Potential multi-project baselines in the power sector in South Africa

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CONTENTS

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1. Introduction

The United Nations Framework Convention on Climate Change (UNFCCC) aims to reduce emissions of greenhouse gases (GHGs) in order to 'prevent dangerous anthropogenic interference with the climate system' and promote sustainable development (UNFCCC 1992). The Kyoto Protocol, which was adopted in 1997, aims to provide means to achieve this objective.

The Clean Development Mechanism (CDM)[1] is one of three 'flexibility mechanisms' in the Protocol, the other two being Joint Implementation (JI) and Emissions Trading (ET). These mechanisms allow flexibility for Annex I Parties[2] to achieve reductions by extra-territorial as well as domestic activities. The underlying concept is that trade and transfer of credits will allow emissions reductions at least cost. Since the atmosphere is a global, well-mixed system, it does not matter where emissions are reduced.

The CDM allows Annex I Parties to meet part of their emissions reductions targets by investing in developing countries. The host developing country benefits from the project. CDM projects must also meet the sustainable development objectives of the developing country. Further criteria are that Parties must participate voluntarily, that emissions reductions are 'real, measurable and long-term', and that they are additional to those that would have occurred anyway. The last requirement makes it essential to define an accurate baseline.

1.1 Baselines and additionality

Reductions of GHG emissions must be additional to business-as-usual. If a project would have happened anyway, it should not be a CDM project and receive investment through that mechanism. Once a project has qualified for the CDM and been implemented, the certified emissions reductions need to be calculated. To do so, the different between the projected baseline and the project performance needs to be calculated.

Like any projection, baselines depend on assumptions about the future. Key assumptions include the level of economic growth, energy supply and demand, and the emissions assumed as a starting point. Baselines are counterfactual, in the sense that, due to climate change policy, the baseline will never occur.

The possibility that the determination of additionality may be separated from the calculation of credits has been discussed in the climate negotiations. Additionality may be tested by use of various 'additionality screens', including environmental, financial, investment and technological additionality (UNFCCC 2000). The methodology for calculating baselines to determine credits may be separate. The purpose of this paper is to consider the calculation of baselines, rather than dealing explicitly with additionality.

1.2 Minimising transaction costs while ensuring environmental integrity

The aim of multi-project (or standardised) baselines must be to seek a balance between ensuring environmental integrity and minimising transaction costs. Setting project-by-project baselines would increase the transaction costs of CDM projects and thus reducing the number of projects that attract investment. The experience of the AIJ[3] pilot phase was that baselines are time-consuming and highly subjective. Hence there have been suggestions to standardise baselines across many projects, to set them for particular sectors, or given technologies. Multi-project baselines based on emissions intensity are known as benchmarks.[4] A concern about multi-project baselines is that they might

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1 See Michael Grubb (1999) for a more detailed description of the CDM and its origin in the negotiations.

2 Annex I Parties are industrialised countries and countries with 'economies in transition', which are listed in Annex I of the Convention. Developing countries are referred to as non-Annex I Parties.

3 Activities Implemented Jointly. The AIJ pilot phase was initiated at the first Conference of the Parties to test the impact of implementing emissions reductions projects in some countries (developing countries or economies in transition) and funded by others without generating credits.

4 See M. Lazarus *et al* (1999) for an evaluation of different approaches to benchmarking, and case studies of Argentina, China, South Africa, Thailand and the United States.

undermine the environmental integrity, in that emissions reductions might be credited that are not 'real'. This paper explores alternative options for multi-project baselines.[5]

Establishing a baseline for a particular activity, sector and/or region potentially simplifies the calculation of emissions reductions. Baselines need to be simple enough to be practical in developing countries. Various proposals for baselines are summarised in the Chairman's Draft Text on Mechanisms (26 October 2000) for the climate change negotiations. In bracketed text, it proposes that baselines for a CDM project should consider the lowest of:

a) 'Existing actual emissions prior to the project;

b) The most reasonable economic technology for the activity;

c) Better-than-average current industry practice in the host country or an appropriate region; and

d) The (average) (top X per cent) for such an existing source in Parties included in Annex (I) (II).'
(UNFCCC 2000, FCCC/SB/2000/Add.2: § 70)

While project-specific baselines may be costly, less stringent baselines pose a potential threat to the environmental integrity of the Protocol. If a multi-project baseline allows projects that would have occurred under business as usual, then free riders can claim credits for something that would have been created anyway. This threatens environmental integrity in that the project does not really add to global emissions reductions. Under the CDM, both investor and host countries would have an incentive to inflate baseline emissions.

This paper considers a number of approaches to multi-project baselines for the electricity generation sector, and the implications for a set of potential CDM projects in South Africa.

2. Background to the SA energy sector

Primary energy consumption in South Africa is dominated by coal (70%). Coal dominates electricity generation (92%), and South Africa has amongst the cheapest coal and electricity in the world. Of primary energy, 17% is attributable to crude oil, the basis of the liquid fuels industry. The energy sector also includes a synthetic fuel industry which produces oil from coal. Nuclear, gas, renewables and biomass make up the balance of the energy supply.

South Africa's GDP ranks 26^{th} in the world, but primary energy consumption is 16^{th} (DME 1996) and energy intensity is 77% above global average. This is largely a result of the presence of large-scale energy-intensive primary minerals beneficiation industries, the reliance on coal for electricity generation, the production of a significant proportion of liquid fuels from coal via the synthetic fuel process, and low efficiency in many industrial and commercial processes.

Energy policy in post-apartheid South Africa locates energy in the context of sustainable development. It aims to:

- improve *social equity* by specifically addressing the energy requirements of the poor;
- enhance the *efficiency and competitiveness* of the South African economy by providing low-cost and high quality energy inputs to industrial, mining and other sectors within restructured and appropriately governed energy markets ; and
- work towards *environmental sustainability* by addressing both short-term environmental problems, and planning for a long-term transition towards sources of energy with minimum negative environmental impacts.

The energy White Paper, released in late 1998, presents a comprehensive set of energy sector policies. Key policy elements from the White Paper and priorities outlined by the Minister of Minerals and Energy are reflected below:

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[5] This paper does not analyse the difference between multi-project baselines and a project-specific approach, a topic that warrants further attention.

- Electricity policies include a continued massive electrification programme; restructuring of the electricity distribution and supply industries; integrated resource planning to meet demand growth; and reform of the pricing system to more accurately reflect costs. While renewables are not explicitly supported, government recognises the role they have to play in rural electrification and is working on an implementation plan for renewables.
- In the oil and gas industry, government plans to progressively re-regulate the industry and to promote the introduction of natural gas from neighbouring countries.
- Coal policies focus mainly on containing the environmental consequences of coal production, and the utilisation of coal-bed methane.
- Integrating concerns about black economic empowerment, HIV/AIDS, empowerment of women, and health and safety into strategies in the energy sector.

2.1 Overview of the electricity generation sector

The electricity supply industry in South Africa is almost entirely in the hands of the public sector – either through Eskom or municipal distributors. Figure 1 illustrates the current structure of the electricity supply industry. Generation and transmission are dominated by Eskom. There are a few self-producers, some of which sell to neighbouring communities. Eskom owns 93% of all generation capacity in South Africa, municipalities own 5% and private generators only 2%.

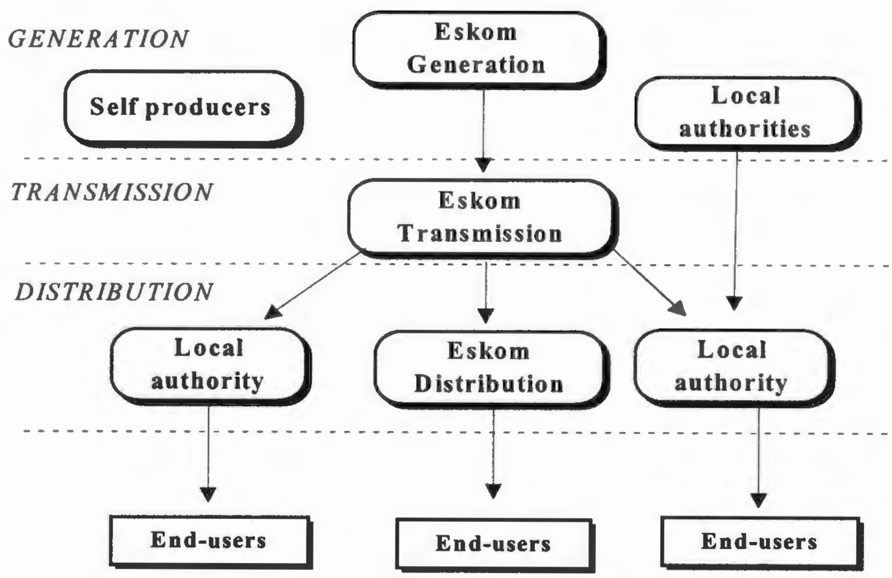

Figure 1: Structure of the South African electricity supply industry

The total quantity of electricity generated in South Africa in 1998 was 189 TWh (Eskom 1999). Eskom accounted for 95% of this total. Figure 2 presents the electricity flows in the South African industry for 1996, the latest year for which such detailed breakdowns are available.

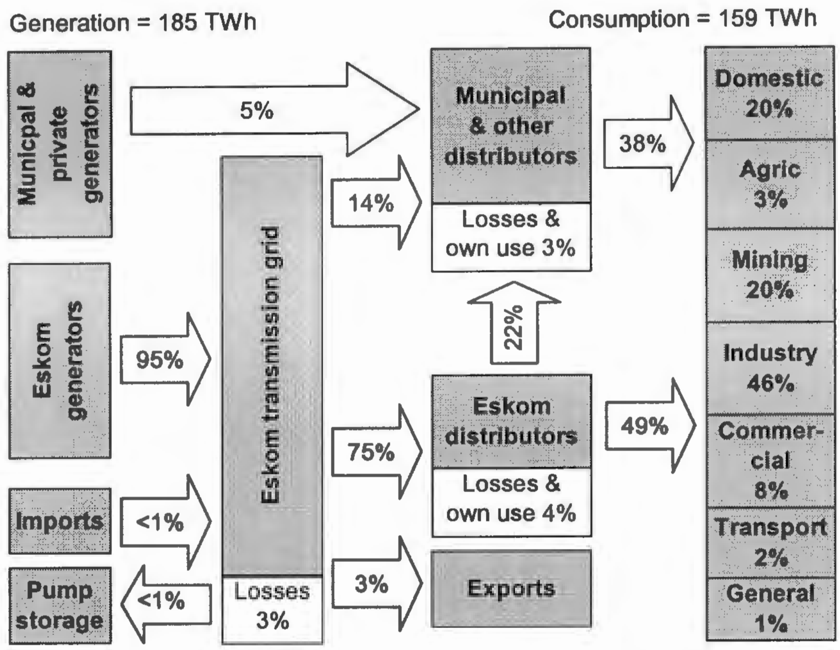

Figure 2: Energy flows in the electricity supply industry in 1996

South Africa's electricity generating technology is based largely on coal-fired power stations, mostly owned and operated by Eskom and largely concentrated near and to the East of Johannesburg – close to the main coal resources as well as the country's major demand centre (see Figure 3).

As at the beginning of 1999, there were 38 power stations in the country, of which 23 were coal-fired accounting for 90% of the total capacity of 42 994 MW (including capacity in reserve and under construction). Many power stations were constructed during the 1960s and 1970s, before growth in demand slowed. Three of Eskom's older coal stations are currently in reserve ('mothballed') due to the existence of excess capacity and these account for 8% of total capacity. The only non-coal stations of significance are the Koeberg station (5% of operational[6] capacity) and three pump storage facilities (4% of operational capacity) (NER 1999; Eskom 1999).

6 'Operational' capacity excludes all moth-balled stations and units under construction.

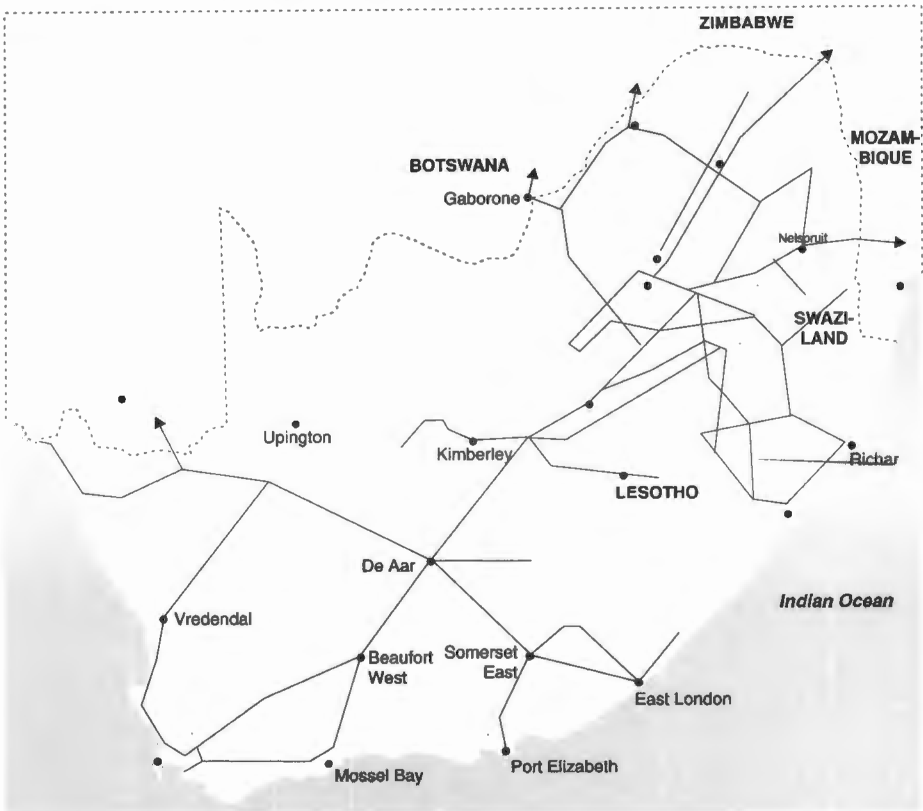

Figure 3: Geographical distribution of electricity generating stations in South Africa

Table 1 presents the breakdown of capacity and electricity production by fuel source. Coal generation accounts for 90% of all electricity produced and nuclear generation a further 7%.

	Capacity (1998)[a] *(MW)*		*Electricity production (1998)*[b] *(GWh)*		*Electricity production (1997)*[c] *(GWh)*	
Coal	32 724	87,4%	170 750	90,4%	179 792	91,0%
Nuclear	1 840	4,9%	13 601	7,2%	12 647	6,4%
Pumped storage[d]	1 580	4,2%	2 626	1,4%	2 815	1,4%
Hydro	668	1,8%	1 852	1,0%	2 349	1,2%
Gas	606	1,6%	23	0,0%	20	0,0%
Bagasse	29	0,1%	86	0,0%	86	0,0%
Total	37 447	100%	188 938	100%	197 708	100%

Notes:

a) Excluding capacity in reserve and under construction.
b) Non-Eskom production estimated as the same as 1997 production.
c) 1997 is the most recent year for which non-Eskom electricity production is available. From 1997 to 1998 Eskom's production of electricity decreased by 0,4%.
d) While pumped storage contributes to gross energy production, it is, in fact, a net user of electricity.

Table 1: Capacity and gross electricity production by fuel type
Source: NER (1997); NER (1999); Eskom (1999)

The average age of Eskom's operational power stations is 14 years (weighted by capacity) – this figure is heavily influenced by several large stations constructed in the 1980s. Eskom's moth-balled stations are 30 years old on average and would typically have lower than average thermal efficiencies.

South Africa is known for being one of the world's low-cost producers of electricity. At the beginning of 1997, Eskom, the electric utility had the lowest industrial electricity tariffs in the world: at 2c/kWh, South Africa was followed closely by only New Zealand at 2,5 c/kWh (SANEA 1998).

Eskom's coal-fired power stations generally exhibit high thermal efficiencies for conventional pulverised fuel technology. Average efficiencies have consistently been over 34% for the past six years, despite the use of low quality (high ash) coal and the use of dry-cooled technology, which is generally slightly less efficient than wet-cooled stations. The weighted average heat content for existing coal-fired power stations is low at 21.3 GJ/t (coal) compared to the IPCC default value of 29.3; carbon content is relatively high at 28.2 tC/TJ compared to the IPCC factor of 25.8 (IPCC 1995).

The high dependence on coal means that South Africa's electricity industry has relatively high greenhouse gas (GHG) emissions of 178 Mt of CO_2 equivalent in 1998 (see Table 2). This is mainly from coal combustion, but includes some methane emissions from coal mines. Overall, South Africa produces 1.04 kg of GHG per kWh produced.

2.2 Energy and GHG emissions

The energy sector in South Africa is one of the major drivers of GHG emissions. The most recent inventory of these shows that South Africa contributed 1.02% to the human-induced additional radiative forcing of the atmosphere due to CO_2, CH_4, and N_2O in 1990. Of the 373 022 Gg of CO_2 equivalent emissions in that year (or 101.8 MtC), the energy sector accounts for 89%. This includes a number of critical energy-related activities such as: generation of electricity (48%), energy used in manufacturing (7%), energy used in transport (9.3%), heat production (8.8%), petroleum industry (9.9%), other energy related activities (7%) (Van der Merwe & Scholes 1998).

While South Africa currently emits only 1.6% of global industrial carbon dioxide emissions, per capita emissions, at 8.5 tons per capita, are close to some OECD countries and far higher than most developing countries (IEA 1999). In fact, South Africa alone contributes 47% of Africa's CO_2 emissions (IEA 1998), while emissions per kWh from electricity generation, for example, are considerably higher than for many industrialised economics (NRDC/PSEG 1998). This is related to the energy intensive structure of the South African economy, as well as the high dependence on coal as a primary energy source.

	Electricity generated (GWh)	*Primary energy used (GWh)*	*GHG emission (Mt CO_2 equiv)*	*Emission factor (kg of CO_2/ kWh generated)*
Coal	170 750	508 988	178	1.04
Nuclear	13 601	n/a	0	0
Pumped storage	2 626	n/a	0	0
Hydro	1 852	n/a	0	0
Gas[7]	23	64	0.2	2.79
Bagasse	86	n/a	n/a	n/a
Total (all fuels)	188 938	509 052	178	0.95

Table 2: Estimated emission of GHGs due to electricity generation (1998)
Source: Based on Eskom (1998b), Eskom (1999)

3. Baselines for SA electricity generation

A key decision in determining baselines is to identify the plants to be included in the baseline. It is the performance of these plants or units that the potential CDM projects will be measured against. Performance is measured in terms of carbon intensity (kg C / kWh).

7 While CCGT stations tend to have thermal efficiencies almost double that of coal plants (and so emit less CO_2), gas stations in South Africa are single-cycle and used for peaking. Thus their efficiency is low resulting is comparatively high CO_2 emissions per kWh generated.

3.1 Recent or near future plants

One approach is to use data for recently constructed plants, assuming that these represent the best available technology. 'Recent' might mean different lengths of time, perhaps three to five years. An advantage of this approach is that the data for such plants is observable. This does not mean that there is no uncertainty about observed data. However, a forward-looking baseline that includes future plants needs to make additional assumptions about which plants would most likely be built. A forward-looking baseline has the advantage that it can consider new, more efficient technologies. Arguably it is more 'realistic' about what new technologies are likely to be used. The negotiating text defines a 'reference scenario' as 'a set of recent and comparable activities or facilities that are defined in a manner sufficient to demonstrate what would likely have occurred in the relevant sector in the absence of the proposed project activity' (UNFCCC 2000, § 60). The reference scenario can therefore be based on recent plants or near future.

In South Africa, the backward-looking approach does not work for practical reasons. Only one power station, Majuba, has been constructed in the last seven years.[8] Here, four units have been constructed between 1996 and 1999, and two more are being constructed during 2000 and 2001. If one uses the 'recent plant' approach, one therefore compares the CDM projects to the performance of a single power station. The slower growth in demand in South Africa in recent years creates some inertia against changes in the capacity mix (Lazarus 1999). Opportunities to change the capacity mix towards low-carbon technologies are constrained by the existence of excess capacity and moth-balled coal stations. These arguments are specific to the power sector in South Africa, and do not imply that other developing countries might not choose recent plant baselines.

A more general point is that forward looking baselines are open to 'gaming'. Countries have an incentive to choose a reference scenario with high carbon intensity, so that CDM projects will be able to sell more credits. Gaming is also a problem for project-specific baselines. It can be avoided to some extent by including factors that are difficult to change – for example, requiring the projection to be based on published government or utility plans. Setting regional baselines also makes gaming more difficult, as would a system of international review (Meyers 2000). To the extent that gaming cannot be avoided, there is a trade-off between this risk and the risk of free riders against a backward-looking baseline that does not promote the best available technology.

In this analysis, we have therefore chosen a baseline that includes 'near future' plants. These include the two new units of Majuba, the recommissioning of two units in moth-balled power stations, the importation of hydro, and new gas plant. Given the directions set by Eskom's Integrated Electricity Plan 6, one could reasonably expect these units to come on line between 2000 and 2005.

	Majuba Unit 5	*Majuba Unit 6*	*Mothballed coal 1*	*Mothballed coal 2*	*New gas*	*Imported hydro*
Capacity (MW)	713	713	570	870	736	400
Efficiency assumed	34%	34%	30%	30%	55%	
Annual generation (TWh)	3.78	3.78	3.02	4.61	4.13	1.84
Annual fuel use (GJ)						None
Coal	39 511 269	39 511 269	6 252 666	55 333 017		
Natural Gas					27 057 200	
Carbon intensity (kg C / kWh)	0.295	0.295	0.338	0.338	0.100	0.000

Table 3: Key characteristics of a 'near future' baseline
Sources: Developed from data in NER (1999), Eskom (1996; 1998a; 1999)

Some key results are compared using the 'recent plant' baseline, that is, considering the Majuba power station only.

[8] The last previous plant was Kendal, whose units were commissioned from 1988-1993 (Eskom 1996).

3.2 Basis of comparison

Three key decisions are required to calculate the baseline:[9]

1. The first decision is which set of plants to include in the reference scenario. For each plant, the essential data is the fuel input (in GJ per year) and the electrical output (in TWh per year). Combining this information with the calorific value of the fuel and its carbon content, we can calculate the carbon intensity. The carbon intensity is measured in mass of carbon per unit of energy produced, e.g. in units of kg CO_2/kWh.
2. The second issue is to which set of plants the potential CDM project should be compared. For example, does a new gas plant need to perform better than the average power station in the whole sector, the average fossil-fueled plant, or better than other gas-fired plants only?

   These comparisons can be applied to different sub-sets of the plants in the baseline. The project can be compared to other plants using the same fuel ('fuel-specific'), to all fossil fuel-fired plants ('all fossil'), or to the whole electricity generation ('sector-wide'). Obviously, the fuel-specific comparison only works if there is a plant or unit in the baseline using the same fuel as the project.
3. The third decision is whether to compare projects against average, better-than-average or best plants. Once the carbon intensity of the plants in the reference scenario are known, we can construct increasingly stringent benchmarks – a weighted average, 25th percentile, 10th percentile or the best plant. One would expect the carbon intensity required by each of these benchmarks to be lower – in other words, the CDM project will have to show lower carbon intensity than a harder target.

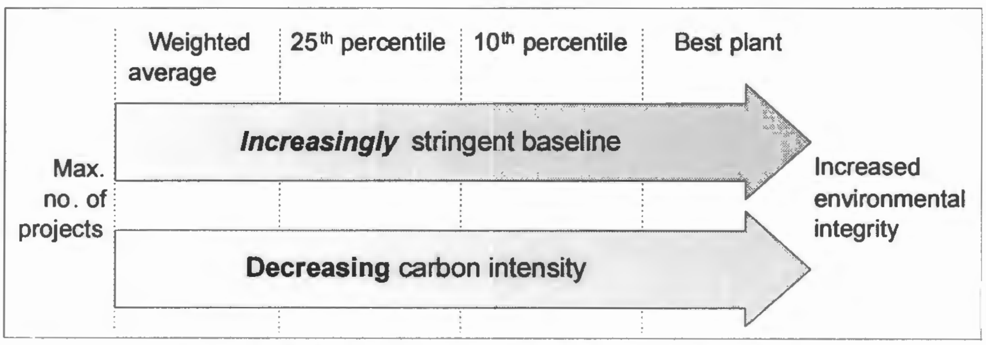

Figure 4 : Relative stringency of different benchmarks

Table 4 shows the baseline intensities – both energy and carbon intensity – given the units included in the 'near future' baseline. No energy intensity is reported for the sector, since this concept has different meanings for fossil fuel plants and those using renewable energy sources. For gas, only the best plant shows a value, since percentiles or a weighted average cannot be calculated from a single plant (at least four are needed). There is no 'fuel' for hydro-power, so no fuel-specific intensities are reported. For the purposes of this analysis, we assume that the carbon intensity is zero, although this may well not be the case (WCD 2000). Carbon intensity represent the baseline for CDM projects; energy intensity is reported for information only.

9 These three decisions are analysed here. Lazarus *et al* (1999) note two further methodological issues – the degree of aggregation, and whether a static of dynamic baseline is used.

				Weighted average	Percentile 25%	Percentile 10%	Best plant
Fuel specific	Energy intensity	MJ/kWh	Coal	11.23	10.46	10.46	10.46
			Gas	6.55*	6.55*	6.55*	6.55
	Carbon intensity	Kg C/kWh	Coal	0.316	0.295	0.295	0.295
			Gas	0.100*	0.100*	0.100*	0.100
All fossil	Energy intensity	MJ/kWh		10.23	7.11	6.55	6.55
	Carbon intensity	Kg C/kWh		0.270	0.128	0.100	0.100
Sector wide	Carbon intensity	Kg C/kWh		0.247	0.065	0.013	0.000

Note: * Based on one plant only – see text.

Table 4: Energy and carbon intensities for the near future baseline

The benchmarks get more stringent from left to right, as expected. However, the coal-specific carbon intensity is identical whether one uses the 25th percentile, 10th percentile or best plant. This is because several of the coal units included in the baseline have identical performance. Natural gas has much lower carbon intensity than coal – and this constitutes the best plant and 10th percentile for the 'all fossil' comparison. The zero carbon intensity sector-wide reflects the inclusion of imported hydro and the assumption that it is zero-emitting.

The baseline generally gets more stringent as one moves from fuel-specific to 'all fossil' and 'sector-wide' comparisons, as 'all fossil' adds in natural gas, and the sector adds the imported hydro, bringing down the weighted average carbon intensity.

Gas does not follow this trend, with the fuel-specific carbon intensity being lower than the all-fossil or sector-wide intensity, which include more carbon-intensive coal. The weighted average and percentiles for gas are based on one plant only. While it may be more mathematically correct to base such measures on more than the one gas plant included here, the value of the single plant is included across all, as that is what one would compare the project against. Figure 5 illustrates the near future baseline graphically, showing each plant's carbon intensity against its share of generation.

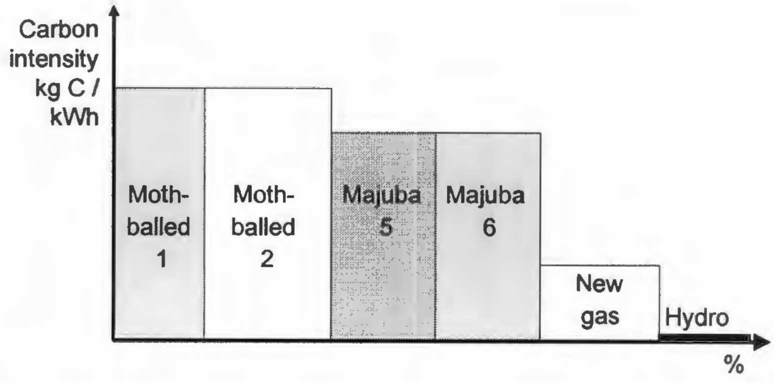

Figure 5: Near future reference scenario carbon intensity (kg CO_2/kWh) against the share of generation (TWh)

4. Potential CDM projects – supply options and demand interventions

A critical methodological choice is which potential CDM projects to include in the analysis. The purpose of this analysis is not to compare different CDM projects, but rather to investigate the impact of different baselines on hypothetical projects in South Africa. To make the analysis worthwhile, the data should be as close to likely reality as possible. For this analysis, we chose diverse projects – some using fossil fuels, others using renewable energy sources, as well as demand-side intervention and an off-grid project. Including both supply and demand-side options ensures that these interventions are treated equally.[10] These projects include the following:

- The Cape Metropolitan Local Authorities are investigating the feasibility of importing gas from the Kudu gas fields for three units of 368 MW each (Roggen 2000). New gas-fired power plants are substantially less carbon-intensive than coal-fired plants. Further possibilities being explored are using natural gas from fields off Mozambique and piping gas to Johannesburg.
- The Darling wind farm is aiming to install 5 MW for production of electricity for the grid. This independent power producer is the renewable energy project in South Africa which has progressed the furthest towards implementation (Asamoah 2000).
- As part of the South African Country Study on Climate Change, the possibility of more efficient, super-critical coal plants was investigated (Howells 1999). The more efficient use of coal in these plants could reduce greenhouse gas emissions.
- Eskom's Efficient Lighting Initiative aims to install 18 million compact fluorescent lights (CFLs) to reduce energy demand in the residential sector (Eskom 2000). Rather than increasing supply, this project aims to reduce demand for electricity, and thus avoid emissions. By including an energy efficiency options, it is possible to measure demand- as well as supply-side options against one multi-project baseline.
- Off-grid solar home systems have been used to electrify rural areas unlikely to receive grid electricity. The aim of the programme is to extend this from initial projects to a target market of 350 000 households (Qase 2000). In comparing this programme to the multi-project baseline, one implicitly assumes that it will displace electricity. It is more likely that paraffin will be displaced for lighting. This trade-off is necessary if one wants to benefit from the simplicity of applying a single baseline to many projects.

This set of CDM projects in no way claims to be comprehensive.[11] We chose a small sample of projects that, in our opinion, are likely early-start CDM projects, are the subject of major pending decisions, and /or use commercially available technologies. On the basis of the data in Table 5, these five CDM projects were compared to various baselines.

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[10] Evaluating demand-side CDM projects requires information about demand, which tends to have greater uncertainty than corresponding figures for supply side options (output and fuel use). So while the multi-project baseline makes the benchmark equal for all, the other half of the comparison is still uncertain. Rather than being an obstacle, however, this can be seen as further motivation to accept the additionality of energy efficiency projects.

[11] Projects that were *not* included in the analysis were the nuclear PBMRs, solar thermal technologies and IGCC new coal. Pebble Bed Modular Reactors are being investigated by Eskom, who are currently conducting an EIA for two pilot plants (110 MW each) at Koeberg. They were not included due the uncertainty whether nuclear technologies can be accepted as CDM projects. Solar thermal technologies for electricity generation are at an early stage of investigation in South Africa. The SA Bulk Renewable Generation (SABRE-Gen) project is conducting feasibility studies and demonstration facilities, but is not as close to implementation as wind. Integrated Gasification Combined Cycle (IGCC) new coal plants may achieve up to 55% efficiency, but are not expected to be implemented before 2025 (Howells 1999).

	New gas: Cape Power Project	*Wind energy: Darling*	*New coal: supercritical steam*	*Efficient Lighting Initiative*	*Off-grid solar home systems*
Capacity (MW)	368	5	1 974	1 080 *	17.5
Efficiency assumed	55%	N/a	47%	N/a	N/a
Annual generation (TWh)	2.07	0.00876	10.46	4.00 *	0.02555
Annual fuel use (GJ)		None		None	None
Coal			80 137 473		
Natural Gas	13 528 600				
Carbon intensity (kg C / kWh)	0.100	0.000	0.216	0.000	0.000

* Avoided capacity and generation.

Table 5: Key characteristics of potential CDM projects
Sources: Developed from data in Roggen (2000),Karottki and Banks (2000); Howells (1999), Eskom (2000), Qase (2000)

5. Comparing potential projects to baselines

Having identified a 'near future' reference scenario and potential CDM projects, the performance of each project can now be compared to various baselines and baselines. Table 6 shows how potential CDM projects perform in terms of carbon intensity. Energy intensity is also reported as background information.

	New gas: Cape Power Project	*Wind energy: Darling*	*New coal: supercritical steam*	*Efficient Lighting Initiative*	*Off-grid solar home systems*
Energy intensity	6.546	n/a	7.660	n/a	n/a
Carbon intensity	0.100	0.000	0.216	0.000	0.000

Table 6: Energy intensity (MJ/kWh) and carbon intensity (kg C/kWh) per CDM project

5.1 Decrease in carbon intensity from CDM projects under near future baseline

Table 7 compares the performance of projects against different baselines. It shows by how much the CDM project's intensity *beat* the baseline. A positive number indicates a lower carbon intensity than the baseline; the bigger the number, the better the performance in terms of carbon intensity. Only with positive numbers is the project viable a CDM project.

	Baseline standard	*New gas: Cape Power Project*	*Wind energy: Darling*	*New coal: Super-critical steam*	*Efficient Lighting Initiative*	*Off-grid Solar Home Systems*
Fuel specific	Weighted average	0.000	n/a	0.101	n/a	n/a
	25th percentile	0.000	n/a	0.079	n/a	n/a
	10th percentile	0.000	n/a	0.079	n/a	n/a
	Best plant	0.000	n/a	0.079	n/a	n/a
All fossil	Weighted average	0.170	0.270	0.054	0.270	0.270
	25th percentile	0.028	0.128	-0.088	0.128	0.128
	10th percentile	0.000	0.100	-0.116	0.100	0.100
	Best plant	0.000	0.100	-0.116	0.100	0.100
Sector wide	Weighted average	0.147	0.247	0.031	0.247	0.247
	25th percentile	-0.035	0.065	-0.150	0.065	0.065
	10th percentile	-0.087	0.013	-0.203	0.013	0.013
	Best plant	-0.100	0.000	-0.216	0.000	0.000

Table 7: Decrease in carbon intensity from CDM project against NEAR FUTURE baseline (kg C/kWh)

These results suggest that:

- Fossil fuel CDM projects struggle to beat the baseline if anything other than fossil fuels is included. One can see this trend for new gas and new coal, as one moves from the 'all fossil' to the 'sector-wide' comparison, with the latter including hydro. New coal, for example, beats the benchmark for 25th percentile under 'all fossil', but exceeds it in for with a sector-wide comparison. In short, with a sector-wide comparison, new coal and new gas projects would be less likely to attract CDM investment.
- Renewables do well under most comparisons, except the best plant sector-wide,[12] which compares them to zero-emitting imported hydro. To determine eligibility, renewables in South Africa probably should be compared to the sector, since they might substitute a wide range of electricity sources, not only coal.
- Gas looks best if you compare it to fossil fuels only, since in South Africa, that means mainly coal. The fuel-specific comparison for gas shows zero (equal performance), since units of new gas were included in the baseline, and another, identical unit included as a CDM project. The implication of this choice is that new gas projects would have to do better than ones included in the 'near future' baseline, in order to qualify as CDM projects and gain CERs. Thus assumptions about the type of gas plant that would have been built anyway are critical.
- In a coal-dominated energy economy, the benefit of moving to gas-fired power are significant. However, in terms of the CDM the question is whether gas can be considered 'additional' in South Africa, or whether it would happen for commercial reasons. The broader debate is whether the CDM should be a means to promote gas, given its lower carbon intensity, or whether scarce CDM investment should go to projects which are not financially viable at current prices.

In the South African context, the sector-wide baseline appears to make the most sense, because the actual electricity displaced by these projects will include the coal, gas and hydro-power that would likely come on-line from 2000 to 2005. The CDM projects will not only displace coal power, so that any fossil-fuel projects that want to attract CDM investment have to compete with gas and hydro, as do renewables.

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12 The fuel-specific comparison does not apply, since no fuel is consumed in the sense that fossil fuels are used.

This approach assumes that one is aiming to ensure environmental integrity – that is, that any emissions reductions claimed are real. If the aim were to maximise the number of CERs produced in South Africa, that would imply a different set of choices.

5.2 Comparing 'near future' to 'recent plant' baselines

If the baseline is taken to include the only recent plant (the four Majuba units commissioned from 1996 – 1999), then the carbon intensities are different from the near future baseline. The performance of the CDM projects remains the same, but they are compared to a different baseline of a recent plant.

One should note that, while there are six Majuba units, they are really two sets of three identical units (for the purposes of this analysis). The first three units are dry-cooled and thus assumed to have a slightly lower thermal efficiency (but better water-use efficiency), while unit 4 is wet-cooled (as are units 5 and 6, to be commissioned 2000 - 2001. Given only two sets of units, the values for the 25th percentile, 10th percentile and best plant are the same, as evident in Table 8.

	Baseline standard	*New gas: Cape Power Project*	*Wind energy: Darling*	*New coal: super-critical steam*	*Efficient Lighting Initiative*	*Off-grid solar home systems*
Fuel specific	Weighted average	n/a	n/a	0.085	n/a	n/a
	25th percentile	n/a	n/a	0.079	n/a	n/a
	10th percentile	n/a	n/a	0.079	n/a	n/a
	Best plant	n/a	n/a	0.079	n/a	n/a
All fossil	Weighted average	0.201	0.301	0.085	0.301	0.301
	25th percentile	0.194	0.295	0.079	0.295	0.295
	10th percentile	0.194	0.295	0.079	0.295	0.295
	Best plant	0.194	0.295	0.079	0.295	0.295
Sector wide	Weighted average	0.201	0.301	0.085	0.301	0.301
	25th percentile	0.194	0.295	0.079	0.295	0.295
	10th percentile	0.194	0.295	0.079	0.295	0.295
	Best plant	0.194	0.295	0.079	0.295	0.295

Table 8: Decrease in carbon intensity from CDM project against RECENT PLANT baseline (kg C/kWh)

A comparison between the harder *near future* baseline and the less stringent *recent plant* baseline in Table 8 shows the following:

- CDM projects generally do better with the *recent plant* reference scenario, since the baseline is 'easier to beat', especially in the sector-wide comparison, since this now only includes coal.
- Renewables show small increases, particularly for the weighted average of all fossil-fuel plants; and in all baselines of the sector-wide comparison.
- New coal does better for the weighted average, fuel-specific comparison – this is because the near future baseline includes bringing back moth-balled coal-fired plants, with lower assumed efficiencies. The only recent plant is Majuba, with four units commissioned to date. However, once one expands the comparison to 'all fossil' for the 10th percentile and best plant, new coal switches from negative to positive – that is, against the near future baseline, there would be no project, while the recent plant baseline would accept this for the CDM. This is due to the inclusion of gas in the near future baseline. Sector-wide, the same switch occurs even for the 25th percentile, as now gas and hydro come into play.

The implications of using 'recent plant' in South Africa is to allow credits that probably overstate the 'real' reductions, given the changes expected in the industry. These results support our argument that for South Africa, a baseline looking at near future plants is more effective in ensuring environmental integrity. The additional credits from a less stringent baseline can be quite substantial, as shown in the annual emissions reductions in kilotons of carbon in Table 9. These tables reflect the different size of projects, as well as their carbon intensity.

	Baseline standard	*New gas: Cape Power Project*	*Wind energy: Darling*	*New coal: supercritical steam*	*Efficient Lighting Initiative*	*Off-grid solar home systems*
Fuel specific	Weighted average	none	N/a	1,053	N/a	N/a
	25th percentile	none	N/a	824	N/a	N/a
	10th percentile	none	N/a	824	N/a	N/a
	Best plant	none	N/a	824	N/a	N/a
All fossil	Weighted average	351	2	569	1,081	7
	25th percentile	58	1	none	513	3
	10th percentile	0	1	none	401	3
	Best plant	none	1	none	401	3
Sector wide	Weighted average	303	2	324	987	6
	25th percentile	none	1	none	262	2
	10th percentile	none	0	none	53	0
	Best plant	none	none	none	none	none

Table 9: Carbon reductions by project based on NEAR FUTURE baseline (kilotons C/yr)

Of note in these results are the relatively small absolute carbon reductions for the wind energy and off-grid SHS projects. For wind, this is primarily due to the small size of the project (5 MW). Given the good performance of wind on carbon intensity, this points to the need to scale up renewable energy projects.

If better-than-average benchmarks (e.g. 25th percentile) are applied, the fossil-fuel CDM projects analysed result in no or relatively small carbon reduction for their size. If one wanted to choose between projects, further analysis would need to take into account both the size of projects and the cost of reduction ($/tC).

The carbon reductions were also compared given the recent plant reference scenario. The results are shown in Table 10. Given a 'softer' baseline based on the recent plant, the carbon reductions are generally higher. If, however, a stricter baseline is applied, these emissions would not be credited.

	Baseline standard	*New gas: Cape Power Project*	*Wind energy: Darling*	*New coal: supercritical steam*	*Efficient Lighting Initiative*	*Off-grid solar home systems*
Fuel specific	Weighted average	N/a	N/a	892	N/a	N/a
	25th percentile	N/a	N/a	824	N/a	N/a
	10th percentile	N/a	N/a	824	N/a	N/a
	Best plant	N/a	N/a	824	N/a	N/a
All fossil	Weighted average	415	3	892	1 204	8
	25th percentile	402	3	824	1 178	8
	10th percentile	402	3	824	1 178	8
	Best plant	402	3	824	1 178	8
Sector wide	Weighted average	415	3	892	1 204	8
	25th percentile	402	3	824	1 178	8
	10th percentile	402	3	824	1 178	8
	Best plant	402	3	824	1 178	8

Table 10: Carbon reductions by project based on RECENT PLANT baseline (kilotons C/yr)

5.3 Comparing projects against multi-project and project-specific baselines

Can one compare these results to those from project-based baselines? No complete analysis has been done in this paper, but some illustrative example raise further research issues. One available project-specific analysis is for off-grid solar home systems in a rural concession area (50 000 households). The study found a total of 11 500 tons of avoided CO_2 emissions per annum (Wamukonya & Tyani 1999: 3). Converting to the same target market and to carbon, the equivalent reduction calculated by project-based baseline is 22 kilotons of carbon per year. Under the near future baseline, the range is from 0 to 7 kilotons carbon per year. However, this comparison does not compare equal quantities, in that the multi-project baseline implicitly assumes that electricity is avoided. In reality, rural South African households would tend to use paraffin or candles for lighting (Wamukonya & Tyani 1999). The comparison between project-specific and multi-project baselines requires further analysis.

Another example is an analysis of efficient lighting (Spalding-Fecher *et al* 1999). Converting to equivalent number of compact fluorescent lightbulbs, the study found that 360 ktC/year would be avoided. This is within the range of results in Table 9, from zero to 1 081 ktC, depending on which comparison set and benchmark is used. The fact that this is in the low range is due to different assumptions – the study assumed 3.2 hours of lighting per day, while six hours were used in the present analysis.

The conclusion from these two examples is that assumptions remain critical. Multi-project baselines, being standardised, can conflate many assumptions in a single number. While that single number provides certainty about the benchmark, subjective elements will always remain in gathering information about the CDM project. So multi-project baselines cannot eliminate all subjectivity from the overall process of determining additionality and calculating CERs.

5.4 Avoided emissions

An issue that has not been dealt with thus far is whether baselines deal only with reducing current emissions, or also with avoiding future emissions. Sokona *et al* argue that an exclusive emphasis on emissions reductions disadvantages least developed countries (LDCs), including many African countries. Emissions in these countries can be expected to grow, perhaps even with CDM projects. These countries will be excluded from the CDM 'unless equal attention is given to the possibility of avoiding future emissions through CDM projects in these countries. Avoidance of future emissions matches both the demand of sustainable development and the overall objectives of the Convention' (Sokona, Humphreys & Thomas in Goldemberg 1998: 111). Rather than reducing historical emissions, development paths that avoid emissions *in the future* should be assisted. Allowance should therefore be made for *avoided future emissions*, which is acknowledged in sections of the current negotiating text (UNFCCC 2000: § 64): 'The baseline may include a scenario where future anthropogenic GHG emissions ... are projected to rise above current levels, due to the specific circumstances of the host party'.

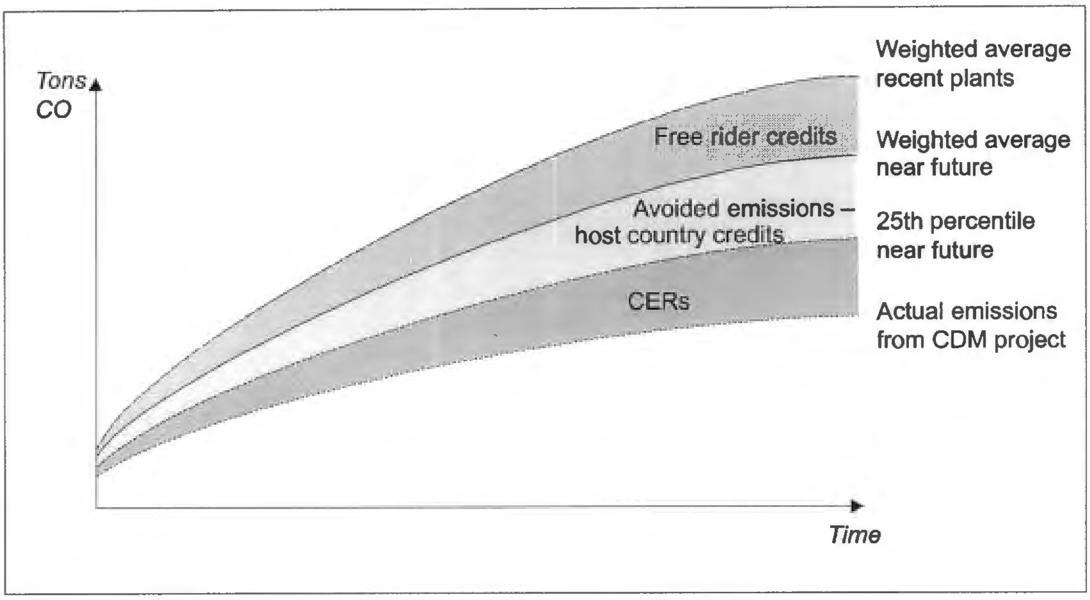

Figure 6: CERs, host country and free-rider credits under different baselines

How can avoided emissions be built into the analysis of baselines? Because this analysis uses a forward-looking baseline, all the reductions from a weighted average near future are our best estimate of the potential future emissions reduction from the CDM project. However, given the uncertainty in baselines, the need to ensure the environmental integrity of the Protocol (particularly during the first commitment period) by minimising free riders,[13] and the importance of ensuring the CDM projects bring cutting edge technology, it makes more sense to only award CERs for some portion of this 'best estimate' of emissions reduction.

Our proposal. therefore, would be to use the better-than-average baseline (in this case 25th percentile performance) for the calculation of CERs, but for the host country to receive credits for the avoided emissions between the better-than-average and weighted average baselines. As long as these credits were not used during the first commitment period, they would not affect the environmental integrity of the Kyoto Protocol. If non-Annex I countries instead bank the credits, this gives them a real stake in emissions reductions. This is illustrated in Figure 6 which compares the areas representing the CERs, avoided emissions credits received by the host country, and free rider credits. Note that if the baseline were set using a backward-looking average of recent plants, this could increase the amount of free rider credits significantly. This is a key reason why using a backward-looking baseline to calculated CERs in South Africa is not recommended.

A possible objection against crediting developing countries with 'avoided emissions' credits is that they may reduce CDM investment (since the benefits returning to investors are diminished). Clearly further research is needed on including avoided emissions in baselines.

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13 Free riders in economic theory are those who benefit from a public good without paying for it. In this case, free riders receive CERs for a business-as-usual project, even though they incurred no additional cost.

6. Conclusion

6.1 'Near future' baseline appropriate for South Africa

The analysis of multi-project baselines for the power generation sector suggests that a backward-looking baseline looking at recent plants is not appropriate in South Africa, because of the small number of recent plants and changes in new, marginal plants. A comparison to recent plants could work in countries where many plants have been constructed, at the margin, in recent years. This is not the case in South Africa, although it may well be true of other developing countries.

Using a 'near future' baseline represents our best estimate of what is likely to happen in the South African power sector. Our analysis is based on the assumption that a separate additionality test would screen out projects that do not meet environmental, financial, investment and technological additionality (UNFCCC 2000). In this case, the danger that a weighted average 'near future' baseline would 'simply be built' and give away many free-rider credits is avoided – such projects are screened out through the additionality test.

If 'recent plant' were to be used in South Africa, one would need to go back some 20 years or so to get a reasonably representative baseline. That would defeat the purpose of 'recent plant' baselines, which is to include marginal, relatively efficient technologies. Any backward-looking baseline, would have to adjust its analysis to take into account technological change – through a factor for autonomous increases in energy efficiency, for example.

Alternatively, if one wanted an observable baseline, one might extend the analysis to a broader region, to include a sufficient number and diversity of recent plants. Regional analysis makes sense where there are grid connections and trading. Future research could look at such an analysis for the Southern African Development Community. For this analysis, we have chosen a baselines looking at six 'near future' plants and units. Since these are future plants, the baseline itself is a projection, determined by the underlying assumptions.

6.2 Balancing investment and environmental integrity

Baselines need to strike a balance between ensuring environmental integrity and attracting CDM investment. Baselines should minimise transaction costs and maximise the number of projects. Two options might be followed by South Africa – to choose a single baseline, or to use different baselines for different projects.

6.2.1 Option A: Choosing a single baseline

Comparing the increasingly strict benchmarks ranging from weighted average, 25th percentile, 10th percentile and best plant. The weighted average, being the 'softest' baseline, allows the largest number of CDM projects to qualify and does reflect the projected mix of the sector. The best plant and 10th percentile benchmarks appear overly restrictive, in that even renewable energy projects show only a marginal improvement in carbon intensity.

The 25th percentile benchmark is an intermediate choice and would still help to provide incentives to introduce advanced technologies. Being a better-than-average benchmark, it reduces the opportunities for free-riders to gain credits. In the 'all fossil' comparison, it allows five projects to qualify. If the comparison is extended to the whole sector, new coal and new gas are excluded.

In the South African context, the sector-wide baseline appears to make the most sense, because the actual electricity displaced by these projects will include the coal, gas and hydro-power that would likely come on line from 2000 to 2005. A single sector-wide benchmark provides a strong incentive to invest in low-carbon technologies. The CDM projects will not only displace coal power. Hence any fossil-fuel projects that want to attract CDM investment have to compete with gas and hydro, as do renewables. More efficient coal plants could still be developed if a weighted average benchmark is used, but the emissions reductions would be relatively small. The crediting of avoided emissions may be a mechanism for assigning some emissions reductions to host countries.

While the purpose of the analysis is to compare baselines, rather than potential CDM projects, we cannot avoid the issue of fossil-fuel CDM projects. New coal would only be eligible under less stringent baselines. The analysis also highlights the debate whether gas can be considered additional in the South African context. This debate turns not so much on technical assessment of carbon intensity, but an assessment of what is financially viable in South Africa currently.

One option for South Africa, based on the analysis in this paper, with all its assumptions, would be to use a sector-wide, 25th percentile baseline for all CDM projects in the electricity generation sector. Another option is to choose different baselines for CDM projects with different attributes.

6.2.2 Option B: Different baselines for different projects

Different CDM projects have specific attributes, and so might be measured against different baselines. One approach is to match projects with the load profile that they would displace. A new super-critical coal plant would be used for baseload, displacing other coal plants. Large new gas plants are also likely to be used for baseload, but can be brought on-line more quickly and hence used for peaking power. Energy efficiency projects displace some average of electricity generation, so that perhaps a weighted average would be appropriate.

Differentiating baselines would allow the test for additionality to be separated from the calculation of CERs. This may be useful, for example, for small-scale renewables and energy efficiency projects. In terms of additionality, these projects could simply be accepted, while their CERs could be calculated against a sector-wide baseline. New coal and gas, by contrast, can be expected to meet a stringent additionality test to qualify for CDM investment, e.g. 10th percentile. However, once such projects have been approved, calculating CERs from a 25th percentile benchmark would make them more attractive to investors, and would also allow some credits to be assigned to the host country.

For this analysis, not enough information was available to explore all the implications of this approach. Further work is required, given that the reference scenario only includes a few near future plants, while load profile are defined in relation to the entire sector, including older plants. On the basis of available information, one might therefore compare new coal and gas to the all-fossil baseline, but use the sector-wide comparison for energy efficiency.

6.3 Choices for South Africa

The advantage of a single baseline is that it is simple, and treats all technologies equally. For the electricity sector, it can include both supply and demand side options. The attraction of different baselines for different CDM projects is that they can more accurately reflect what the project displaces. A single benchmark for the electricity sector is attractively simple. A project-specific approach promises more accuracy in 'getting the reductions right', but has higher costs.

This analysis provides initial thoughts towards constructing such baselines. Hopefully it has made a small contribution to outlining possible policy options for South Africa and their implications. A final decision will require further research and a consultative process of decision-making. Particular areas that require further attention include:

- extending the analysis from South Africa to the entire Southern African Development Community;
- more detailed comparison of multi-project against project-specific baseline, applied to specific projects, which may require additional project-specific studies;
- introducing some dynamics over time to the static analysis presented here;
- considering different types of power stations being displaced, e.g. base-load and peak-load;
- improving data quality, such as coal consumption per power station or unit; and
- considering individual units within power stations, where they differ significantly from one another.

Such research would place South Africa in a better position to choose a baseline methodology. In doing so, it will need to strike a balance between maximising the number of CDM projects and minimising transaction costs on the one hand, and allowing free-riders in the CDM, threatening environmental integrity.

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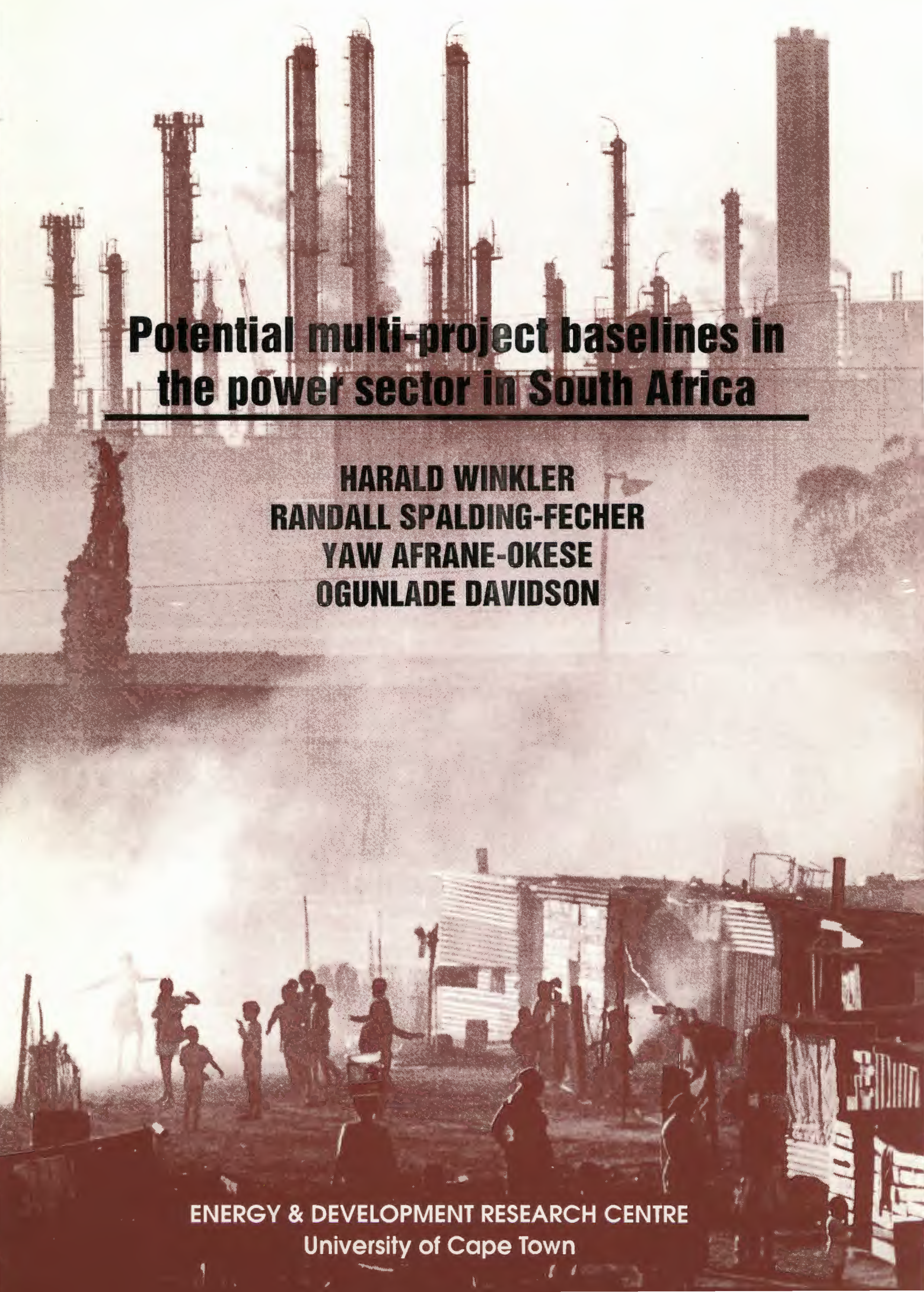

Potential multi-project baselines in the power sector in South Africa

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