wind speed in the period T, that is:

$$\mathbf{V} = \frac{1}{T}\int_0^T V_i\,dt; \quad \mathbf{V}_3 = \left[\frac{1}{T}\int_0^T V_i^3\,dt\right]^{1/3}. \quad (1)$$

If in eqn (1) V_i is the instantaneous wind speed, $\mathbf{V}_3$ is the "exact" or "full" cmws (cubic mean wind speed); its difference from $\mathbf{V}$ depends on all the wind irregularities of any scale. However, $\mathbf{V}_3$ can unlikely be calculated as no instrument gives instantaneous wind speeds. In ref. 8 it has been shown to be suitable to introduce a time scale of the wind irregularities and of the approximations. If the mws (mean wind speed) of a subperiod (10 min, 1 hr, 1 day, etc.) replaces the instantaneous one in eqn (1) an approximate (reduced) value of $\mathbf{V}_3$ is calculated, where physical significance depends on the subperiod that has been adopted.

Four degrees of wind fluctuations have been considered:

1. Short-scale fluctuations, shorter than 10 minutes ("gusts")
2. Period from 10 minutes to 1 hour ("squalls")
3. Period from 1 hour to 1 day ("breezes")
4. Seasonal variations longer than 1 day ("monsoons").

Accordingly, four degrees of approximation for the cumulative cmws can be defined. The first of which is the "full" mean $\mathbf{V}_3$ that includes all the fluctuations.

Table 2. SNU sites: main informations and overall data

SNU Anemometer Stations									
N.	Locality	Anem	N_h	$\bar{V}$	$\bar{V}_3$	E	σ	k	c
A00	MOGADISHO	a	6	5.2	5.8	2.09	.362	3.3	6.3
A01	OARDO	a	6	3.7	4.6	1.02	.520	2.2	4.2
A02	JALLALAXI	c	5	4.2	5.4	1.71	.588	1.7	4.7
A03	ADALE	c	5	6.6	7.3	4.13	.373	2.9	7.2
A04	BRAWA	c	5	6.7	7.3	4.21	.298	3.7	7.5
A05	YAK BRAWAI	c	3	3.2	3.9	0.66	.498	2.1	3.6
A06	DUJIUMA	c	5	3.7	4.3	0.87	.615	2.6	4.2
A07	LUGH	c	1	unreliable - cancelled					
A08	TIJIEGLO	c	5	3.2	3.9	0.63	.491	2.2	3.6
A09	MAAS	c	5	4.4	5.3	1.60	.476	2.2	5.0
A10	EL DEER	c	5	5.0	6.5	2.94	.583	1.8	5.7
A11	UEGIT	c	2	3.9	4.3	0.86	.351	3.1	4.3

Anemometers: a = anemograph ; c = counter
N_h = number of full years of data
E = available mean daily specific energy ($kWh/m^2/d$)
σ = relative standard deviation
k,c = Weibull's coefficients
All quantities are calculated at 10m of elevation

The others are the "reduced" cumulative cmws $\mathbf{V}_{3e}$, $\mathbf{V}_{3h}$, $\mathbf{V}_{3d}$ that are calculated by replacing V_i with the 10 min (elemental), the hourly and the daily mws, respectively. As a matter of fact, $\mathbf{V}_{3e}$ depends on all the wind irregularities except the gusts. It "filters" the gusts. $\mathbf{V}_{3h}$ filters gusts and squalls; $\mathbf{V}_{3d}$ depends only on seasonal fluctuations. As no resolution higher than 10 min was available in our measurements, gusts could not be filtered and $\mathbf{V}_{3e} = \mathbf{V}_3$.

At last, we can define the following *coefficients of fluctuation*:

$$k'_f = \mathbf{V}_3/\mathbf{V}_{3h}; \quad k''_f = \mathbf{V}_{3h}/\mathbf{V}_{3d}; \quad k'''_f = \mathbf{V}_{3h}/\mathbf{V}$$

$$k_f = k'_f k''_f k'''_f = \mathbf{V}_3/\mathbf{V}. \tag{2}$$

k'_f, k''_f, and k'''_f are a measure of the wind irregularities respectively on hourly, daily and seasonal scale, while k_f measures the overall wind fluctuation; it is the cubic root of the "energy pattern factor", K_e, defined by Golding[9]. As they are calculated by the *cumulative* cmws, all the k_f's show an asymptotic time-trend. Its *rising time* is a local characteristic, which is very useful to follow the progress of the measurement strategy. We point out that this is actually the use we make of the fluctuation coefficients as they are; otherwise, they are just used as a suitable algorithm for energy computations.

The available mean wind power, $\mathbf{P}$, and the overall wind energy, E, of a wind turbine in standard atmosphere at 30°C during the period T are

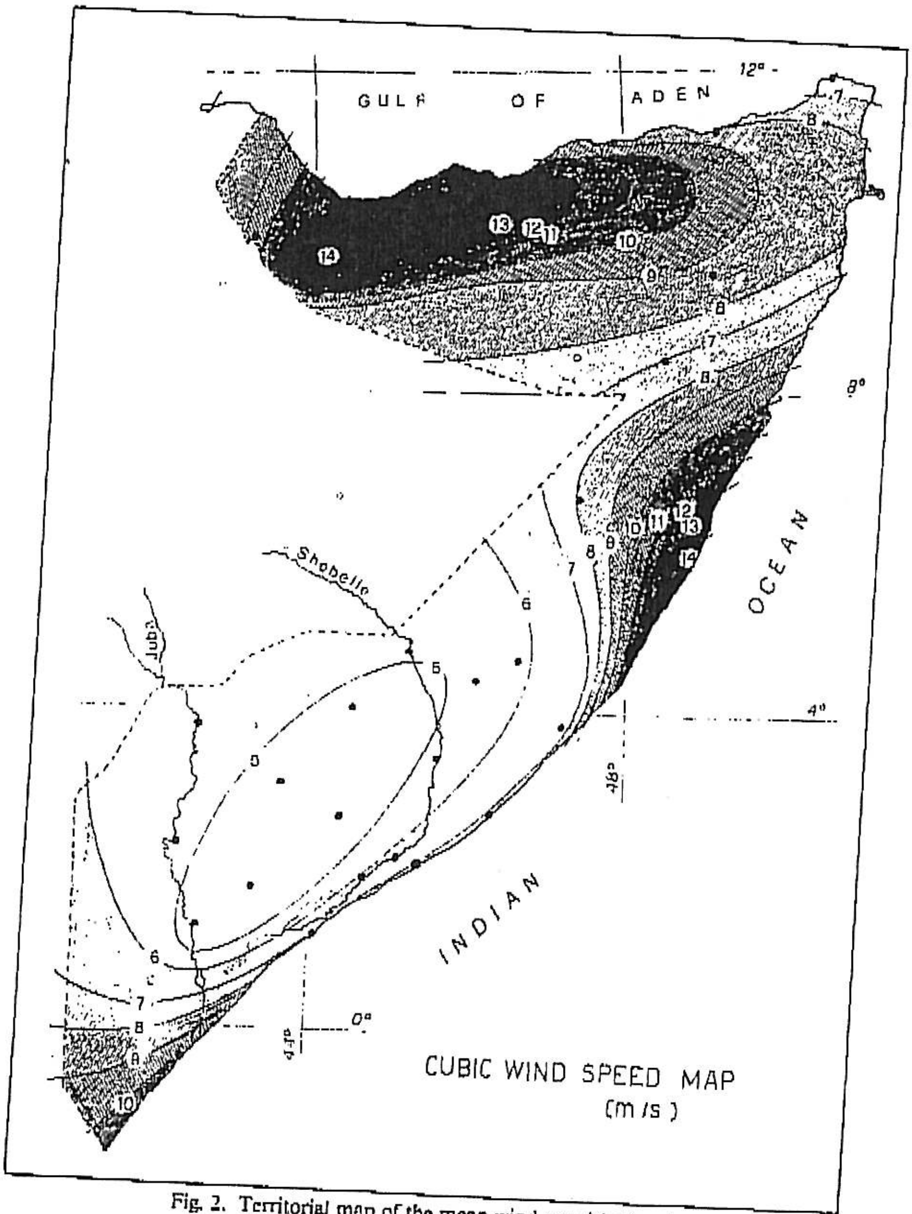

Fig. 2. Territorial map of the mean wind speed (m/sec).

$$\mathbf{P} = \tfrac{1}{2}\rho\tfrac{1}{4}\pi D^2\mathbf{V}_3^3 = 0.44\,D^2\mathbf{V}_3^3(W)$$

$$E = \mathbf{P}T = 0.44\,D^2\mathbf{V}_3^3 T(Wh). \qquad (3)$$

When dividing $\mathbf{P}$ and E by D^2, *specific* quantities are obtained; therefore, $\mathbf{V}_3$ is proportional to the cubic root of the specific mean power. If the "full" cumulative cmws is replaced by a "reduced" cmws, a reduced value of E is obtained, whose computation is needed when the mean energy that can be stored in a given period has to be considered.

4. PRESENTATION OF THE MAIN RESULTS

Table 2 collects the main informations and overall results at the SNU sites; the relative standard deviation and the Weibull's coefficients are given together with the mws and the cmws. E is the overall average of the daily specific energy of the wind flow. Figures 2 and 3 present the territorial maps of the mws and cmws. Figures 4 to 9 show some computer drawings of the analysis (three coastal and three inland representative sites have been selected): in Figs. 4 and 5 the wind-speed and specific-power distributions, in Figs. 6 and 7 the frequency histograms, in Fig. 8 the duration curves and in Fig. 9 the cumulative trends of the fluctuation coefficients.

All the wind speeds are calculated at 10 meters of elevation above ground; a logarithmic law of the wind profile (Prandtl's profile) was assumed, that is [9][10]:

$$V_o = V[\ln(10/r)/\ln(z/r)] \qquad (4)$$

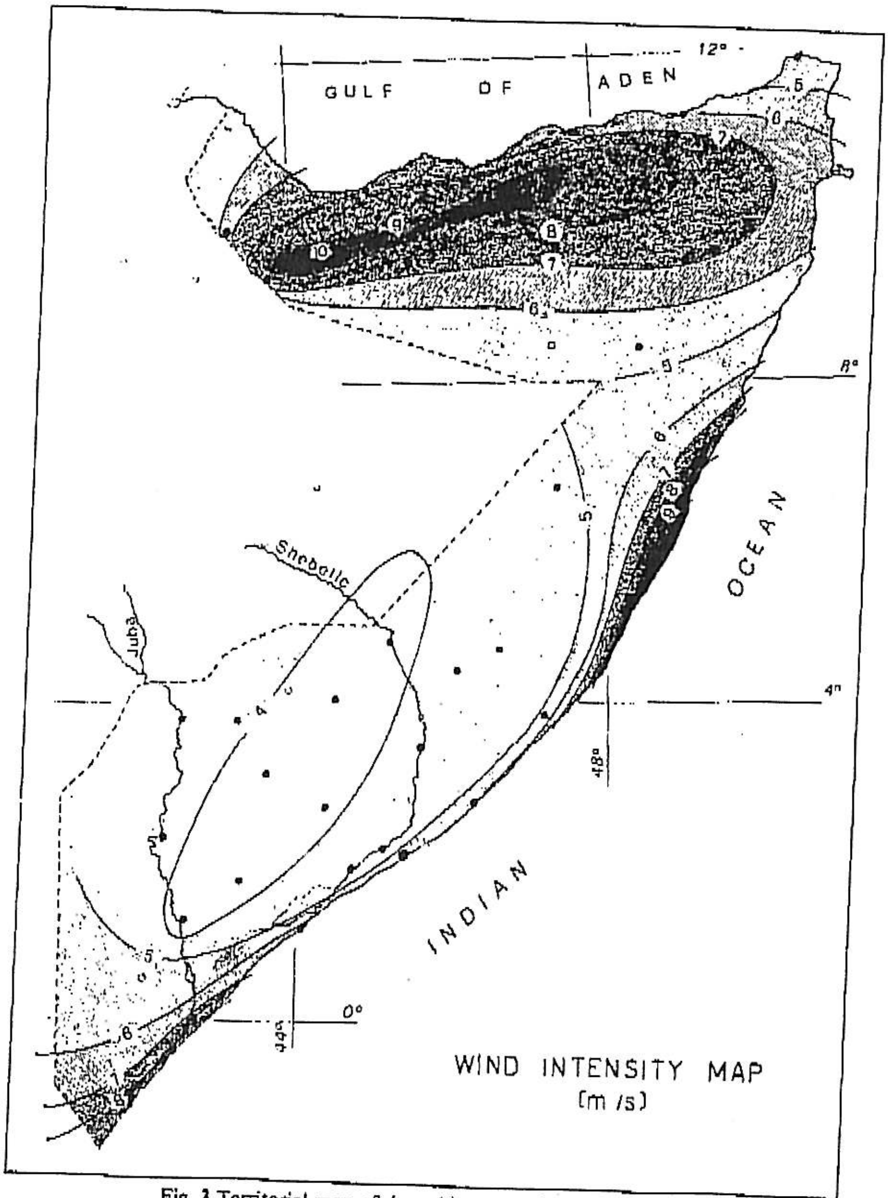

Fig. 3. Territorial map of the cubic mean wind speed (m/sec).

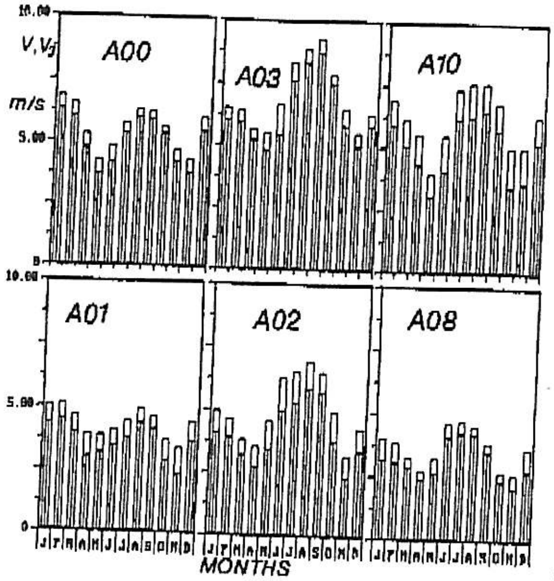

Fig. 4. Yearly distributions of the monthly mws and cmws; the hystograms are overlapped.

where V and V_o are the wind speeds respectively at z and 10 m of elevation and r is the ground roughness parameter (usually $r = 0.003 \div 0.25$ m). Wind profile measurements[4] have been carried out in a typical Somalian environment (brush) and $r = 0.035$ was measured. However, for the sake of caution, $r = 0.05$ has been assumed all throughout the country (in any case, no SNU measurement station was amid buildings or trees).

For the sake of simplicity, in the following all the cmws will be indicated as V_3; however, they all are "reduced" cmws.

In A00 and A01, where the anemographes provide hourly data, V_3 actually is V_{3h}. In all the other SNU and SMT stations, where 3-hours data are available, V_3 is a value lightly reduced of V_{3h} (computations made with the hourly data of A00 and A01 show that the wind fluctuation of period between 3 hours and 1 hour is very little).

The territorial maps have been drawn by matching SMT and SNU data. Thirty data-point is still a small number to draw exact isowind lines through a large country; however, in the case of Somalia the drafting was facilitated by the low irregularity of the winds and by the levelness of most country. Help was given by the wind distribution studies for bordering countries, Ethiopia and Kenya[11,12]. A careful examination of the SMT data has been carried out: all the sporadic records and the irregular or incomplete years have been rejected. It may be that some unreliable data has been included; however, considering the high number of years of data that is available for most of the stations and comparing the SMT data with that given for the Northeastern region (in some case same station) by Fantoli[3] and other sporadic sources, we think the SMT data can be accepted. That is, the maps of Figs. 2 and 3 can be considered as a good approximation of the actual territorial wind distribution.

5. ANALYSIS AND DISCUSSION

As it can be seen from the maps, the isowinds rather follow the profile of the Horn of Africa, showing the

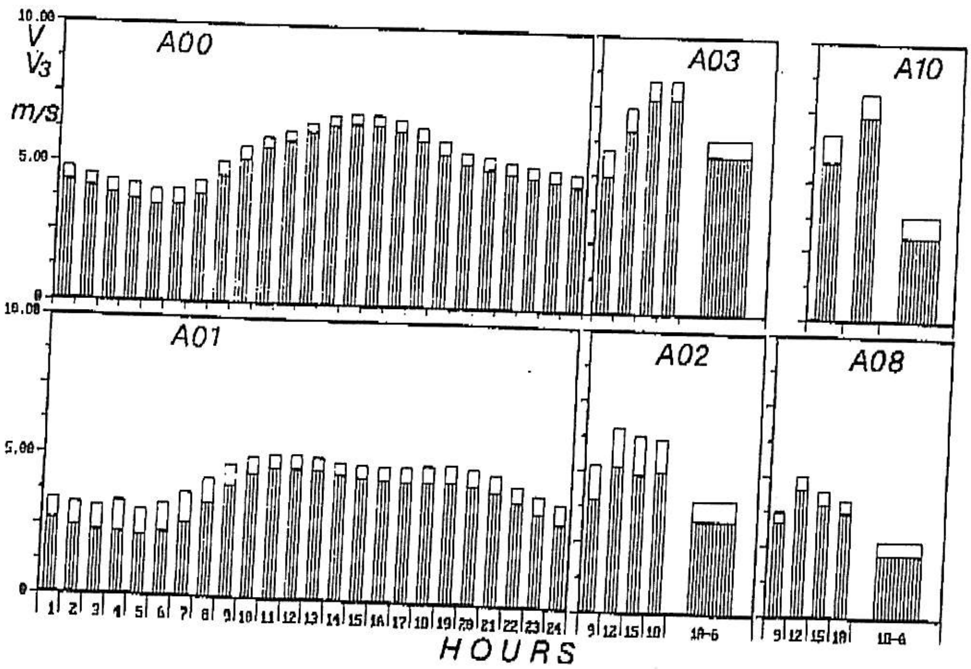

Fig. 5. Daily distributions of the hourly mws and cmws.

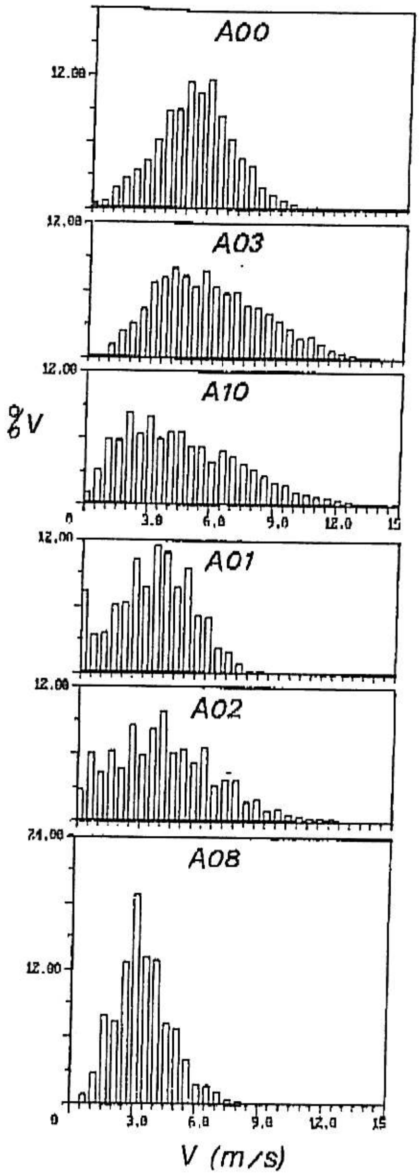

Fig. 6. Wind speed frequency hystograms.

definite influence of the monsoons. Therefore, as regards the winds, Somalia can be approximately divided in two regions: the North with the eastern coastal band, and the inland territory. The flow in the first region is governed by intense winds (> 10 m/sec) directly yielded by the oceanic trade-monsoon. The inner region of central and southern Somalia is not very windy. Sometimes, not far from the coast, it is not very windy since both monsoons are rather parallel to the oceanic coast (see wind-roses in Fig. 1). The inland winds seem to be induced by the monsoon shearing rather than by the monsoon penetration into the continent.

All the northern region north of 9°N is a mountain massif facing to the NE monsoon, therefore subjected to intense winds. Two eastern areas as well—south of 0° and between 4°N and 8°N—are particularly windy compared with the next areas. In fact, the northern massif shades the downflow region from the NE monsoon, while the SW monsoon is less intense than the NE one and weakens north of 0°. The area of minimum wind in the South is probably due to some reciprocal compensation between the monsoons during the months, as this lower wind intensity is not uniform through the year.

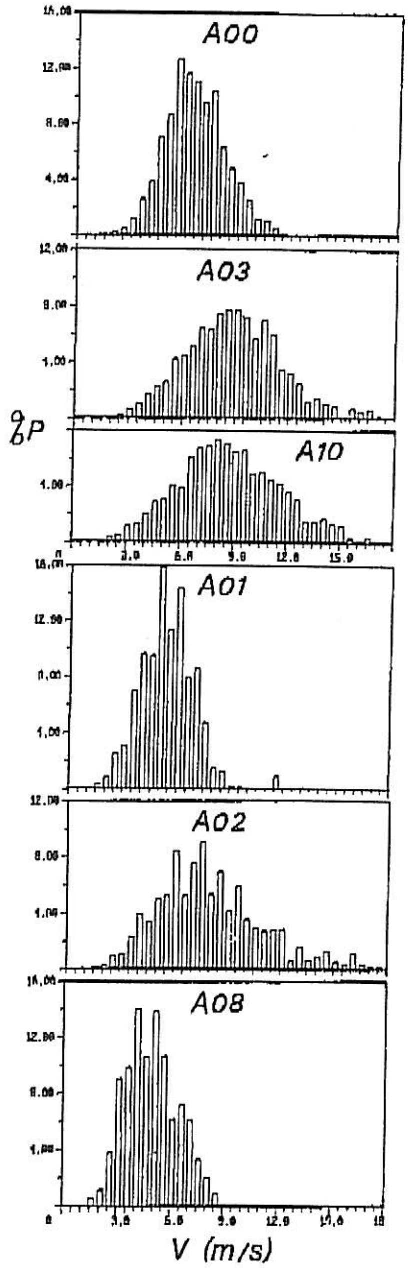

Fig. 7. Power frequency hystograms, as functions of V.

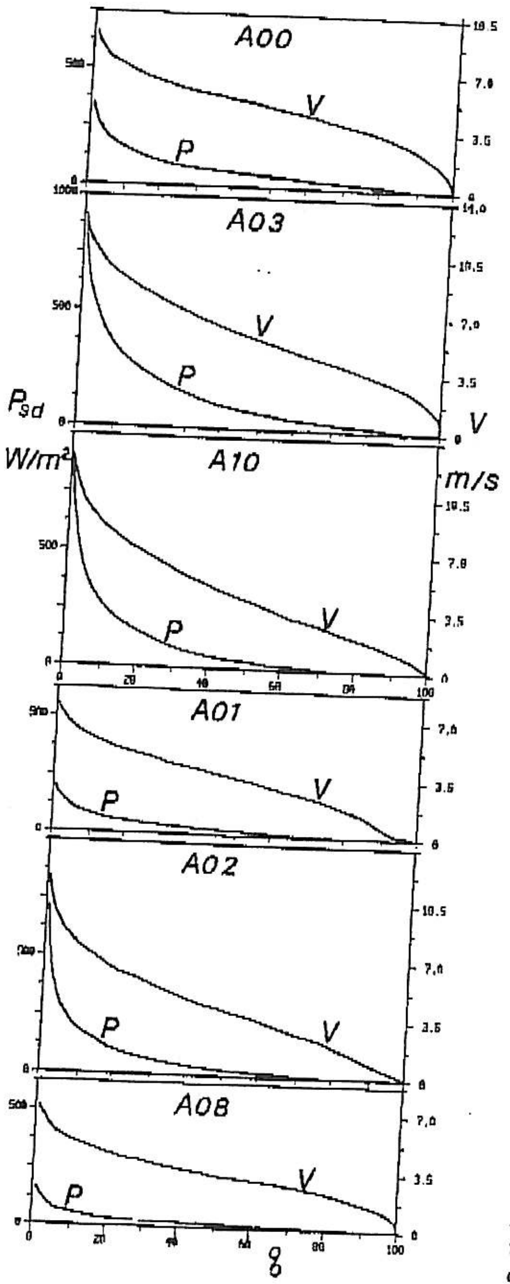

Fig. 8. Wind speed and specific power duration curves.

To sum up, the maps show that the cumulative mws exceeds 4 m/sec on 85% of the territory and 5 m/s on 50%. Values higher than 10 m/sec are available on at least 10% of the land. The wind energy distribution is very uniform throughout 70% of the country, which is rather flat.

As the wind characteristics on the sites of the same area are rather homogenous, the SNU sites can be assembled in two groups.

5.1 *Coastal band* (*sites*: *A*00, *A*03, *A*04, *A*10)

The first three places are sea towns. The last one is located 20 km from the sea, on a desert plain exposed to the sea winds. Figure 4 shows the cyclic course of the winds, which are intense during the monsoonic seasons and drop during the calm periods between them. Most of the wind energy is concentrated from June to September and from December to March (this is during monsoons) when about the 80% of it is produced. However, the monthly mws are still rather high (about 4 m/sec) during doldrums, rising to 8 m/sec during monsoons. In this area, the daily mws seldom drops to zero, even during the calms.

In Fig. 5, the wind rising from 10 a.m. to 6 p.m. shows the breeze contribution. While the monsoons yield an intense and stable background air flow, the frequency hystograms (Figs. 6, 7) show the Gaussian behaviour, with wind-speed peaks in the range 3–8 m/sec and power peaks in the range 5–10 m/sec. From the duration curves (Fig. 8) it can be seen that more than 60% of the wind speeds are higher than 5 m/s (cut-in wind speed of most medium-large size fast-running wind turbines). A mean specific power of about 200 W/m^2 is available during more than 60% of the year, which can be considered as a good potential resource for the local needs.

All these sites show very little wind irregularity (Fig. 9; k_f around 1.1), with the third fluctuation coefficient higher than the second one. The k_f in A10 is a little higher (1.28), this depending more on the value of the mws being lower than on being higher than the wind fluctuation. The first fluctuation coefficient k_f' is very low in Mogadisho (1.006), and the asymptotic trend is achieved after a few days; this means a very low little-scale fluctuation and a very stable wind.

In conclusion, the coast-band wind resource is very favourable, with good mean wind speeds, very good daily and seasonal regularity, and with moderate maximum wind speeds (not higher than 15 m/sec).

5.2 *Inland territory* (*A*01, *A*02, *A*05, *A*06, *A*07, *A*08, *A*09)

The qualitative behaviour of the inland sites is similar to the coastal ones, but the wind power potential is about 4 times lower: the cumulative cmws V_3 is around 4.5 m/sec (7 m/sec on the coast), which means that the power is 3.8 less (about 40 W/m^2 on an average).

The monsoon cycle is followed here as well, and the monsoon seasons contribute about 80% to the annual wind energy resource. During the day the breeze contribution is still present from 10 a.m. to 6 p.m. The frequency peaks are about 2 m/sec less than on the coast; the calms ($V < 1$–2 m/sec) occur between 5% and 15% of the time.

Lastly, the duration curves show that for most of the year the wind speed is too low for a fast running wind generator: on the average, wind speeds higher than 5 m/s are available only for 15%–20% of the year. With such a level of intensity, only slow wind machines (multibladed water-pumping wind mills, or wind electric pumping systems on low water heads) could be set up suitably. The inland wind resource is rather poor and unsuitable for a very concentrated energy exploi-

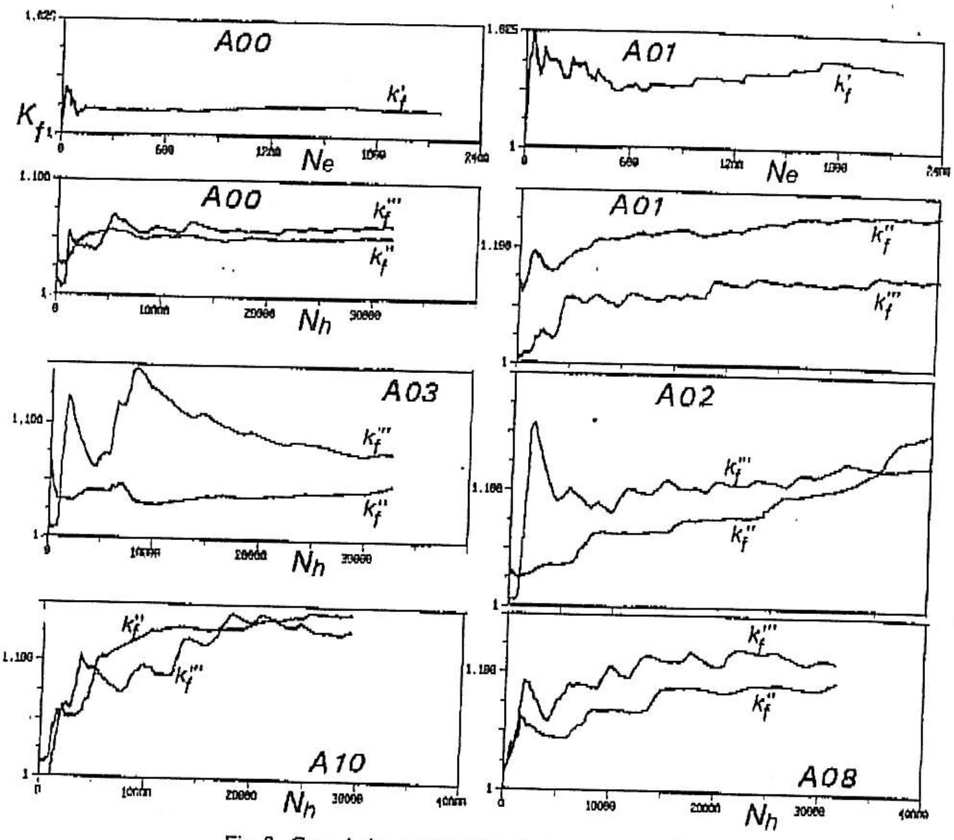

Fig. 9. Cumulative trends of the fluctuation coefficients.

tation; however, the regularity of the winds could make it fit to answer the basic energy needs.

The fluctuation coefficients are a little higher (≈ 1.2) than the coastal ones, but are low in comparison with many areas in the world; besides, the k_f's become stable sooner on the coast, where the trade-monsoon regularity is dominant. The second coefficient is of the same order of the third one, as inland the breeze effect is as important as the monsoon effect. The first coefficient in A01 is a little higher than in A00 but it is low as well: 1.018. That is: low little-scale wind dynamics inland, too. The wind regularity seems to be the important merit of the wind resource all throughout Somalia.

6. CONCLUSIONS

Both the character of the Somalian territory and the informations that can be inferred by the maps prove a large climatic uniformity and allow to extend the results of the SNU stations to most of the country: all of the central-southern area.

There is an high-energy coastal band, that is rather narrow (few tens of km) around 2°N and widens out and intensifies southwards and mostly northwards; it extends as far as 80–100 km inland. The specific wind energy that is available in this area goes from 5 to 20 kWh/m^2/d: therefore, a little-size (5–6 m diameter) fast-running wind-generator can fulfil the basic energy needs of some hundreds inhabitants and/or the watering needs of some thousands heads. Owing to the high wind regularity, this energy can be provided during about 70% of the year with a reduction of 30%–50% during the rest.

The inland area between 0.5°N and 4°N instead is poor, as less than 1.5 kWh/m^2/d are available, and a 5–6 m wind machine could provide less than 5–7 kWh/d. At least a 10-m turbine is needed to supply energy to 200 people. Therefore, in this area the wind energy is economically suitable only to pump water, as a 5–6 m multibladed turbine could supply water to many hundreds of people as well as cattle. At last, in an annular zone intermediate opportunities take place.

In conclusion, the investigation showed that the wind resource is good enough in Somalia, especially along the coast, to supply the people with basic energy needs. This resource was quantified and characterized. On this ground, projects for wind-power utilization become feasible and desirable.

NOMENCLATURE

- D turbine diameter
- E available wind energy in the period T, eqn. (3)
- k_f coefficients of fluctuation, eqn. (2)
- P available mean wind power, eqn. (3)
- t time
- T period of time
- V mean wind speed, eqn. (1)

V_3 cubic mean wind speed, eqn. (1)
ρ air density
mws mean wind speed
cmws cubic mean wind speed

REFERENCES

1. J. K. Krenz, *Energy*, Allyn & Bacon, Newton, MA (1988).
2. "National Energy Document", *Somali Democratic Republic Report*, (1988).
3. A. Fantoli, Contributo alla climatologia della Somalia, *Report No. IAO-BI-BA, Ministero degli Affari Esteri*, Roma, (1965).
4. R. Pallabazzer *et al.*, Water from wind in Somalia—Progress Reports (nos. 1–7), *S.N.U. Report*, Mogadisho (1983—88).
5. R. Pallabazzer, Wind Energy Map and Project in Somalia, *Renewable Energy Sources: International Progress, Part B*, Elsevier, 165–181 (1984).
6. R. Pallabazzer, Towards a wind map of Somalia, *Proceedings of INTERSOL '85*, 4, Pergamon Press, New York, 2577–2581 (1986).
7. R. Pallabazzer and A. A. Gabow, Wind analysis for a monsoonic country: Somalia, *Proceedings of EWEC 86, Reguzzi Publ.* **1**, 311–315 (1987).
8. R. Pallabazzer, Analisi della irregolarità del vento ai fini della valutazione delle risorse energetiche e dell'ottimizzazione degli aeromotori, *Energie Alternative HTE* 12(63), 13–22 (1990).
9. E. W. Golding, *The generation of electricity by wind power*, E.&F.N. Spon Ltd., New York (1980).
10. S. Petterssen, Some aspects of wind profiles, *Proceedings of the Conference on New Sources of Energy—U.N.*, Rome, W26, (1961).
11. W. Wolde-Ghiorgis, Wind energy survey in Ethiopia, *Solar & Wind Technology* 5(4), 341–351 (1988).
12. W. Ogana, Wind energy development in Kenya—A review, *Solar & Wind Technology* 4(3), 291–303 (1987).