Department of Minerals and Energy Pretoria

Capacity Building in Energy Efficiency and Renewable Energy

Report No. – 2.2.3-06

ENERGY EFFICIENCY SAVINGS PROJECTIONS

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ABBREVIATIONS AND ACRONYMS

CaBEERE	Capacity Building in Energy Efficiency and Renewable Energy
DANCED	Danish Cooperation for Environment and Development
DME	Department of Minerals and Energy
EE	Energy Efficiency
ERI	Energy Research Institute
GDP	Gross Domestic Product
HVAC	Heating Ventilation and Cooling
IEP	Integrated Energy Plan
ISEP	Integrated Strategic Energy Planning
LEAP	Long Range Energy Alternatives Planning System
VSD	Variable Speed Drives
SAEDES	South African Energy and Demand Efficiency Standards
p.a.	per annum
MJ	Megajoules
GJ	Gigajoules
PJ	Petajoules
RDP	Reconstruction and Development Plan

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1. INTRODUCTION

This report develops indicative scenarios for energy savings from various proposed government energy efficiency policies. The following sectors are considered:

- Industry
  - Paper and Pulp,
  - Iron and Steel,
  - Chemicals and Petrochemicals,
  - Food and Tobacco,
  - Non-metallic Minerals,
  - Other (including textiles),
  - Non-Ferrous metals,
- Mining and Quarrying
- Commerce,
- Residential,
- Transport.

The measures are broadly included under the following headings:

- Standards and labelling,
- Free audit schemes,
- Promotion of new technologies,
- Awareness campaigns and green accounting.

The report outlines the assumptions and modelling techniques used to develop the scenarios and then describes the results. The assumptions are documented in order to invite specific refinement and maintain transparency.

2. ASSUMPTIONS FOR THE ENERGY EFFICIENCY SCENARIOS

This section describes the methodology, modelling and assumptions used to develop the savings potential, likely savings and baseline fuel consumption in the South African economy.

2.1 Methodology

The basic methodology is outlined as follows:

- An average technical potential for energy saving was established for key items of equipment.
- Two sets of implementation rates were estimated, one for the maximum theoretical potential and a second for a ‘likely savings’ scenario, based on international experience for various measures, similar to those proposed by the DME.
- The effect of the measure was estimated in terms of the maximum theoretical potential implementation and in terms of the likely potential scenario.
- These effects were evaluated using the Long Range Energy Alternatives Planning Model (LEAP) for South Africa, run under various “business-as-usual” scenarios.

In this context there are three overarching scenarios that were modelled. These are:

- The baseline, which is an approximation of business as usual developed by previous modelling work (Howells et al 2002).
- The maximum theoretical potential, based on an average saving potential and a maximum uptake of the measures considered,
- The 'likely savings scenario', which assumes various rates of uptake, based on international experience. The results are indicative and do not represent the savings of specific anticipated local programmes. This would need to be evaluated in future work.

Using these scenarios, savings estimates are developed for energy consuming sectors for specific policies. These are then aggregated and overall savings are estimated.

The energy efficiency strategy is divided into three slices which in turn influence the choice of measure implemented. Phase one is from 2003 to 2006, phase two is from 2006 to 2010 and phase 3 is from 2010 to 2013.

The following section details the model and the modelling assumption used for the baseline. As this forms the basis of the savings estimated it is covered in some detail.

2.2 The South African Energy Model and the Baseline Scenario

This section describes both the model used for this work and the assumptions used to develop a 'business as usual' or baseline scenario in order to evaluate the effects of the potential savings and likely savings scenarios.

2.2.1 The modelling tool used

The model used was the Long range Energy Alternatives Planning tool (LEAP), developed by the Stockholm Environmental Institute. The South African model structure was developed and populated by the ERI for the national Integrated Energy Planning (IEP) process of the DME (Howells et al. 2002).

The baseline scenario is similar to the 'base case' scenario of the IEP. The following description is adapted from Howells et al (2002), and details the most relevant assumptions used for developing the baseline. Selected general assumptions made for all scenarios are:

- The years 2003 to 2013 are evaluated.
- Population growth: 2000 = 44 million 2010 = 50 million (1.3% p.a.), 2025 = 57 million (0.87% p.a.) GDP growth: 2.8% average annual growth over period.
- The economic growth for the period is assumed to be 2.8%.
- Fuel switching is limited apart from a general increase in electricity consumption in the residential sector, with electrification.

The following sections describe how the energy projections were derived using the LEAP model. This begins with a description of sector growth in terms of overall economic (and population) growth, then 'useful energy demand' is discussed. This in turn is related to 'useful energy intensity' and the ensuing energy consumption projections are discussed.

2.2.2 Sectoral growth rates in relation to total economic and population growth

An elasticity, as defined in this text, relates the rate of growth of GDP (or another driver, such as population growth) to the growth of the sector, and can be positive or negative. The definition of elasticity in this context is:

(rate of growth of the sector) = (rate of growth of GDP)^ elasticity

The elasticities were derived by considering growth estimates for various sectors in the context of an average GDP growth of 2.8% over the period 2001 to 2020. The growth of selected sectors, their proportional energy service requirements, and assumptions on some sector growth prospects are summarised in the summary Table 1. These assumptions are kept constant for all scenarios.

Table 1: Summary of selected elasticities and growth estimates for South African industry

Sector	Elasticity or growth	2001 Energy requirements of selected activities as a percentage of the total energy requirement.							Comment
	Unless otherwise stated, elasticity's refer to *GDP* growth.	*High Temperature thermal*	*Compressed air*	*Lighting*	*Cooling*	*HVAC*	*Pumping*	*Fans*	The model includes further desegregation including energy used for: Processing, Other motive, Hostels and materials handling. These account for the remaining percentage of energy use.
INDUSTRY									
Gold mining	Negative growth of 1.7% pa	9%	19%	4%	6%	0%	16%	7%	This may change depending on efficiency improvements in the sector.
Iron & steel	Elasticity of 1.6	91%	1%	1%	0%	2%	1%	1%	Growth in this sector is expected to come from the Ferro-Chrome industry.
Chemical	Elasticity of 1.2	84%	3%	1%	1%	2%	6%	2%	Continued growth.
Other mining	Elasticity of 0.53	41%	12%	2%	4%	0%	10%	5%	Should be further disaggregated into more sectors in the future.
Non-ferrous metals	Elasticity of 1.87	61%	4%	3%	0%	7%	3%	5%	Aluminium growth is expected during the period.
Non-metallic minerals	Elasticity of 1.37	75%	6%	2%	0%	0%	1%	6%	Increased local building and joint ventures with neighbouring countries with GDP growth is likely.
Pulp & paper	Elasticity of 0.25	81%	1%	2%	1%	2%	5%	3%	Growth due forest limits and water restrictions was thought to be limiting here. This assumption may need revisiting.
Other industry	Elasticity of 2.0	78%	4%	2%	1%	0%	4%	2%	Small processing industries are likely to increase over the period.
Food & tobacco	Elasticity of 1.5	91%	1%	1%	2%	0%	1%	1%	Increased processing is likely within this sector as wealth increases.
Commerce	Elasticity of 1.08	47%		15%	3%	25%			The measure of commercial growth is m^2 of floor space.
Agriculture	Elasticity of 0.45	82%		0%	1%	2%	1%	5%	This sectors growth is limited by arable land constraints.

Other	Elasticity of 1	100 %							Essentially this sector exists because the statistics do not balance. Therefore it is assumed to grow with GDP.
TRANSPORT									Sub-sectors not included in the table are international marine.
Passenger		Petrol cars	Petrol taxis	Diesel cars	Diesel Buses	Electric trains			Recently trends relating to expendable income and fuel price have become evident. It should be necessary to remodel this sector as the trends become better defined.
	Elasticity of 1	65%	24%	6%	4%	1%			
Freight		Diesel trucks	Diesel trains	Electric trains					Freight transport is linked to production. Two competing trends have maintained an elasticity of 1 with GDP. The trends are lower tonnages being transported more due to increased processing.
	Elasticity of 1	86%	7%	7%					
Air passenger		Jet aircraft	Gasoline turbo prop						
		2%	98%						
Residential	Elasticity of 1 to Population growth								Cooking and lighting are used for illustrative purposes. Much of the data for this section was taken from EDRC, and is referenced in the appendix.
Cooking		Elec hot plate	Elec stove	Kerosene primus	Kerosene wick	Coal brazier	Coal stove	Wood stove	Other devices modelled but not included in the table are LPG ring stoves and electric microwaves. Provision is made for natural gas ring stoves in the future. Devices were modelled to only supply one energy service. This is an artificial simplification, as stoves often supply the service of cooking, space heating and water heating.
		3%	16%	8%	10%	26%	23%	12%	
Lighting		Elec CFL	Elec fluorescent	Elec Incandescent	Kerosene pressure	Kerosene wick	LPG pres		
		<1%	6%	75%	9%	9%	<1%		
Space Heating		Anthr heater	Dung open fire	Elec heater	Kero heater	LPG heater	Wood		Refer to the note under 'Cooking'.
		2%	5%	12%	2%	1%	78%		
Water heating		Elec geyser	LPG geyser	Solar	Agri. waste	Coal	Wood		Refer to the note under 'Cooking'.
		98%	1%	1%	<1%	<1%	<1%		
Other		LPG	Elec						This energy service refers to items such as refrigerators, televisions, Hi-fi's etc. It is assumed to grow with electrification over the period. It should be noted, however, that demand levels are likely to relate not only to access but also expendable income.
		4%	96%						

2.2.3 Useful energy demand

Useful energy is, broadly speaking, a measure of the 'energy service delivered'. An energy carrier such as coal is burned in a boiler to provide thermal energy which is delivered to the user by a steam system. The useful energy is the heat delivered. The 'final energy' is the coal consumed. The useful energy is related to the final energy by the efficiency of the boiler and steam system. In order to perform a given activity, energy services are normally required.

2.2.4 Useful energy intensity

Energy intensity refers either to the amount of fuel required to perform a given activity, such as to produce a ton of product, to satisfy the services required by an average household or to produce a unit of GDP or it refers to some other index of activity, such as moving one passenger by one kilometre. Energy is often changed from an end use fuel such as diesel to a more useful form such as compressed air. The useful energy is estimated and the 'useful energy intensity' is derived from this. 'Useful energy intensity' is the amount of energy 'service' required per unit of activity. An example would be the amount of compressed air required to produce a ton of gold. The useful energy intensity, together with sector growth, is used to predict useful energy demand into the future.

As processes change, a more efficient practice is often taken up and useful energy intensities may drop. Estimates were developed with Eskom's Integrated Strategic Energy Planning (ISEP) office. It was assumed that there would be a drop in useful energy intensity of close to 10% over the period for agriculture, commerce and most of industry, because of a gradual passive modernisation of practice. The exceptions in industry were gold mining and other mining. Gold mining intensities have been increasing and this trend is likely to continue because of the increase in mining depth and the decrease in ore quality. Other mining energy intensity was kept constant as moves to more efficient equipment were thought to counter increased depths that would be required in the future. The residential sector and the transport sectors are modelled more explicitly.

The energy intensity for passenger transport for the following modes has been estimated (MJ of fuel per passenger-km in brackets) (Howells et al 2002).

- Petrol taxis (0.6).
- Diesel taxis (0.4).
- Passenger trains (0.2).
- Petrol cars (2.9).
- Diesel cars (2.6).

The above values, taken together with the percentage of passenger kilometres by the modes above, represent an estimate of current practice in South Africa. With the exception of passenger trains, a less energy-intensive (more efficient) option has been established compared to the above. Change in the vehicle stock and practice is represented by allowing for different penetrations of efficient options.

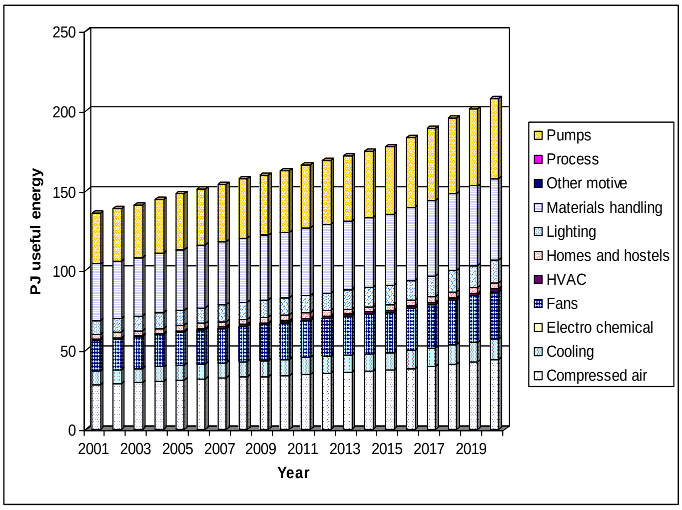
In the residential sector different estimates are given for each service required, such as useful cooking energy required per household. These assumptions should be carefully considered in further iterations of this work. Work should be done to establish different intensities based on income levels and geographical distribution. Also, it is often difficult to separate water heating, space heating and cooking demand, when a single device (such as a coal brazier) may be used to supply all three services. Work should be done to describe this sector more accurately. In the residential sector, ‘other’ demand refers to electrical requirements such as refrigeration, television etc. This service is not supplied to all of the households in South Africa, and is dependent on access to electricity and financing. It is assumed that in 2001 60% of households had access to ‘other’ services, such as television, refrigeration etc., and that this figure increases to 80% by 2020. Estimates of the energy intensity of household activities are summarised below in Table 2. These are derived from population, fuel consumption and device efficiencies (de Villiers & Matimbe 2000).

Table 2: Energy intensity for various activities in the residential sector

Service	Intensity (GJ/household)
Cooking	12.3
Lighting	1.6
Water heating	3.0
Space heating	9.5
Other	5.6

2.2.5 Useful energy requirements into the future

After relating sector activities, drivers, elasticities and useful energy intensity changes, useful energy demand projections can be made. Figure 1 illustrates these projections for the various sectors calculated by LEAP. The useful energy requirements are consistent across all scenarios.



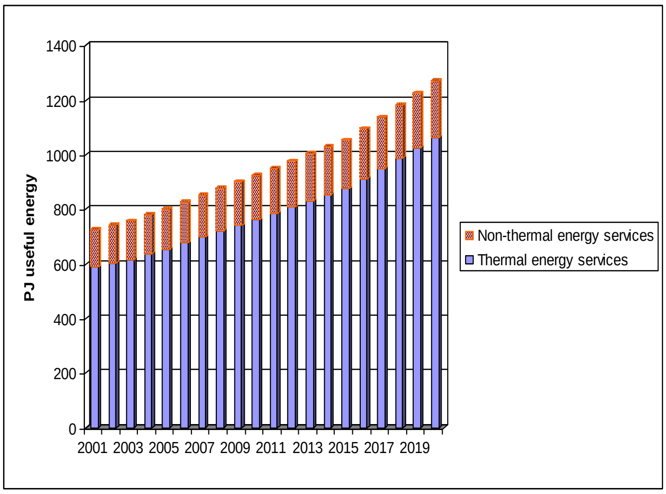
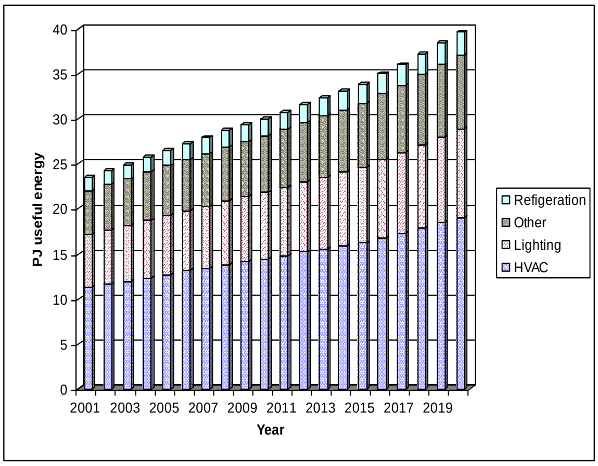


Figure 1: Industrial energy service requirements

The top figure shows the breakdown of the useful energy required by non-thermal energy services such as lighting, air conditioning, pumping etc. The lower figure shows the total useful energy required by the industrial sector in terms of non-thermal energy services and thermal energy services. This also applies to Figure 2, Figure 3, and Figure 4.



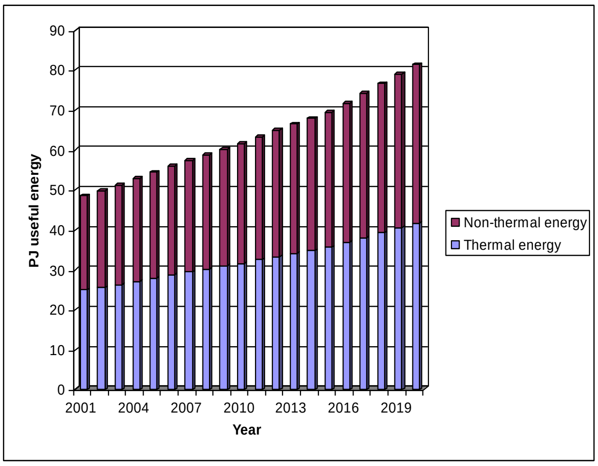


Figure 2: Commercial energy service requirements

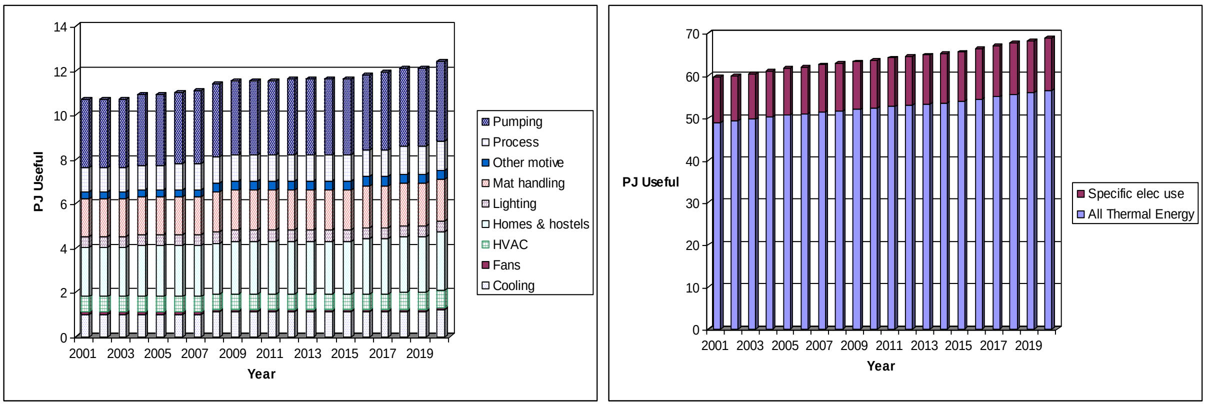


Figure 3: Agricultural energy service requirements

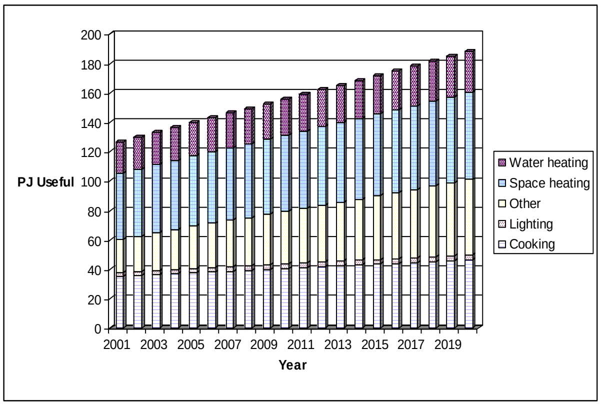
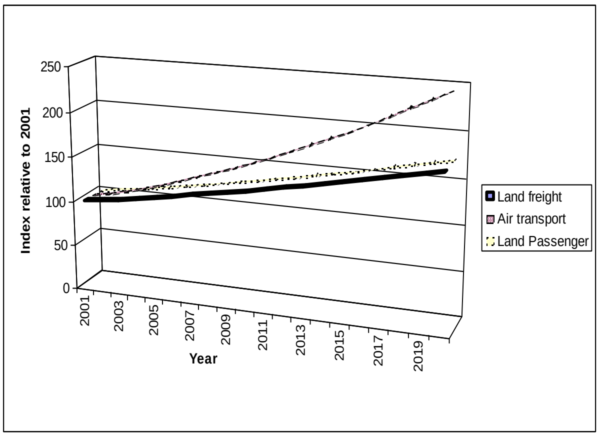


Figure 4: Residential energy service requirements

Transport services considered are divided into four major groups, namely: air, passenger surface (including cars, minibus taxis, buses and trains), freight surface, and international marine travel. International marine bunkers are not considered in the analysis. Local marine travel is small. Figure 5 illustrates the demand projections for the transport sector relative to 2001 figures, and the relative consumption of fuel by vehicle type.



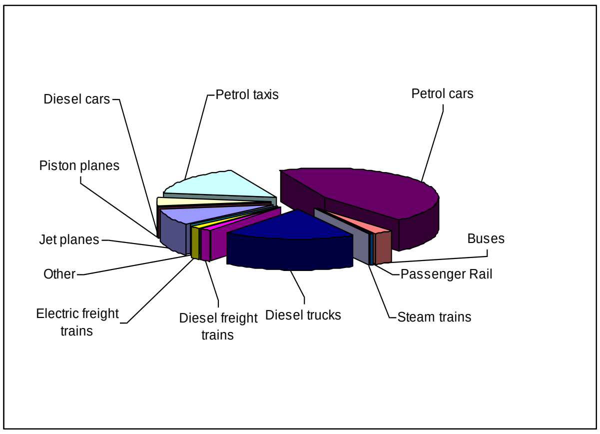


Figure 5: Transport energy demand

The useful energy demand for the agricultural, industrial and commercial sectors has been split into thermal requirements (such as furnaces and steam raising) and non-thermal requirements. The latter are considered to be dominated by electricity use. Figure 6 indicates the thermal and non-thermal useful electricity requirements for industry in 2001 (Kenny & Howells 2002).

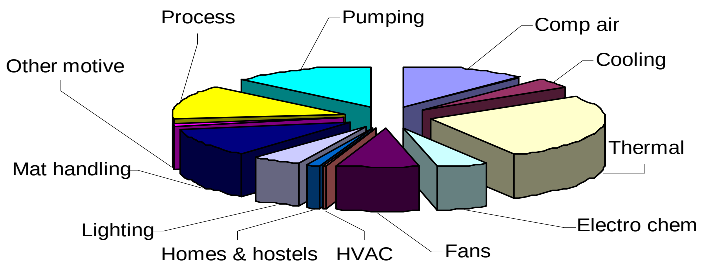


Figure 6: Electricity use in industry

2.3 The Potential and Likely Savings Scenarios and modelling efficiency improvements

Using the above-mentioned split it is possible to determine the effects of different equipment efficiencies. For example, suppose the efficiency of a compressed air system were to improve and 50% less energy was used to deliver the required amount of compressed air. This would be reflected by a change in the efficiency between useful and final energy in the model. The improvement would take place over time, so the efficiency would change over time.

This section describes assumptions for average efficiency improvements and their penetration over time for the scenarios.

2.3.1 Energy efficiency improvements

Table 3 gives energy efficiency improvements due to technology improvements and is taken from Hughes et al 2002.

Table 3: Energy efficiency improvements resulting from technology improvements

Measure	Fuel affected	Fuel Saving potential	When economic[1]?
VSD	Electricity	30%	2000-2010
Motors	Electricity	5%	2006-2010
Comp air	Electricity	20%	Immediately
Lighting	Electricity	35%	2002-2006
HVAC includes some VSDs	Electricity	25%	2002-2010
Energy Star Equipment	Electricity	30%	Immediately
Commercial building design	Electricity[2]	40%	Immediately[3]
Thermal Fuel:	Solid	15%	Immediately

[1] These results are very sensitive to initial assumptions. A range has therefore been suggested.
[2] Affects other fuels, but the primary effect is for electricity.
[3] Authors estimate. This has not yet been modelled in the MARKAL IEP model.

Industry, Agriculture and commerce.			Immediately
			Immediately
			Immediately
		13%	Immediately
			Immediately
	Liquid		Immediately
	Gas	11%	Immediately
	Electricity	10%	Immediately
Household CFL use	Electricity	65%	2002-2010
	Coal	30%	Immediately
Efficient stoves	Wood		Immediately
Electricity to LP gas	Electricity	50% system efficiency.	Immediately
Solar hot water heater (residential)	Electricity	75%[4]	2002-2010[5]
Geyser insulation	Electricity	5%	2002-2010[6]
Add ceilings to RDP houses and insulation to existing houses.	Thermal fuels	15-40% (15%)[7]	Immediately[8]

The savings represent averages assumed for the systems considered, which are later used in the 'potential savings' and 'likely savings' scenarios. The realisation of these savings would depend on how extensively they are implemented and during what time period.

2.3.2 Energy efficiency uptake/penetration over time

The following section concludes with tables indicating the uptake or penetration of energy efficiency over time for the likely scenarios.

There are two sets of penetration rates described in the modelling for the Potential and Likely Savings scenarios. The former indicates the maximum potential savings and the latter, the uptake proposed as for the strategy suggested.

The maximum potential savings was derived from assuming that either the measure (for example, fixing compressed air leaks) could be implemented immediately or (as in the case of motor replacements) would probably take place as existing stock was retired and new equipment was needed as industry grows[9]. Each industrial sub-sector is projected to grow at different rates; therefore there is a different potential uptake (as a percentage of the total for that industry) for each industry. These were evaluated for each sub-sector considered. Figure 7 below shows the maximum uptake for new / replaced equipment in the Iron and Steel industrial sub-sector.

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4 Proponents claim 90% saving of electricity.
5 Authors estimate. This has not yet been modelled in the MARKAL IEP model.
6 Authors estimate. This has not yet been modelled in the MARKAL IEP model.
7 It was assumed that only 50% of households had significant winter heating requirements. A total penetration of 30% was assumed.
8 Authors estimate. This has not yet been modelled in the MARKAL IEP model.
9 While existing equipment could be replaced immediately, this is often less economic than simply replacing retiring equipment, hence this approach.

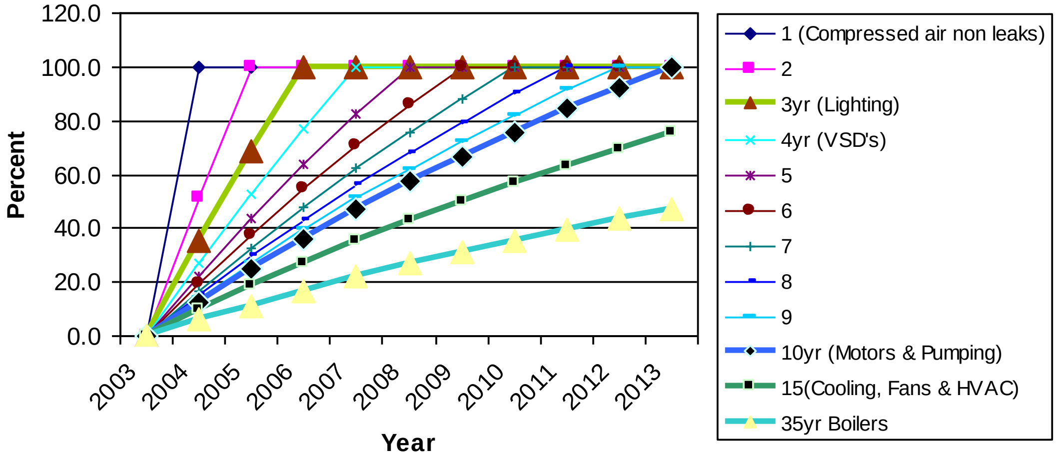


Figure 7: Equipment replacement rates

The likely savings are derived from assumptions based on studies which have evaluated national energy efficiency programmes. It must be noted however that these can only be indicative, as the extent of the programme and financing is specific and tailored to the region where the programme was implemented. In the case of equipment standards, however, the maximum potential is likely to be followed as energy users will have no option other than buying efficient devices. Illustrated in Figure 8 below is the penetration rate for efficient motors assuming a ten year equipment life for a programme beginning in phase two.

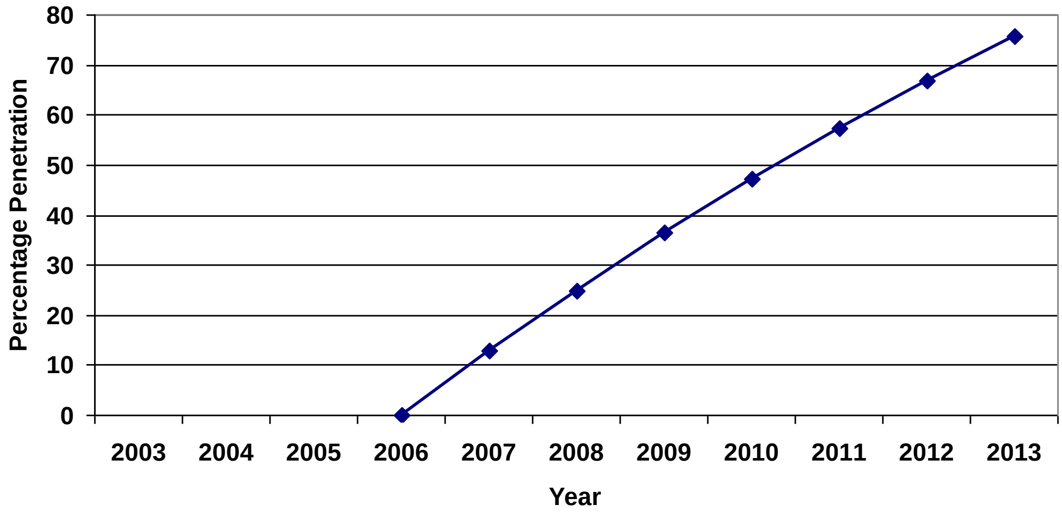


Figure 8: Motor standards

The following tables give the assumed penetrations that were used for developing the 'likely savings' scenario. These are in terms of penetration of the efficiency measure in either 2006, 2010, and in 2013.

2.3.2.1 Industry and mining

The proposed policies to be implemented for industry by government include:

- Equipment standards for
  - Motors
  - Boilers
  - Insulation,
- Free energy audits,
- Energy management in the form of
  - Green accounting,
  - Awareness programmes (for compressed air, other maintenance)
- Focus on technologies, variable speed drives (VSDs), thermal measures, and efficient lighting) including:
  - Research and development programmes
  - Further awareness programmes
  - In the case of mining, detailed heating ventilation and cooling (HVAC) audits and replacement of pneumatic tools with hydraulic and electric tools.

The assumptions for the penetration rates for the 'likely' scenario are given in Table 4 to 7.

Table 4: Standards

	System affected Assuming a 35yr life for Boilers, 10yr life for motors (Howells et al 2002) and 1 audit per 100 employees	**2006**	**2010**	**2013**
Gold Mining	Boilers	0	10	18
	Insulation	0	13	24
	Electric motors	0	39	69
Iron & Steel	Boilers	0	22	36
	Insulation	0	30	47
	Electric motors	0	47	76
Chemical	Boilers	0	24	38
	Insulation	0	31	51
	Electric motors	0	48	77
Other mining	Boilers	0	20	32
	Insulation	0	26	43
	Electric motors	0	46	75
Non-ferrous Metals	Boilers	0	21	35
	Insulation	0	28	47
	Electric motors	0	50	76
Non-metallic Minerals	Boilers	0	21	35
	Insulation	0	28	47
	Electric motors	0	46	75
Pulp & Paper	Boilers	0	12	21
	Insulation	0	15	28
	Electric motors	0	40	70
Other Industry	Boilers	0	23	37
	Insulation	0	31	49
	Electric motors	0	48	76
Food & Tobacco	Boilers	0	23	36
	Insulation	0	30	48
	Electric motors	0	48	76

Table 5: Energy Audits

System affected	Gold Mining			Iron & Steel			Chemical			Other Mining			Non-ferrous Metals			Non-metallic Minerals			Pulp & Paper			Other Industry			Food & Tobacco		
Phases[10]	2006	2010	2013	2006	2010	2013	2006	2010	2013	2006	2010	2013	2006	2010	2013	2006	2010	2013	2006	2010	2013	2006	2010	2013	2006	2010	2013
Boilers, furnaces & steam[11]	0	16	25	0	16	25	0	16	25	0	16	25	0	16	25	0	16	25	0	16	25	0	16	25	0	16	25
Compressed air[12]	0	17	27	0	40	70	0	40	70	0	40	70	0	40	70	0	40	70	0	40	70	0	40	70	0	40	70
Cooling[13]	0	7	11	0	7	11	0	15	25	0	7	11	0	15	25	0	7	11	0	7	11	0	7	11	0	7	11
Fans (VSDs)[13]	0	7	11	0	7	11	0	20	40	0	20	40	0	20	40	0	20	40	0	20	40	0	20	40	0	20	40
HVAC[13]	0	7	11	0	7	11	0	30	60	0	7	11	0	30	60	0	7	11	0	7	11	0	7	11	0	7	11
Motors[13]	0	7	11	0	7	11	0	7	11	0	7	11	0	7	11	0	7	11	0	7	11	0	7	11	0	7	11
Lighting[14]	0	13	21	0	13	21	0	13	21	0	13	21	0	13	21	0	13	21	0	13	21	0	13	21	0	20	40

10 Assumed that up to 540 audits per year was achievable based on US experience (US DOE IAC database). This represents 4% of industry per year. The implementation of measures is based on rates from the US Industrial assessment centre. Assuming one audit per hundred employees.

11 High rate of implementation (seventy nine percent for adjusting fuel/air intake) due to profitability. (Clarke 2003)

12 High rate of implementation (83% for fixing compressed air leaks) due to profitability. (Clarke 2003)

13 Based on a longer payback period up to 2.4 years (34% implementation). (Clarke 2003)

14 Relatively high implementation rate due to easily achieved re-lamping. (Clarke 2003)

Table 6: Energy Management (awareness and green accounts)

System affected	2006	2010	2013	Comments: Based on a 10% to 15% percent penetration observed for other awareness campaigns (Robinson J B). With implementation based on observed rates from the US IAC programme, as above (Clarke 2003).
Thermal	7.9	7.9	11.9	
Compressed air	8.3	8.3	12.45	
Cooling	3.4	3.4	3.4	
Fans (VSDs)	3.4	3.4	3.4	
HVAC	3.4	3.4	3.4	
Motors	3.4	3.4	3.4	
Lighting	6.7	6.7	10.0	

Table 7: Technologies

System affected	2006	2010	2013	Comments: Based on a 10% to 15% percent penetration observed for other awareness campaigns (Robinson J B). With implementation based on observed rates from the US IAC programme. (Clarke 2003)
Thermal	7.9	7.9	11.8	
Cooling	3.4	3.4	5.1	
Fans (VSDs)	3.4	3.4	5.1	
HVAC	3.4	3.4	5.1	
Lighting	6.7	6.7	10.0	
Pneumatic tools	8.3	8.3	12.45	

2.3.2.2 Commercial

It was assumed that industrial auditing and awareness campaigns would produce similar results, in terms of penetration. Specific to the commercial sector and not covered in the industry section are SAEDES and lighting standards. These are summarised in Table 8 and Table 9.

Table 8: SAEDES Standards for new buildings

System affected	2006	2010	2013	Comments
HVAC	8	20	28	Based on new commercial floor-space required. (Howells et al 2002)

Table 9: Lighting Standards buildings

System affected	2006	2010	2013	Comments
Lighting	100	100	100	Based lighting equipment life.

2.3.2.3 Residential

Interventions in the residential sector include the implementation of

- Standards for
  - New RDP households and,
  - Efficiency standards/labelling for household appliances
- Awareness campaigns to change wasteful behaviour,
- Technology-directed campaigns focusing on efficient lighting.

The scenario assumptions are given in Table 10 and Table 11 below.

Table 10: Building standards for new RDP households

System affected	2006	2010	2013	Comments
Heating	1.4	3.1	4.2	Based on current trends and statistics (Hughes et al 2002), and assuming that 30% of new households built are 'RDP households'.

Table 11: Appliance standards (awareness and green accounts)

System affected	2006	2010	2013	Comments: Based on appliance life
Coal stoves	22	46	61	10
Wood stoves	22	46	61	10
Paraffin wick	88-11	100	100	4
Electric oven	39	81	100	10
Hotplates	63	100	100	5
Geysers	22	46	62	10
Other appliances (Fridges etc.)	10	20	30	20

2.3.2.4 Transport

Saving fuel in the transport sector has an impact on the amount of fuel used in vehicles and the amount of energy used in the fuel transformation process. The potential and likely savings reflected here represent only the fuel energy savings of the vehicles themselves. The proposed interventions in the transport sector are

- Standards
  - Efficiency standards for vehicles
  - Fuel quality standards
  - Emissions standards
- Technology
  - Promote efficient technology
  - Promote diesel vehicles
- Energy Audits
  - Audits on vehicles
  - Roadworthy test to include emissions
  - Training of vehicle inspectors
- Energy management
  - Awareness and education programmes

2.3.2.4.1 Standards

The assumptions for the likely penetration rate of more efficient vehicles after the implementation of standards are shown in Table 12. The penetration rates include the anticipated growth of vehicle traffic and the lifetime of the vehicles.

Table 12: Penetration rates after standards are implemented

System affected		2006	2010	2013	Comments
Efficiency standards for vehicles	Diesel vehicle	16.77	58.42	75.58	Assumed average vehicle age for cars and commercial vehicles is 10 years, trucks 13 years and busses 12 years, average vehicle life for cars and light delivery vehicles is 18 years, trucks 25 years, busses 14 years, and taxis 11 years. (www.transport.gov.za; Moving South Africa)
	Petrol Taxi	11.89	52.90	78.43	
	Petrol Car	6.76	31.41	48.54	
	Public bus	9.90	44.44	66.07	
	Diesel freight	6.91	30.91	46.21	
Fuel quality standards		0	0	0	Fuel quality standards are generally set to control the level of emissions. Improved emissions levels do not imply improved vehicle efficiency. Transformation emissions and the energy required in the transformation process may increase when altering fuel quality and emissions standards.
Emissions standards		0	0	0	South Africa has little control over the emissions standards of imported vehicles, these standards do not affect the efficiency of vehicles which is generally governed by the CO2 content of the exhaust gas. It is thus unlikely that setting emissions standards will have any effect on vehicle efficiency.

2.3.2.4.2 Technology

Promote efficient technologies through a scrapping incentive

Scrapping incentives are introduced to remove the oldest vehicles from the road, these vehicles are often not used to travel long distances which limits the impact of the scrapping scheme. If financial incentives were provided to reduce the average vehicle life by 2 years the penetration rates of new vehicles based on this assumption are shown in Table 13 below.

Table 13: Penetration rates due to a scrapping incentive

	2006	2010	2013
Diesel vehicle	17.38	60.42	78.02
Petrol Taxis	13.85	61.62	91.21
Petrol cars	7.45	34.71	53.68

The decrease in vehicle efficiency per year of vehicle age is around 1% (Oregon Department of Transportation, 2002). Similarly a Canadian survey found that light vehicles 14 years or older may use 11% more fuel, medium weight trucks 42%, heavy trucks 7% and buses 30% more fuel than vehicles that are less than 2 years old (Statistics Canada, 2000).

Promote diesel vehicles

The percentage share of passenger kilometers in the base case is shown in Table 14 below. The assumed percentage share of passenger kilometers after the promotion of diesel vehicles is shown below in Table 15.

Table 14: Percentage share of passenger km

	2000	2006	2010	2013
Diesel Taxis	0	0	0	0
Diesel vehicle	2.5	5.5	7.5	9
Electric vehicle	0	0	0	0
Petrol Taxis	52.2	52.2	52.2	52.2
Petrol cars	29.1	26.2	24.3	22.8
Public bus	11.1	11.1	11.1	11.1
Public rail	4.2	4.2	4.2	4.2
Steam trains	0.9	0.8	0.8	0.7

Table 15: Assumed percentage share after diesel vehicle promotion

	2000	2006	2010	2013
Diesel Taxis	0	6.5	10.8	14.1
Diesel vehicle	2.4	5.4	7.4	8.8
Petrol Taxis	52.2	45.7	41.3	38.1
Petrol cars	29.2	26.3	24.4	23.0
Public bus	11.1	11.1	11.1	11.1
Public rail	4.2	4.2	4.2	4.2
Steam trains	0.9	0.8	0.8	0.7

2.3.2.4.3 Energy Audits

Audits on vehicles

It is assumed that audits on vehicle fleets could improve fuel use by taxis, buses and trucks 4.5%.

Roadworthy test to include emissions

Roadworthy tests that include emissions would force older cars unable to meet emissions standards to be removed from the road, thereby reducing the average vehicle age and life. The assumed impact in terms of the penetration rate of new technology is shown below in Table 16.

Table 16: Penetration rates of roadworthy test impacts

	2006	2010	2013
Diesel vehicle	17.75	61.62	79.49
Petrol Taxis	15.20	67.62	100.00
Petrol cars	7.86	36.69	56.77
Public bus	11.79	52.86	78.41
Diesel Freight	7.44	33.27	49.67

2.3.2.4.4 Energy Management

Energy management schemes suggested are based on driver awareness and training, these programmemes have achieved efficiency improvements in vehicle fleets of 6-8%, it is suggested that 10–20% can be achieved (DETR, 1999). The Energy Efficiency Conservation Authority of New Zealand also suggests that 10 -20% of fuel can be saved through the introduction of simple techniques (Energy Efficiency and Conservation Authority, http://www.eeca.gov.nz). It is assumed that a fuel saving of 3.5% can be achieved.

2.3.2.4.5 Other

The impact of improving public transport has not been considered in this report. Public transport has a low energy intensity (GJ/passenger km) and helps to improve road congestion which can increase vehicle efficiency by up to 20%.

3. RESULTS

The results given below are in terms of energy savings for each measure, and then in terms of aggregates.

SECTOR: Industry (PJ)	**Phase One (Saving in year 2005)**				**Phase Two (Saving in year 2009)**				**Phase Three (Saving in year 2013)**			
Energy carrier / Intervention	Electricity	Coal	Liquid	Other	Electricity	Coal	Liquid	Other	Electricity	Coal	Liquid	Other
Standards:												
- boilers	0.00	0.00	0.00	0.00	0.27	6.63	0.32	1.78	0.62	15.70	0.75	4.06
- technical insulation	0.00	0.00	0.00	0.00	2.71	18.86	1.29	6.58	6.26	44.68	3.00	15.06
- electric motors	0.00	0.00	0.00	0.00	1.94	0.00	0.00	0.00	4.59	0.00	0.00	0.00
Energy Audits	0.00	0.00	0.00	0.00	3.58	4.54	0.30	1.79	8.19	10.93	0.71	4.20
Energy management	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
- compressed air	0.65	0.00	0.00	0.00	1.08	0.00	0.00	0.00	1.78	0.00	0.00	0.00
- other maintenance	0.80	1.76	0.12	0.71	1.32	3.03	0.21	1.19	2.19	5.16	0.34	1.98
- green accounts	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
New technologies:	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
- efficient light	0.21	0.00	0.00	0.00	0.36	0.00	0.00	0.00	0.70	0.00	0.00	0.00
- thermal measures	0.22	1.77	0.12	0.71	0.36	3.03	0.20	1.19	0.60	5.15	0.33	1.98
- VSD	0.15	0.00	0.00	0.00	0.25	0.00	0.00	0.00	0.42	0.00	0.00	0.00
- others	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total all measures	2.03	3.53	0.24	1.42	14.54	36.09	2.32	12.53	31.95	81.62	5.13	27.28
Total likely savings	1.93	3.38	0.15	1.35	11.99	28.89	1.74	10.37	25.76	63.76	3.84	22.10

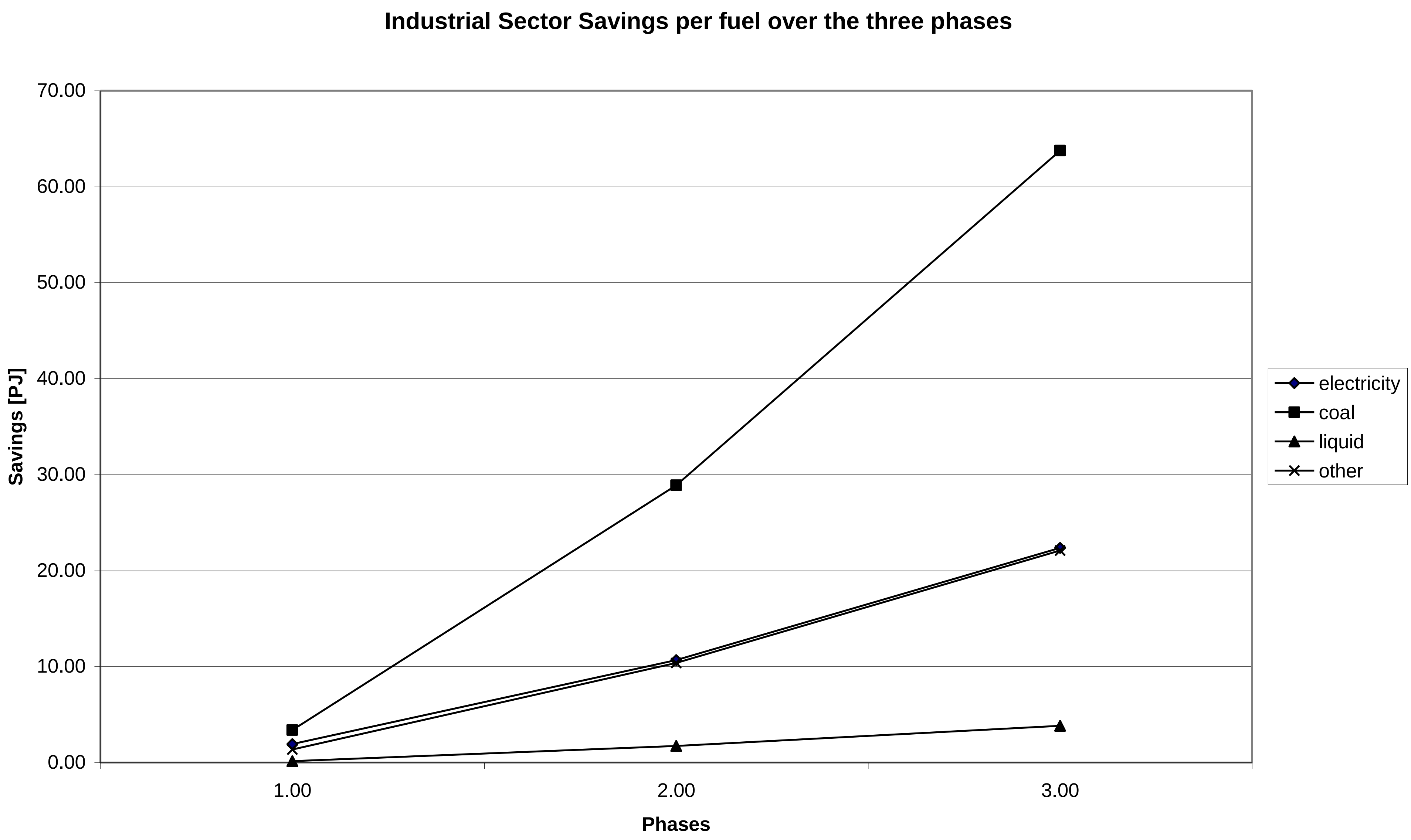
SECTOR: Mining (PJ)	**Phase One (Saving in year 2005)**				**Phase Two (Saving in year 2009)**				**Phase Three (Saving in year 2013)**			
Energy carrier Intervention	Electricity	Coal	Liquid	Other	Electricity	Coal	Liquid	Other	Electricity	Coal	Liquid	Other
Standards:												
- boilers	0.00	0.00	0.00	0.00	0.00	0.16	0.11	0.00	0.01	0.39	0.26	0.00
- technical insulation	0.00	0.00	0.00	0.00	0.03	0.47	0.44	0.01	0.07	1.10	1.05	0.03
- electric motors	0.00	0.00	0.00	0.00	1.06	0.00	0.00	0.00	2.41	0.00	0.00	0.00
Energy Audits	0.00	0.00	0.00	0.00	1.71	0.13	0.13	0.00	3.62	0.30	0.31	0.00
Energy management												
- compressed air	0.51	0.00	0.00	0.00	0.79	0.00	0.00	0.00	1.20	0.00	0.00	0.00
- other maintenance	0.23	0.06	0.05	0.00	0.37	0.09	0.08	0.00	0.56	0.14	0.14	0.00
- green accounts												
New technologies:												
- efficient light	0.06	0.00	0.00	0.00	0.05	0.00	0.00	0.00	0.07	0.00	0.00	0.00
- thermal measures	0.04	0.00	0.00	0.00	0.07	0.00	0.00	0.00	0.10	0.00	0.00	0.00
- VSD	0.05	0.00	0.00	0.00	0.08	0.00	0.00	0.00	0.12	0.00	0.00	0.00
- others	1.73	0.00	0.00	0.00	2.47	0.00	0.00	0.00	3.46	0.00	0.00	0.00
Total all measures	2.62	0.06	0.05	0.00	7.44	0.85	0.76	0.01	13.49	1.93	1.76	0.03
Total likely savings	**2.62**	**0.06**	**0.05**	**0.00**	**7.28**	**0.69**	**0.61**	**0.01**	**13.03**	**1.55**	**1.40**	**0.03**

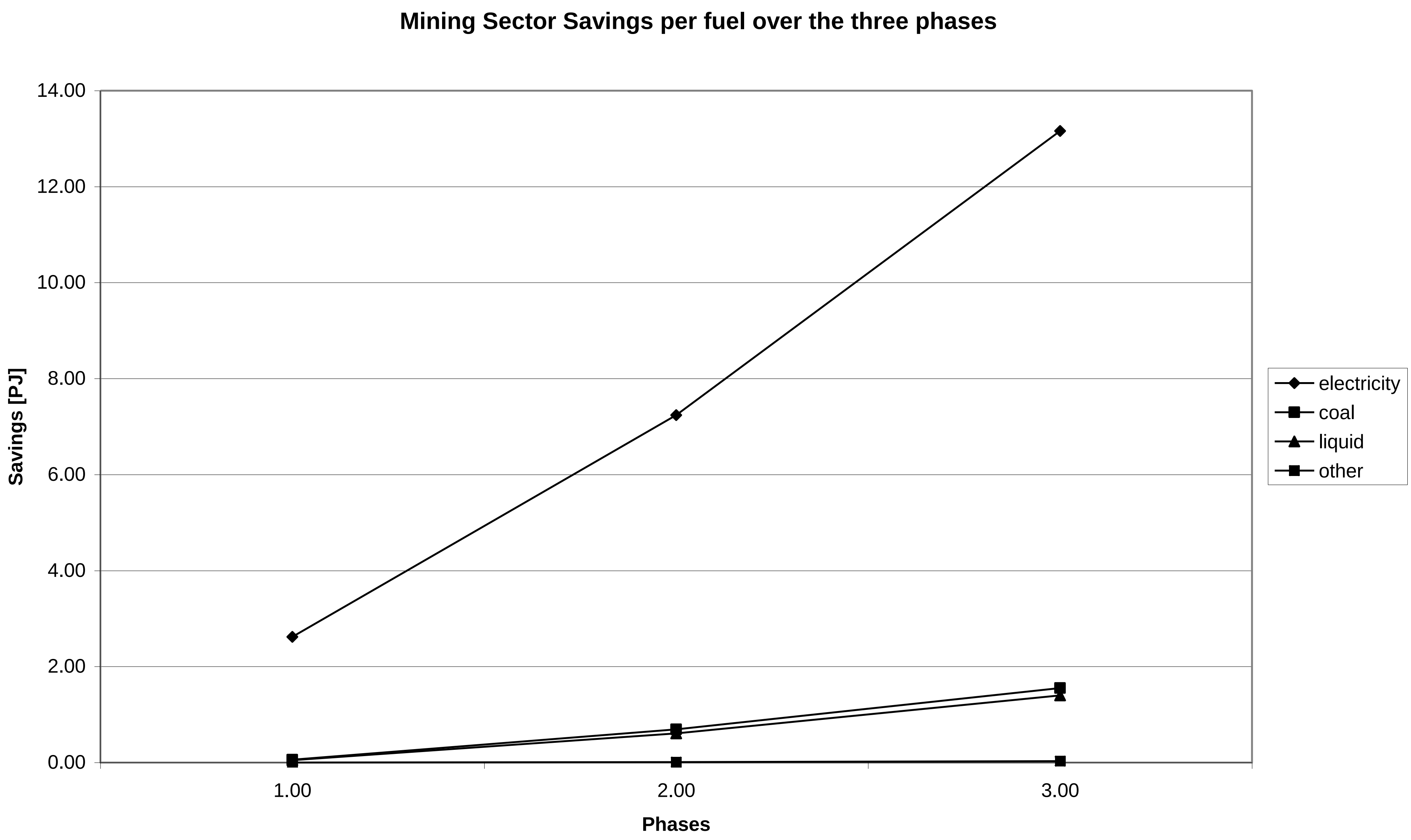
SECTOR: Commerce (PJ)	**Phase One (Saving in year 2005)**				**Phase Two (Saving in year 2009)**				**Phase Three (Saving in year 2013)**			
Energy carrier Intervention	Electricity	Coal	Liquid	Other	Electricity	Coal	Liquid	Other	Electricity	Coal	Liquid	Other
Standards:												
- Energy Efficiency standards	0.8	0	0	0	2.5	0.2	0	0	4.4	0.3	0	0
Energy Audits	4.8	0	0	0	7.8	0	0	0	11.5	0	0	0
Energy management												
- Management Systems	0	0	0	0	0	0	0	0	7.4	0	0	0
New technologies:												
- efficient light	0	0	0	0	0	0	0	0	3.7	0	0	0
- thermal measures (HVAC)	0	0	0	0	0	0	0	0	4.2	0	0	0
Total Likely Savings	2.80	0.05	0.01	0.00	6.03	0.22	0.06	0.01	11.25	0.31	0.09	0.01

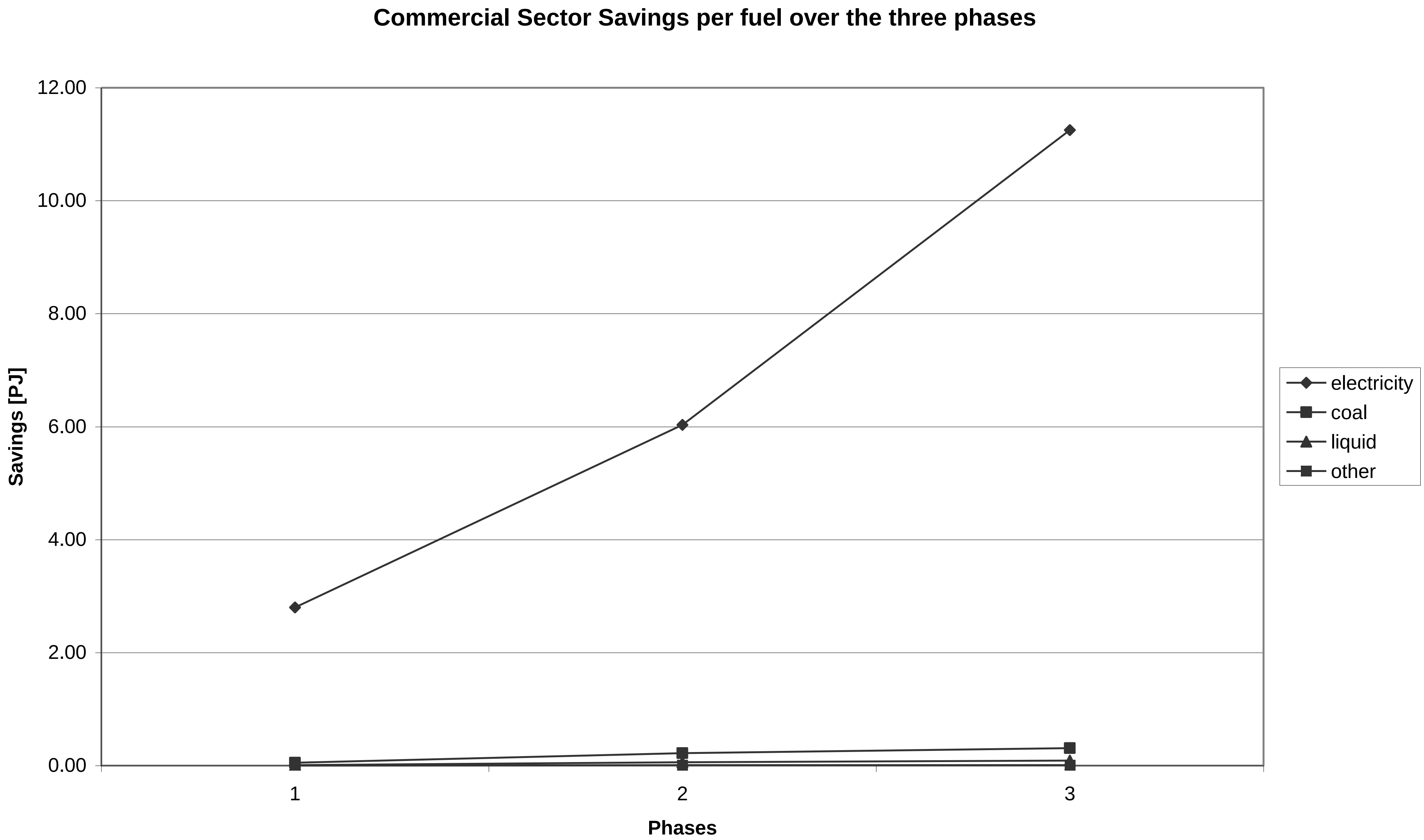
SECTOR: Residential (PJ)	**Phase One (Saving in year 2005)**				**Phase Two (Saving in year 2009)**				**Phase Three (Saving in year 2013)**			
Energy carrier Intervention	Electricity	Coal	Liquid	Other	Electricity	Coal	Liquid	Other	Electricity	Coal	Liquid	Other
Standards:												
- Energy Efficiency standards	0.1	0	0	0.7	0.4	0.1	0.1	2.1	0.7	0.1	0.1	3.5
- Labelling/efficiency standards for household appliances	0.9	0.8	0.4	0.4	2.1	1.7	0.9	1.0	4.1	2.8	1.4	1.5
Energy Audits	0	0	0	0	0	0	0	0	0	0	0	0
Energy management												
- Behaviour changes	0.32	0	0	0	0.5	0	0	0	0.79	0	0	0
New technologies:												
- efficient light	2.09	0	0	0	3.07	0	0	0	4.36	0	0	0
Total Likely Savings	3.07	0.73	0.37	1.16	6.55	2.50	1.27	4.39	9.52	2.75	1.38	5.14

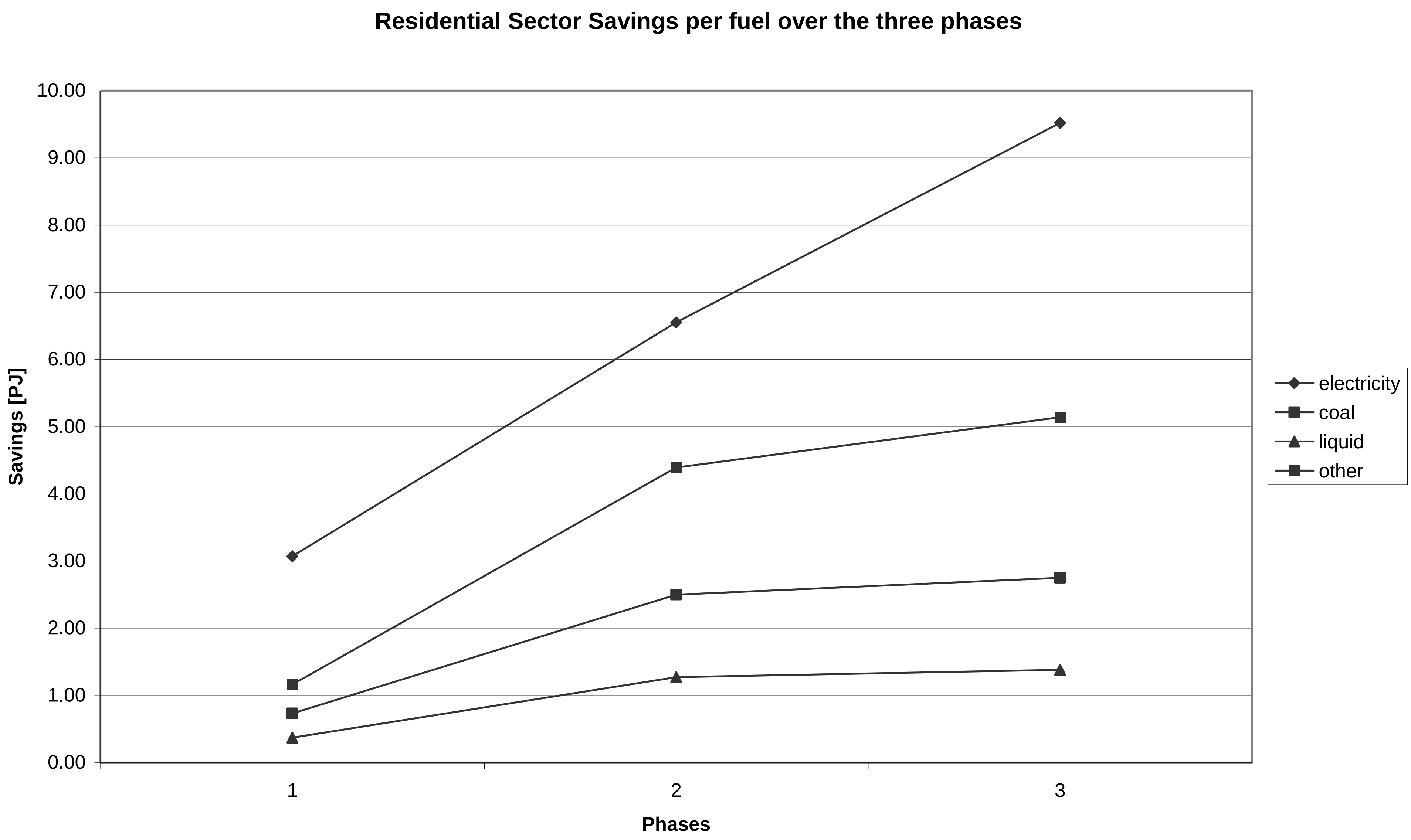
SECTOR: Transport (PJ)	**Phase One (Saving in year 2005)**				**Phase Two (Saving in year 2009)**				**Phase Three (Saving in year 2013)**			
Energy carrier Intervention	Electricity	Coal	Liquid	Other	Electricity	Coal	Liquid	Other	Electricity	Coal	Liquid	Other
Standards:												
- Efficiency standards for vehicles	0	0	0	0	0	0	14.10	0	0	0	40.20	0
- Fuel quality standards	0	0	0	0	0	0	0.00	0	0	0	0.00	0
Emissions standards	0	0	0	0	0	0	0.00	0	0	0	0.00	0
Energy Audits												
- audits on vehicle fleet operators	0	0	0	0	0	0	11.60	0	0	0	18.80	0
- Roadworthy test to include emissions	0	0	0	0	0	0	12.40	0	0	0	37.90	0
- Training of vehicle inspectors	0	0	0	0	0	0	0.00	0	0	0	0.00	0
Energy management												
- General awareness	0	0	0	0	0	0	17.00	0	0	0	19.10	0
New technologies:												
- Promote efficient technologies	0	0	0	0	0	0	7.92	0	0	0	27.19	0
Promote diesel vehicles	0	0	0	0	0	0	6.58	0	0	0	10.67	0
Total Likely Savings	0	0	0	0	0	0	33.34	0	0	0	64.66	0

Sector	Present Consumption, 2000					Potential Savings (by Phases)			Likely Savings (by Fuel and Phases)														
	Coal	Electricity	Gas	Other	Total	Savings			Coal			Electricity			Liquid			Other			Total in 2013	% saving
	PJ	PJ	PJ	PJ	PJ	PJ			PJ			PJ			PJ			PJ			PJ	2013
Phases						1	2	3	1	2	3	1	2	3	1	2	3	1	2	3		
Industrial Sector																						
- Paper and Pulp	51.80	26.30	0.40	34.70	113.20	2.60	5.20	7.80	0.20	1.20	2.60	0.15	0.69	1.41	0.00	0.00	0.00	0.20	0.90	1.80	5.70	5.0
- Iron and Steel	197.40	86.90	70.00	8.90	363.20	11.20	28.00	44.80	1.00	7.70	16.20	0.51	3.29	6.96	0.00	0.40	0.80	0.80	5.70	12.00	35.80	6.8
- Chemicals and Petrochemicals	230.40	49.40	2.60	0.50	282.90	12.00	28.30	46.00	1.40	13.20	30.20	0.39	2.87	6.35	0.00	0.00	0.10	0.00	0.00	0.20	36.80	8.2
- Food and Tobacco	48.90	12.60	0.90	50.80	113.20	4.10	10.30	16.50	0.40	2.80	5.80	0.10	0.59	1.32	0.00	0.10	0.10	0.40	2.80	6.00	13.20	7.8
- Non-metallic Minerals	33.60	19.90	6.60	3.50	63.60	3.70	6.50	9.40	0.20	1.60	3.60	0.20	1.36	2.99	0.00	0.10	0.30	0.00	0.20	0.50	7.60	8.4
- Other – including Textiles	44.00	35.70	7.40	32.30	119.40	6.20	12.00	17.50	0.20	2.40	5.20	0.20	0.57	1.24	0.00	1.00	2.30	0.00	0.60	1.50	13.60	7.6
- Non-ferrous Metals	1.50	61.00	1.40	0.00	63.90	3.70	5.70	7.40	0.00	0.10	0.20	0.38	2.62	5.49	0.00	0.10	0.30	0.00	0.10	0.10	6.10	6.2
Mining Sector	17.20	114.30	0.70	18.70	150.90	11.50	15.30	18.90	0.00	0.60	1.50	2.62	7.28	13.03	0.00	0.50	1.30	0.00	0.00	0.00	16.40	9.4
Commercial Sector	14.90	56.80	2.50	3.30	77.50	7.50	11.90	15.10	0.00	0.20	0.30	2.80	6.03	11.25	0.00	0.00	0.00	0.00	0.00	0.00	11.70	10.8
Residential Sector	58.00	106.41	4.60	111.10	280.10	20.70	30.40	37.80	3.10	6.70	9.60	3.07	6.55	9.52	0.40	1.30	1.40	1.20	4.40	5.10	25.70	7.5
Transport Sector	0.60	12.30	0.00	568.20	581.10	0	114.95	164.51	0	0	0	0	0	0	0	33.34	64.66	0	0	0	64.66	8.8
Total	**663.6**	**547.88**	**90.01**	**802.00**	**2103.90**	**83.2**	**268.55**	**385.71**	**6.5**	**36.5**	**75.2**	**10.42**	**31.85**	**59.56**	**0.4**	**36.84**	**71.26**	**2.6**	**14.7**	**27.2**	**237.26**	**7.6**

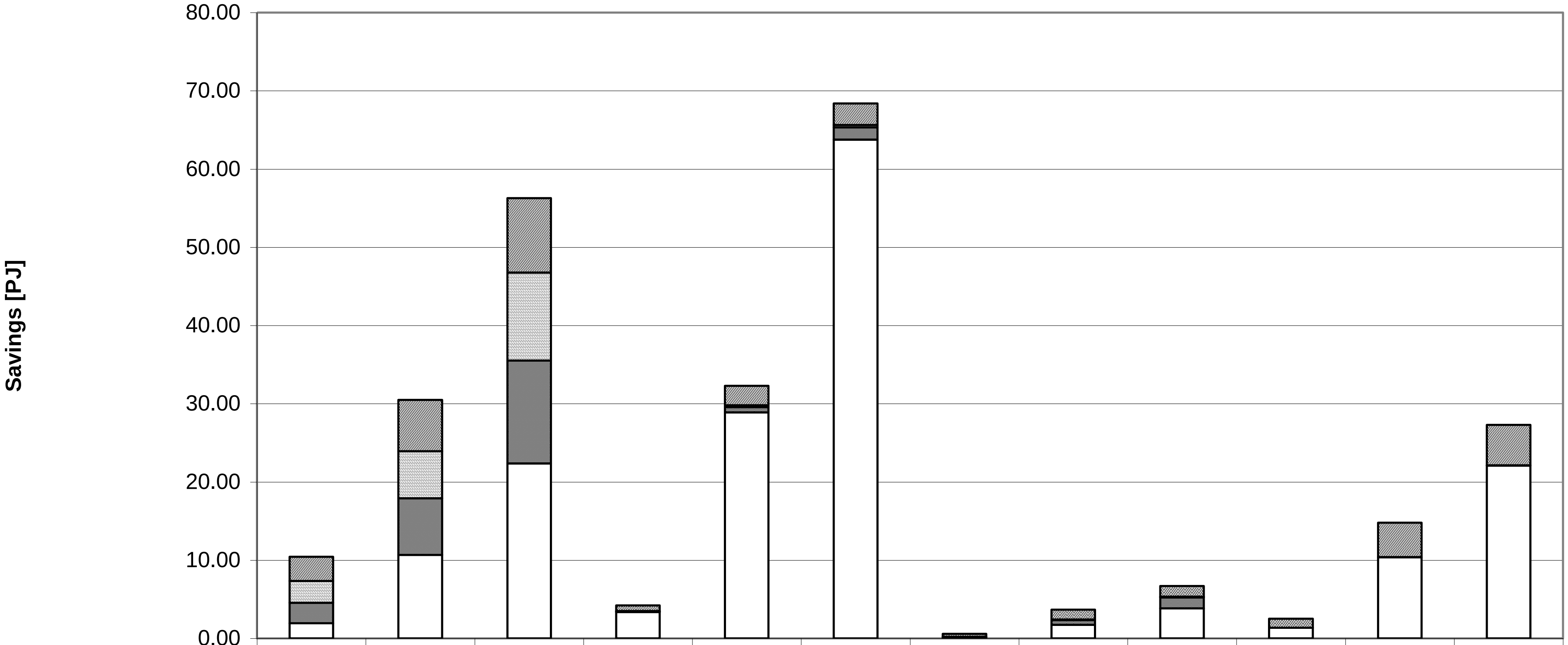

Industrial Sector Savings per fuel over the three phases
Savings [PJ]
70.00
60.00
50.00
40.00
30.00
20.00
10.00
0.00
1.00
2.00
3.00
Phases
electricity
coal
liquid
other


Mining Sector Savings per fuel over the three phases
Savings [PJ]
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
1.00
2.00
3.00
Phases
electricity
coal
liquid
other


Commercial Sector Savings per fuel over the three phases
12.00
10.00
8.00
6.00
4.00
2.00
0.00
Savings [PJ]
1
2
3
Phases
electricity
coal
liquid
other


Residential Sector Savings per fuel over the three phases
Savings [PJ]
10.00
9.00
8.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
1
2
3
Phases
electricity
coal
liquid
other

Sectoral Energy Savings split according to Fuel and Phase



	Elec P1	Elec P2	Elec P3	Coal P1	Coal P2	Coal P3	Liquid P1	Liquid P2	Liquid P3	Other P1	Other P2	Other P3
Residential Sector	3.07	6.55	9.52	0.73	2.50	2.75	0.37	1.27	1.38	1.16	4.39	5.14
Commercial Sector	2.80	6.03	11.25	0.05	0.22	0.31	0.01	0.06	0.09	0.00	0.01	0.01
Mining & Quarrying	2.62	7.24	13.16	0.06	0.69	1.55	0.05	0.61	1.40	0.00	0.01	0.03
industry	1.93	10.67	22.36	3.38	28.89	63.76	0.15	1.74	3.84	1.35	10.37	22.10

Fuels per Phase

4. DISCUSSION OF RESULTS

It is important to note that the results reported are based on assumptions drawn from observed effects of international experience. However the extent of resources allocated to the international programmemes has not been discussed. The resource allocation to local programmes should also be carefully costed in terms of required infrastructure, existing capacity for the programme ‘roll out’ vs. potential savings.

It is also worth noting that the ‘green accounting’ concept, where the reporting of energy data and potential improvements in energy intensity is made mandatory, is not well described in the literature. It has therefore been treated as an awareness programmeme – which it is. However it may be that this fairly novel approach is an exceptionally effective awareness tool, and results in more aggressive savings.

Due to a degree of overlap of the interventions, the likely savings cannot be the sum of the programmemes. Thus, the likely savings were calculated giving preference to standards and energy audit interventions. Energy management and energy technology interventions were added where applicable.

The work does not attempt to be more than indicative, as details of broadly similar programmemes differ and are specific to the programmeme situation. The detail of the programmemes suggested by the DME still needs to be worked out and in this context appropriate savings established in a further study. This is not undertaken in this work; rather assumptions are made about these which are then used to inform scenarios.

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APPENDIX A

TERMS OF REFERENCE: STRATEGIC INTERVENTIONS

Industry	**Phase One (year 1-3)**	**Phase Two (year 4-7)**	**Phase Three (year 7-10)**
Standards:			
- boilers	- Formulation and approval of standards - show cases + Monitoring & Evaluation	-Implementation of standards -training inspectors/operators	-Implementation of standards - training inspectors/operators
- technical insulation	- Formulation and approval of standards - show cases + Monitoring & Evaluation	Implementation of standards	Implementation of standards
- electric motors	- Formulation and approval of standards - show cases + Monitoring & Evaluation	Implementation of standards	Implementation of standards
Energy Audits	- develop certificate curriculum for auditors - test "free/subsidised" audit scheme through selected utilities - awareness & information	- certification of auditors - decision on continuation of "free/subsidised" audits - awareness & information	- certification of auditors - awareness & information
Energy management			
- compressed air	Awareness	Awareness	Awareness
- other maintenance	Awareness	Awareness	Awareness
- green accounts	-introduce "green accounts"	- further development of "green accounts" concept	- further development of "green accounts" concept
Technologies:			
- efficient light	Awareness	Awareness	Awareness
- thermal measures	Support to research Awareness	Support to research Awareness	Support to research Awareness
- VSD	Awareness	Awareness	Awareness
- others	Support to research Awareness	Support to research Awareness	Support to research Awareness

Mining	**Phase One (year 1-3)**	**Phase Two (year 4-7)**	**Phase Three (year 7-10)**
Standards:			
- electric motors	- Formulation and approval of standards - show cases + M&E	Implementation of standards	Implementation of standards
Energy Audits	formulate and test audit scheme	implement audit scheme	implement audit scheme
Energy management			
- compressed air	formulate and test compressed air awareness programmeme	compressed air awareness programmeme	compressed air awareness programmeme
- other maintenance	- awareness	- awareness	- awareness
- green accounts	- introduce "green accounts"	- further develop green accounts	- further develop green accounts
Technologies:			
- efficient light	efficient lights programmeme	efficient lights programmeme	efficient lights programmeme
- thermal measures (HVAC)	- Detailed audits of HVAC leading to redesign recommendations. - awareness raising	- awareness raising	- awareness raising
- VSD			
- other technology		replace pneumatic tools with hydraulic/electric	replace pneumatic tools with hydraulic/electric

Commercial	**Phase One (year 1-3)**	**Phase Two (year 4-7)**	**Phase Three (year 7-10)**
Standards:			
- Energy efficiency standards	making SAEDES mandatory	Implementation of standards	Implementation of standards
Energy Audits	Audits scheme for public/commercial buildings	Energy labels (compliance rating) re. SAEDES	Energy labels (compliance rating) re. SAEDES
Energy management			
- management systems		test and show case energy management systems	promote energy management systems
- green accounts	initiate green accounts systems	implement	implement
Technologies:			
- efficient light	efficient lights programmeme	efficient lights programmeme	efficient lights programmeme
- thermal measures (HVAC)	part of SAEDES	part of SAEDES	part of SAEDES

Residential	**Phase One (year 1-3)**	**Phase Two (year 4-7)**	**Phase Three (year 7-10)**
Standards:			
- Energy efficiency standards	draft standards/building codes for housing	Implementation of standards subsidy for RDP	Implementation of standards Subsidy for RDP
- labelling/efficiency standards for household appliances	draft and make ee standards mandatory for appliances	Implement standards	Implement standards
Energy Audits		N/A	N/A
Energy management			
- behaviour changes	Awareness/information	Awareness/information	Awareness/information
Technologies:			
- efficient light	efficient lights programmeme	efficient lights programmeme	efficient lights programmeme

TRANSPORT	**Phase One (year 1-3)**	**Phase Two (year 4-7)**	**Phase Three (7-10)**
STANDARDS			
- EFFICIENCY STANDARDS FOR VEHICLES	-Research and propose standards and regulations for vehicle efficiency - Vehicle licensing; differential licensing fee	Implementation and monitoring	Implementation
- Fuel quality standards	Revise fuel quality standards	Implementation	Implementation
- Emission standards	SABS to develop vehicle emissions standards	Implementation	Implementation
Technologies			
PROMOTE EFFICIENT CARS	Develop and introduce scrapping incentive allowance to renew car park	Implementation	Implementation
- Promote diesel vehicles	-Taxi re-capitalisation -Tax differential on petrol and diesel	Implementation	Implementation
ENERGY AUDITS			
- Audits on vehicle fleet operators	Develop audit standards for fleet operators	Implementation	Implementation
- Roadworthy test to include emissions	Liaise with MOT to include emission standards in RWC	Implementation	Implementation
- Training of vehicle inspectors	Develop curriculum for vehicle inspectors	Implementation	Implementation
Energy Management			
- General awareness	Awareness and education on driving efficiently	Implementation	Implementation