

Economics of Wind Power Projects in Developing and Threshold Countries

Field Report of a Financier



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KC Energie

Wind Energy and Development Dialogue
Berlin, 17.09.2008

The KfW Bankengruppe

- Development Bank of the Federal Republic of Germany
- Foundation: 1948
- Shareholders: 80% Federal Government, 20% Federal States
- Headquarters: Frankfurt / Main
- Branch Offices: Bonn and Berlin
- Foreign Offices: approx. 60 offices and representations worldwide
- Credit Ratings: AAA / Aaa / AAA

The KfW Bankengruppe

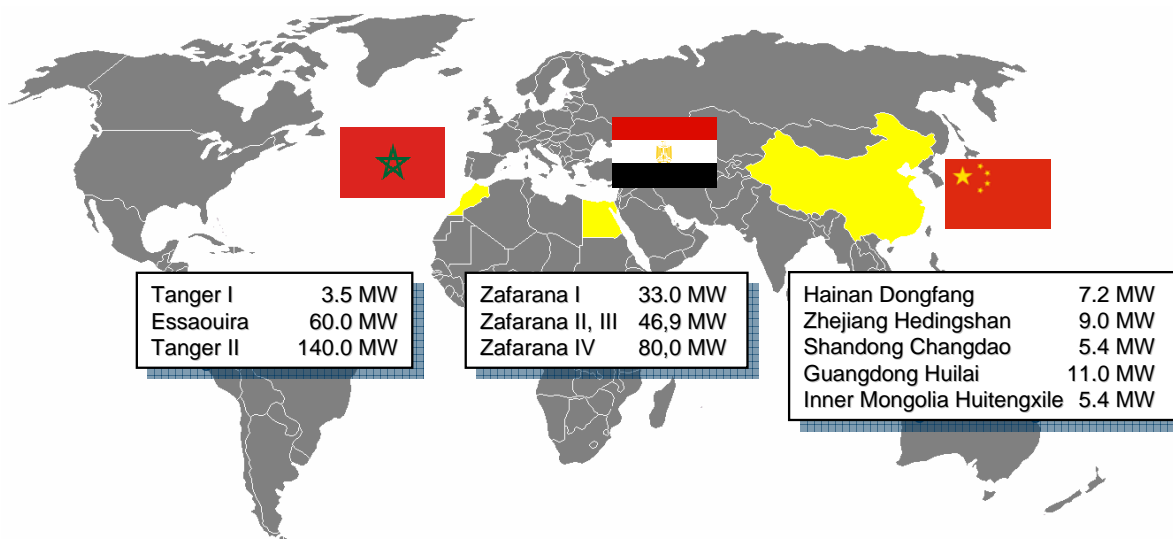


Key Figures

	2007	2006
• Employees (Yearly Average):	4,003	3,831
• Total Assets (Year-End):	354.0 B€	334.0 B€
• Financing Volume:	87.1 B€	76.7 B€
• Financing Volume FZ:	3.0 B€	2.4 B€

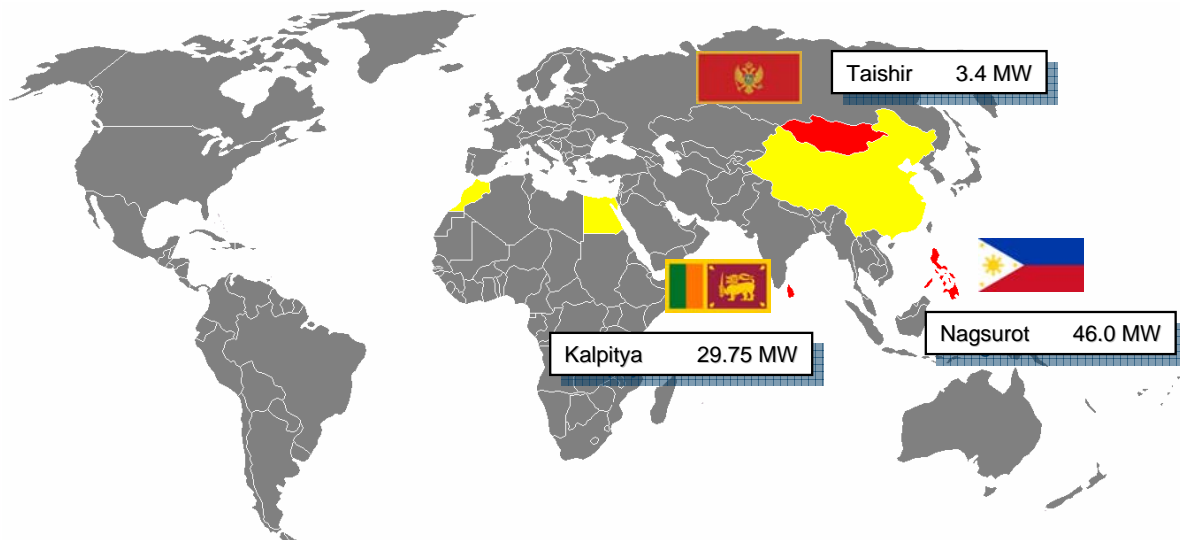
B€ = 1 Billion Euros = 10⁹ Euros

Completed Projects



Total Capacity: 401.4 MW

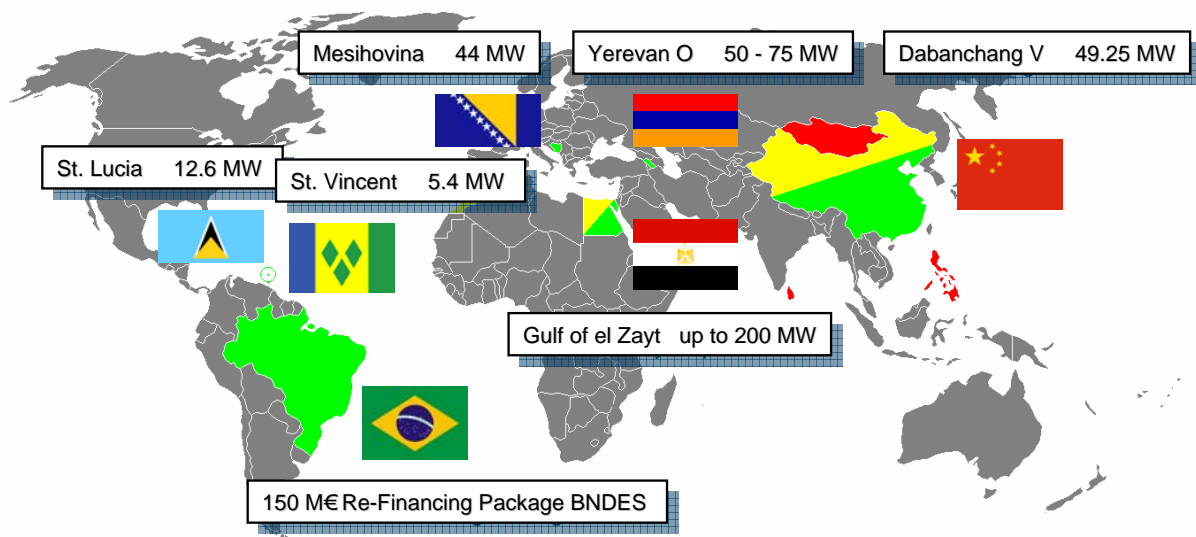
Projects on Hold



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Projects Pipeline



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Project Key Figures China

Project	Capacity	Start of Operation	Specific Investment Cost	Capacity Factor		Dynamic Production Cost		Tariff
	MW			year	EUR/kW	Project Appraisal	Actual	
				%	%	cEUR/kWh	cEUR/kWh	cEUR/kWh
Hainan Dongfang	7.2	1997	1,020	22.8	15.7	7.00	8.29	6.24
Zhejiang Hedingshan	9.0	1999	1,232	22.8	18.8			13.17
Shandong Changdao	5.4	1999	969	25.1	20.5	6.00	6,74	9.98
Guangdong Huilai	11.0	1999	993	28.5	20.5			7.84
Inner Mongolia Huitengxile	5.4	2002	871	31.7	24.1	4.10	5.39	6.97
<i>Xinjiang Dabanchang V</i>	<i>49.25</i>	<i>2010*</i>	<i>882</i>	<i>29.6</i>	<i>--</i>	<i>4.13</i>	<i>--</i>	<i>4,33</i>

* expected

Project Key Figures Egypt

Project	Capacity	Start of Operation	Specific Investment Cost	Capacity Factor		Dynamic Production Cost		Tariff
	MW			year	EUR/kW	Project Appraisal	Actual	
				%	%	cEUR/kWh	cEUR/kWh	cEUR/kWh
Zafarana I	33.0	2001	1,009	39.9	39.8	4.55	3.37	2.10
Zafarana II / III	46.9	2004	971	46.2	42.2	2.80		2.10
Zafarana IV	80.0	2008	1,340	46.5	--	2.94		2.10
<i>Gulf of el-Zayt</i>	<i>200.0</i>	<i>2013*</i>	<i>1,700</i>	<i>45.6</i>	<i>--</i>	<i>4.00</i>	<i>--</i>	<i>2.10</i>

* expected

Project Key Figures Morocco

Project	Capacity	Start of Operation	Specific Investment Cost	Capacity Factor		Dynamic Production Cost		Tariff
	MW	year	EUR/kW	Project Appraisal	Actual	Project Appraisal	Actual	cEUR/kWh
Tanger I	3.5	2000	1,738	48.9	48.0	4.50	4.55	n.a.
Essaouira	60.0	2007	1,171	38.1	32.5	4.40	5.10	n.a.
Tanger II	140.0	2009*	1,393	40.8		4.30		n.a.

* expected

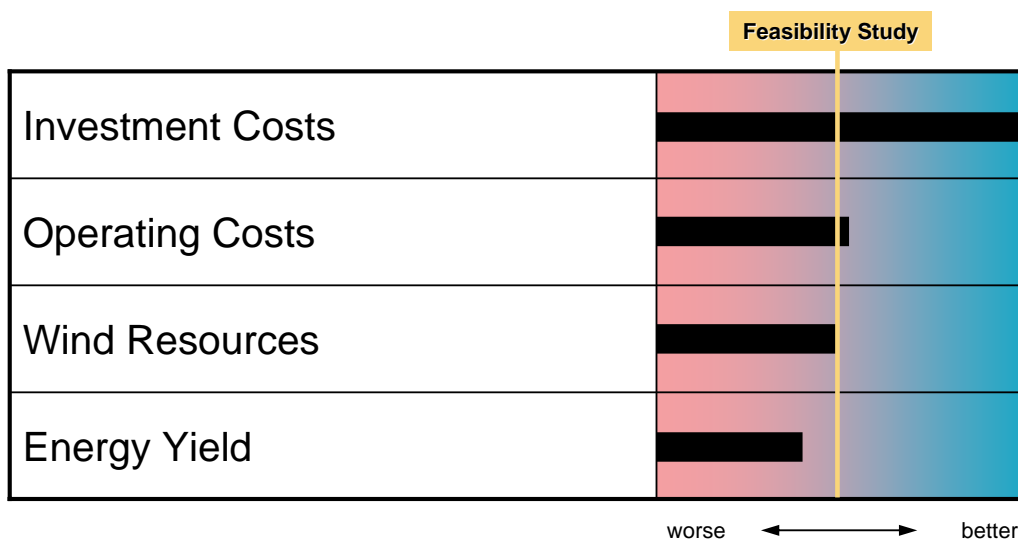
Lessons learned: What went wrong?

- Wind Resource Assessment
 - Wind measurement height (e.g. @ 10 m a.g.) ⇒ Extrapolation to hub height
 - Duration of measurement regime
 - Long-term correlation (duration, distance)
- Micrositing
 - More wind turbines than originally planned
 - Turbine spacing
- Relocation of Wind Farm Site
 - Different wind conditions
- Energy Yield Prediction
 - Often only electrical losses considered
 - No allowances for outages and downtimes

Lessons learned: Where has all the money gone?

- Investment Costs
 - Higher than in Europe (⇒ Transportation costs, installation costs)
 - Exception: Countries with own production capacities (e.g. China)
- Operation Costs
 - Higher than in Europe despite lower manpower costs
 - Higher maintenance requirements due to environmental conditions and higher wear and tear
 - Higher spare parts costs (⇒ Transportation costs, customs duties)
- Production Costs of Wind Power
 - More competitive than other renewables (with exception of large hydro)
 - Usually less competitive than conventional thermal power generation

Lessons learned: Target/Actual Comparison



Major Obstacles

- No Sustainable Tariff Regime
 - Developing countries opt for low offtake prices plus subsidies instead of full cost coverage (incl. depreciation).
 - Increase of profitability through CDM.
- After Sales Service Organization
 - For manufacturers a minimum capacity build up required (> 100 MW)
 - Owners are required to build up own organization
 - Availability of suitable personnel
 - High fluctuation levels (low payment in state-run companies)

Political Situation

- Preferences of developing and threshold countries:
 - Low energy prices to secure social peace.
 - Tariffs only sufficient for maintenance and repair coverage.
 - Subsidise state-run utilities.
- The developing and threshold countries' dilemma:
 - Dependence on primary fuel imports.
 - Rising electricity generation costs.
 - Rising budget deficit.

Political Requirements

- **Legal framework with a sustainable tariff regime for renewables needs to be in place for private investments and accelerated capacity build-up!**
- **Financial cooperation can break ground for future renewable energy legislative framework.**

Potential Markets

- **Egypt** (targets 14,000 MW by 2020)
- **Brazil** (notorious energy shortage)
- **Chile** (dependence on imported gas)
- **Carribbean** (dependence on imported oil)
- **Bosnia** (high costs for imported electrical energy)

Available Facilities

- Initiative Climate and Environmental Protection (IKLU) for Energy Efficiency and Renewable Energies
 - Facility of the Federal Ministry for Economic Cooperation and Development (BMZ)
 - 2.4 Billion Euros until 2011
- International Climate Protection Initiative (IKSI) for Energy Efficiency and Renewable Energies
 - Facility of the Federal Ministry for the Environment (BMU)
 - 120 Million Euros for international measures within 2008
- KfW Carbon Fund
 - Purchase of CO₂ Certificates



Wind Resource and Energy Yield Deductions and Uncertainties



		Deduction		Uncertainty
1.	Measurement Configuration			4,00%
1.1	Steady state calibration			3,00%
1.2	Possible variation or change in calibration			0,80%
1.3	Flow inclination effect on calibration			0,50%
1.4	Possible overspeeding caused by instrument dynamics			1,00%
1.5	Flow distortion from the mast			1,50%
1.6	Flow distortion from the boom			1,20%
1.7	Flow distortion from mounting clamps or other protrusions			0,40%
1.8	Asymmetry of flow (shear) incident on anemometer			1,00%
1.9	Instrumentation system uncertainties including calibration and quantisation effects			0,50%

As per "Recommended Practices for Wind Turbine Testing and Evaluation - 11. Wind Speed Measurement and Use of Cup Anemometry"

Figures shown are taken from a real life project.

Wind Resource and Energy Yield Deductions and Uncertainties



		Deduction		Uncertainty
2.	Wind Resource			12,91%
2.1	Duration of Measurement Regime			7,50%
2.2	Completeness of measurement data			3,00%
2.3	Consistency of measured data			1,00%
2.4	Wind shear extrapolation			1,00%
2.5	Transfer of wind data to site			3,00%
2.6	Topographic characteristics			1,00%
2.7	Flow distortion uncertainty			0,50%
2.8	Turbidity			1,00%
2.9	Wind frequency distribution			0,50%
2.10	Distance to long term correlation mast			4,00%

cont'd

Figures shown are taken from a real life project.

Wind Resource and Energy Yield Deductions and Uncertainties



		Deduction		Uncertainty
2.	Wind Resource (cont'd)			
2.11	Period of long term correlation data			5,00%
2.12	Completeness of long term correlation data			5,00%
2.13	Consistency of long term reference data			1,00%
2.14	Representativeness of period of data			3,00%
2.15	Reference site annual average wind speed variability			1,00%
2.16	Cross-correlation uncertainty			1,00%
2.17	Windflow model uncertainty			3,00%
2.18	Changes in long term average wind speed			1,00%
2.19	Correlation with production data			0,00%

Figures shown are taken from a real life project.

Wind Resource and Energy Yield Deductions and Uncertainties



		Deduction		Uncertainty
3.	Wind Turbine		6,30%	6,73%
3.1	Availability	3,00%	97,00%	0,00%
3.2	Power curve	0,75%	96,27%	6,00%
3.3	Hysteresis effect	0,25%	96,03%	1,00%
3.4	Blade soiling	1,25%	94,83%	1,00%
3.5	Blade degradation	1,00%	93,88%	1,00%
3.6	Downtime for flicker mitigation	0,00%	93,88%	0,00%
3.7	Production loss due to noise reduction	0,00%	93,88%	0,00%
3.8	Weather losses (icing, lightning, impaired site access)	0,00%	93,88%	0,20%
3.9	Cable undrilling	0,05%	93,84%	0,10%
3.10	Azimuth error	0,10%	93,74%	2,00%
3.11	Pitch error	0,05%	93,70%	1,50%

Figures shown are taken from a real life project.

Wind Resource and Energy Yield Deductions and Uncertainties

		Deduction		Uncertainty
4.	Wind Farm		6,68%	0,68%
4.1	Electrical losses	3,50%	90,55%	0,00%
4.2	Routine maintenance downtime	0,40%	90,19%	0,20%
4.3	Fault downtime	1,20%	89,11%	0,20%
4.4	Minor component downtime	0,80%	88,39%	0,30%
4.5	Major component failure downtime	1,20%	87,33%	0,50%
4.6	Electrical system downtime	0,25%	87,12%	0,20%
4.7	Wake / array losses		87,12%	

Total Deductions			12,88%	
Total Uncertainty				15,12%

Figures shown are taken from a real life project.

Wind Resource and Energy Yield Deductions and Uncertainties

Gross energy yield:		1,036,500 MWh
Deductions:	12.88%	-133,500 MWh
✚ Net energy yield (p50):		903,000 MWh
⇒ „optimistic scenario“		
✚ Net energy yield (p70):		825,600 MWh
⇒ „realistic scenario“		
✚ Net energy yield (p90):		732,300 MWh
⇒ „pessimistic scenario“		

Figures shown are taken from a real life project.