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The targeting of industrial energy audits for DSM planning

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Abstract
The scope of this section of the study is to establish which industries to target for energy audits and demand side management (DSM) projects. As only a limited number of audits will be conducted, it is important to establish how to maximise the return on the invested efforts and resources. The aim is thus, to develop a ranking of industries based on their potential for savings from DSM interventions.

It considers the following criteria:

1. *Electricity consumption and potential DSM savings from retrofits at existing plants;*
2. *Electricity consumption and potential DSM savings for new plants;*
3. *Potential DSM interventions by industry;*
4. *The costs of a suite of DSM interventions by industry; and*
5. *The technical ease with which DSM may be implemented by industry.*

The potential for DSM savings for different industrial sectors is evaluated based on these criteria, using aggregated values sourced from local and international studies. DSM measures are applied to the various 'end uses' of electricity within each industry.

From these we suggest a shortlist of 10 industries to target for energy audits and data gathering. We consider both industry and mining, and refer to the group collectively as industry.

The data gathered in the energy audits will be used to refine estimates of the potential for DSM savings in each sector. Data loggers will be installed to measure electricity consumption and demand profiles (kW load as a function of time), which will be used to estimate the impact of DSM interventions on national demand for energy and power. This can provide valuable input to power system planning and analysis in the future.

Keywords: electricity consumption, demand side management, industrial energy audits, energy saving, energy audits, payback periods

Electricity consumption

In this section, we list the industries that will be considered as well as their current and projected electricity consumption.

Current electricity consumption

Figure 1 illustrates the proportion of electricity consumption in the industrial and mining sectors, as well as total national consumption.

Table 1 ranks industrial sectors according to total electricity consumption.

Table 1: Ranking of sectors by current electricity consumption

Sector	*Consumption (GWhr)*	*% of total industry consumption*	*Ranking*
Iron & steel	26 923	22.91%	1
Precious & non-ferrous metals	19 447	16.55%	2
Gold mining	18 051	15.36%	3
Chemicals	14 736	12.54%	4
Wood & wood products (inc. paper & pulp)	9 613	8.18%	5
Platinum mining	7 209	6.13%	6
Non metallic minerals	5 899	5.02%	7
Rest of manufacture	4 837	4.12%	8
Food bev & tobacco	3 759	3.20%	9
Coal mining	2 964	2.52%	10
Copper mining	1 037	0.88%	11
Rest of mining	945	0.80%	12
Diamond mining	709	0.60%	13
Textile, cloth & leather	445	0.38%	14
Iron ore mining	372	0.32%	15
Rest of basic metals	217	0.18%	16
Chrome mining	187	0.16%	17
Manganese mining	149	0.13%	18
Asbestos mining	20	0.02%	19

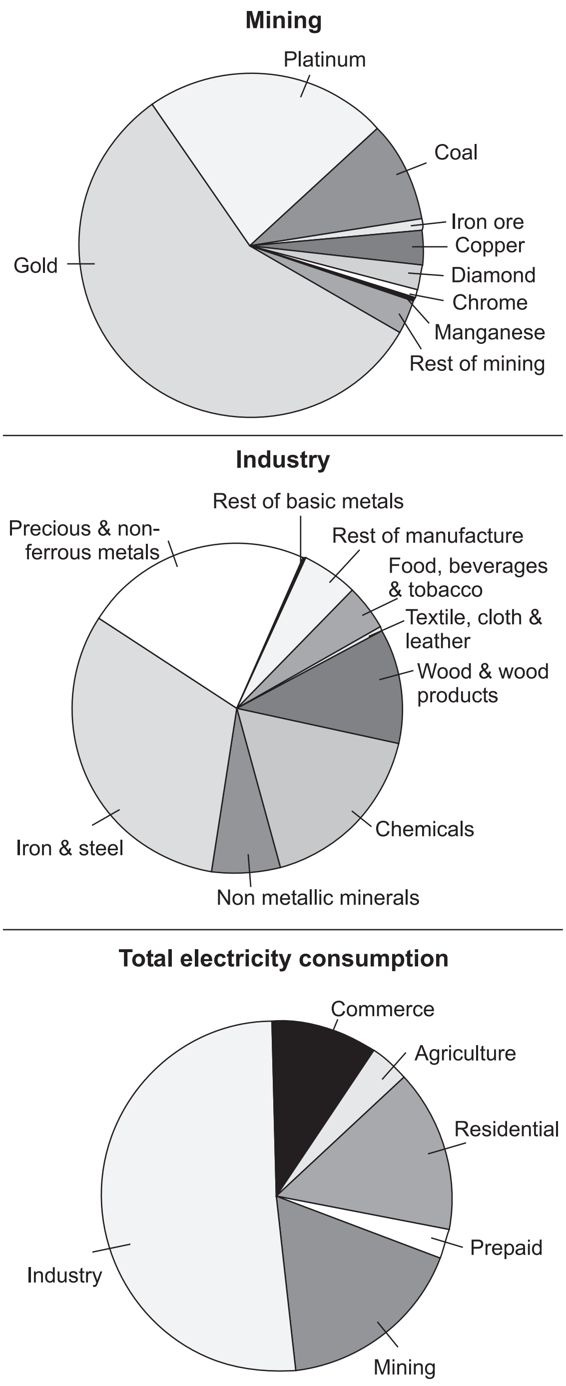


Figure 1: National electricity consumption 2003

This information is useful as it indicates current levels of electricity consumption and can be used to select the industrial sectors that have the greatest potential for savings from DSM retrofit options.

Future electricity consumption

It is important to consider future growth of industries, as including DSM interventions during the construction and design of the new plant may help reduce costs. That is, the economics of DSM may favour a wider range of options for new plant, than for retrofits.

Figure 2 and Figure 3 give a forecast of moderate growth in electricity demand for different mining and industrial sectors (this is derived from the ERC electricity forecasting tool for a moderate GDP forecast of between 3-4% growth).

Table 2 is a ranking of industrial sectors according to the total (absolute) increase in electricity consumption.

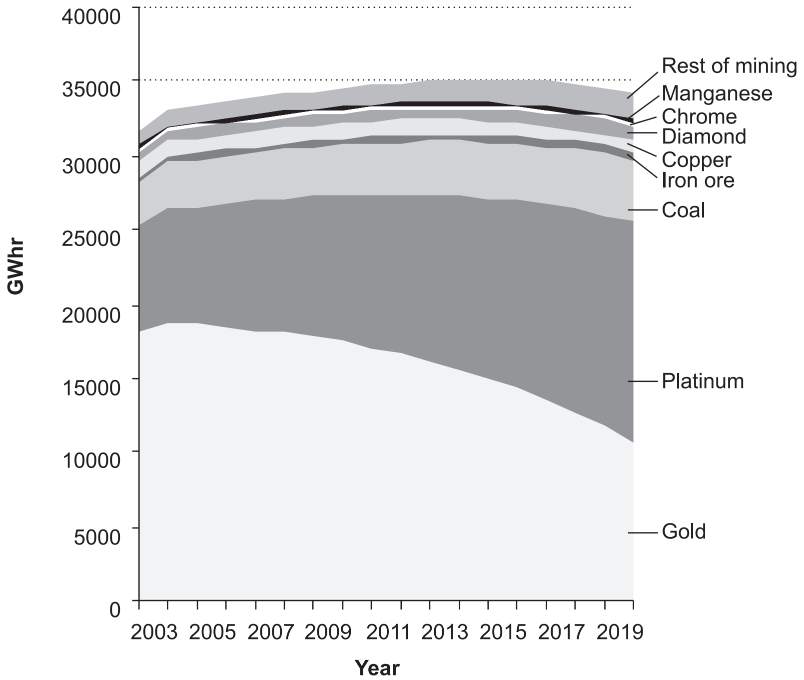
Table 2: Ranking of electricity demand growth by sector

Sector	*Growth [GWh]*	*Ranking*
Iron & steel	28 316	1
Precious & non-ferrous metals	20 218	2
Chemicals	14 485	3
Wood & wood products	12 209	4
Non metallic minerals	12 017	5
Platinum mining	8 286	6
Food bev & tobacco	6 767	7
Rest of manufacture	4 425	8
Coal mining	1 372	9
Rest of mining	911	10
Textile, cloth & leather	778	11
Iron ore mining	269	12
Diamond mining	233	13
Rest of basic metals	166	14
Chrome mining	114	15
Manganese mining	68	16
Asbestos mining	-2	17
Copper mining	-207	18
Gold mining	-6 882	19

Potential interventions

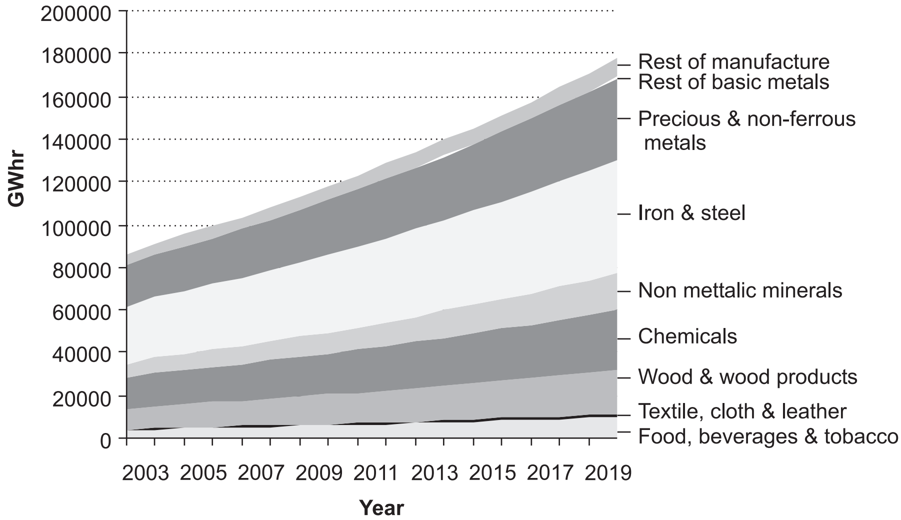
The next aspect to investigate is the potential for various DSM interventions in each industry. An assumption of what end-uses (motors, process heat, lighting etc.) electricity is actually used for in the different industries is needed to do this. These assumptions were taken from the US Department of Energy's Energy Information Administration (EIA 2004) and the British Department of Trade and Industry (DTI 2004), and, for mining, the South African Department of Energy's Integrated Energy Plan (Howells et al 2002). This data is given in Table 3, which shows the consumption by end-use as a percentage of total consumption for each industry sector. It is important to note, that these values are indicative, and based on international, not local practice.

Table 4 shows the potential savings from DSM measures for a list of end-use processes. These savings are conservative estimates based on Howells et



Sector	*Demand in 2020 relative to 2003*
Gold	-38%
Platinum	115%
Coal	46%
Iron ore	72%
Copper	-20%
Diamond	33%
Chrome	61%
Manganese	45%
Rest of mining	96%

Figure 2: Forecast of electricity consumption in mining



Sector	*Demand in 2020 relative to 2003*
Food, beverages & tobacco	160%
Textile, cloth & leather	175%
Wood & wood products	127%
Chemicals	98%
Non metallic minerals	204%
Iron & steel	105%
Precious & non-ferrrous metals	104%
Rest of basic metals	76%
Rest of manufacture	9%

Figure 3: Forecast of electricity consumption in industry

al (2002).That report based its results on findings from energy audits conducted at local plants. Again, it is important to note, that the number of studies from which these estimates were drawn are limited, and there is no guarantee that they are representative. The data is also limited in that it considers only a narrow set of interventions, whose selection was related to the average payback period. The interventions should be disaggregated further in future.

The savings estimates of represent a conservative estimate of savings potential. These measures are not independent. If one measure is implemented in an end use category, this will reduce the energy consumed by that end use. If another DSM measure is subsequently implemented to the same category, there is less energy being consumed by this end use, and therefore, less energy that can be saved by the second measure, and so on. Therefore, the savings by end use, by measure are revised downward to consider the potential savings were all measures to be introduced. This could lead to an underestimate of the potential of individual measures. In this study, the assumption is that a suite of DSM measures is implemented in each industry sector.

From this, we derive a saving potential (expressed as a percentage of total energy consumption) for each of the end uses. The percentage

Table 3: Percentage usage of electricity by industrial sector

	Food and beverages (%)	*Textiles* (%)	*Wood & wood products* (%)	*Chemicals* (%)	*Iron and steel* (%)	*Non ferrous metals* (%)	*Rest of basic metals* (%)	*Rest of manu-facture* (%)	*Non metallic minerals* (%)	*Gold mining* (%)	*Other mining* (%)
Indirect uses-boiler fuel	2	1	3	1	0	0	0	1	0	0	0
Process heating	4	5	6	3	39	1	17	10	8	2	2
Process cooling and refrigeration	24	7	0	6	1	0	0	5	0	7	7
Compressed air	8	10	38	10	8	0	11	9	14	20	20
Other machine drive	44	50	38	53	40	2	56	47	72	45	45
Electro-chemical processes	0	0	0	18	2	95	17	11	0	0	0
Other process use	0	1	1	0	1	0	0	1	0	10	10
Facility heating, ventilation, and air conditioning	8	15	4	4	3	1	0	8	3	8	8
Facility lighting	7	10	7	3	4	1	0	7	3	4	4
Facility support	2	2	1	1	1	0	0	2	0	4	4
Onsite transportation	0	0	0	0	0	0	0	0	0	0	0

Table 4: DSM interventions and their potential (stand alone) savings by end use

Use of electricity / measure considered	*Steam system*	*Thermal measures*	*Efficient motors*	*VSDs*	*Efficient lighting*	*Compressed air saving*	*HVAC*	*Refrigeration*	*Load shifting*
Indirect uses boiler fuel	15%	5%							
Process heating		5%							
Process cooling and refrigeration				10%					20%
Machine drive (inc compressed air)			5%	5%		15%		15%	
Electro-chemical processes									
Other process use									
Facility heating, ventilation, and air conditioning			5%	10%			30%		20%
Facility lighting					40%				
Facility support									
Onsite transportation									

saving is multiplied by the energy consumed by each end use to give an estimate of potential DSM savings for the individual sectors. From this, a ranking of DSM potential by industrial sub-sector is established. This is shown in Table 5.

Table 5: Energy saving, DSM potential and ranking of industries based on current electricity consumption

Sector	*GWhr equivalent saved*	*% of DSM*	*Ranking*
Gold mining	2311	21	1
Iron and steel	2289	21	2
Wood and wood products	1458	13	3
Chemicals	1370	12	4
Platinum mining	927	8	5
Food and beverages	605	5	6
Rest of manufacture	542	5	7
Non metallic minerals	524	5	8
Coal mining	381	3	9
Non ferrous metals	184	2	10
Copper mining	133	1	11
Rest of mining	121	1	12
Diamond mining	91	1	13
Textiles	67	1	14
Iron ore mining	48	0	15
Chrome mining	24	0	16
Manganese mining	19	0	17
Rest of basic metals	13	0	18
Asbestos mining	3	0	19

In order to derive the total DSM savings potential for each measure, the quantity of energy consumed for each end use was determined for all industry and mining. For each DSM measure, the potential percentage savings (for each end use they affect) are multiplied by the total energy consumption by end use. The percentage savings are adjusted as described above. From this, the total energy savings are estimated per DSM measure, and the DSM interventions are ranked accordingly. The ranking derived for these sectors represents an estimate of savings from retrofit at existing facilities, and is given in Table 6.

When considering new installations (assuming similar end use splits) the ranking of industries will change, as shown in Table 7. It is useful to separate new installations from existing ones as the implementation of DSM may be possible during the commissioning of new plants at different costs from retrofitting. This means that DSM implementation costs (associated with a measure implemented on an existing industrial plant) would decrease. It is also useful to consider that some industries may see a reduction in output over time and, consequently, so will the potential for DSM.

Table 6: DSM saving by measure and ranking for current electricity use

Measure	*GWhr equiv savings*	*% of DSM*	*Ranking*
Compressed air saving	2 900	26	1
VSDs	1 977	18	2
Efficient motors	1 902	17	3
Efficient lighting	1 384	12	4
Load shifting	1 018 (equivalent)	9	5
HVAC	710	6	6
Other thermal measures	697	6	7
Refrigeration	415	4	8
Steam system	107	1	9

Table 7: Energy saving, DSM potential and ranking of industries based on future (2020) electricity consumption

Sector	*GWhr equivalent saved*	*% of DSM*	*Ranking*
Iron and steel	1 885	24	1
Wood and wood products	1 483	19	2
Chemicals	1 045	13	3
Food and beverages	900	11	4
Non metallic minerals	891	11	5
Platinum mining	844	11	6
Rest of manufacture	381	5	7
Non ferrous metals	149	2	8
Coal mining	114	1	9
Textiles	97	1	10
Rest of mining	91	1	11
Iron ore mining	25	0	12
Diamond mining	16	0	13
Chrome mining	10	0	14
Rest of basic metals	7	0	15
Manganese mining	6	0	16
Asbestos mining	0	0	17
Copper minng	-38	(-6)	18
Gold mining	-1 040	(-15)	19

Further considerations: Ease of implementation and cost

Howells and Laitner (2003) describe average payback periods (based on Howells et al 2003, and therefore consistent with this analysis) for the measures considered. If these estimates of payback periods are multiplied by the percentage attributable to each DSM measure, and the products summed up for each sector, we get an estimated payback period for the full range of interventions. The ranking of sectors under this approach is given in Table 8.

Table 8: Payback period of a suite of DSM interventions applied to and ranked by industry

Sector	*Payback*	*Rank*
Wood and wood products	2.2	1
Textiles	2.6	2
Rest of manufacture	2.6	3
Rest of basic metals	2.8	4
Other mining	2.4	5
Non metallic minerals	2.9	6
Non ferrous metals	2.6	7
Iron and steel	2.3	8
Gold mining	2.4	9
Food and beverages	2.4	10
Chemicals	2.7	11

Howells and Laitner (2003) and Kenny et al (2000 a, b, & c) describe the technical ease of implementation of each DSM measure. The lower the index, the less technically complex the implementation of the particular suite of DSM measures is. By considering the spread of savings by measure for each industry, we again rank industries in terms of the ease of technical implementation of a range of options in (It should be noted that this does not account for 'ease of behavioural change' which may be required).

Table 9: Technical ease of implementation of a suite of DSM interventions applied to and ranked by industry

Sector	*Ease of implementation*	*Rank*
Wood and wood products	1.9	1
Rest of basic metals	2.0	2
Iron and steel	2.2	3
Non metallic minerals	2.3	4
Gold mining	2.4	5
Other mining	2.4	6
Chemicals	2.5	7
Rest of manufacture	2.5	8
Textiles	2.7	9
Food and beverages	2.7	10
Non ferrous metals	2.7	11

It is interesting that 'Wood and wood products' is both most cost effective and requires the least technical effort. It is also interesting to note that sectors which score well in terms of payback and technical ease of implementation also have the greatest potential for DSM savings.

Conclusions

Table 10 gives an indication of DSM saving potential by industry based on the literature survey and analysis undertaken. The table shows the ranking of industries both in terms of current consumption and

Table 10: Summary of DSM savings potential for current and future industries

Existing industries Year 2004				*Industries of the future year 2020*			
Sector	*GWhr equivalent saved*	*% of DSM*	*Ranking*	*Sector*	*GWhr equivalent saved*	*% of DSM*	*Ranking*
Gold mining	2311	21	1	Iron and steel	1885	24	1
Iron and steel	2289	21	2	Wood and wood products	1483	19	2
Wood and wood products	1458	13	3	Chemicals	1045	13	3
Chemicals	1370	12	4	Food and beverages	900	11	4
Platinum mining	927	8	5	Non metallic minerals	891	11	5
Food and beverages	605	5	6	Platinum mining	844	11	6
Rest of manufacture	542	5	7	Rest of manufacture	381	5	7
Non metallic minerals	524	5	8	Non ferrous metals	149	2	8
Coal mining	381	3	9	Coal mining	114	1	9
Non ferrous metals	184	2	10	Textiles	97	1	10

future. Cells coloured light gray indicate industries in the top five ranking for both time periods and cells shaded darker gray those (remaining) in the top ten of both periods. The sector 'Rest of manufacture' is not considered as this 'sector' effectively includes many industrial processes, while we expect some similarity within other defined sector groupings.

Work in gold mines is important in terms of retrofit DSM. However, in future, energy consumption in this sector is expected to decline. This could mean that interventions in this sector may be short lived, as their effect would reduce as electricity demand declines.

The importance of including DSM from the onset in new industrial growth projects is in part related to the new process that will be taken up in the futureused in that project. This process may be different from current processes used in the sector concerned. For a DSM strategy that would target new industrial growth, , therefore iit may be sensible to quantify examine potential new process and design features specific to the growing industrial sector. From this, DSM strategies specific to that process for growing sub-sectors should be derived. which may reduce energy consumption of new plants, rather than simply extrapolating tIt may not be appropriate to simply extrapolate the findings of current energy audits. Combined with energy audits, this knowledge may provide strategic insight into the planning of potentially interruptible electricity supply agreements.

The current work is primarily aimed at developing a strategy for DSM based on audits of existing plants, and not on the impact of a new plant layout or process design which may affect future energy use. Focus is therefore on assessing existing plants, with the possible exclusion of gold mines which have declining production output and whose consumption has been described in detail in previous, albeit dated work (Gildenhuys 2003).

Recommendations

It is recommended that audits are conducted at sites representing the industries with the greatest potential for DSM savings. The audits should be distributed among these industries according to their proportional contribution to total DSM potential as established in the above analysis. Within the industries, the customers with the largest electricity consumption should be selected.

As an example, we consider a case where the total number of audits is 10. Table 11 shows the recommended number of audits for each industrial sector for this scenario.

Increasing the number of audits will have two main benefits. It will improve the accuracy of the projected potential for savings in each sector and produce statistics for a larger number of sectors.

Table 11: Allocation of audits

Sector	*With gold mining*	*Without gold mining*
	Number of audits	
Gold mining	2	
Iron and steel	2	3
Wood and wood products	1	2
Chemicals	1	2
Platinum mining	1	1
Food and beverages	1	1
Non metallic minerals	1	1
Coal mining	1	
Non ferrous metals		

Further it is suggested that work be carried out considering the potential processes to be used by growing industries. This should be carried out in order to scope the potential for DSM interventions to be included in the commissioning of new industrial plants. For example, Aa special focus area, not considered here, would be assessing the potential for inturruptibility of supply agreements in planned industrial investments. The latter, securing inturruptibility of supply agreements has been identified as an imperative by the current National Integrated Resource Plan for electricity (NER 2003).

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