Department of Minerals and Energy Pretoria

Capacity Building in Energy Efficiency and Renewable Energy

Report No. 2.3.4-30(B)

MONITORING OF ENERGY EFFICIENCY TARGETS:

Selection of Indicators

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Abbreviations and Acronyms

BEE	Black Economic Empowerment
CaBEERE	Capacity Building in Energy Efficiency and Renewable Energy
CB	Capacity Building
CEF	Central Energy Fund
DANIDA	Danish International Development Assistance
DDG	Deputy Director-General
DEAT	Department of Environmental Affairs and Tourism
DK	Kingdom of Denmark
DKK	Danish Kroner
DME	Department of Minerals and Energy
DTI	Department of Trade and Industry
EE	Energy Efficiency
ESETA	Energy Sector Education Training Authority
FIDIC	International Federation of Consulting Engineers
IDC	Industrial Development Corporation of South Africa
IPM	International Project Manager
NT	National Treasury
NER	National Electricity Regulator
NGO	Non-Governmental Organisation
PDI	Previously Disadvantaged Individual
PM	Project Manager
PQ	Pre-qualification
PSC	Project Steering Committee
PTT	Project Task Team
QA	Quality Assurance
RE	Renewable Energy
RSA	Republic of South Africa
SA	South Africa/South African
SALGA	South African Local Government Association
SANGOCO	South African Non-Governmental Organisations' Committee
SARS	South African Revenue Services
SMME	Small, Medium and Micro Enterprises
SP	Service Provider
ST	Short Term Adviser
TA	Technical Assistance
TOR	Terms of Reference
VAT	Value Added Tax
ZAR	South African Rand

1 Introduction

1.1 Background

Under the Energy Efficiency Strategy of the Republic of South Africa (Department of Minerals and Energy, March 2005) the South African Government set targets for reductions in final energy demand (both overall and sectoral) to be achieved by 2014. Under the auspices of the CaBEERE programme (Capacity Building for Energy Efficiency and Renewable Energy) supported by Danida, IIEC-Africa has been commissioned to design protocols for data gathering and processing that will allow the Department of Minerals and Energy (DME) to monitor progress towards achieving these targets.

A crucial part of monitoring progress towards energy efficiency targets is the identification of the variables that will allow an assessment to be made as to whether targets have been, or will be, met. The monitoring process should also be able to comment on the likely reasons behind the success or failure to meet targets, something for which additional data will be required. The purpose of this paper is to look in more detail at the data requirements for energy efficiency monitoring, to draw up a complete list of required indicators to perform a comprehensive monitoring of energy efficiency progress, to summarise the curernt availability of indicators and to make recommendations regarding the main data gaps.

The rest of this section provides some background information to the process of indicator selection. Sections 2-7 provide 'wish lists' of indicators that would ideally be required to perform a comprehensive monitoring. Section 8 summarises the actual availability of these indicators, including frequency of collection / publication and expected source. Section 8 also provides a brief description of how best to deal with gaps in the data, either by facilitating additional flows of data, or by modifying the methodology to work with the available data.

1.2 Overview of Indicator Selection

There is no unique definition of the energy efficiency of an economy. The most useful working definition is the amount of useful output obtained per unit of energy consumed. Quantifying the 'true' energy efficiency of an economy is virtually impossible in reality, as it would require a detailed examination of every energy-using activity. In practice, sets of indicators are used to characterise energy efficiency, in much the same way as indicators such as blood pressure and weight to height ratio are used to characterise a patient's health.

The indicators that form the basis of a system for monitoring progress towards achieving energy efficiency targets should be able to answer two basic types of question:

- quantitative questions about *whether* targets have been met, the size of any shortfall, the relative contributions of different sub-sectors towards the achievement of (or failure to meet) a sectoral target;
- qualitative questions concerning *why* targets have or haven't been met.

The indicators selected here therefore fall into two categories: 'state' indicators that characterise the current state of energy efficiency (including its rate and direction of change), and 'driving force' indicators that characterise the factors behind the observed trends in energy consumption and energy efficiency, for example the impacts of policy initiatives, or the attitudes of energy consumers towards energy efficiency.

1.2.1 'State' indicators

The theoretical background behind the selection of quantitative indicators is discussed in the accompanying report 'Monitoring of Energy Efficiency Targets: A Theoretical Review'. The paper outlines the reasons for selecting the Log-Mean Divisia Decomposition methodology as the basis for data analysis. The choice of methodology determines to a large extent the type of data required. In general, the 'state' indicators required are the activity level and total energy consumption for each activity analysed. This data is required for both the base year and for the year of analysis.

Activity levels may be quantified either in monetary terms (value-added, or contribution to GDP), or in terms of physical units where appropriate data is available. In general, the use of physical units for quantifying activity is preferable, as this gives a picture of 'true' changes in energy efficiency, independent of any exogenous price effects. Sections 3 - 7 below discuss in more detail the types of activity level indicators appropriate for each sector and sub-sector.

1.2.2 'Driving force' indicators

Knowing whether or not a target has been achieved is of limited usefulness unless there is also an understanding of why the target was or wasn't met. Qualitative information provides policymakers with this understanding, allowing them to adjust the policy environment to better achieve the desired outcomes. The 'driving force' indicators should aim to provide this information.

'Driving force' indicators are more difficult to define, as there is less of a strict theoretical basis for their selection. Furthermore, the information underpinning these indicators is less likely already to exist. In most cases, surveys and questionnaires will be required to provide the necessary information. Because qualitative information is not needed to decide *whether* an energy efficiency target has been met, there is no need to restrict its collection to those sub-sectors and activities for which decomposition techniques are to be applied. In fact, for those sub-sectors and activities that are, for whatever reason, not amenable to decomposition analysis, qualitative data is the only way of gaining an insight into energy efficiency changes.

A number of options exist for the collection of data on 'driving force' indicators. Detailed face-to-face interviews with previously selected and prepared individuals have the potential to yield useful information, but they are time-consuming. It is difficult to envisage sufficient numbers of interviews being conducted in response to the DME's data request event[1] to yield adequate coverage. Questionnaires sent to unprepared individuals are relatively simple and quick, and have the potential to yield some valuable insights from the more spontaneous expressions of opinion that they are likely to elicit. However, the most useful information is only likely to arise from detailed questions, and there is a trade-off between the effort required from the informants and the response rates obtained. Detailed questionnaires may work better if the informants are expecting the questionnaire, are familiar with the purpose of the survey, and have given prior agreement that they will set aside the time to provide a complete response.

1.3 Standard Industrial Classification Codes

The classification of activities within the industrial, transport, commercial and public sectors used in this paper follows the South African Standard Industrial Classification (SIC) system as defined by Statistics South Africa. This system is closely based on the International Standard Industrial Classification system (ISIC) as defined by the United Nations, but whereas ISIC has moved over to the use of an initial letter

[1] A data request from the DME is the event that will trigger the data collection and processing structures and protocols into action. It is envisaged that, in the fully operational system, the data required will flow back within a period not exceeding two weeks.

to signify the highest level classification, the SIC system remains purely numerical. Other minor differences between ISIC and SIC exist, primarily aimed at making SIC more closely suited to the particular characteristics of the South African economy. A full definition of the SIC system, and details of how it differs from ISIC, can be found in '*Standard Industrial Classification of all Economic Activities (SIC): Fifth Edition*' (Statistics South Africa, January 1993)[2].

The levels of the SIC system hierarchy are referred to by the following names:

- Major division (one-digit level)
- Division (two-digit level)
- Major group (three-digit level)
- Group (four-digit level)
- Subgroup (five-digit level)

The five-digit level is seldom used, and is not defined for the majority of groups. Note that the SIC classification is based on outputs, rather than processes. So, for example, an activity such as 'Manufacture of Basic Iron and Steel' features at the three-digit level, but it is not sub-divided further at the four-digit level, despite there being a very wide range of different processes available for iron and steel making.

1.4 Sectoral coverage and depth of disaggregation

The Energy Efficiency Strategy sets an overall economy-wide target as well as sectoral targets for the industrial & mining, commercial & public, residential and transportation sectors. In addition to these targets for final demand reduction, there is also a target to reduce 'parasitic' energy usage in the electricity generation sector[3]. Although no target is set for fossil fuel conversion processes (oil from coal plants and petroleum refineries), these processes are sufficiently energy-intensive that it is felt essential to include them in the monitoring methodology.

A decomposition analysis is clearly necessary at the economy-wide level, to determine whether the economy-wide target has been met. In order to accurately separate out structural effects from the observed changes in economy-wide energy intensity, this analysis must include *all* sectors, not only those for which targets have been set. Hence the economy-wide analysis must include the agricultural sector. However, the economy-wide decomposition analysis should *not* include electricity generation and fossil fuel conversion processes. This is because the Energy Efficiency Strategy targets are expressed in terms of reductions in final energy demand, whereas the the energy consumed in these energy conversion processes is not a component of final energy demand. In the sections below, these processes are therefore considered separately from the end-use sectors.

At the sectoral level, to ensure that 'real' energy efficiency changes are separated out from structural and activity effects, decomposition analyses must be conducted for the industrial & mining, commercial & public, residential and transportation sectors. These sectoral decomposition analyses require the disaggregation of each sector into sub-sectors, to permit the identification of structural shifts within the sector under analysis. For the industrial sector, the most useful disaggregation is into the seven main energy-using sub-sectors plus an eighth sub-sector consisting of 'other industrial'. The transportation

2 Downloadable from the Statistics South Africa web-site at: http://www.statssa.gov.za/additional_services/code_lists.asp

3 Parasitic usage in this context is defined as energy usage anywhere except in turbines, generators and immediate ancilliary equipment. It includes energy used for pumps and compressors and for HVAC within power plants.

sector can be conveniently disaggregated into freight versus passenger and road versus rail. Data availability largely dictates the possiblities for dissagregating the commercial & public sector, although the distinct energy usage patterns of the wholesale and retail sub-sector mean that it should constitute one of the disaggregated sub-sectors. The residential sector presents particular difficulties that are discussed in an accompanying paper[4] and also in Section 5 below.

Beyond the sectoral level, certain industrial sub-sectors and individual industries are sufficiently significant users of energy that it is considered desirable (subject to data availability) to analyse their energy consumption further. The level to which different branches of the economy are disaggregated is determined according to three main criteria:

- How important a contribution does that branch make to overall energy consumption?
- How much useful information could be gained by disaggregating the branch further?
- How likely is it that the data required for further disaggregation is available?

The sub-sectors where this additional analysis is recommended are iron & steel, mining & quarrying, chemicals & petrochemicals and non-ferrous metals. Pulp & paper is not included for further analysis because, although it is a very significant consumer of energy, very little useful information could be gained by further analysis. Furthermore, the structure of the sub-sector is such that issues of data confidentiality may prove problematic. The non-metallic minerals sub-sector is dominated from an energy perspective by cement manufacture so, again, there is little to be learned from further analysis. The construction sub-sector is likely to prove very difficult to analyse in any greater depth because of the likely unavailability of sufficiently detailed data on energy consumption. Other industrial sub-sectors are considered too small to be worth the effort of further analysis.

In some cases, this more detailed analysis could take the form of a decomposition of energy intensity changes into their component parts, following the same approach taken at the sectoral and economy-wide level. However, in most cases, the data requirements for conducting a decomposition analysis at this level of detail are likely to prove impossible.

4 ‘Energy Efficiency Monitoring of Targets: A Theoretical Review’

2 Decomposition at the Economy-Wide Level

The highest level of decomposition attempts to break down changes in the total energy consumption of the economy into their constituent factors. In order to separate out structural effects from the observed changes in energy intensity, disaggregation into sectors in necessary. Five main sectors are used for this disaggregation: industry, agriculture, commercial / public, transport and residential. Note that, for the purposes of performing a top-level decomposition, the agricultural sector needs to be included in order to derive a complete picture of structural changes, even though this sector does not have a sectoral level target established.

The data requirements for this decomposition are as follows (note that all data is required both for the base year and for the year of analysis):

- Total economy-wide GDP
- Total final energy consumption

Sector contribution to GDP for:

  - Industrial sector
  - Agricultural sector
  - Commercial / public sector
  - Transport sector

Final energy consumption for:

  - Industrial sector
  - Agricultural sector
  - Commercial / public sector
  - Transport sector
  - Residential sector

- Number of households

The data for value-added should be corrected for purchasing power parity (PPP), to ensure that changes in value-added correspond to real changes in the production of the sector in question.

3 Industrial Sector

For the purposes of this analysis, the industrial sector is interpreted as consisting of SIC Major Divisions 2 (mining and quarrying), 3 (manufacturing) and 5 (construction). Since a sector-level target for final demand reduction is set for this sector in the Draft Energy Efficiency Strategy, a sector-level decomposition of the industry sector is necessary to separate out the effects of underlying structural changes from the effects of energy intensity changes. The data requirements for this sector-level decomposition are discussed in Section 3.1 below.

Some industry sub-sectors are sufficiently significant in terms of their energy consumption that further detailed analysis is desirable, subject to the availability of suitable data. The sub-sectors of interest are iron & steel, mining & quarrying, chemicals & petrochemicals and non-ferrous metals. For these sub-sectors, quantitative data is required in order to perform an additional stage of decomposition. To gain an insight into the factors driving changes in energy efficiency, 'driving force' indicators based on more qualitative data are required for all industrial sub-sectors.

3.1 Sector level decomposition

To perform a sector-level decomposition, the sector is disaggregated into the following seven sub-sectors, which represent the most important energy consumers in the industrial sector:

- Mining & quarrying (SIC Major Division 2)
- Manufacture of iron & steel (SIC Major Group 351)
- Manufacture of precious and non-ferrous metals (SIC Major Group 352)
- Chemicals production (SIC Division 33)
- Manufacture of paper and paper products (SIC Major Group 323)
- Manufacture of non-metallic mineral products (SIC Division 34)
- Construction (SIC Major Division 5)

An eighth category is defined as containing all other industrial activities. Note that, in the official energy balance statistics, most of the energy consumption of the pulp & paper industry is included in the category termed 'Non-specified'. This category accounts for all the industrial sector activities that, for one reason or another, cannot be identified precisely. However, data from other sources on the pulp & paper industry in South Africa[5] confirms the important role it plays in industrial sector energy consumption, placing it third in importance after iron & steel and mining.

It is likely that a large proportion of the remaining 'Non-specified' energy consumption in the industrial sector is accounted for by food processing[6]. However, much of this food processing takes place on a very small scale across a large number of small and micro-enterprises. It is therefore likely to prove very difficult to gain detailed insights into the factors driving changes in energy consumption from such a diverse sub-sector. For this reason, detailed analysis of the sub-sector is not recommended at this stage.

Table 1 below shows the shares of industry sector energy consumption accounted for by the sub-sectors identified above. Between them, these seven sub-sectors account for about 72% of the electricity consumed in the industry sector, about 83% of the coal (excluding non-energy feedstock use) and about

5 See for example DME / Eskom 'Energy Outlook for South Africa 2002'.

6 See for example Trikam A.; 'Greenhouse gas mitigation options in the industrial sector'. Energy Research Institute, University of Cape Town (2001).

42% of the petroleum products. Overall, these seven sectors account for about 79% of industry sector energy consumption. This disaggregation can therefore be expected to give a reasonably clear picture of the impact of structural effects on industry sector energy consumption.

Table 1 Share of industry sector energy consumption by sub-sector[7]

	Share of industry sector total			
	Energy (excl. feedstock)	**Coal (excl. feedstock)**	**Petroleum products**	**Electricity**
Iron & steel	29%	41%	0%	19%
Mining & quarrying	18%	9%	26%	29%
Pulp & paper	12%	12%	0%	7%
Chemicals & petrochemicals	8%	13%	0%	2%
Non-ferrous metals	6%	0%	0%	14%
Non-metallic minerals	5%	8%	0%	1%
Construction	1%	0%	16%	0%
Other / non-specified	21%	17%	58%	28%

For the mining & quarrying and the pulp & paper sub-sectors, there are indicators based on physical units that provide a relatively good indication of the sub-sectoral activity level. For the other sub-sectors, monetary-based units must be used for activity levels. The data requirements for the industry sector decomposition are therefore as follows (note that all data is required both for the base year and for the year of analysis):

- Mining & quarrying:
  - total value-added
  - total tonnage of material extracted
  - total energy consumption
- Pulp & paper
  - total value-added
  - total tonnage of pulp processed
  - total energy consumption
- All other sub-sectors:
  - total value added in the sub-sector
  - total energy consumption by the sub-sector

The value-added and energy consumption for the eighth category ('other industrial') can be derived simply by subtracting the values for the other seven sub-sectors from the corresponding sectoral totals.

7 The figures in this table are approximate estimates, synthesised from IEA Energy Balance data and the DME / Eskom 'Energy Outlook for South Africa 2002'.

3.2 Qualitative indicators

The types of qualitative data needed to provide 'driving force' indicators for the industrial sector are similar across all sub-sectors. It is expected that this data will be collected through surveys, conducted either face-to-face or by telephone and e-mail, of a sample of industrial enterprises. The types of information sought include:

- the approximate fraction of total operating costs accounted for by energy
- an assessment of the extent to which energy savings have been a significant factor driving investment decisions
- the informant's estimate of the potential for energy saving investments (if possible broken down according to payback period)
- the informant's perception of what have been, and are likely to be, the most important factors driving improvements in energy efficiency (e.g. energy prices, regulation, energy efficiency improvements as an incidental by-product of other improvements)

3.3 Major industrial sub-sectors

3.3.1 Iron and steel

The iron and steel industry is the most important user of energy in the industrial sector, accounting for approximately 19% of the sector's electricity consumption, and 41% of its coal consumption. The industry is fairly complex in structure, producing a wide range of different products and utilising many alternative processes. These facts suggest that there is much to be learned by performing a decomposition of the total industry-level energy consumption.

The products produced by the iron and steel industry are diverse and, although by far the greatest share of the production consists of plain carbon steel, a wide range of alloy steels and special steels are produced in smaller volumes. These alloy steels and special steels are higher value-added products than ordinary carbon steels, so a structural shift towards their production would, all else being equal, result in the energy intensity of the industry decreasing. A decomposition of industry-wide energy consumption based on a disaggregation by product type may therefore yield useful information on the significance of such structural shift. However, such a decomposition is possible only if steel-makers maintain separate data on the energy consumed in the manufacture of speciality steels.

The energy consumption of the iron and steel industry is strongly influenced by the technology used for iron-making (e.g. Corex[8] versus conventional blast furnace), and for steel-making (electric arc furnace versus basic oxygen furnace). The energy intensity of steel-making processes is further influenced by the scrap utilisation rate, which in turn is affected by the price and availability of scrap. The situation is further complicated by the fact that steel scrap is internationally traded, so sector-wide steel production is not directly related to the total amount of hot-metal produced by the various iron-making processes.

The complexity of the iron and steel industry makes it very difficult to devise a means of decomposing total energy consumption according to the process involved, as in most cases these processes are not direct substitutes for one another. One possible type of analysis to conduct would be to consider iron-making only. The total energy consumed in iron-making can then be decomposed according to the iron-

[8] Because South Africa's coal is unsuitable for coking, the Corex process is particularly attractive as it used coal directly, without the need for coking. It is less energy intensive than conventional blast furnace iron-making, but only if the highly calorific off-gas is fully utilised. For the purposes of this project, it is essential that the energy consumption in Corex plants is calculated as a net value (i.e. full credit should be given for any useful energy exported from the process).

making process employed. This will provide an indication of the relative importance of efficiency improvements at the process level versus energy savings resulting from greater adoption of inherently less energy-intensive processes.

Quantitative Indicators

The following quantitative indicators are proposed for this industry:

For steel-making:

- production of carbon steels
- energy consumption in carbon steel production
- value-added in carbon steel production
- production of special and alloy steels
- energy consumption in special and alloy steel production
- value-added in special and alloy steel production

For iron-making:

- industry total iron production
- industry total energy consumed in iron-making
- iron production in blast furnaces
- energy consumption in blast furnaces
- iron production in Corex process
- energy consumption in Corex process
- iron production in other processes
- energy consumption in other processes

The major players in the iron and steel industry are Ispat Iscor, Highveld Steel, Cape Gate, Cisco, Columbus and Scaw Metals. The first two firms operate iron-making plant as well as steel-making furnaces, while the four smaller firms operate electric arc furnaces to produce steel products from scrap. All of these firms are proposed as informants for the collection of qualitative indicators on the factors influencing energy consumption.

3.3.2 Mining and quarrying

Mining & quarrying account for 29% of the electricity consumed by the industrial sector, and 26% of the consumption of petroleum products (not including non-energy feedstocks). Overall, this sub-sector is the second most significant consumer of energy in the industrial sector, and therefore merits closer examination. The most significant activities into which the sub-sector can be further disaggregated are gold mining (SIC Division 23), mining of platinum group metals (SIC Group 2424), diamond mining (SIC Major Group 252) and coal mining (SIC Division 21). The sub-sector may therefore be disaggregated into five parts, consisting of these four activities plus a fifth category of ‘other mining & quarrying’.

The real measure of how efficiently, or otherwise, the mining and quarrying sector is functioning is to look at the energy consumed per tonne of material extracted (including any preliminary processing that

is considered by SIC to be part of the mining operation)[9]. The tonnage of material extracted therefore provides a convenient common physical unit for all the activities considered. Using this measure of activity across the whole sub-sector means that changes in the sub-sectoral structure can be described and quantified without reference to value-added.

The following quantitative indicators are proposed for this sub-sector:

- sub-sector total tonnes of material extracted
- sub-sector total energy consumption
- gold mining tonnes of ore extracted
- gold mining energy consumption
- PGM mining tonnes of ore extracted
- PGM mining energy consumption
- diamond mining tonnes of ore extracted
- diamond mining energy consumption
- coal mining tonnes of production
- coal mining energy consumption

All of South Africa's mining industries are prone to frequent restructurings, mergers and acquisitions. The major players in the South African mining sub-sector are currently as follows:

Gold: Anglo Gold; Gold Fields; Harmony; Durban Roodepoort Deep

PGM: Anglo Platinum; Impala Platinum; Lonmin Platinum; Northam Platinum; Aquarius Platinum

Diamonds: De Beers; Trans Hex; Southern Era

Coal: Anglo Coal; Ingwe; Xstrata; Eyesizwe

All of these firms are proposed as informants for the collection of qualitative data on the factors driving changes in energy efficiency.

3.3.3 Pulp and Paper

The pulp and paper industry in South Africa accounts for about 12% of industry sector energy consumption, and the same fraction of sectoral coal consumption. It is less significant as a counsumer of electricity, accounting for only 7% of the sectoral total. Its consumption of petroleum products is negligible. Although not figuring in the official energy balance statistics, the pulp and paper industry also derives significant amounts of energy (over 30% of its total requirements) from biomass waste. This takes the form of either bark stripped from incoming logs, or concentrated 'black liquor' residue from the pulping process. This biomass waste is used to provide process heat and electric power in pulp mills.

Although energy consumption in the form of biomass waste in the pulp & paper sub-sector is not included in the energy balance table, it is recommended here that this energy should be taken into account when quantifying the total energy consumption of the sub-sector for the purposes of energy

[9] The Mining and Quarrying major division includes…"supplementary activities aimed at preparing the crude materials for marketing, for example, crushing, grinding, cleaning, drying, sorting, concentrating ores, liquefaction of natural gas and agglomeration of solid fuels." (http://unstats.un.org/unsd/cr/registry/regcs.asp?Cl=17&Lg=1&Co=C)

efficiency monitoring. This biomass energy could potentially constitute a valuable source of renewable energy for external use in the future, so improvements in the efficiency with which it is used should be considered just as desirable as any other energy efficiency improvements.

The pulp and paper industry produces a very diverse range of products, using a variety of processes. The most energy-intensive single process is the production of pulp. Since the pulp production process is common to all products, the total tonnage of pulp produced represents a convenient physical indicator for the level of activity in the sub-sector as a whole.

The pulp and paper industry in South Africa is dominated by two major players: Sappi and Mondi. A number of smaller firms operate downstream packaging and paper recycling plant, but these are relatively insignificant from an energy perspective. For quantitative and qualitative data, Sappi and Mondi are therefore proposed as informants.

3.3.4 Chemicals and petrochemicals

The chemical and petrochemical sub-sector is a very significant consumer of coal, through Sasol's coal to oil plants. However, only one third of the coal consumed in these plants is used for its energy content – the remainder is a chemical feedstock. Considering only coal consumed for its energy content, the chemical and petrochemical sub-sector accounts for about 13% of the total industry sector coal consumption. Its share of industry sector electricity consumption is only about 2%.

The South African chemicals sub-sector is dominated by three major players: Sasol Chemical Industries, AECI and Dow Sentrachem. These firms are particularly dominant in the base and intermediate chemicals industries, which constitute the most significant part of the sub-sector from an energy perspective. In the chemical end-products and speciality chemicals industries, a more diverse range of firms are active. However, these industries comprise less energy-intensive, higher value-added activities, and are therefore less significant from the perspective of energy consumption.

The chemicals sub-sector is very complex, comprising many interconnected material and energy flows, and a diverse range of products ranging from basic chemicals such as ethylene and ammonia to sophisticated, high value-added products such as pharmaceuticals. Many processes produce more than one product, and the synthesis of one product may involve several processes, some of which are endothermic and some exothermic. Given this complexity and diversity, it is difficult to envisage how an informative decomposition of the total energy consumption of the sub-sector could be carried out. For this reason, although this sub-sector a significant consumer of energy, a full decomposition analysis is not recommended at this stage.

The manufacture of certain base chemicals dominates the sub-sector in terms of energy consumption. The most important are ethylene and its co-products[10], methanol, ammonia and chlorine. Although exact figures are not available for South Africa, production of these chemicals typically accounts for almost half of the energy consumption of the chemicals sub-sector. To provide additional information about energy intensity trends in this sub-sector in the absence of a full decomposition analysis, it is recommended that the energy intensity of production of these products is tracked. The indicators required are therefore:

- total production of ethylene
- total energy consumed in the manufacture of ethylene
- total production of methanol

[10] The steam cracking of hydrocarbon feedstocks to produce ethylene also produces propylene, butadiene, benzene, toluene and xylenes. The relative proportions of these products are determined by the type of feedstock used and the use of catalysts.

- total energy consumed in the manufacture of methanol
- total production of chlorine
- total energy consumed in the manufacture of chlorine
- total production of ammonia
- total energy consumed in the manufacture of ammonia

3.3.5 Non-ferrous metals

Although the non-ferrous metals sub-sector accounts for only about 6% of overall industry sector energy consumption (its consumption of coal and petroleum products is negligible), it is such a significant consumer of electricity that it merits closer study. About 15% of the total industrial sector electricity consumption is accounted for by non-ferrous metals production.

The most important activites from the point of view of energy consumption are the production of aluminium and titanium (in the form of titania slag[11]). Between them, these activities account for about 85% of the energy consumption by the non-ferrous metals sub-sector. South Africa's production of aluminium is accounted for entirely by two smelters at Richards Bay, operated by BHP Billiton. Titanium production is dominated by Richards Bay Minerals, with Namakwa Sands and Ticor also very significant producers.

In addition to the firms mentioned above, producers of other energy-intensive non-ferrous metals are suggested as informants for the collection of quantitative and qualitative data on energy intensity and the factors driving changes in energy efficiency. Three firms are responsible for South Africa's vanadium production: Highveld Steel and Vanadium; Xstrata and Vametco. Zinc production is currently domniated by Zinc Corporation of South Africa (Zincor), while the leading producers of manganese and chromium are Samancor and Xstrata.

The quantitative indicators suggested for the non-ferrous metals sub-sector are as follows:

- tonnes of aluminium produced
- energy consumed in aluminium production
- value-added in aluminium production
- tonnes of titania slag produced
- energy consumed in titania slag production
- value-added in titanium production
- tonnes of vanadium pentoxide produced[12]
- energy consumed in vanadium pentoxide production
- value-added in vanadium production
- tonnes of zinc produced

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[11] Although South Africa does not produce metallic titanium, the production of titania slag is nevertheless classified as non-ferrous metals production according to the SIC system.

[12] Much of South Africa's vanadium production is sold as vanadium pentoxide, while some is processed further into ferrovanadium. However, the production of vanadium pentoxide is a universal intermediate stage regardless of the final product, so this product represents a convenient indicator for the level of activity in the vanadium industry.

- energy consumed in zinc production
- value-added in zinc production

3.3.6 Non-metallic minerals

Over three-quarters of the non-metallic minerals sub-sector's energy consumption is in the form of coal, with about 14% accounted for by gas and the remaining 10% as electricity. From an energy perspective, the sub-sector is dominated by the manufacture of cement, which relies very heavily on coal as its main energy source. The strong dominance of cement combined with the relatively diverse nature of other activities in this sub-sector mean that a decomposition analysis is likely to prove both difficult and uninformative. Four firms account for virtually all of the cement production in South Africa: PPC Cement, Lafarge, Alpha and Natal Portland Cement. These four firms are suggested as informants for the collection of both qualitative indicators

3.3.7 Construction

Although the construction sub-sector is significant in terms of its consumption of petroleum products (about 16% of the industrial sector total), it's share of overall industrial sector energy consumption is only marginally above 1%. It is difficult to envisage a way of disaggregating the sub-sector in a way that would allow an insightful decomposition analysis to be performed. For this reason, decomposition analysis of the construction sub-sector is not recommended.

The construction sector is characterised by a very large number of enterprises, most of which are small. Mbendi, a leading source of information on business in South Africa, lists 148 construction companies, but given that the sector as a whole is estimated to employ about 260,000 people, there are probably many thousands of micro-enterprises and sole traders active in construction. For information on energy consumption and attitudes to energy efficiency, it is impractical to approach any but the largest civil engineering and construction firms. Industry associations may also prove useful sources of information.

4 Commercial / Public Sector

4.1 Introduction

This sector includes SIC Major Divisions 6 (Wholesale and retail trade; repair of motor vehicles and household goods; hotels and restaurants), 8 (Financial intermediation, insurance, real estate and business services) and 9 (Community, social and personal services). The main constraint on performing an analysis of the commercial / public sector is likely to be the non-availability of reliable disaggregated data on energy consumption. Lack of such data will limit the extent to which structural effects can be identified, effects which may be significant explanatory factors for changes in overall sectoral energy consumption.

As outlined in the accompanying paper 'Energy Efficiency Monitoring of Targets – A Theoretical Background', the floor area in use represents a convenient indicator for the level of activity in the commercial / public sector. The main energy-consuming activities in this sector are lighting and HVAC (heating, ventilation and air-conditioning) both of which are likely to correlate more closely with floor area than with other indicators such as number of employees. The exception to this is the hotel industry, where the key indicator of activity is the floor area of the rooms actually let (as opposed to the total floor area available).

In food wholesale and retailing, refrigeration is also likely to be a significant energy consumer. A relative increase in the importance of this sub-sector would therefore manifest itself as an increase in the total sectoral energy consumption. The analysis proposed here should correctly identify such a change as a structural shift rather than a change in energy efficiency.

4.2 Quantitative Indicators

The following quantitative indicators are suggested for this sector:

- sector total floor area in use
- sector total energy consumption
- floor area used for wholesale and retail trade
- energy consumption by wholesale and retail trade
- floor area used for education
- energy consumption by education
- floor area used for health-care
- energy consumption by health-care
- floor area used for hospitality
- energy consumption by hospitality
- floor area used for public administration
- energy consumption by public administration

4.3 Qualitative Indicators

The qualitative indicators required to give a picture of the driving forces behind energy efficiency changes in the commercial / public sector are broadly similar to those that were described above for the industrial sector. The types of information sought include:

- the approximate fraction of total operating costs accounted for by energy
- an assessment of the extent to which energy savings have been a significant factor driving investment decisions
- the informant's estimate of the potential for energy saving investments (if possible broken down according to payback period)
- the informant's perception of what have been, and are likely to be, the most important factors driving improvements in energy efficiency (e.g. energy prices, regulation, energy efficiency improvements as an incidental by-product of other improvements)

As was the case in the industrial sector, this information must be obtained by means of surveys of a cross-section of commercial enterprises and public sector bodies.

5 Residential Sector

5.1 Introduction

The residential sector requires a somewhat different treatment from the economically productive sectors. As discussed in the paper 'Monitoring of Energy Efficiency Targets: A Theoretical Review', two potentially useful ways of decomposing residential sector energy consumption are: (i) according to lifestyle, using the LSM stratification; (ii) considering ownership levels and specific energy consumption figures for appliances. These two approaches are not entirely independent of each other, since the criteria that determine into which LSM bracket a given household falls include ownership levels of certain electrical appliances.

The LSM approach may prove problematic because the definitions of LSMs are revised periodically. The number of LSM brackets was recently increased from eight to ten, and the list of criteria by which LSMs are determined is continually updated. A further drawback of this approach is that the information of relevance to this analysis, namely information on energy usage, would be 'diluted' by the presence of many non-energy related variables used in the LSM definition. However, data availability is good, and SAARF (South African Advertising Research Foundation – the organisation responsible for the research behind LSMs) have indicated that there may be a possibility of including extra questions relating to energy usage in future surveys.

A decomposition based on appliance ownership level splits changes in total energy consumption into four factors: (i) population effect (number of households); (ii) ownership level of energy-using appliances; (iii) specific energy consumption of energy-using appliances (measured in energy per standard unit of usage); (iv) usage levels of energy-using appliances. The last of these factors is likely to be very difficult to determine, even if detailed household surveys are conducted. In practice therefore, the first three factors would be evaluated, and the contribution due to the fourth factor would be assumed to be equal to the portion of the total change in energy consumption not explained by the first three factors.

The second factor, ownership levels of appliances, needs further elaboration. For refrigerators, freezers, washing machines and electric lamps, the data required is simply the average number of each appliance per household. However, for some energy end-uses, analysis is simpler if this factor is defined as the fraction of households who carry out the activity in question. For cooking and water heating, this can then be assumed to be 100%, while for space heating, data on the fraction of households who use space heating would be required.

Using this approach, the specific energy consumption for cooking, water heating and space heating would then depend purely on the characteristics of the technology used, but not on the usage patterns and other behavioural characteristics of the household. For space heating, specific energy consumption depends on the characteristics of the dwelling, but not on factors such as indoor temperature or building occupancy rates (which are behavioural quantities, and are therefore subsumed into the usage level factor). For cooking and water heating, specific energy consumption would be dependent on the fuel-technology combination used. It would be defined as the amount of energy required to deliver a given level of energy service for that particular combination of fuel amd technology under normal usage.

For cooking, water heating and space heating, standardised algorithms would need to be derived for calculating specific energy consumption for each particular fuel-technology combination. The detailed derivation of these algorithms requires further research and is beyond the scope of this report. However, the parameters on which specific energy consumption depends are listed in Table 2 for each application. For electric lamps, the wattage of the lamp can be used as the indicator for specific energy consumption. For electric household appliances, (refrigerators, freezers, washing machines) the nameplate rating of

the appliance would be used in the first instance. Ultimately, a more accurate solution would be to derive a look-up table that would translate the make, model and age of an appliance into a specific energy consumption figure.

Table 2 Parameters for the calculation of specific energy consumption

Cooking	fuel and technology used
Water heating	fuel and technology used; amount of insulation (geysers only)
Space heating	floor area of dwelling; construction material of walls; construction material of roof; window area; amount of insulation; geographical location

5.2 Quantitative Indicators

For a decomposition based on a disaggregation into LSMs, the data requirements are as follows:

- total number of households
- number of households in each LSM category
- total energy consumption of each LSM category

For a decomposition according to appliance ownership and specific energy consumption, the data requirements are as follows:

- total number of households
- average number of households using space heating
- specific energy consumption per household using space heating
- specific energy consumption per household for cooking
- specific energy consumption per household for water heating
- average number of electric lamps per household
- average wattage of lamps in use
- fraction of households owning and using a refrigerator
- specific energy consumption of refrigerators in use
- fraction of households owning and using a washing machine
- specific energy consumption of washing machines in use
- fraction of households owning and using a deep freezer
- specific energy consumption of deep freezers in use

Other energy-using activities are considered at present to be insignificant in terms of total energy consumption. However, these activities can be added into the analysis at a later date as energy usage patterns in South Africa's households evolve.

5.3 'Driving force' indicators

The types of qualitative indicator that will provide an insight into the factors driving energy efficiency improvements in households will need to be collected using household surveys, where householders themselves are questioned directly (either face-to-face or through questionnaires). Since it is envisaged that such surveys will be necessary for collecting much of the quantitative data required, the additional level of effort involved in gathering qualitative data at the same time is relatively modest.

The indicators sought relate to the following factors:

- rate of turnover of appliance stock
- the extent to which householders are aware of their energy costs
- householders' understanding of where energy is used and what can be done to reduce usage
- consideration of energy efficiency as a criterion when purchasing domestic appliances

6 Transport Sector

6.1 Introduction

The transport sector (SIC Major Division 7) accounts for 26% of South Africa's total final energy consumption. From an energy perspective, road transport is strongly dominant, accounting for 85% of the sectoral total energy consumption. Rail transport accounts for only about 3% of the total transport sector energy consumption, but over three-quarters of the sector's electricity consumption. Virtually all of the remainder is accounted for by air transport, with water transport and pipelines being negligible.

For the purposes of the decomposition analysis proposed here, the sector can be conveniently divided into freight and passenger sub-sectors. The aim of the analysis is to separate out the effects on total energy consumption of efficiency improvements, modal shifts and total activity. The analysis of modal shifts provides information about the energy impact of alternative ways of meeting the same transportation service. For this reason, international air transport is omitted from this analysis, as it provides a fundamentally different service from road or rail transport, and is not a direct substitute. However, domestic air transport is included, as it can be considered a substitute for at least part of the road and rail transportation service.

6.2 Passenger transport

For passenger transport, the obvious choice of indicator for activity levels is passenger-km. Of particular interest is the extent to which changes in total energy consumption by passenger transportation is due to changes in total passenger-km travelled, to changes in the efficiency of the transport technologies in use and to changes in the relative shares of different modes of transport. Subject to data availability, it is suggested here that the modes considered should be: private car; bus / minibus; suburban rail; inter-city rail; domestic air transport.

6.2.1 Quantitative Indicators

The following quantitative indicators are proposed for the passenger transport sub-sector:

- total passenger-km covered
- total energy consumption in passenger transportation
- passenger-km covered by private car
- energy consumption by private cars
- passenger-km covered by bus / minibus
- energy consumption by bus / minibus
- passenger-km covered by urban rail
- energy consumption by urban rail
- passenger-km covered by inter-city rail
- energy consumption by inter-city rail
- passenger-km covered by domestic air transport
- energy consumption by domestic flights

6.2.2 'Driving force' indicators

Driving force indicators for the passenger transport sub-sector fall into two main categories: those connected with the characteristics of the vehicle fleet, and those that relate to the attitudes and behaviour of those operating vehicles. In both cases, these indicators are likely to be most relevant for road-based passenger transport modes. Indicators in the first category would include:

- average fuel efficiency of new vehicles sold
- average age of current vehicle stock

To provide a more complete picture, data would also be required on scapping rates of vehicles according to age and vehicle type. However, this information is unlikely to be available in a sufficiently detailed or comprehensive form to be useful for this analysis.

Driving force indicators in the second category would be obtained from surveys of vehicle operators. In the case of private cars, the types of question asked would be similar to those proposed for the residential sector, namely questions relating to drivers' awareness of their fuel consumption and of behavioural changes that might affect fuel consumption. For commercial passenger transport modes, the major carriers would be approached as informants. The large but very diverse minibus-taxi industry is likely to prove intractable in this respect.

6.3 Freight transport

The preferred indicator of activity level for freight transport is tonne-km. Freight transport modes considered are road, rail and domestic air freight.

6.3.1 Quantitative Indicators

The following quantitative indicators are proposed for the freight transport sub-sector:

- total tonne-km transported
- total energy consumption in freight transportation
- tonne-km transported by road
- energy consumption by road freight
- tonne-km transported by rail
- energy consumption by rail freight
- tonne-km transported by domestic air freight
- energy consumption by domestic air freight

6.3.2 'Driving force' indicators

As was the case for the passenger transport sub-sector, most of the driving force indicators in freight transport are more relevant for road-based modes. Collection of this data will be through surveys of a cross-section of haulage companies. The types of indicator sought include:

- fraction of total costs accounted for by fuel
- average age of vehicle fleet
- perceived importance of energy efficiency as a driving force behind investment decisions (e.g. how does fuel consumption rank among the criteria used when procuring new vehicles)

- extent to which drivers are trained in, or are aware of, the relationship between driving behaviour and fuel consumption.

7 Energy Conversion Processes

7.1 Electricity generation

The Energy Efficiency Strategy sets a target for reducing ‘parasitic’ losses in electricity generation by 15% by 2015. It is to be assumed that this target implies a 15% reduction per unit of power produced – in other words, the effect of activity level changes has to be separated out, as is the case in the other sectors analysed. However, in the case of parasitic losses in power generation, there is no analogous structural effect. The data requirements for this sector are therefore straightforward, with the following indicators required:

- total electricity production
- total parasitic losses

7.2 Fossil fuel conversion

Although the Energy Efficiency Strategy does not specify a target for reducing energy losses in fossil fuel conversion[13], preliminary discussions between DME and Sasol indicated that there was an expectation that the strategy targets would implicitly cover these activities[14]. However, since the energy consumed in fossil fuel conversion processes is not usually treated as part of the industry sector energy consumption in energy balance tables, it is more convenient for the purposes of monitoring energy efficiency to separate out fossil fuel conversion from other industry sector activities. This being the case, it can be assumed that the target for the fossil fuel conversion sector is the same as that for the industry sector, namely a 15% reduction in energy demand by 2015.

It should be noted that, in Sasol’s ‘Sustainability Report’, which provides detailed information on energy usage, the coal that forms the input into their synfuel operations is reported as a material usage, rather than as an energy input. However, since this process is one of converting one energy carrier to another, it is recommended that the coal input into synfuel processes be considered an energy input.

The data requirements for monitoring the energy lossses in fossil fuel conversion are therefore straightforward. The indicators required are:

- energy content of inputs into synfuel processes
- other energy consumption at synfuel plants
- energy content of products from synfuel processes
- energy consumption by crude oil refineries
- energy content of products from crude oil refineries

13 The targets are expressed in terms of energy end-use, and therefore do not explicitly cover energy conversion processes.

14 Sasol representatives who attended the Stakeholder Workshop in April 2005 confirmed that their understanding was that the strategy targets would indeed apply to Sasol’s fuel conversion processes. However, for the purposes of monitoring, these processes must be treated separately from the petrochemical industry, which is an energy end-user, to ensure consistency with the presentation of data in the energy balance table.

8 Availability of Indicators

It is unrealistic to expect data for every indicator described in this paper to be available immediately and in a useable form. However, some indicators are more critical to the setting up of an effective monitoring system than others. The early focus should be on ensuring that a robust system is created based around these core indicators. Once the data collection formats and protocols have been set up and proven based around the core indicators, it becomes a relatively simple task to include further indicators at a later date.

In the summary of indicator availability presented below, the indicators identified in this paper are therefore categorised into three tiers: (i) 'core' indicators that are essential for the creation of a working system; (ii) 'necessary' indicators that are needed for a reasonably clear picture of progress towards energy efficiency targets; (iii) 'desirable' indicators that are only needed for a very detailed analysis of progress towards energy efficiency targets. Alongside each available (or potentially available) indicator is given the name(s) of the organisation(s) anticipated to be the provider of the data required.

Where an indicator is available from a known source, it is marked as 'available', possibly with some qualification or additional comment. Where an indicator is marked as 'not available', this implies that a reasonably exhaustive search has failed to yield a reliable source for the data in question. Indicators marked as 'not published' are probably available from the sources mentioned, but further discussion and negotiation is likely to be necessary before the data can be accessed. Any of the more critical indicators that are not obviously available are flagged (⚐) to receive immediate and urgent attention.

Where 'core' or 'necessary' indicators are currently unavailable, recommendations are given regarding (i) how the indicator in question can be obtained; (ii) how the methodology should be modified in the short-term to work around the data gap. For the less critical 'desirable' indicators that are unavailable, a decision has to be made regarding whether it is worth devoting effort and resources to collect the missing data.

8.1 Indicators required for an economy-wide analysis

Table 3 below summarises the availability of the core indicators required to perform an economy-wide analysis. All of the indicators required to perform a top-level economy-wide analysis are available at least annually. However, there are considerable delays in the availability of some essential data. Results for the 'General Household Survey', for example, are published about a year after the date of the survey (the July 2004 survey was published at the end of June 2005). The delay has reduced from approximately 16 months in the case of the 2002 and 2003 surveys, and there may be some scope for shortening this delay further, or obtaining a preliminary preview of the individual indicators of interest before the main survey report is published.

Table 3 Indicator availability for economy-wide analysis

Indicator	Category	Status	Source
Total GDP	core	available quarterly	Statistics South Africa 'Gross Domestic Product' (report P0441)
GDP by main sector	core	available quarterly	Statistics South Africa 'Gross Domestic Product' (report P0441)
Total energy	core	available annually, but with a	DME

consumption		delay of 12-18 months	
Energy consumption by main sector (including residential)	core	available annually, but with a delay of 12-18 months	DME
Number of households	core	available annually, but with a delay of about a year	Statistics South Africa "General household survey" (report P0318)

Since all the core indicators essential for an economy-wide analysis are already available, no provision needs to be made for obtaining missing data, or modifying the methodology to work around data gaps. However, the delay in the availability of the energy consumption data means that the top-level analysis can only take place after at least a year.

8.2 Indicators required for industrial sector analysis

For a clear picture of whether the sectoral target for the industrial sector has been met, a decomposition analysis is necessary based on disaggregation into the main industrial sub-sectors. The indicators required for this are listed in Table 4. It would be desirable also to perform a more detailed analysis of the most important energy-using industrial sub-sectors, in order to develop a thorough understanding of the dynamics of changes in industrial sector energy efficiency. The indicators required for this analysis are listed in Table 5 - Table 7. Finally, Table 8 lists the more qualitative 'driving force' indicators that can provide a useful indication of the reasons why energy efficiency is changing as it is.

Table 4 Indicator availability for industrial sector analysis

Indicator	**Category**	**Status**	**Source**
Total GDP of industrial sector	core	available quarterly	Statistics South Africa 'Gross Domestic Product' (report P0441)
GDP of each major sub-sector	core	available quarterly for mining available quarterly for construction available quarterly for manufacturing	Statistics South Africa 'Gross Domestic Product' (report P0441)
		available only approximately every 4-5 years at the required level of disaggregation	Statistics South Africa 'Large Sample Survey of the Manufacturing Industry'
Total energy consumption of each major sub-sector	core	available annually, but see Note 1 below	DME
Total tonnage of material processed in the mining sub-sector	desirable	available at least annually, but data needs to be assembled from diverse sources	Individual mining companies (see Note 2 below)
Total tonnage of pulp	desirable	not published	Sappi

processed in the pulp & paper sub-sector			Mondi

Note 1: The data on sub-sectoral energy consumption currently allocates most of the pulp & paper sub-sector energy consumption to the category ‘Non-specified’.

Note 2: The companies in question are those listed in Section 3.3.2 above. Virtually all of these companies publish data on the total tonnage of material extracted / processed on their respective company web pages. In some cases, this data is published as frequently as monthly, and is always published at least annually. However, in the case of Xstrata, this data is published in an aggregated form across operations in several countries. Only two of the companies, De Beers (diamonds) and Eyesizwe (coal), do not appear to publish any data on the internet on tonnage of material processed, but it is expected that this data would be available on enquiry. In any case, it is recommended that the informant companies are all contacted directly to verify the data.

Table 5 Indicator availability for iron & steel sub-sector analysis

Indicator	**Category**	**Status**	**Source**
Physical production of iron by process	desirable	available monthly	South African Iron and Steel Institute
Energy consumption of iron-making by process	desirable	not published	South African Iron and Steel Institute
Physical production of steel by process	desirable	available monthly	South African Iron and Steel Institute
Energy consumption of steel-making by process	desirable	not published	South African Iron and Steel Institute

Table 6 Indicator availability for mining sub-sector analysis

Indicator	**Category**	**Status**	**Source**
Tonnes of material processed in the gold industry	desirable	available annually	Anglo-Gold; Gold Fields; Harmony; Durban Roodepoort Deep.
Gold industry energy consumption	desirable	not published	Anglo-Gold; Gold Fields; Harmony; Durban Roodepoort Deep.
Tonnes of material processed in the PGM industry	desirable	available annually	Anglo-Platinum; Impala Platinum; Lonmin Platinum; Northam; Aquarius
PGM industry energy consumption	desirable	partly available in published form (see Note 1 below)	Anglo-Platinum; Impala Platinum; Lonmin Platinum; Northam;

			Aquarius
Tonnes of material processed in the diamond industry	desirable	partly available in published form (see Note 2 below)	De Beers; Trans-Hex; Southern Era
Diamond industry energy consumption	desirable	partly available in published form (see Note 2 below)	De Beers; Trans-Hex; Southern Era
Tonnes of material processed in the coal industry	desirable	available, but see Note 3 below	Anglo-Coal; Ingwe; Xstrata; Eyesizwe
Coal industry energy consumption	desirable	available, but see Note 3 below	Anglo-Coal; Ingwe; Xstrata; Eyesizwe

Note 1: Anglo-Platinum and Impala Platinum publish detailed data on energy consumption. The other three companies do not publish energy consumption data.

Note 2: Trans-Hex and Southern Era publish data on tonnes of material processed, but not on energy consumption. De Beers publish data on energy consumption, but this is aggregated across operations in several countries. De Beers do not publish data on tonnes of material procesed.

Note 3: All companies except Eyesizwe publish data on physical production and on energy consumption. However, in the case of Xstrata, this is aggregated across operations in several countries.

Table 7 Indicator availability for non-ferrous metals sub-sector analysis

Indicator	**Category**	**Status**	**Source**
Value-added of aluminium industry	desirable	not directly available, but see Note 3 below	BHP Billiton
Energy consumption of aluminium industry	desirable	available	BHP Billiton
Tonnes of aluminium produced	desirable	available	BHP Billiton
Value-added of titanium industry	desirable	not directly available, but see Note 3 below	Richards Bay Minerals Namakwa Sands Ticor
Energy consumption of titanium industry	desirable	partly available in published form (see Note 1 below)	Richards Bay Minerals Namakwa Sands Ticor
Tonnes of titania slag produced	desirable	partly available in published form (see Note 1 below)	Richards Bay Minerals Namakwa Sands Ticor
Value-added of vanaduim industry	desirable	not directly available, but see Note 3 below	Highveld Xstrata Vametco
Energy consumption of	desirable	partly available in published	Highveld

vanadium industry		form (see Note 2 below)	Xstrata Vametco
Tonnes of vanadium pentoxide produced	desirable	partly available in published form (see Note 2 below)	Highveld Xstrata Vametco
Value-added of zinc industry	desirable	not directly available, but see Note 3 below	Zincor
Energy consumption of zinc industry	desirable	not published	Zincor
Tonnes of zinc produced	desirable	not published	Zincor

Note 1: Namakwa Sands publish full data on physical production and energy consumption in their Sustainable Development Report. Ticor publish physical production data in their Annual Report, but nothing on energy consumption. Richards Bay Minerals do not publish any data on physical production or energy consumption.

Note 2: Highveld publish data on physical production, but nothing on energy consumption. Xstrata publish full data on physical production and energy consumption, but this is aggregated across operations in several countries. Vametco do not publish any data on physical production or energy consumpton.

Note 3: Data on total value added for each industry branch is not directly available, but it should be possible to calculate it from data available in the annual reports of the firms listed. Value added is equal to the total value of production minus the cost of non-labour inputs.

Table 8 'Driving force' indicator availability for industrial sector

Indicator	**Category**	**Status**	**Source**
Approximate fraction of total operating costs accounted for by energy	desirable	not available	See Section 8.2.1 below
Extent to which potential for energy savings is a criterion driving investment decisions	desirable	not available	See Section 8.2.1 below
Estimate of the potential for economically viable energy savings	desirable	not available	See Section 8.2.1 below
Perception of the main factors driving improvements in energy efficiency (past and future)	desirable	not available	See Section 8.2.1 below

8.2.1 Obtaining missing data

The most obvious gap in the data needed for analysing the industrial sector is on sub-sectoral GDP. Although this data is available from Statistics South Africa's 'Large Sample Survey of the Manufacturing Industry', this survey is carried out only every 4-5 years. This is insufficiently frequent for the effective tracking of changes in energy efficiency. As indicated in Table 4 above, more frequent data is available from the quarterly reports on GDP produced by Statistics South Africa, but the level of disaggregation is much less detailed. It is recommended therefore that discussions are held with Statistics South Africa at the earliest opportunity, to establish whether the more disaggregated data on GDP could be made available more frequently.

Another possibility for obtaining more disaggregated data on activity levels is to assemble it from data obtained from individual firms or from industry association. For many of the key sub-sectors, there are sufficiently few major players that this may be feasible. In the meantime, the methodology should be slightly modified to make use of the less disaggregated data that is readily available.

Much of the data required to perform a very detailed analysis of the industrial sector is either not currently available or is not published by the firms concerned. Although this data is not strictly necessary to answer the question of whether the industrial sector is on course to meet its energy efficiency target, it would be useful in order to derive a complete picture of energy efficiency trends at the sub-sectoral and industry level. Many of the firms from whom this data would be obtained are signatories to the Energy Efficiency Accord, and as such have implicitly indicated a willingness to share the information required to track energy efficiency trends. It is therefore recommended that an approach to these firms is co-ordinated with the National Business Initiative, with a view to obtaining the required data.

8.2.2 Modified methodology

Until such time as more disaggregated data becomes available, the methodology used for decomposing changes in industrial sector energy consumption will need to use the less detailed data available from Statistics South Africa's GDP reports. This does not require a significant change to the methodology itself, merely a redefinition of the sub-sectors into which the industrial sector is disaggregated.

8.3 Indicators required for commercial / public sector analysis

The indicators required for performing a decomposition analysis on the commercial / public sector are listed in . The more qualitiative 'driving force' indicators that are required to understand the underlying reasons for movements in energy efficiency are more or less the same for the commercial / public sector as they are for the industrial sector. These indicators are listed in Table 8 above, and sources for this data in the commercial / public sector would be a cross section of bodies from each of the main sub-sectors (retail & wholesale trade; financial services; hospitality; health care; education; municipal, provincial and national government services).

Table 9 Indicator availability for the commercial / public sector

Indicator	Category	Status	Source
Total floor area in use across sector	necessary	not available	-
Total energy	necessary	available annually	DME

consumption of sector			
Floor area in use in each major sub-sector	necessary	not available	-
Energy consumption of each major sub-sector	necessary	not available	-

8.3.1 Obtaining missing data

The most serious gap in the available data is the lack of disaggregated figures for energy consumption by sub-sector. The data available from DME originates from the fuel and energy suppliers, who provide information on the type of enterprise they supply. Data on coal consumption is provided by the Minerals Bureau, SAPIA provides data on liquid fuels, while Eskom provides data on electricity consumption. Discussions with the Data Directorate at DME indicate that this data is unlikely to be available in a more disaggregated form from these sources, partly because of the impracticality of disaggregating further, and partly because of issues of commercial confidentiality.

For the government sub-sector, information on total energy *expenditure* (but not on physical usage) is obtainable from the StatsSA reports on government expenditure (Central Government Expenditure, report P9119; Provincial Government Expenditure, report P9120; Financial Census of Municipalities, report P9114). It seems unlikely that this information could be reliably converted to figures for physical usage without some knowledge of the approximate fuel-mix used by the sub-sector, which could only be obtained through surveys. For both government services and for the other sub-sectors in the commercial / public sector, large-scale surveys would therefore seem to be the only possibility for obtaining energy consumption data disaggregated by sub-sector.

8.3.2 Modified methodology

The data gaps in the commercial / public sector are so numerous that no meaningful decomposition analysis can realistically be conducted using the data currently available. To avoid the need for a detailed survey of floor areas in use, a methodology could be adopted that uses number of employees rather than floor area as the activity-level indicator. As a purely physical quantity, using the number of employees as an indicator for activity level means that data on value-added is not required – a distinct advantage, since determining value-added in the public sector is very problematic. Data on number of employees by sub-sector is available quarterly from Statistics South Africa's 'Employment Statistics' report (P0277). The level of disaggregation of this data is less than ideal[15], nevertheless this data is sufficient to permit a limited analysis to be performed.

A very crude indication of the energy intensity trends in this sector can be made simply by relating changes in overall sectoral energy consumption to changes in the total number of employees. Until such time as detailed data on sub-sectoral energy use becomes available from surveys, using the sector-wide 'energy per employee' as an indicator probably represents the best that can reasonably be achieved.

8.4 Indicators required for residential sector analysis

As described in the accompanying paper 'Monitoring of Energy Efficiency Targets: A Theoretical Review', there are two suggested types of analysis that can be conducted on the residential sector. One of these approaches is based on the stratification of households according to standard of living, using the

[15] Disaggregation is into only three sub-sectors: wholesale & retail trade is grouped together with hospitality in one sub-sector; healthcare, education and and government services form a second sub-sector; financial services constitutes the third sub-sector.

well-established ‘LSM’ classification. Table 10 lists the indicators needed for this tye of analysis. The second approach is to examine the individual energy-using activities that households carry out, which requires the indicators listed in Table 11. Finally, Table 12 lists the ‘driving force’ indicators that are necessary to gain a complete picture of the factors influencing trends in residential energy efficiency.

Table 10 Indicator availability for residential sector analysis based on LSMs

Indicator	**Category**	**Status**	**Source**
Number of households	core	available annually, but data is published about a year after the survey is completed	Statistics South Africa “General household survey” (report P0318)
Number of households in each LSM category	necessary	available annually	SAARF “All Media and Products Survey”
Total energy consumption in each LSM category	necessary	not available	See Section 8.4.1 below

Table 11 Indicator availability for residential sector analysis based on

Indicator	**Category**	**Status**	**Source**
Number of households	core	available annually, but data is published about a year after the survey is completed	Statistics South Africa “General household survey” (report P0318)
Number of households using space heating	necessary	available annually, but data is published about a year after the survey is completed	Statistics South Africa “General household survey” (report P0318)
Specific energy consumption per household for space heating	necessary	not available	See Section 8.4.1 below
Specific energy consumption per household for cooking	necessary	not available	See Section 8.4.1 below
Specific energy consumption per household for water heating	necessary	not available	See Section 8.4.1 below
Average number of electric lamps per household	necessary	not available	See Section 8.4.1 below
Average wattage per lamp in use	necessary	not available	See Section 8.4.1 below

Fraction of households owning and using a refrigerator	necessary	available annually	SAARF “All Media and Products Survey”
Specific energy consumption (nameplate power rating) of refrigerators in use	necessary	not available	See Section 8.4.1 below
Fraction of households owning and using a washing machine	necessary	available annually	SAARF “All Media and Products Survey”
Specific energy consumption of washing machines in use	necessary	not available	See Section 8.4.1 below
Fraction of households owning and using a deep freezer	necessary	available annually	SAARF “All Media and Products Survey”
Specific energy consumption (nameplate power rating) of deep freezers in use	necessary	not available	See Section 8.4.1 below

Table 12 ‘Driving force’ indicator availability for residential sector

Indicator	**Category**	**Status**	**Source**
Rate of turnover of appliance stock	desirable	A proxy indicator, the number of households who have bought new appliances in the last year, is available annually	SAARF “All Media and Products Survey”
Householders’ awareness of their energy costs	desirable	not available	See Section 8.4.1 below
Householders’ understanding of opportunities for energy efficiency	desirable	not available	See Section 8.4.1 below
Consideration of energy efficiency as a criterion when purchasing domestic appliances	desirable	not available	See Section 8.4.1 below

8.4.1 Obtaining missing data

Data availability in the residential sector is poor, as the tables above illustrate. Although there are possibilities to work around the data gaps (see Section 8.4.2 below), such a work-around should be regarded as a stop-gap, which will never be able to provide a true picture of the impact on residential energy consumption of changes in energy efficiency. It is therefore strongly recommended that the data gaps are filled at the earliest opportunity through household energy surveys.

For an analysis based on LSM categories, the missing data is on the average household energy consumption in each LSM group. The obvious source for the missing data is the South African Advertising Research Foundation (SAARF), who are responsible for the surveys on which the LSM categorisation is based. Although Statistics South Africa collect data on household expenditure (including expenditure on fuels and electricity) as part of their 'Income and Expenditure of Households' survey, this survey is conducted only every five years at present. Furthermore, even if the survey could be conducted more frequently, it would be very difficult to cross-tabulate the results in terms of LSMs.

All of the missing indicators listed in Table 11 and Table 12 above could be collected as part of a comprehensive household energy survey. Alternatively, a cheaper way of acquiring the missing data could be to approach organisations who are already conducting surveys that cover the required population, and that cover similar subjects. For example, to derive the specific energy consumption for space heating, data on the physical characteristics of dwellings is required. Some of the necessary data on the construction material of dwellings is already collected as part of the annual Labour Force Survey, conducted by Statistics South Africa. It is therefore recommended that Statistics South Africa be approached with a view to adding questions on insulation levels to the Labour Force Survey.

The data required for deriving the specific energy consumption for cooking and water heating is probably best obtained through the General Household Survey, conducted annually by Statistics South Africa. This survey already collects data on the main fuel used for cooking (but not for water heating), so it would only minor additions to the survey to collect the necessary data on the details of the technology used for cooking and water heating. Similarly, since the General Household Survey already collects data on the fuel used for lighting, relatively minor additions to the survey could also yield the required data on the number and power rating of the electric lamps in use.

In the case of electrical appliances (refrigerators, washing machines and deep freezers), annual data on ownership levels is already collected by SAARF as part of their All Media and Products Survey (AMPS). For data on power rating and / or specific energy consumption, it is recommended that SAARF be approached with a view to adding questions to AMPS on the make, model and age of the appliances in question. This information could then be used to derive the required specific energy consumption data.

8.4.2 Modified methodology

Pending the availability of a more complete data set required to perform a thorough analysis of the residential sector, some recommendations can be made for adaptations of the methodology, to work with the data that is currently available. As observed in Section 5.1, if the data-set is incomplete, an approximate estimate of the contribution of one factor to changes in total energy consumption can be made by assuming that it is equal to the unexplained portion that remains when other factors have been calculated. In the case of the residential sector, if a reasonable estimate can be made of the effects on total energy consumption attributable to changes in the number of households and in the ownership levels of appliances, then it can be assumed that any remaining change is due to a combination of changes in technical efficiency and behavioural changes (mainly usage levels).

In order to perform such an analysis, it is still necessary to have a reasonably good estimate of the fraction of total household energy consumption that is accounted for by each of the activities in the

analysis. This information is needed to derive the weighting functions upon which the decomposition depends. However, this estimate can be synthesised from the results of a range of studies reported in the literature. A worked example of this modified methodology is provided in the accompanying report ‘Monitoring of Energy Efficiency Targets: Methodology Handbook’.

8.5 Indicators required for transport sector analysis

Ideally, an analysis of the transport sector would allow for disaggregation both by mode (air, road, rail etc.) and by main sub-sector (passenger versus freight). In order to permit physical activity level indicators to be used, the freight and passenger branches should be analysed separately. This allows each sub-sector analysis to be conducted without the need for disaggregated data on value-added. Table 13 and Table 14 list the indicators required to perform decomposition analyses of the energy consumption of each transport sub-sector. Table 15 lists some of the more qualitative ‘driving force’ indcators that will provide a picture of the factors influencing changes in transport sector energy efficiency.

Table 13 Indicator availability for freight transport sector analysis

Indicator	**Category**	**Status**	**Source**
Air freight transport energy consumption	necessary	not available	-
Air freight transport total tonne-km	necessary	not available	-
Road freight energy consumption	necessary	not available	-
Road freight total tonne-km	necessary	available, but see Note 1 below	CSIR
Rail freight energy consumption	necessary	not available	-
Rail freight total tonne-km	necessary	available	Spoornet
Other freight (pipeline, internal navigation, non-specified) energy consumption	necessary	available	DME
Other freight total tonne-km	necessary	not available	-

Note 1: CSIR in partnership with Spoornet have recently published the first ‘State of Logistics Survey for South Africa’. This survey derives estimates for tonne-km by road and rail, where the road transport estimates derive from a model based on data obtained from the South African National Roads Agency Comprehensive Traffic Observations. Data for the model was from measurements made in 1990, 1993, 1997 and 2003. It is CSIR’s intention to conduct the ‘State of Logistics’ survey annually, although the data upon which the model is based will not be collected annually.

Table 14 Indicator availability for passenger transport sector analysis

Indicator	Category	Status	Source
Passenger air transport energy consumption	necessary	not available	-
Passenger air transport total passenger-km	necessary	not published (see Note 1 below)	Transnet (SAA), Comair, Nationwide, 1Stop
Private car energy consumption	necessary	available, but see Note 2 below	Statistics South Africa 'Income and Expenditure of Households' (P0111)
Private car total passenger-km	necessary	not directly available (see Note 3 below)	South African Advertising Research Foundation (All Media and Products Survey)
Bus, coach & taxi energy consumption	necessary	not available	-
Bus, coach & taxi total passenger-km	necessary	not directly available (see Note 3 below)	South African Advertising Research Foundation (All Media and Products Survey)
Passenger rail energy consumption	necessary	not available	-
Passenger rail total passenger-km	necessary	not published (see Note 4 below)	Spoornet, Metrorail

Note 1: SAA publish data on passenger-km in their annual report, although this is aggregated across all flights, bith domestic and international. The other airlines operating domestic passenger services do not publish these figures, but it is expected that this data will be available on request.

Note 2: Statstics South Africa's 'Income and Expenditure of Households' report includes data for expenditure on fuel consumption by private cars, from which physical consumption can be derived using current fuel prices. However, this report is published only every five years, the next being due in 2006.

Note 3: SAARF's annual survey includes questions on average monthly distance travelled by respondents. Although this data is not published in the AMPS Report, the raw data is available from SAARF. The data is structured in such a way that it should be possible to derive an estimate for the average number of person-kilometres travelled per month by differrent categories of road transport.

Note 4: Metrorail have published data on total passenger-km in the past, but the most recent published data is for 1999/2000. It is expected that up-to-date information will be available on request. Spoornet publish data on passengers carried, but not on passenger-km, in their annual report. Again, it is expected that the required data will be available on request.

Table 15 'Driving force' indicator availability for transport sector

Indicator	Category	Status	Source
Proportion of journeys made by different	desirable	available	SAARF "All Media and Products Survey"

transport modes			
Average age of private cars	desirable	available	SAARF "All Media and Products Survey"
Average age of other motor vehicles	desirable	not available, but see Note 1 below	-
Attitudes to, and awareness of energy efficiency among road haulage firms	desirable	not available	-

Note 1: This data has been available from Department of Transport in the past. Their 'Transport Statistics 2001' report provides data on the average age of all categories of motor vehicle, but only up to 1992.

8.5.1 Obtaining missing data

With regard to activity-level indicators, data availability in the transport sector is reasonable. For rail and road freight, data on tonne-km is already available, from Spoornet and from the CSIR 'State of Logistics' survey. As soon as Statistics South Africa commence their improved survey of land transport statistics in 2006[16], the situation will improve further. Data on rail and domestic air passenger transport activity levels (in passenger-km) is partly available, and the gaps can be filled through consultation with the service operators listed in Table 14. Reasonable estimates of road transport activity levels can be derived from the SAARF AMPS survey, which collects data from householders on distances travelled by different modes of transport. With respect to activity-level indicators, the biggest gap is domestic air freight, for which data will need to be assembled through consultation with air freight operators.

With regard to energy consumption data, the situation is less encouraging. DME data on transport sector energy consumption is disaggregated by mode (rail, road and air) but not by passenger versus freight. This data is obtained from information provided by the suppliers of transport fuel (and electricity, in the case of railways), so it is difficult to envisage how a disaggregation into passenger versus freight could be estimated from this information alone. The only option for obtaining energy consumption data at the required level of disaggregation would appear to be a detailed survey on the demand side. Such a survey may nevertheless present a number of difficulties, some of which are:

- separating electricity consumed by freight trains from electricity consumed by passenger trains
- separating fuel consumption of air freight versus air passenger transport, since approximately one-third of total air freight is carried on passenger flights
- estimating total fuel consumption in the minibus-taxi industry

Given the likely difficulties in obtaining energy consumption data in a sufficiently disaggregated form, it might seem that a preferred option would be to adopt a methodology that can make use of the data that is currently available. However, as outlined in the following section, this cannot compensate for the particular data gaps that exist.

[16] Statistics South Africa's 'Land Freight Transport' report (P7142) would normally be expected to yield useful data on activity levels. Although previously published monthly, this report has been suspended since the March 2004 report, which carried data from December 2003. Communication with StatsSA indicates that this report is to be replaced with an improved and more comprehensive reporting of transport statistics, which is currently under development and should be launched some time in mid-2006.

8.5.2 Modified methodology

As observed above, modifying the methodology to work with existing data may appear to be easier than attempting to obtain the data required to use the 'ideal' methodology. However, this perception is misleading. A modified methodology would need to be based around the same disaggregation by mode that the DME energy consumption data is based upon. Such a methodology woud therefore require activity-level indicators that mirror this disaggregation; i.e. indicators that reflect the total activity level in road, rail and air transport respectively, but that are aggregated across freight versus passenger transport.

The problem therefore arises of how to combine a percentage change in a freight transport activity indicator with a percentage change in a passenger transport activity indicator to yield a percentage change in overall activity for the mode. Combining percentage changes in indicators that are measuring different quantities suggests the use of a weighted mean, so the problem reduces to that of deciding what weightings to use for this weighted mean calculation. The arithmetically correct weightings to use would be the respective energy consumption figures, but the absence of such data is the very reason why this modified methodology is required.

To summarise, any data (whether precise, or in the form of crude estimates) that allows the activity-level indicators to be aggregated by mode across passenger and freight transport could equally well be used to *dis*aggregate the energy data from DME into passenger versus freight. Thus the need to collect additional data before a meaningful analysis can be performed is unavoidable. For road transport, approximate data can be estimated by assuming that petrol consumption is entirely accounted for by passenger transport and diesel consumption by freight transport. For rail and air transport, however, there is little option but to obtain estimates directly from the main operators. In all cases where crude estimates are used, it is recommended that a sensitivity analysis be conducted to assess how robust the final result of the analysis is against errors in the estimate upon which it is based.

8.6 Indicators required for analysis of electricity generation

A decomposition analysis is not required in the electricity generation sector, since the target is expressed simply as a reduction in parasitic usage per unit of electricity generated. The data required for the monitoring of progress towards this target is therefore straightforward and, at present, Eskom can be regarded as the only necessary source of data, since they account for over 95% of the electricity generated in South Africa. However, over the targeting period to 2015, independent power produces are likely to account for up to 30% of the additional generating capacity. It is therefore important that, as new IPPs aer established, mechanisms are put in place to ensure that they also report their parasitic usage to DME on an annual basis.

8.7 Indicators required for analysis of fossil fuel conversion

Fossil fuel conversion includes oil refineries and coal-gas works as well as gas-to-liquid and oil-from-coal processes. Although it was understood by the main players in the fossil fuel conversion industry that they would be subject to the same 15% target as the industrial sector, the fossil fuel conversion processes are treated separately from the main industrial sector to make analysis simpler. This is because the energy consumption data available from DME treats fossil fuel conversion as an intermediate step rather than an energy end-use. For the purposes of this analysis, the target is interpreted as a reduction by 15% of the energy lost in these processes relative to the energy content of the products. The required data is already collected annually by DME for inclusion in the energy balance table.