Decentralised solar power versus centralised coal-based power: A life-cycle costing approach

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INTRODUCTION

Although renewable energy sources have a potentially beneficial role to play as part of South Africa's energy portfolio, the common belief is that renewable energy technology, especially solar photovoltaic (PV), is unviable for electricity production because it is too expensive compared to coal-based electricity. Statements such as these are made because the initial capital costs (procurement costs) are often used as the primary (and sometimes only) criterion for project, equipment or system selection based on a simple payback period. Due to life-cycle stages, often the real costs of the project or equipment, either to the decision maker or the cost bearer, are not reflected by the upfront capital costs. In this paper, the life-cycle costing approach is investigated as a means to improve decision-making on economic viability of energy systems. The investigation is based on the comparative analysis of decentralised residential solar power systems, referred to here as Lynedoch RSPS, and centralised coal-fired electricity generation systems, referred to as Maluti coal-fired power station. The case study demonstrates the ineffectiveness of the conventional (cost) analysis approaches.

APPROACH: LIFE-CYCLE COSTING (LCC)

Life-cycle costing (LCC) is a method for assessing the total cost of system/facility or equipment ownership. It takes into account all costs of acquiring, operating, maintaining and disposing of a system (Barringer, 2003; Fuller, 2008, Hunkeler *et al.*, 2008). Often the purchase price or initial cost does not reflect the real cost, either to the decision maker or cost bearer. This is due to the life-cycle stages, up and downstream from purchasing to production, contributing to the cost of ownership (Hunkeler et al., 2008). According to Fuller (2008), in addition to LCC, there are other measures of economic evaluation, such as savings-to-investment ratio, internal rate of return and payback period, which can be used to determine cost effectiveness. But LCC is especially useful when project alternatives that fulfil the same performance requirements, but differ with respect to initial costs and operating costs, have to be compared in order to select the one that maximises net savings (Fuller, 2008).

THE COSTS

Cost items for the two alternatives were divided into capital expenditure items incurred in the base year and operating expenditure items incurred from year one. The cost items included initial costs (purchase, acquisition and construction), fuel costs (coal, sorbent and water), operation, maintenance and repair (OM&R) costs, replacement costs, residual values (resale or salvage values or disposal costs, and carbon costs.

The calculations of results use generic assumptions for the main technical and economic parameters, such as economic lifetime of 40 years, average capacity factor of 90% (base-load), and a discount rate of 9% for Maluti coal-fired power plant. For a Lynedoch RSPS, the economic lifetime is 25 years, average capacity factor is 23% (using South African average radiation levels of 5.5 kWh/m2/day), and discount rate is 9%.

The main sources of data on the capital and operating cost items relating to Maluti coal-fired power plant and Lynedoch RSPS are summarised in **Table 1**.

Table 1: Main sources of data on the capital and operating cost items relating to the two project alternatives

Project alternative	Sources of data
Coal-fired power plant	Eskom Annual Report (2008; 2009)
	Department of Public Enterprises (DPE, 2008)
	Department of Minerals and Energy (DME, 2009)
	Engineering News (2009)
	Mining Weekly (2009)
	Sustainability Institute (2009)
Lynedoch RSPS	Sieckmann Engineering (installer of PV system)
	Atlantic Solar (installer of SWH)

COMPARISON OF ELECTRICITY GENERATION COSTS

Figure 1 indicates the comparison of cost-effectiveness between Maluti coal-based electricity (represented just as coal) and electricity generated by Lynedoch RSPS (represented as PV, SWH + Roof).

The Lynedoch RSPS (PV roof tile and SWH) including the cost of the reinforced roof at LCC of R10.77/kWh is superior to Maluti coal-fired power plant with the LCC of R13.63/kWh at the end of a 40 year life-cycle.

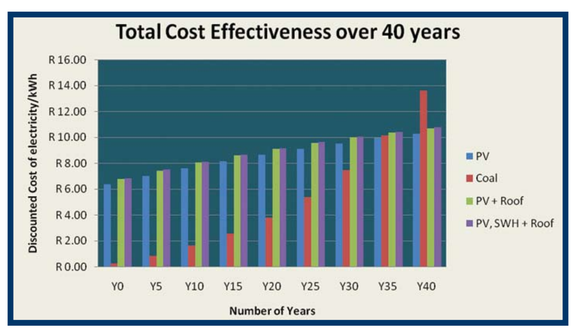

Figure 1: Total cost effectiveness comparison of Maluti coal-based electricity and Lynedoch RSPS (PV roof tile and SWH, including roof costs) electricity over a 40-year period in R/kWh.

SENSITIVITY ASSESSMENT

Coal price

Figure 2 shows how the upper bound of the coal price (at R369.50/tonne) affects the LCC of Maluti coal-based electricity over 40 years. This upper bound of coal price almost doubles the LCC of electricity generated by Maluti coal-fired power plant at the end of 40 years.
The Lynedoch RSPS breaks even just after year 25 compared to breaking even after year 35 in the case where the price of coal is R175/tonne. Overall, the Lynedoch RSPS has the lowest LCC of R10.77/kWh compared to a LCC of R22.41/kWh (based on R369.50/tonne of coal) of Maluti coal-based electricity over a period of 40 years.

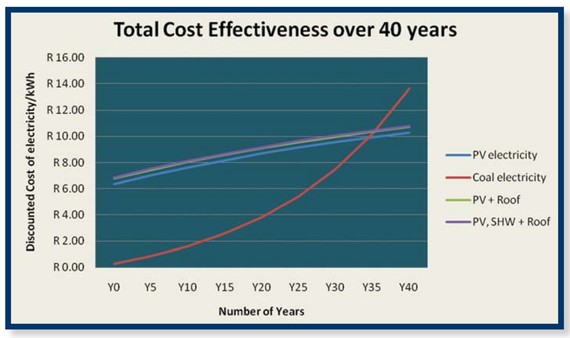

Figure 2: The effect of R369.50/tonne of coal on a 40-year LCC of Maluti coal-based electricity compared with Lynedoch RSPS electricity in R/kWh.

Figure 3 shows the lower bound of the coal price at R90/tonne and what impact it has on the LCC of Maluti coal-based electricity over 40 years. The coal option is cost effective for the entire life-cycle of the two project alternatives. Overall, the Lynedoch RSPS has a LCC of R10.77/kWh compared to a LCC of R8.61/kWh of Maluti coal-based electricity over a period of 40 years. Here it is shown how the variability in the coal price affects the range of LCC of Maluti coal-based electricity when all other items are kept constant.

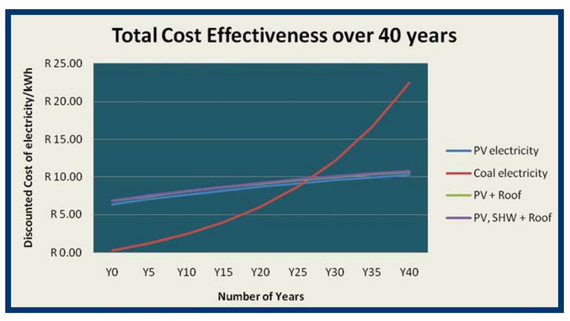

Figure 3: The effect of R90/tonne of coal on a 40-year LCC of Maluti coal-based electricity compared with Lynedoch RSPS electricity in R/kWh

ENERGY PRODUCTION

All other items were kept constant while changing energy yield from 10 038 kWh (calculated) to 4 906 kWh (actual energy yield) to see the effect on the LCC of the Lynedoch RSPS. The Lynedoch RSPS has a LCC of R17.93/kWh compared to the LCC of R13.63/kWh of Maluti coal-based electricity (see **Figure 4**).

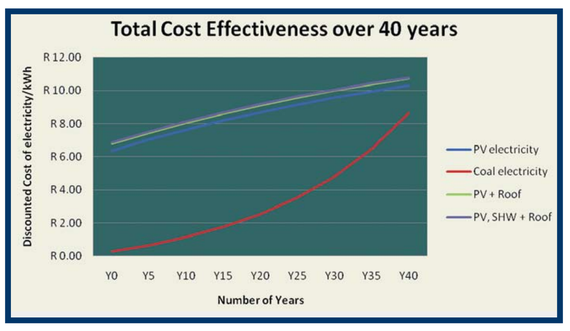

Figure 4: The effect of uncertainty in energy yield from the 5 kW PV roof tile system resulting in actual outcome of 4 906 kWh differing from estimated outcome of 10 038 kWh on a 40-year LCC in kWh

Figure 5 shows the effect that the revenue from carbon credits has on the 40-year LCC of a Lynedoch RSPS compared to that of coal-based electricity.

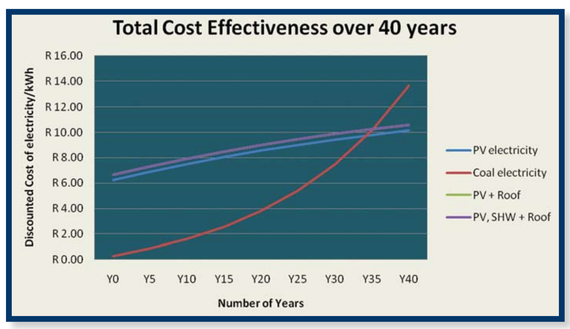

Figure 5: The effect of carbon credits on a 40-year LCC of solar power system (PV and SWH including roof costs) electricity compared with coal-based electricity in R/kWh

The life-cycle costing of a Lynedoch residential solar power system reveals that, over a life-span of 40 years, it becomes a superior energy provision solution that promotes ecological, social and economic sustainability through less resource consumption, improved access to energy services and lowest life-cycle operating costs.

The effect of carbon credits (CERs) at a price of €10/tonne CO_2e on the LCC of Lynedoch RSPS is minimal. A Lynedoch RSPS has a LCC of R10.59/kWh. The Lynedoch RSPS breaks even in year 35 – this is similar to the case without carbon credits (where the LCC is R10.77/kWh).

Figure 6: A Lynedoch Residential Solar Power System (RSPS)

CONCLUSION

The LCC reveals that the common belief that sustainable and renewable energy alternatives are too expensive is a false perception created by looking no further than initial capital costs. Lynedoch RSPS becomes a superior energy provision solution that promotes ecological, social and economic sustainability through less resource consumption, improved access to energy services and lowest life-cycle operating costs. It must be stated, however, that the lower bound of the coal price at R90/tonne (**Figure 3**) and the actual annual energy output of 4 906 kWh (**Figure 4**) makes Maluti coal-based electricity a superior energy provision solution in terms of LCC over 40 years. Therefore, coal price and energy production from Lynedoch RSPS become the uncertain input values which have the greatest impact on the LCC of both Maluti and Lynedoch energy systems

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