

# Wind Power Station GAO/MALI

## Public Private Partnership



Deutsche Gesellschaft für Technische  
Zusammenarbeit (GTZ) GmbH

**BASIC**

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**Feasibility Study**  
**for a 900-kW Wind Farm**  
**in Gao, Mali**  
**Wind-Diesel System**  
**Final Report**

July 2004

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# PROJECT SITE



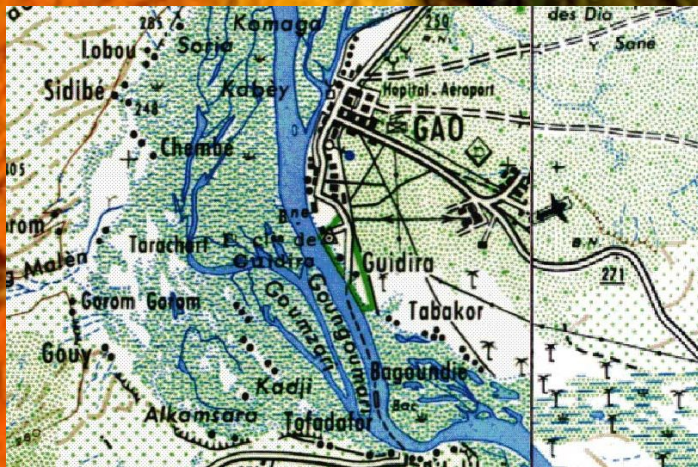
Gao a small city of 40,000 inhabitants is located 1,200 km north east of the capital Bamako on the shore of river Niger and at the south rim of Sahara desert



Figure: Cattle market of Touareg Nomads near Gao

# PROJECT SITE

Latitude: 16.26674°  
Longitude: -0.05000°  
Heading: -0.00010°  
Tilt: 0.00000°  
Altitude: 15131m  
Distance: 15131m  
FOV: 45.00000°  
Terrain Elevation: 258,00 meters



# PROJECT GOAL

A wind park shall be connected to an existing Diesel power station of an isolated grid. The main goal is to substitute diesel fuel, which has to be transported by trucks for more than 2500 km



Source: GTZ Study

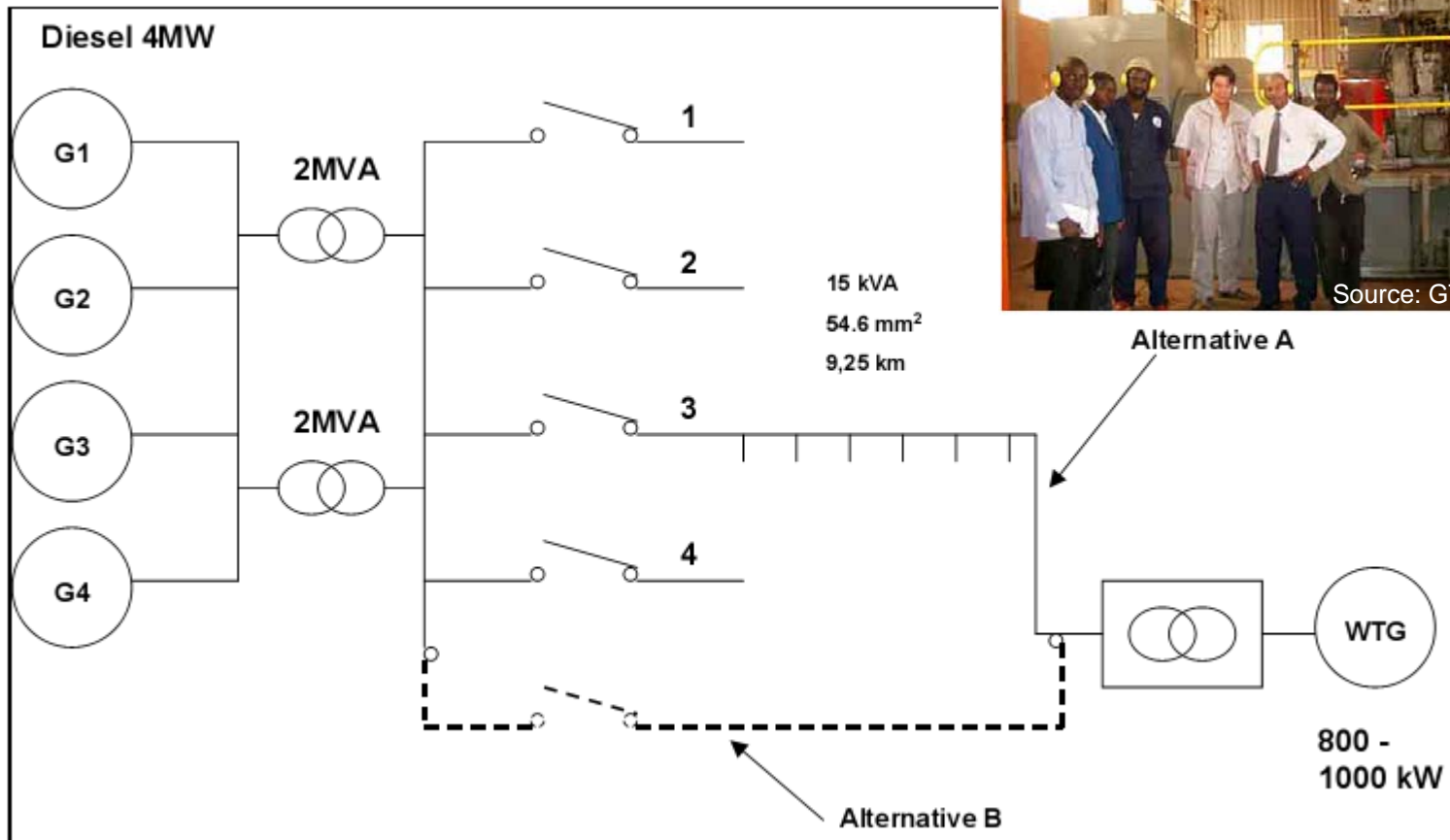


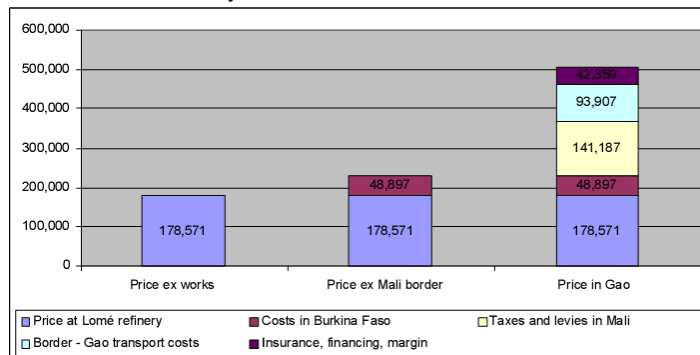
Figure: Electrical Scheme of the Wind –Diesel System

# PROJECT GOAL

Components of the microeconomic price for DDO in Gao, January 2004

Component	[FCFA /t]	[FCFA /l]	Notes
Price ex refinery in Lomé	178,571	160.00	
Taxes and duties in Burkina Faso			
- Fixed rate	500	0.45	500 FCFA/t
- Proportional rate	307	0.28	0.17% of selling price at refinery
Transport to Mali	48,090	43.09	35.49 FCFA/t + km
Price prepaid to Malian border	227,468	203.81	
Taxes and duties in Mali	141,187	126.50	62.07% of Mali import price
Transport from border to Gao	93,907	84.14	35.49 FCFA/t + km
Insurance, financing, margin			
- fixed rate	37,116	33.26	
- proportional rate	5,243	4.70	2.31% Mali import price
Selling price in Gao	504,922	452.41	

Source: GTZ Study



Basic: Oil price 30 USD/Barrel

Costs per kWh: 0.211 €/kWh

2006: 60 USD/Barrel – 0.275 €/kWh

# WIND POTENZIAL

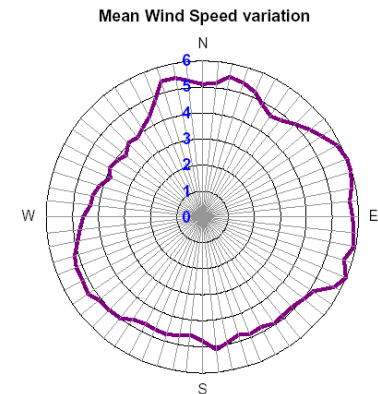
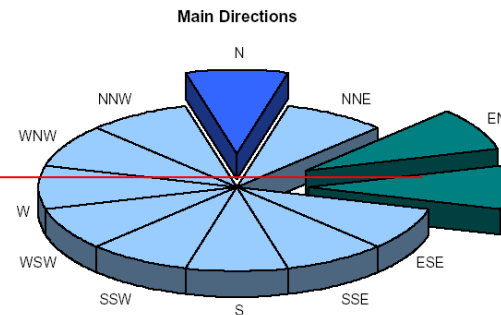
**Gao / Mali 40meter station**  
**16° 14' 45.7" North 0° 1' 9.1" East Altitude 249m**

Measurements Period : from 2/7/2003 to 11/6/2004

Mean Wind Speed (at 41m height)	<b>5.1 m/s</b>	
Mean Turbulence Intensity (at 10m/s)	11.4 %	
Max. 10min Average Wind Speed	32.4 m/s	(29/8/2003 14:20)
Maximum Gust	44.0 m/s	(29/8/2003 14:20)
Mean Wind Power	131.0 Watt/m <sup>2</sup>	
Total Wind Energy	1085.5 kWh/m <sup>2</sup>	

A short acceptable average compared to the European data, but exploitable potential taking into account the local costs of production of electricity (Diesel)

Main wind



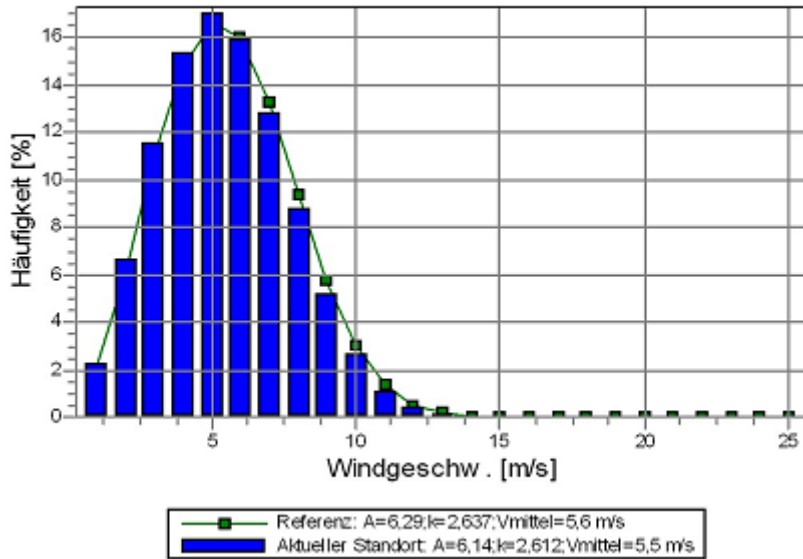
## Wind measurements

Since 2001 measurement at 26 m and 41 m were performed. The average wind speed at 41 m height is 5,1 m/s.



Source: GTZ Study

## Weibull-Verteilung

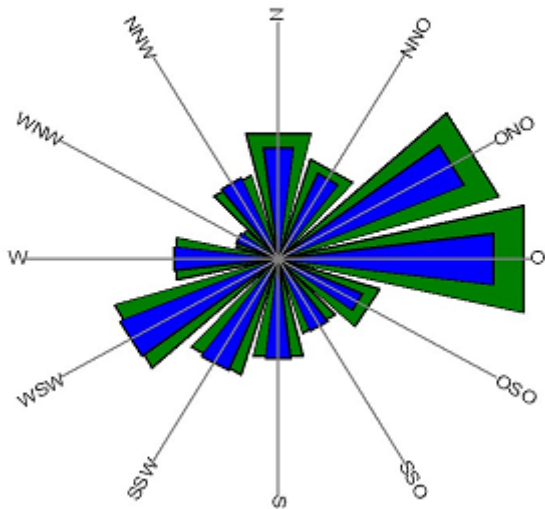


# WIND POTENZIAL

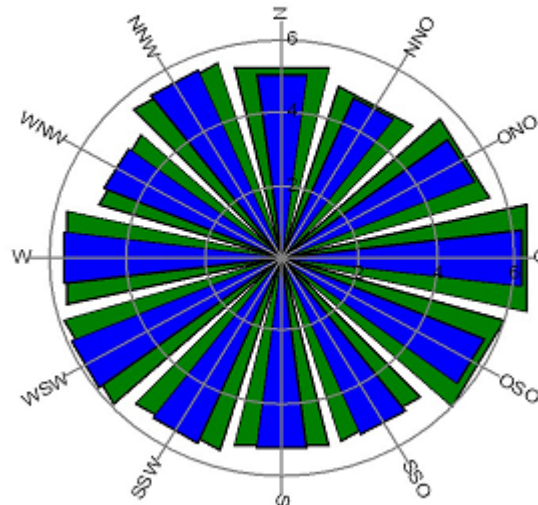
## Weibull-Daten

Sektor	Aktueller Standort				Referenz			
	A-Parameter [m/s]	Windgeschw. [m/s]	k-Parameter	Häufigkeit [%]	A-Parameter [m/s]	k-Parameter	Häufigkeit [%]	
0 N	5,70	5,09	2,935	11,0	5,98	3,003	11,0	
1 NNO	5,37	4,76	2,482	10,0	5,57	2,457	9,7	
2 ONO	5,98	5,36	3,512	17,1	6,21	3,597	17,3	
3 O	6,94	6,20	3,012	11,0	7,27	3,057	11,2	
4 OSO	6,40	5,67	2,228	5,0	6,74	2,277	5,0	
5 SSO	5,92	5,26	1,853	4,6	5,92	1,853	4,6	
6 S	5,97	5,29	2,127	6,9	5,97	2,127	6,9	
7 SSW	6,22	5,51	2,447	8,1	6,22	2,447	8,1	
8 WSW	6,60	5,88	2,817	9,8	6,60	2,817	9,8	
9 W	6,37	5,66	2,607	6,4	6,37	2,607	6,4	
10 WNW	5,59	4,95	2,163	3,6	5,59	2,163	3,6	
11 NNW	6,26	5,60	3,110	6,5	6,26	3,110	6,5	
Gesamt	6,14	5,45	2,612	100,0	6,29	2,637	100,0	

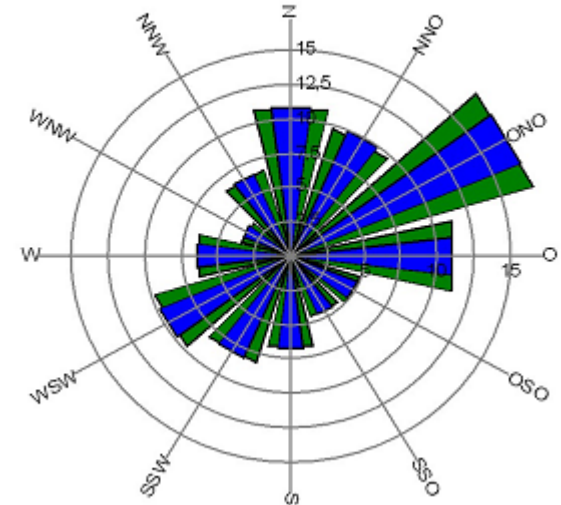
## Windenergieerose (kWh/m2/Jahr)



## Mittlere Windgeschw. (m/s)

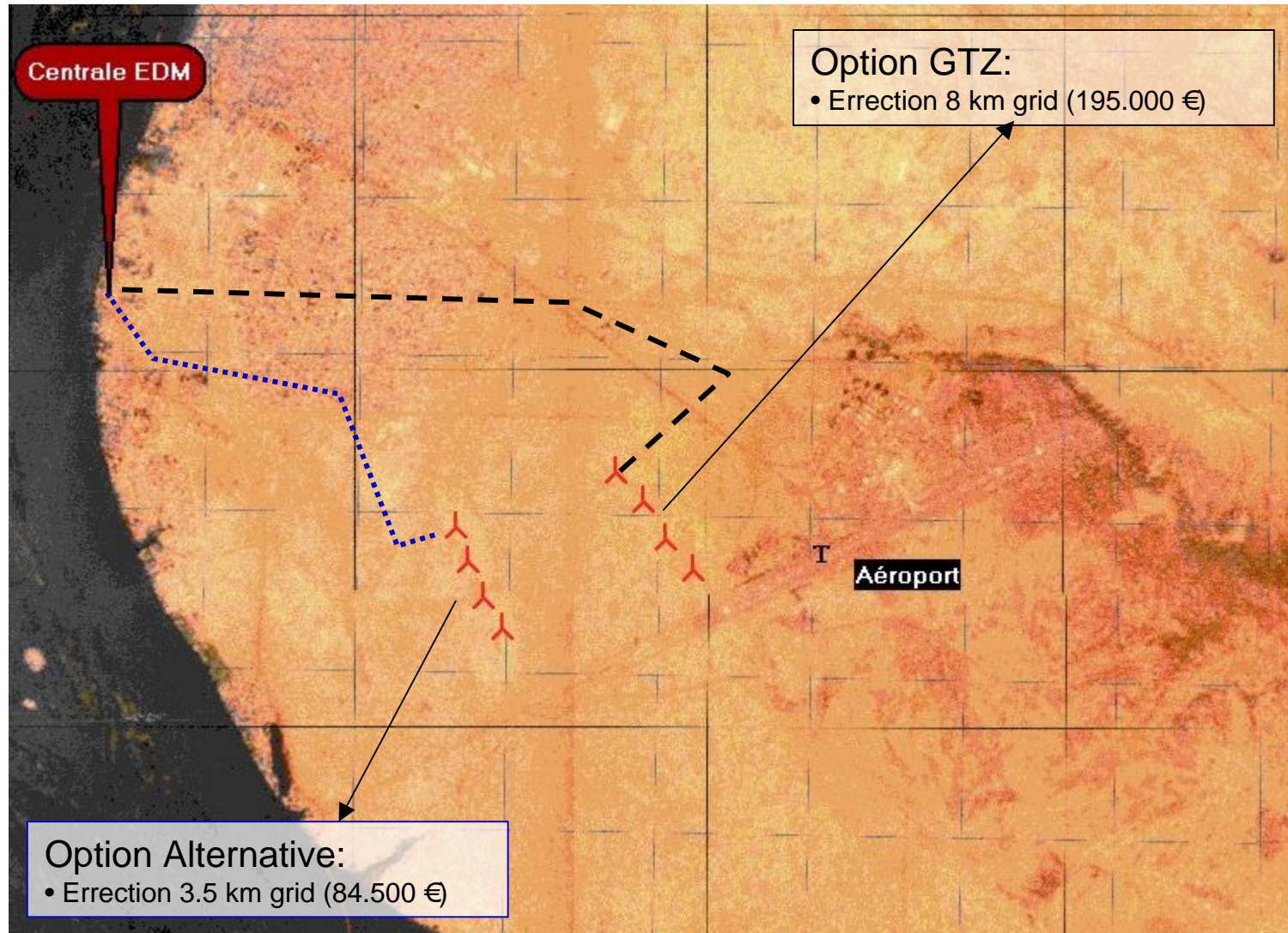


## Häufigkeit (%)

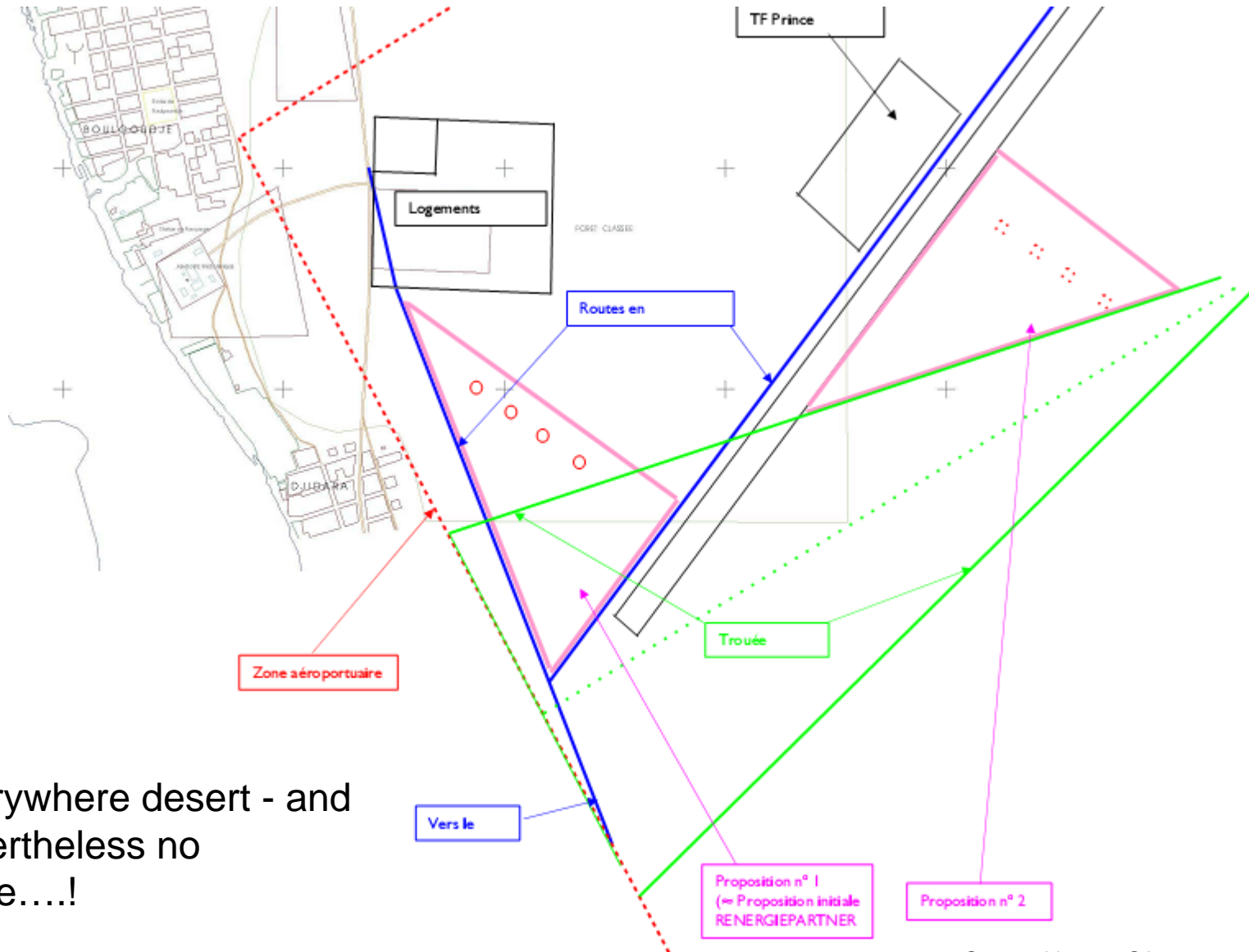


Source: RENERGIEPARTNER GmbH

# PROJECT SITE – ELECTRICAL GRID



# PROJECT SITE - LOCATION



Everywhere desert - and nevertheless no place....!

Source: Vergnet SA

# SELECTION OF WGT

~~ENERCON E30 – 300 kW~~

~~FUHLRLÄNDER FL250 – 250 kW~~

~~FUHLRLÄNDER FL100 – 100 kW~~

~~VESTAS V29 – 225 kW~~

~~BONUS 150 – 150 kW~~

~~EOLTEC CHINOOK – 85 kW~~

VERGNET GEV MP – 275 kW

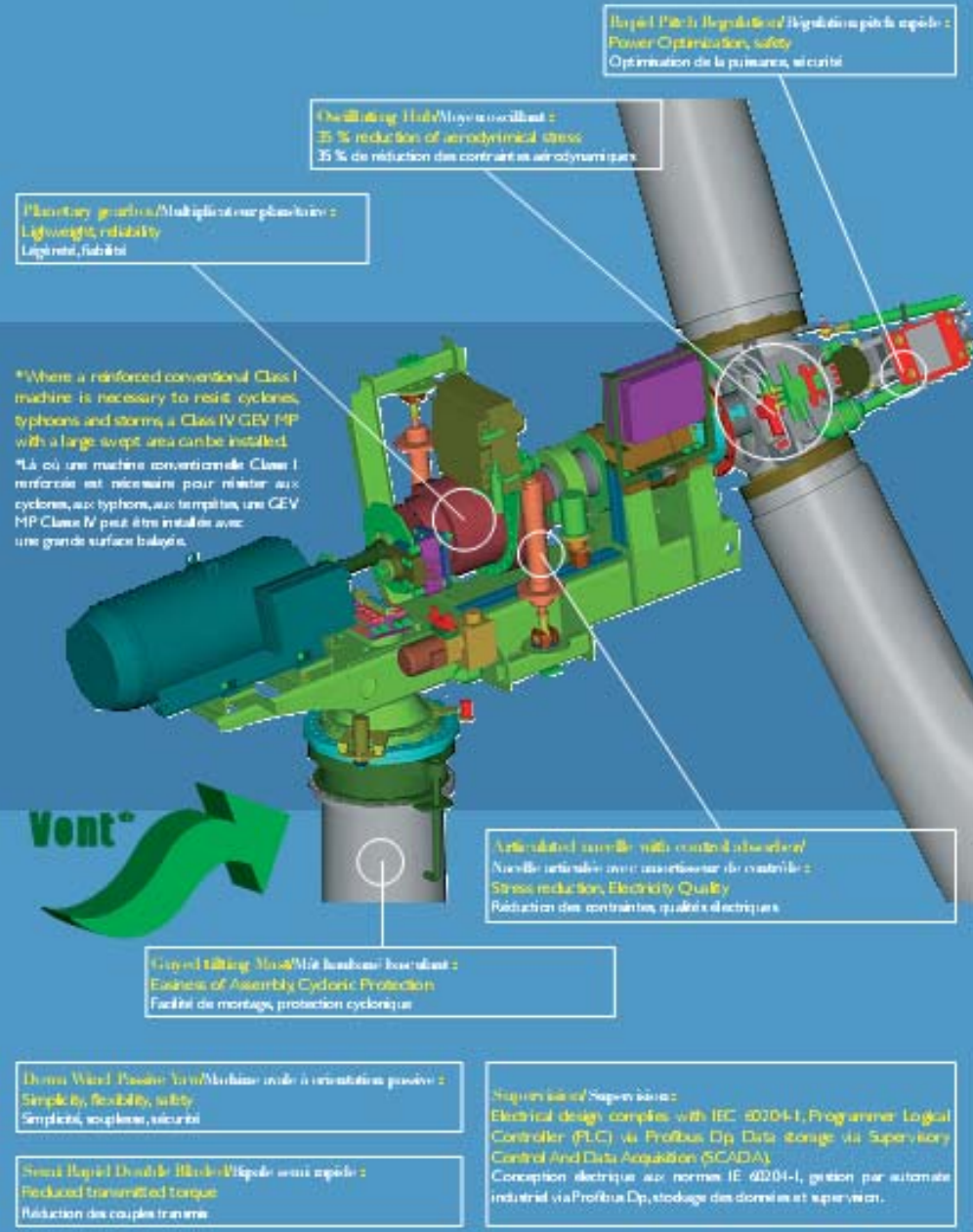


Discussion with producers of WTG:

- Supply
- Service and Maintenance

# As nature, we build simple and flexible

A l'image de la nature, nous construisons simple et souple



# TECHNICAL SOLUTION



4 WTG GEV-MP 275 kW = 1,1 MW

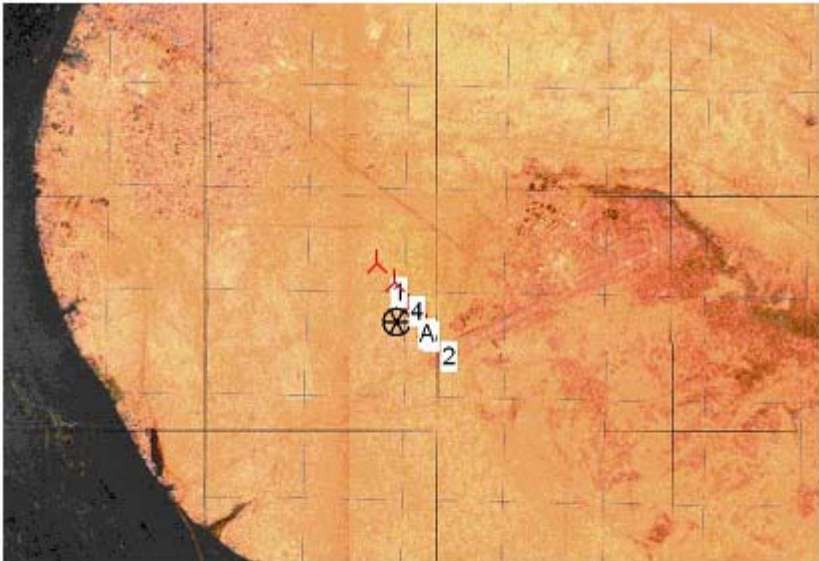
Hub high 55 m

Rotor 32 m diameter

Erecting without crane



# RESULTS OF ELECTRICAL OUTPUT



Maßstab 1:100.000

Terraindaten

Neue WEA

Luftdichte 1,122 kg/m<sup>3</sup>  
 Höhe über Meeresspiegel 249 m  
 Mittlere Temperatur 33,0 °C

Ausbreitungskonstante für Nachlaufströmung 0,075

Windstatistiken	Abstand [km]	Wichtung [%]
ML Gao 10,00 m Weibull-Parameter.wws	4	33
ML Gao 26,00 m Weibull-Parameter.wws	4	33
ML Gao 41,00 m Weibull-Parameter.wws	4	33

### WEA-Platzierung

UTM WGS84 Zone: 30

	Ost	Nord	Z [m]	Beschreibung
1 Neu	818.148	1.799.060	277	VERGNET MP 275 32,0 #! Nabe: 55,0 m
2 Neu	818.716	1.798.382	280	VERGNET MP 275 32,0 #! Nabe: 55,0 m
3 Neu	818.515	1.798.599	279	VERGNET MP 275 32,0 #! Nabe: 55,0 m
4 Neu	818.349	1.798.853	278	VERGNET MP 275 32,0 #! Nabe: 55,0 m

### Hauptergebnis für Windpark-Berechnung

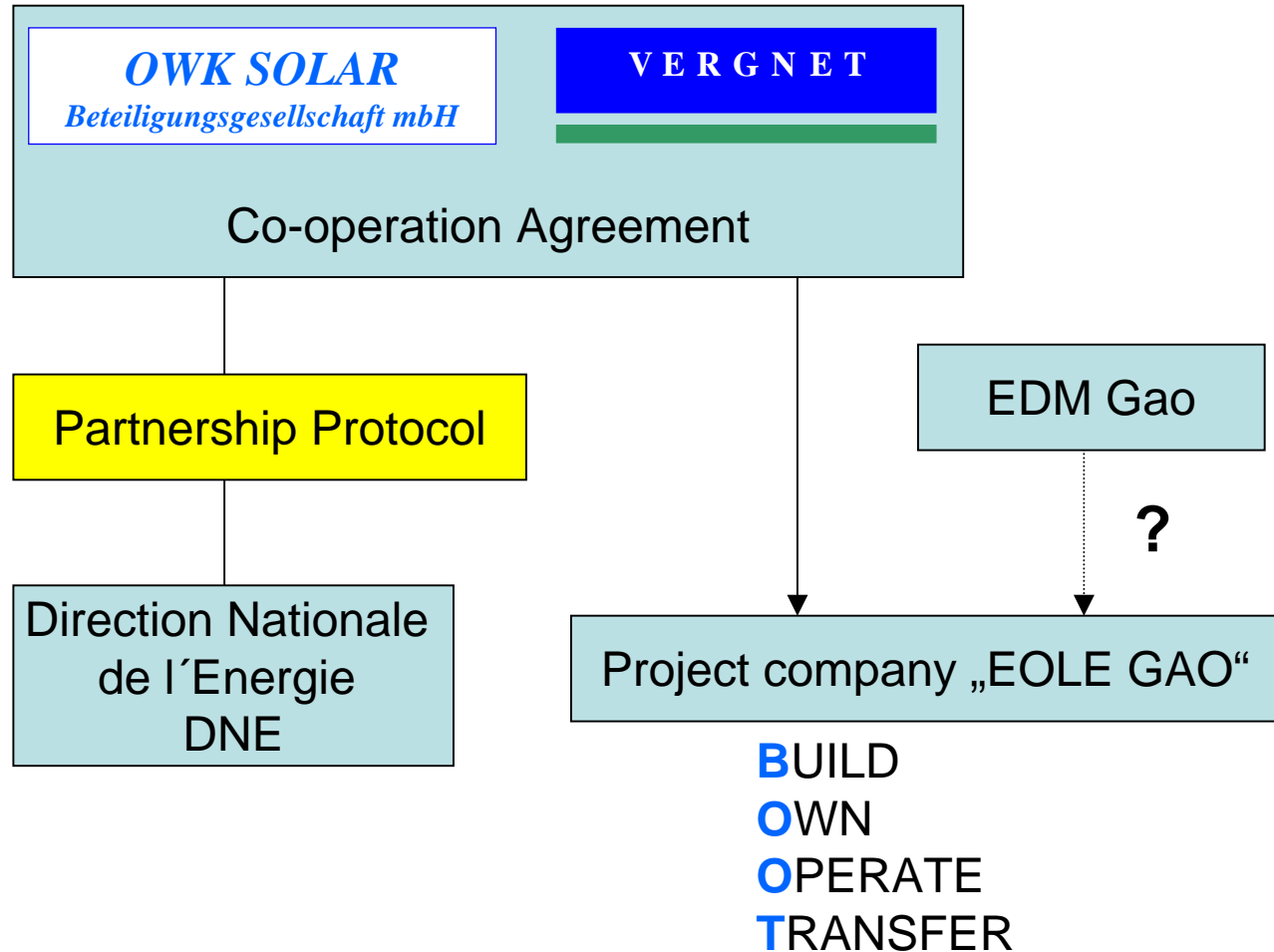
WEA-Kombination Windpark Energieproduktion Windpark Energieproduktion - 15 Parkwirkungsgrad Mittlere WEA-Produktion Kapazitätsfaktor

Windpark	[MWh]	1.518,8	%	[MWh]	1.291,0	[%]	99,0	[MWh]	379,7	[%]	15,8
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### Berechnete jährliche Energieproduktion für neue WEA

WEA-Typ	Terrain	Aktuell	Hersteller	Typ	Leistung [kW]	Rotord. Höhe [m]	Kreis-Quelle radius [m]	Name	Jährliche Energieproduktion Park				
									Ergebnis [MWh]	Ergebnis-15% [MWh]	Parkwirkungsgrad [%]	Mittlere Windgeschw [m/s]	
1 A	Ja	VERGNET	MP	275	32,0	55,0	129,0	USER	Vergnet 32m Rotor,	381,2	324	99,3	5,6
2 A	Ja	VERGNET	MP	275	32,0	55,0	129,0	USER	Vergnet 32m Rotor,	380,6	323	99,2	5,6
3 A	Ja	VERGNET	MP	275	32,0	55,0	129,0	USER	Vergnet 32m Rotor,	378,0	321	98,5	5,6
4 A	Ja	VERGNET	MP	275	32,0	55,0	129,0	USER	Vergnet 32m Rotor,	379,1	322	98,8	5,6

# REALIZATION - OPERATION



# FINANCING

Financing	EOLE GAO		Government of the Republic of Mali
	Equity capital	Credits of Banks	Europe Union – Energy Facility
	10%	40%	50%
Realization	Wind Power Station GAO 1.1 MW		
BOOT	<u>Tariff</u> Operation and Transfer time		

# THE NEXT STEPS

- 06.10.2006 - Delivery of the European Union request in Brussels (Decision up to April 2007)
- Financing agreements (Eole Gao with African Development Bank, Energy House, French Cooperation Agency, DEG ....)
- Tariff agreement and electrical sales contract (Eole Gao with EDM SA)
- Subsidy agreement (Europe Union with GDM)
- BOOT agreement (GDM and Eole Gao)