Economic viability of wind turbines for Western Cape farms, using Germany's example

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Abstract

With a surge in Eskom's electricity prices and their unreliable service delivery, it could be more economically feasible for farmers in the Western Cape to rely on small wind turbines as their source of electricity. This paper seeks to establish whether this is actually the case over a period of 20 years, using Germany's renewable energy model as an example of its implementation process. The results prove that it is more economically feasible for framers to draw electricity from small wind turbines as opposed to drawing it from Eskom's grid system.

Introduction

As the depletion of the world's natural resources reaches an alarming level, governments across the world are looking into alternative ways of sustainably satisfying their economies' need for electricity. In the Western Cape region of South Africa the introduction of a renewable energy source could greatly assist farmers in the region. A possible renewable energy source can be found in small wind turbines. These small wind turbines have been proven to generate enough electricity to operate a single farm and the excess electricity can then be sold to the government for profit. A good example of this can be seen in Germany, where wind turbines have been generating electricity since the late 1980's.

This paper will try to establish the economic feasibility of introducing similar small wind turbines on farms in the Western Cape region of South Africa over a period of 20 years. A similar question was asked by Brosius in 2009 at the SAB Newlands plant, where the major problems highlighted were high initial capital costs and high maintenance costs. This is also the view taken by Nilsson and Bertling in their 2007 study done on the life cycle costs of a wind turbine in Norway. However, both these papers fail to compare costs to a farmers' electricity expenditure using Eskom's grid over a period of 20 years. In this study the feasibility/unfeasibility of wind turbines are highlighted using this approach. Using a similar approach in 2009, Whelan and Muchapondwa conclude that wind turbines are more feasible in a broader South African context, but still fail to specifically analyse this notion from a farmer's viewpoint.

Data is used from studies done in Germany to analyze the effect that the implementation of small wind turbines had on German farmers and the running of their farms. The paper will also try to identify any similar challenges that might need to be overcome in the process of introducing small wind turbines in the Western Cape. The paper will not solely focus on the economic effects of the wind turbines and will first seek to establish establish whether the region's wind conditions are suitable for wind turbines.

Background to Successful German Implementation

During the late 1980's increasing awareness was developed throughout the world about the issues related to the industrial pollution. This was done in order to defeat the increasing release of green - house gases as FCKW, CO_2, methane and nitrogen oxide, caused by the increasing global industrial development (German WindEnergy Association, 2008). Germany had set itself the goal to reduce its emission level by 21% from 1990 to 2010(German WindEnergy Association, 2008). Governmental support and incentives where implemented in order to foster private and institutional investments in renewable energy production. By 1992 the policies at place had triggered an ever-increasing number of farmers who now rely on their own wind turbines as a growing part of their income source. In this point in time already 47% of the installed wind turbines, which had a capacity up to 80kw, were located on farms (Keuper, Molly and Stückemann, 1992).

A major issue harming the development of renewable energy production was that Germany's grid operators enjoyed a monopoly position in the completely privatized energy market, making it very difficult for renewable energy projects to gain access to the grid (Wachsmann, U. & Tolmasquim, 2003) This is a similar situation to South Africa. In order to overcome this issue the government decided to support the production of renewable energy production by passing the so called "Act on Granting Priority to Renewable Energy Sources" in April of 2000 (Wachsmann & Tolmasquim, 2003). Now the grid operators are required to connect their grid to renewable energy sources in order to purchase preferable green energy and furthermore compensate the producers with a minimum price, which is set as a percentage of yearly average revenues generated by sales of energy by the grid operators. In order to further foster private initiative this minimum price is only paid to producers other than public sector power providers (Wachsmann & Tolmasquim, 2003).

By 2007 wind energy had become Germany's major renewable energy source with a capacity of 20 GW and an average annual production of 40TWh (Weigt, 2009).

Background to South African Energy sector

Electricity generation in South Africa is currently dominated by the publicly owned enterprise Eskom, which accounts for 95% of the electricity consumption in the country (Hansen, 2000, 340-356). However, since January 2008, Eskom has been unable to consistently meet the country's growing demand for electricity. The result has been a series of rolling blackouts as well as substantial price increases. Both have had a negative effect on the rest of South Africa's economy (Inglesi & Pouris, 2010, 50-53). South Africa's demand for electricity increased by approximately 50% between 1994 and 2010, and is set to increase annually by a rate of 6% (South Africa's projected GDP growth) (Inglesi & Pouris, 2010, 50-53). In February 2010, the NERSA (National energy regulator of South Africa) approved a large, systematic price increase for ESKOM. The nominal tariffs will increase by 24.8% for 2010/2011 financial year and by 25.8% and 29.9% for the 2011/2012 and 2012/2013 financial years respectively (Electro Sense, 2010, 1029-1038).

South Africa predominantly uses coal to fuel its electricity generation. South Africa has a large coal reserve and as a result of its massive reliance on coal it is the world 14th largest emitter of greenhouse gases (SAinfo, 2010). Electricity generated via coal-fired generating plants amounts nearly 90% of Eskom's generated power (Hansen, 2000, 340-356). Other sources of electricity in South Africa include nuclear (Koeberg), Hydro and on a smaller scale wind.

90% of the electricity generated in Cape Town comes from Non-renewable sources. With demand for electricity in cape town rising dramatically in the last few years. Cape town's reserve margin for electricity has dropped below the 15% level, the international norm is between 15-30%(Crane & Swilling, 2008, 263–287). Below is a summary of the energy production by source in the Western cape as well as the different sectors that consume the most energy. (Crane & Swilling, 2008, 263–287).

Table 1: Energy use by source and sector in WC (Crane & Swilling, 2008)

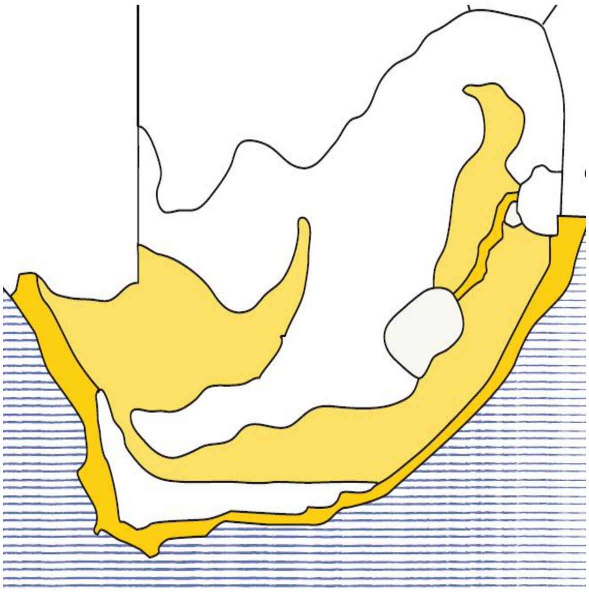
Table 1	
Energy use by source in WC	%
Electricity	29
Petrol/Diesel	46
Other oil based products	17
Coal	7
Wood	1
Energy use by sector in WC	
Transport	34
Industry	48
Households	9
Agriculture	5
Other	4

It is clear to see from the data (tab. 1) that most of the Western Cape's energy is generated via non-renewable sources such as Petrol and diesel (Oil) and that most of that energy is consumed by the industry and transport (This was the case in Germany pre-1992). Agriculture only consumes 5% of the total energy produced in the Western Cape. Hence, if electricity supply was to be rationed, the agricultural sector would not be a priority to the government in terms of allocating electricity. This would be a motivating factor to find alternative, sustainable electricity sources.

Suitability of Region

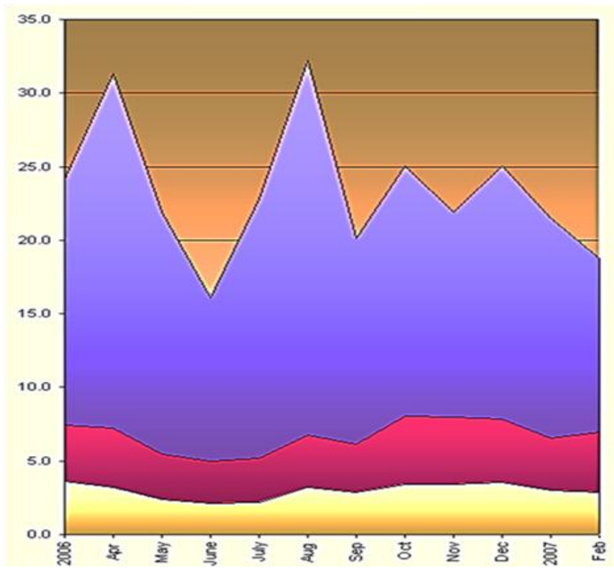
Before an economic analysis of Wind power on farms can be done, it must be established whether the Western Cape region is suitable for wind-powered electricity. There is conclusive data to prove that the WC region is suitable for sustainable wind powered electricity production. Energy production of a wind farm is reliant on the mean wind speed and standard deviation of wind speed. (Wang & Yeh, 2009, 692-704)

FIGURE 2: AVERAGE ANNUAL WIND SPEED MAP, SOUTH AFRICA



	Good	>4m per second
	Moderate	3-4m per second
	Low	< 3m per second

FIGURE 3: MONTH MAXIMUM, MAXIMUM SUSTAINED AND AVERAGE WIND SPEED FOR THE WESTERN CAPE



	Maximum gust
	Maximum sustained
	Average

Wind turbines are normally programmed to start generating power at a wind speed of 3m/s (Brosius, 2009, 1-73). Figure 2 shows that most of the Western Cape's coastal region consistently has winds of over 4 m/s, which would be strong enough to generate consistent wind generated electricity. Figure 3 shows that the average wind speed in the Western Cape is consistent throughout the year, with minimal variance in wind speed in the different months. This will ensure that farmers have a consistent supply of energy throughout the year. In a recent news article on Southafricainfo.com, the Western Cape region was described as "perfect for wind energy - prevailing winds are from two directions, and tend to blow during peak electricity consumption periods." (SAinfo, 2004). Different farms will obviously vary in their suitability for wind turbines, however, the Western Cape region in general is suitable for Wind energy, similar to the case in Germany. Hence, most of the regions farms will be suitable. An individual analysis of each farm's suitability will however need to be conducted.

Method

Cost benefit analysis of installing wind Turbines on Western Cape farms

The method used to analyse the cost of implementation is the Life cycle cost (LCC) method. This method is used to calculate the entire cost of the wind turbine throughout its entire life cycle (Nilsson & Bertling, 2007). The expected life of a small horizontal axis wind turbine is 20 years (Wang & Yeh, 2009).

$$\text{Life Cycle Cost} = C_{Inv} + C_{CM} + C_{PM} + C_{PL} + C_{Rem}$$

- C_{Inv} represents the initial cost of the investment
- C_{CM} is the life time cost of maintenance
- C_{PM} represents the cost of precautionary maintenance
- C_{PL} is the cost for loss of production (opportunity cost)
- C_{Rem} represents the remainder/scrap value (Nilsson & Bertling, 2007)

This model is adopted from a case study done in Sweden by Nilsson and Bertling. Figures for the calculation will be represented by figures from a South African perspective. The general rule within the academic world is that a normal 3kW rated (vertical axis) turbine would be able to generate enough electricity for one household (Nilsson & Bertling, 2007, 223-229).

Method for analysing electricity expenditure using Eskom's grid

The mean expenditure on electricity for WC farms (pooled 34 farms from Robertson, 36 farms from Worcester and 37 farms from De Doorns) was approximately R92.42 per ton of grapes processed in 2004 (Conradie, Cookson , & Thirtle, 2006, 334-343) However, electricty prices have increased dramatically in the last 7 year. The average price increase in this period was 12.7% (This includes the latest tariff increases approved by the NERSA (Electro Sense, 2010). For the purpose of the study, we have projected that the average price increase in the next 20 years will be 5%, 12% and 40%. This allows us analyze all possible scenarios as it is hard to predict what future electricity prices will do. The average production for these farms was between 1036 tons and 1480 tons per year, depending on whether it is a wine farm or a table grape farm respectively. An average of 1200 tons per year is used for the study. (Conradie, Cookson & Thirtle, 2006, 334-343). A simple addition formula is used to calculate the expenditure over a period of 20 years.

2011's average expenditure on electricity per WC farm + projected expenditure on electricity per farm for 20 years starting 2011 using 5%, 12% and 40% per annum tariff increase.

Results

Results of cost benefit analysis of installing wind Turbines on Western Cape farms

	Formula Used	Figure
1-Investment	($1866*7*20)	R 261 240
2-Cost of maintenance	(100*10*20*20)	R 400 000
3-Precautionary maintenance	(200*20)	R 4 000
4-Opportunity cost	(261240(1.055)^20	R 762 234.96
5-Remainder/Scrap value	0	R 0
Total Life cycle cost		**R 1 427 654.90**

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1- Represents initial installation cost and investment per 3kW turbine. Each farm will have a projected avg. of 20 turbines. The $/R exchane rate is currently 6.92:1 (rounded to 7 for simplification. Total- R261 240.

2- Yearly maintenance cost per turbine is approx. 100 Euros. The Euro/Rand exchange rate is approx. 10:1 and there are 20 turbines on avg. per farm for 20 years. Total- R 400 000

3- Initial preacutionary costs will be about R200 per turbine. These costs represent the safety mechanism that are around each turbine e.g. Signs to warn people of dangerous turbines. This will be an initial outlay of about R200 per turbine. Total- R4000

4- This is the opportunity cost of the initial investment for 20 years at current interest rates (5.5%) . Total-R 762234.96

5- No scrap value is projected

Hence total LCC =261420+400000+4000+762234.96

= R 1 427 654.90 for 20 years if wind turbines were installed on a WC farm

Results for analysing electricity expenditure using Eskom's grid

Initial calculations: These figures were needed in order to calculate the total expenditure.

- Today's price of electricity per ton of grapes- R 92.42$(1.127)^7$= R 213.41
- 2011's average expenditure on electricity per WC farm- R213. 41*1200= R 256 092

Projected expenditure on electricity per farm for 20 years using varying tariff increases.

Annual tariff increases	5%	12%	40%
Formula used	**R 256 092 (((1.05)^21-1)/.05)**	**R 256 092 (((1.12)^21-1)/.12)**	**R 256 092 (((1.40)^21-1)/.40)**
Resultant expenditure over 20 years	***R 9 142 484.40***	***R 20 922 392.58***	***R 74 929 750***

Discussion

(1) Although there is an initially high cost of installation (R261 240), it must be noted that this is a once off payment. Over 20 years the maintenance of these turbines will only be R 400 000, averaging R 20 000 per annum. The precautionary costs are also a once of cost and only amount to R 4000. Thus it can be said that once the initial capital has been invested, the maintenance of the wind turbines are fairly economical. The opportunity cost of the investment is taken into consideration to account for the potential money that other investments would have generated; this is part of the cost.

However, there is no guarantee that Eskom will connect the energy generated by the farmers to the national grid system. A law was passed in Germany to ensure this was not a problem. South Africa could do the same to avoid a conflict of interest. The German government decided to support the production of renewable energy production by passing the so-called "Act on Granting Priority to Renewable Energy Sources" in April of 2000 (Wachsmann & Tolmasquim, 2003). Now the grid operators are required to connect their grid to renewable energy sources in order to purchase preferable green energy and furthermore compensate the producers with a minimum price, which is set as a percentage of yearly average revenues generated by sales of energy by the grid operators.

(2) A modest increase in tariffs per annum (5%) is used to compensate for the **best-case scenario** when it comes to Eskom's electricity supply. This concludes that the favourable result for wind turbines is a favourable result in all circumstances. Even though the increase is modest, it compounds annually leading to a massive increase in electricity prices, as can be seen from the results. Even the best-case scenario is far more expensive that the implementation of the wind turbines. Naturally a 12% increase and 40% increase give rise to an even greater incentive to implement small wind turbines.

Conclusion

As can be seen from the above results, it is much more economically feasible for farmers to install wind turbines instead of continuing to use Eskoms grid power. The projected amount saved (5% Eskom tarrif increase) will be *9 142 484.40-1 427 654.90= R 7 714 829.* This is clearly a massive saving. Apart from the financial benefit, farmers will benefit from the constant,uniterupted supply of electricity. With eskom planning on future rolling black outs (SAinfo, 2010), a sustainable supply of electricity could ensure that farmers maintain their crops even in the face of adversity. If we use Germany's example of co-operation between farmers, grid operators and government, there is no reason why Western cape farmers can't implement their own wind turbines to generate renewable electricity.

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