CARL VON OSSIETZKY universität OLDENBURG

Wind Energy Projects – a feasible Option for South Africa to achieve Sustainability?

An economic analysis with a wind resource assessment of a South African Wind energy farm and recommendations for political action.

Master-Thesis

SEM-Master programme

Stephan Beyer

State of research 04. November 2011

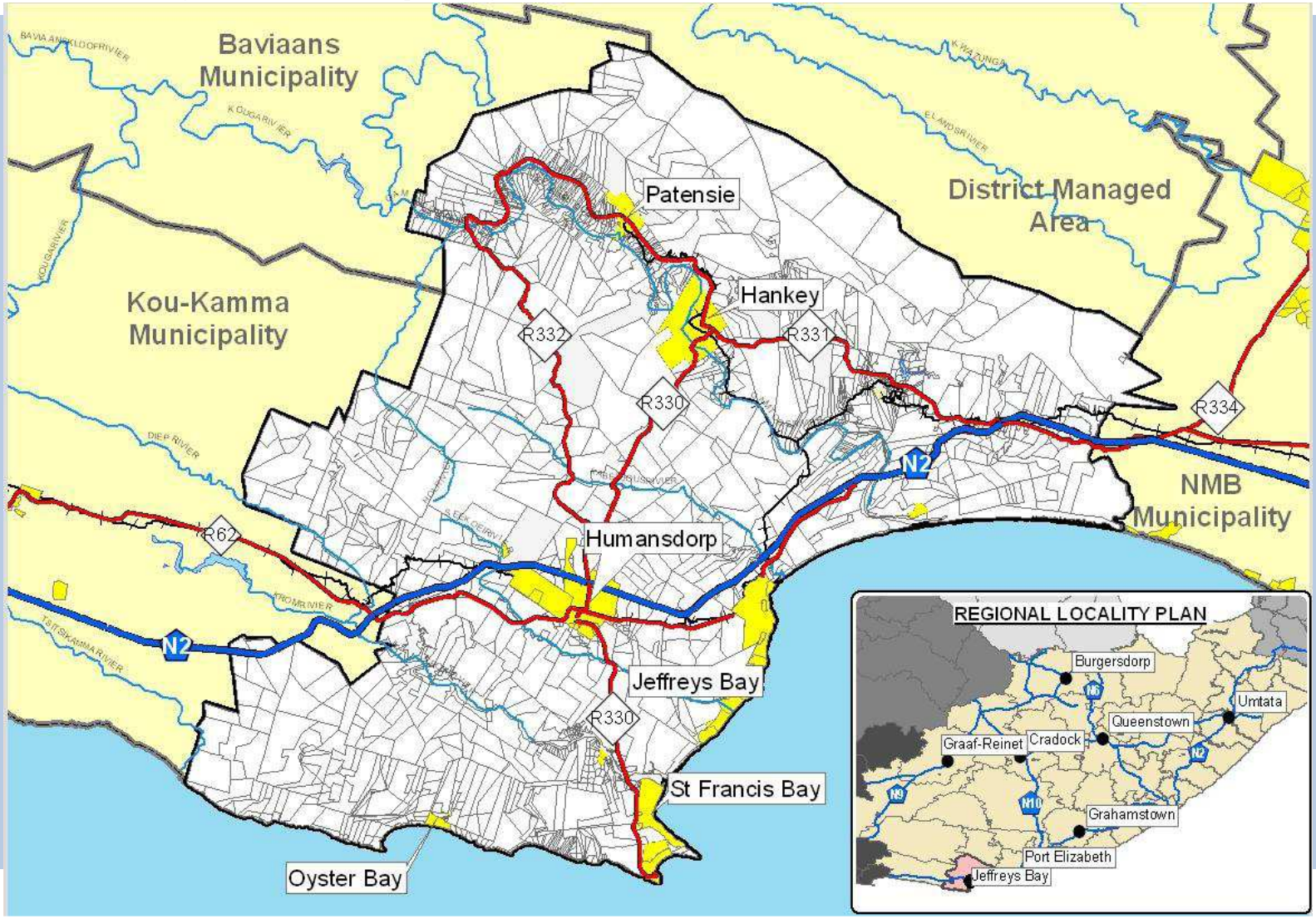
Agenda

- Kouga Wind project, South Africa
- Research objectives and Methodology
- Resource assessment and wind energy forecast
- Social CBA
- Private CBA
- CBA Results: social vs. private NPVs/IRRs
- Recommendations and Outlook

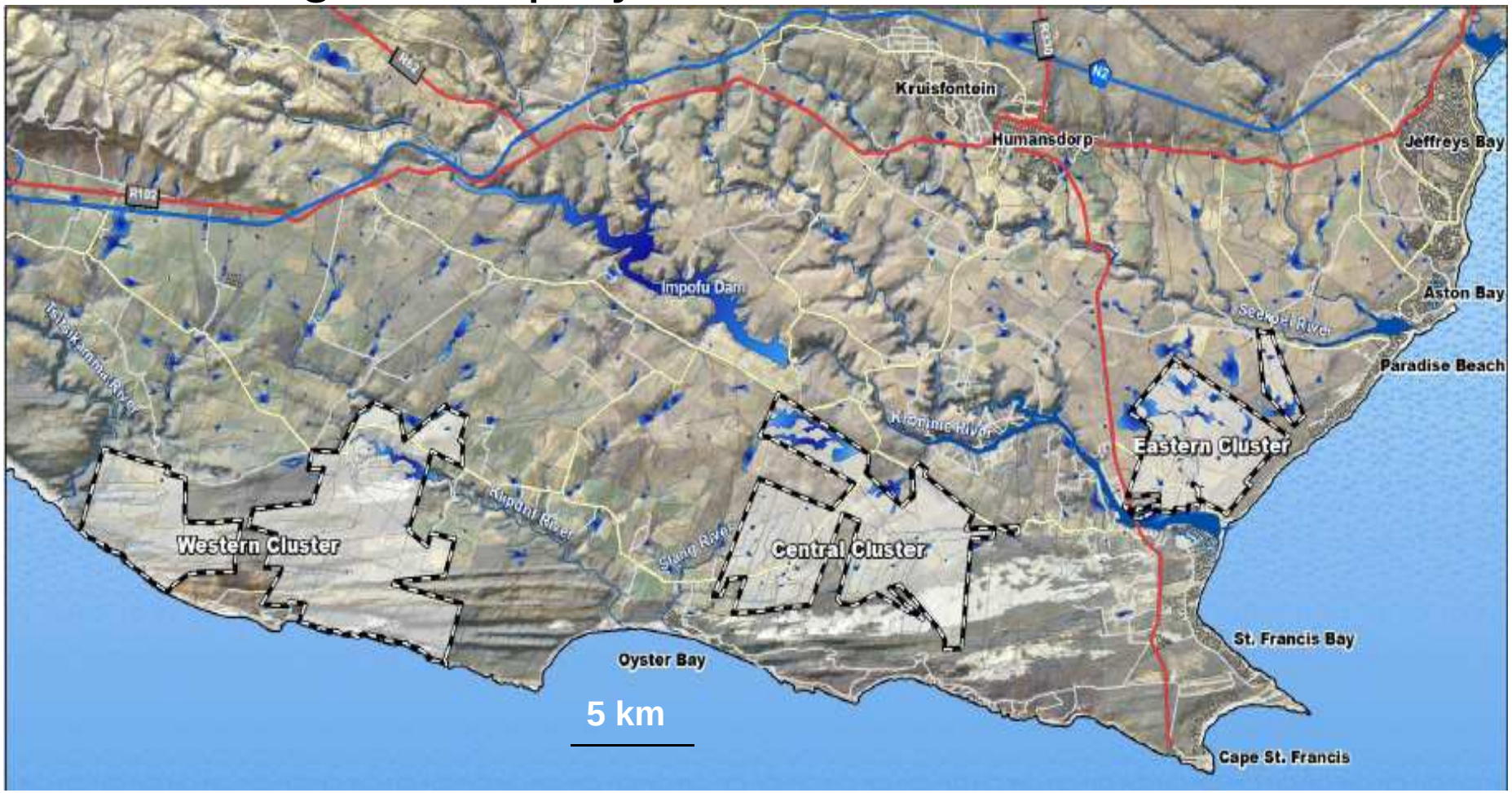
Kouga Wind project

- Kouga Municipality, Eastern Cape, S.A.
- Wind capacity: 300 MW, first phase 100MW
- Investment Vol.: ca. 411 Mio€ (incl. 123 Mio€ equity)
- Three clusters, 56ha (0.56km$^{2)}$ altered land
- Turbines: N.N. likely 121xVestas V90-2.0 & 3.0 MW
- Developer: RedCap Investments (Pty) Ltd
- Finance: e.g. UN seed capital assist. and Inspired Evolution Investment (backed by foreign dev. funds, African Dev. Bank, Ind. Dev. Bank SA and others)

Kouga wind project: Location



Kouga wind project: Location



Research objectives:

- Evaluation of the prospective overall sustainability (and business) impact of Kouga Wind Farm.
  - Evaluation of wind resources
  - Assessment of direct and indirect costs/benefits of farm
  - Assessment of costs and benefits in the absence of wind project (i.e. if alternatively coal capacity)
  - Determination of social & private NPV, IRR, payback period, BCR, LCOE etc
  - Recommendation of political solutions

Methodology: Social CBA (25years, DR 3%)

Costs with wind park

	Capital	O&M	…
Y0	X	0	
Y1	.	X	
Y2	.	X	
.	.	.	
.	.	.	
Y25	.	X	

Costs without wind/with coal

	Capital	O&M	…
Y0	X	0	
Y1	.	X	
Y2	.	X	
.	.	.	
.	.	.	
Y25	.	X	

Δ O&M value Y1 (i.e. wind – coal)
Δ O&M value Y2

…and so on

∑ of all incremental cost values

∑ of all Present incremental cost values (PV)

Same for the benefits!

Methodology: Social CBA

(∑PV incremental benefit) - (∑ PV incremental cost) = social NPV

Then

Internal Rate of Return (social IRR)
Benefit cost ratio (BCR)
Payback period

Also: social CBA results without comparison to coal case calculated!

-Methodology: Private CBA (20 years, DR 6%)

- "Standard" CBA with discounting of Costs and Benefits including Depreciation and tax analysis

Resource assessment and energy forecast

(Data adjusted from 62m to hub-height 105m)

Wind range (m/s)	Frequency (counts)	Frequency (%)	Cumulative Percentage (%)
0.0000 – 0.9999	667	1.27	1.3
1.0000 – 1.9999	1799	3.42	4.7
2.0000 – 2.9999	2814	5.35	10.0
3.0000 – 3.9999	3398	6.46	16.5
4.0000 – 4.9999	4516	8.59	25.1
5.0000 – 5.9999	5192	9.88	35.0
6.0000 – 6.9999	5219	9.93	44.9
7.0000 – 7.9999	5520	10.50	55.4
8.0000 – 8.9999	5093	9.69	65.1
9.0000 – 9.9999	4461	8.49	73.6
10.0000 – 10.9999	3364	6.99	80.6
11.0000 – 11.9999	2871	5.46	86.0
12.0000 – 12.9999	2077	3,59	90.0
13.0000 – 13.9999	1652	3.14	93.1
14.0000 – 14.9999	1122	2.13	95.3
15.0000 – 15.9999	732	1.39	96.7
16.0000 – 16.9999	530	1.01	97.7
17.0000 – 17.9999	371	0.71	98.4
18.0000 – 18.9999	255	0.49	98.9
19.0000 – 19.9999	206	0.39	99.3
>=20.0000	391	0.75	100.0
TOTAL	**52.560**	**100.0**	

CARL VON OSSIETZKY universität OLDENBURG

8760 hours/a

Resource assessment and energy forecast

Wind Speed m/s	Power curve data kW	Percentage %	Windhours H	= Energy data kWh
0	**0,0**	1,27	111,2	0
1	**0,0**	3,42	299,8	0
2	**0,0**	5,35	469,0	0
3	**0,0**	6,46	566,3	0
4	**77,0**	8,59	752,7	57.955
5	**190,0**	9,88	865,3	164.413
6	**353,0**	9,93	869,8	307.051
7	**581,0**	10,50	920,0	534.520
8	**886,0**	9,69	848,8	752.066
9	**1.273,0**	8,49	743,5	946.476
10	**1.710,0**	6,99	612,3	1.047.090
11	**2.145,0**	5,46	478,5	1.026.383
12	**2.544,0**	3,95	346,2	880.648
13	**2.837,0**	3,14	275,3	781.121
14	**2.965,0**	2,13	187,0	554.455
15	**2.995,0**	1,39	122,0	365.390
16	**3.000,0**	1,01	88,3	265.000
17	**3.000,0**	,71	61,8	185.500
18	**3.000,0**	,49	42,5	127.500
19	**3.000,0**	,39	34,3	103.000
20	**3.000,0**	,28	24,3	73.000
21	**3.000,0**	,23	20,2	60.500
22 - 30	**3.000,0**	,24	20,7	62.000
SUM		**100,0**	**8760,0**	**8.294.068**

X

CARL VON OSSIETZKY universität OLDENBURG

Resource assessment and energy forecast

Total unadjusted annual energy production (100 x V90-3.0 MW, 50Hz turbines)		
829.406.783	**kWh**	
Pressure coefficient	0,985	
Temperature coefficient	0,986	
Gross energy production	**805.528.162**	**kWh**
Array losses	5,0%	
Airfoil losses	2,0%	
Miscellaneous losses	3,0%	
Availability	2,0%	
Losses coefficient	0,88	
Electricity exported to grid	**708.864.783**	**kWh**
capacity factor	**26,97%**	
capacity factor (without losses)	**30,65%**	
Full-load hours	**2363**	**Hours**

Social CBA – Economics with wind

Overview with Kouga wind farm (numbers in ZAR)			
Social benefit category	**Estimate**	**Social cost category**	**Estimate**
Direct benefits		***Direct costs***	
Sales revenues (annual)	466.787.460	Capital investment (one time)	3.986.700.000
Salvage value (one time) scrap steel value	45.590.000	Operation and Maintenance (annual)	95.568.723
		Extra balancing costs to the grid (annual)	7.088.648
Indirect benefits		***Indirect costs***	
Carbon emissions avoided - PV annual average value	147.800.865	WTA/Inconvenience costs (annual)	31.174.375

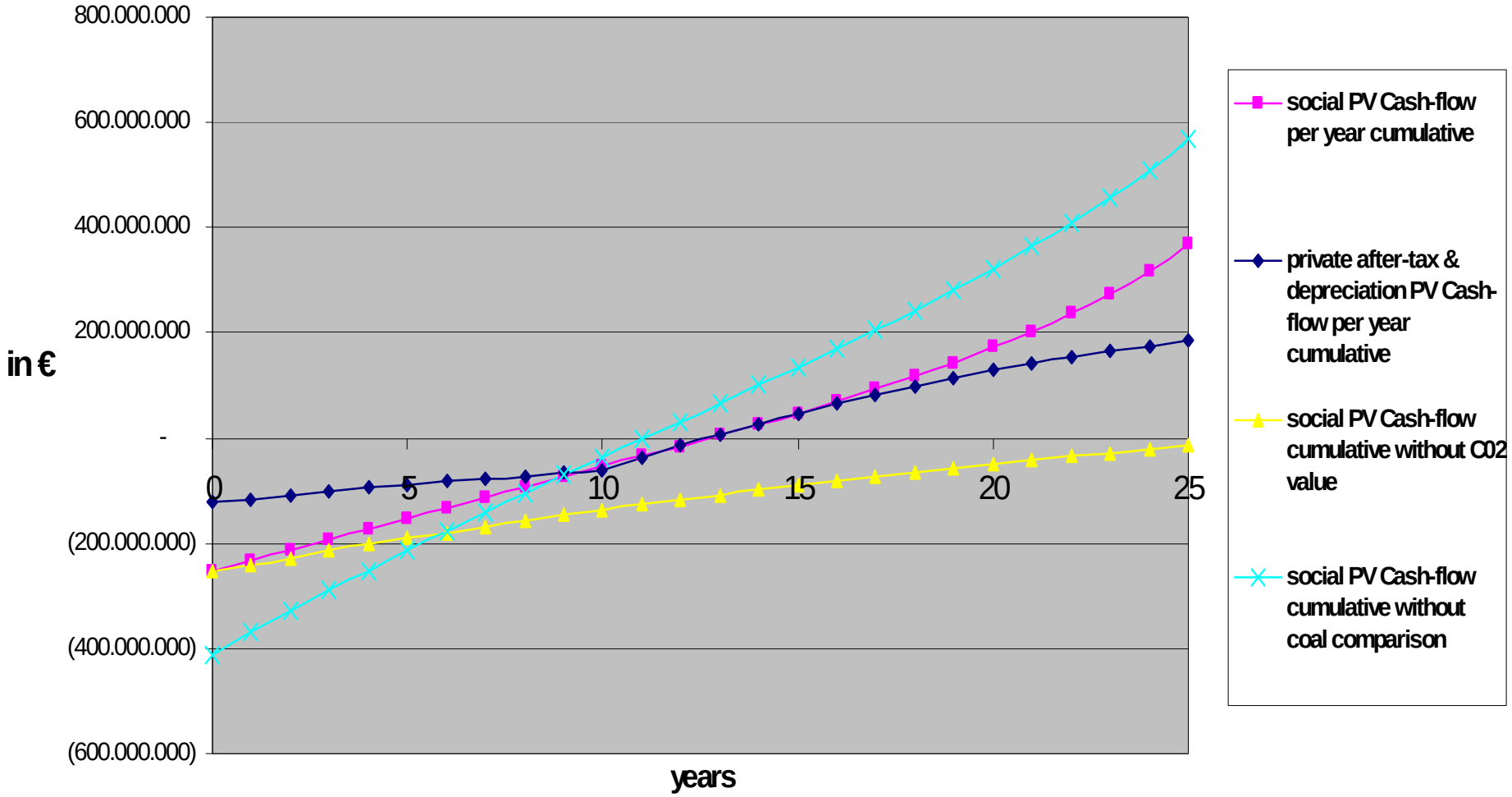
Social CBA – Economics without wind (coal)

Overview coal-fired case (numbers in ZAR)			
Social benefit category	**Estimate**	**Social cost category**	**Estimate**
Direct benefits		***Direct costs***	
Sales revenues (annual)	466.787.460	Capital investment (one time)	1.523.688.001
Salvage value (one-time)	-	Cost of production (incl. all O&M) (annual)	210.813.019
		Indirect costs	
		Environmental costs (annual)	56.151.838

Private CBA Kouga Wind Farm

Overview Kouga wind case (numbers in ZAR)			
Social benefit category	**Estimate**	**Social cost category**	**Estimate**
Direct benefits		***Direct costs***	
Sales revenues	669.877.220	Capital investment (equity)	1.196.010.000
		O&M	95.568.723
		Rental costs	6.570.000
		Av. Annual debt payment (interest and instalments) for 10years	487.858.043

Results: NPVs are positive (private + social)



Results: Social vs. Private view (2 wind scenarios)

Return	Low wind case Capacity factor 27%	High wind case Capacity factor 32%
IRR Social (25 years)	**11,11 % (without coal comparison)** **10,48%**	**14,01%**
IRR Equity (20 years, post tax & deprecitation)	**12,65%**	**19,18%**

Conclusion and Outlook

- Overall sustainability effect in terms of social NPV and IRR positive (with both social CBA approaches)
- Return for private investors positive and attractive
- Wind yield (capacity factor), escalation rates and some cost figures (e.g. €/kW) substantially influence results
- Kouga wind farm probably not “competitve” yet – Levelized COE: 68-76 €/MWh vs. Eskom coal 38-52 €/MWh
- Political action (education, public financial participation, spatial planning, fin. incentives, ISMO etc) can promote RE projects

Source: windpowermonthly.com