Ea Energy Analyses

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Analysis of changes in LCOE for wind power since REFIT 2009

Levelised cost of electricity (LCOE) is a simple way of comparing unit costs of different generation technologies and is widely used in policy decisions. The LCOE can be seen to represent a breakeven tariff per MWh for a electricity generating facility based on the sum of all costs over the lifetime of a given project, discounted to the present time, and levelised based on annual energy production.

NERSA approved a feed-in tariff for wind power and other renewable energy technologies in 2009 with the aim of achieving the South African government's target of 10,000 GWh of renewable energy production annually by the end of 2013. The feed-in tariff for each technology was based on LCOE calculations. The tariff was developed at a time when wind turbine prices per MW were at a peak and demand for turbines outstripped supply.

Once the economic downturn set in at the close of 2008 the demand for turbines cooled somewhat. This resulted in the cost per MW for wind turbines falling significantly. This trend persists and wind turbine prices are expected to continue to fall over the next couple of years. This is due to overcapacity in manufacturing and increased international competition from Asian based turbine manufacturers. Currently the market for wind turbines is very much a buyers' market. Especially for the large, international developers who play a more and more dominant role on the market.

This analysis is based on data from the International Energy Agency's Wind Task 26: Cost of Wind Power, work package 2. All LCOE calculations are made using the IEA Wind Task 26 LCOE excel sheet for calculating LCOE for wind power. Information on this can be accessed at http://www.ieawind.org/Task_26.html.

Changes in performance and costs of wind turbines

The downward pressure on turbine prices has coincided with the introduction of a new generation of wind turbines with higher hub heights and larger rotor diameters. These factors increase the performance of turbines as more wind energy is captured by the larger rotors and wind speeds are greater at e.g. 80m compared to 60m due to shear effect. This results in higher capacity factors for wind turbines and therefore greater production per installed MW.

Figure 1 below shows how the average rotor diameter and hub height for onshore turbines installed in Denmark each year since 2000 has increased and the effect this has had on the average capacity factor for all turbines commissioned in that year. The average capacity factor for turbines has been calculated from actual generation figures for wind turbines in Denmark for 2010 adjusted to represent a normal wind year. The capacity factor for onshore turbines in Denmark has increased by approximately 50 % over the last ten years. The spike in 2004 is due to the commissioning of a number of prototype wind turbines at a test site in Denmark.

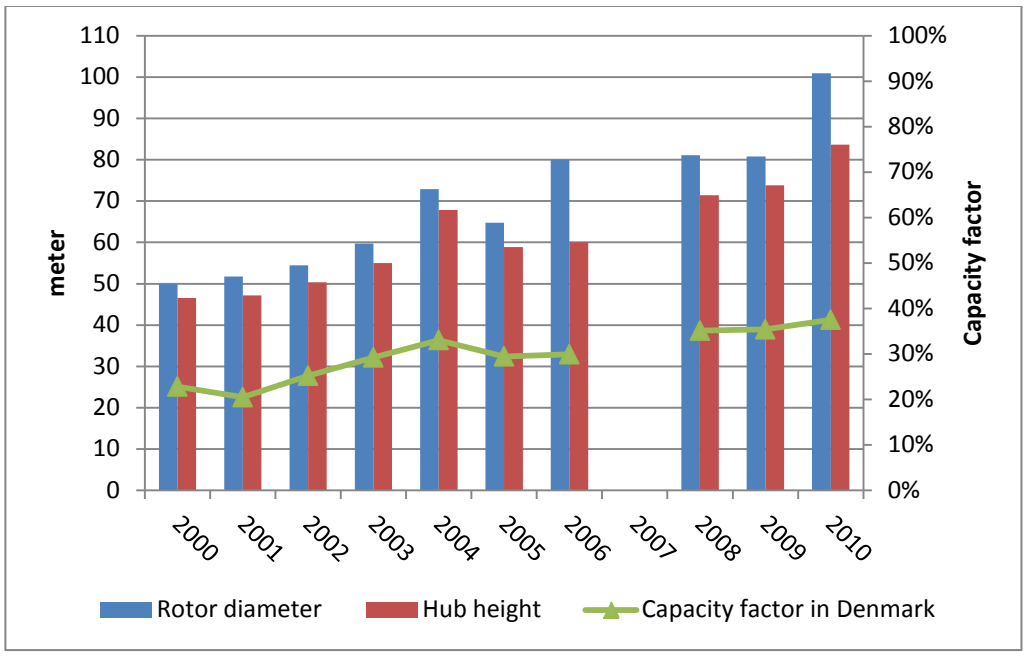

Figure 1: Development in average rotor diameter, hub height and capacity factor for onshore wind turbines commissioned in Denmark between 2000 and 2010 based on generation data for 2010. (No turbines commissioned in 2007)

During the high price years increasing performance of turbines played an important role in keeping the cost of energy from wind power more or less stable despite increasing costs per MW. If one compares the costs per installed kW and LCOE from wind turbines commissioned in Denmark from 2001 to

2010 it can be seen that despite a sharp increase in costs per kW the LCOE increased at a much slower rate between 2005 and 2009 before falling again in 2010[1]. This is illustrated in Figure 2 below.

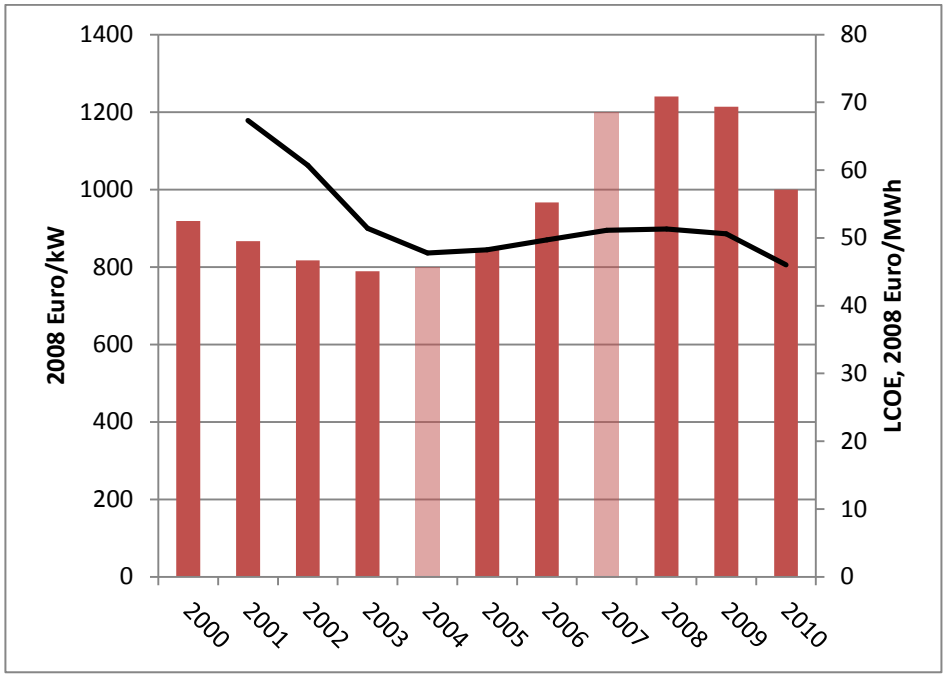

Figure 2: Average costs per kW for wind turbines commissioned in Denmark (columns) compared to development in average LCOE for wind power projects commissioned in that year (line) in Denmark. Data for 2004 and 2007 are estimates based on offers made to developers as no project cost data could be accessed for commissioned projects.

The trend of falling prices and increasing performance since 2008 has had a marked effect on the cost of wind power from new projects. The latest price data available indicates that high performance turbines ordered in 2011 will cost from $1,300 to $1,800/kW as turnkey projects in the US including connection costs and transmission upgrades. This compared to prices in 2008/9 where wind power projects cost on average $2,150/kW in the US.

Change in LCOE for wind turbines in South Africa from 2009 to 2011

The two major reasons for the cost of wind power falling internationally over the last three years are increased performance and lower prices per kW as explained above. In South Africa these and some other parameters have influ-

[1] It should be kept in mind that the LCOE for wind power in Denmark cannot be directly compared with the LCOE for wind power in South Africa as Denmark has historically had some of the lowest turbine prices due to a large local manufacturing base and the project owner only having to pay shallow connection costs, which have traditionally been low when compared internationally. This is not the case in South Africa.

enced the LCOE for wind power since the first REFIT tariffs were released in 2009.

Most turbines ordered in 2008/9 could be expected to have a capacity factor of approximately 30 - 35 % at an average wind speed of 7.5 m/s at hub height and a Weibull K factor 2. The new GE 1.62 80/100 has an expected capacity factor of approximately 41 % under the same wind conditions whilst the Vestas V100 1.8MW is expected to have a capacity factor of 38 %. This will have a significant influence on the LCOE for wind power, over and above the fact that both turbines are more currently than $300 cheaper per kW than turbines were in 2008/9.

The capacity factor used in REFIT 2009 was 27 %, which is in line with expectations for turbines ordered from 2003 to 2007 with an average wind speed of 7.0 m/s and a Weibull K factor 2. It is assumed that high performance turbines will be able to achieve capacity factors of approximately 35 % in South African conditions with average wind speeds at hub height of 7 – 7.5 m/s and Weibull K factor 2. This is the equivalent of approximately 3000 full load hours.

If one changes the capacity factor and the price of wind power projects to those expected for a project ordered in 2011 and leave all other parameters from REFIT 2009 unchanged then the LCOE for projects ordered in 2011 will be in the vicinity of ZAR 800/MWh. The figure below compares the LCOE for REFIT 2009 and a calculated LCOE for 2011 using new performance data and project prices per kW. The green columns show that increased performance results in savings of approximately ZAR 265/MWh and lower investment costs in savings of approximately ZAR 183/kW.

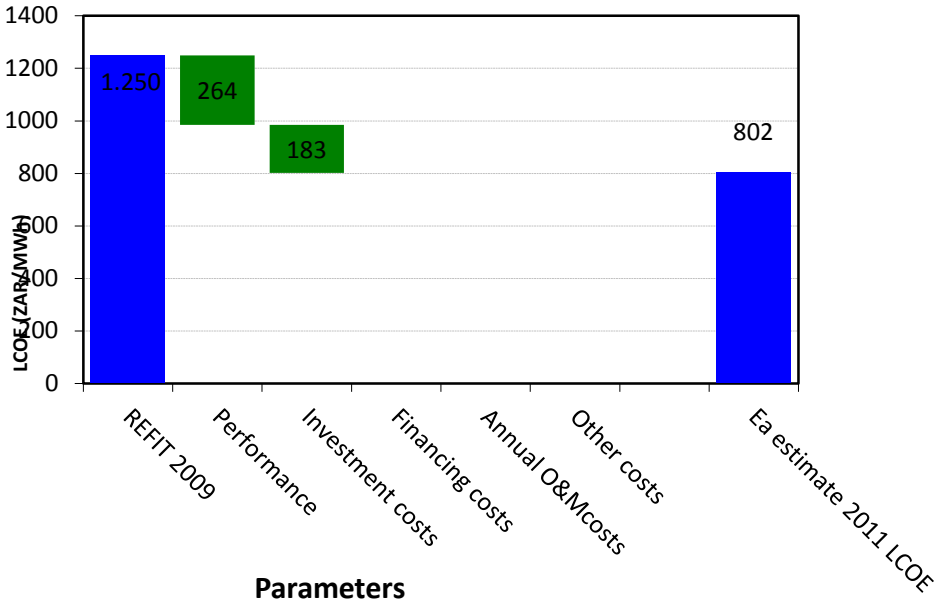

Figure 3: Influence of performance and investment costs on LCOE for wind power in 2011 compared with REFIT 2009.

Other parameters

There have been changes in other important parameters apart from performance and investment costs for determining the LCOE for wind power.

The choice of interest rate used in determining REFIT tariffs has been somewhat controversial. If one considers a 15 year interest rate swap the nominal interest rate for projects ordered in 2011 will be in the vicinity of 12 to 13 %. If using the Reserve Bank's target maximum inflation rate of 6 % one gets a real interest rate of approximately 7 %. This is more or less the same level as used in 2009 despite the fact that interest rates have generally been at a low level since then. The reason for this is that an inflation rate of 8 % was used in calculating the real interest rate in REFIT 2009, whilst 6 % is used at this time based on Reserve Bank expectations and targets. The discount rate used in calculating LCOE for 2011 is, therefore, unchanged compared to REFIT 2009.

The USD/ZAR exchange rate used in the REFIT 2009 calculations was ZAR 10 per dollar. This is quite high compared to the average exchange rate from January 2000 to mid-July 2011, which was ZAR 7.62 per dollar according to data from the Federal Reserve. This exchange rate is used in LCOE calculations for 2011. This has a strong influence on the investment costs compared to those used in REFIT 2009 calculations and in Figure 3. The current exchange rate is a bit lower than ZAR 7.62 being approximately ZAR 6.90 per dollar.

Operating and maintenance costs used in the REFIT model were given as $24/kW. The expected operating and maintenance costs for the turbines referred to in the previous chapter are in the vicinity of $0.02/kWh. This is higher than assumed in the REFIT calculations of 2009.

If one takes these additional parameters and include them in a LCOE calculation for wind projects ordered in 2011 the result is a LCOE of ZAR 703/MWh. This is shown in Figure 4 below. The effect of the lower exchange rate on investment costs is clearly seen when compared with Figure 3.

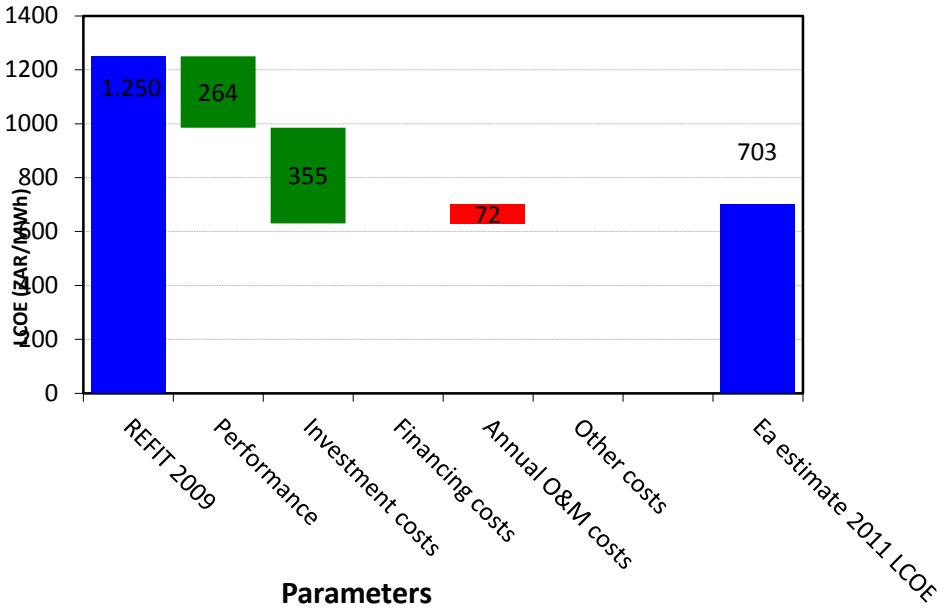

Figure 4: Influence of different parameters on LCOE for wind power in 2011 compared with REFIT 2009.The green columns indicate parameters that have reduced the 2011 LCOE compared with REFIT 2009, whilst the red columns indicate parameters that increase LCOE 2011 compared to REFIT 2009.

Conclusion

The performance of new generation wind turbines has increased due to developments in rotor diameter and hub heights. This together with lower cost of wind turbines per installed kW has resulted in the LCOE for new wind power projects being at a lower level than was the case in 2009. It is estimated that the LCOE for wind power may be up to 40 % lower than in 2009 and be in the vicinity of ZAR 700/MWh to ZAR 800/MWh.

The cost data is taken from projects in mature wind power markets in the US. Costs in South Africa may well be slightly higher due to the lack of experience in erecting turbines in the country as well as the small size of the market. This is more likely to be relevant for local project developers as large international

developers will be better positioned to utilise the buyers' market to their advantage and their experience in building wind power projects. The LCOE may, therefore, vary quite substantially from project to project due to the volatility of the wind turbine market, the positioning of the developer on the international market for turbines and other variables such as the ZAR/USD exchange rate as well as the usual variables such as wind resource, geological conditions, access etc at the selected site. It should, however, be kept in mind that the costs used here are taken from the high end of the US price margin and include connection costs and transmission upgrades.