APPENDIX C: ENERGY BALANCES AND EFFICIENCY MEASURES

1. INTRODUCTION

This appendix outlines some of the data sources and energy efficiency measures and includes a report of their expected effect on energy use.

All of the energy efficiency measures discussed are measures which have minimal reliance on changing behaviour patterns. This is an attempt to establish a minimum achievable estimate of the savings potential in the South African socio-economy.

As a result many options are excluded, most notably in the transport sector. Other options with high capital cost components are also excluded.

2. ENERGY BALANCE AND EFFICIENCY MEASURES FOR COMMERCIAL ACTIVITY

2.1. Fuel consumption

To benchmark South Africa's industrial energy consumption it is necessary to establish accurate data for energy use across sectors and sub-sectors.

The Department of Minerals and Energy collects and maintains a national energy database. This was compiled by Cooper [DME 1998] of Rand Afrikaans University (1993 to 1996/7). Pouris has covered the years from 1997 to date [DME 2002].

The last revised balances compiled by Chris Cooper were for the years 1995 and 1996 [DME 1998]. The work was compiled after several iterations by the author and peer review. It is therefore considered to be one of the more authoritative pieces of work in this field. Doubt is raised by Cooper over the accuracy of the biomass consumption statistics he reported [Cooper 2002].

Industry specific data was compiled from work by the Energy Research Institute [Kenny 2002] and other industry specific studies [Howells et al 2001a,b,&c, Fawkes et al 2002, De Villiers 2001 and Voest 1997].

2.1.1. Electricity

Electricity consumption data is sourced from Prinsloo [Prinsloo 2002] of ESKOM's Integrated Strategic Electricity Planning Office. It is assumed, that the electricity consumption data is accurate. Assumptions regarding municipal demand split ratios were based on estimates, while actual ESKOM sales were reported.

Discrepancies exist between this data and that of some case studies. An example is the textile industry where higher than reported consumption has been recorded [Voest 1997].

The National Electricity Regulator [NER 2002] also has estimates of consumption. It appears that significant discrepancies still exist between ESKOM's data [Prinsloo] and that of the NER.

2.1.2. Liquid fuels

There is little data available regarding the use of fuels by sub-sector after bulk depot sales. Data was compiled from Cooper, Pouris, Kenny and individual case studies.

The overall individual fuel balances were verified using data from SAPIA.

Concern was raised regarding the complexity of usage chains [Cooper 2002]. A large amount of liquid fuel sold, for example, is used by companies for non-energy purposes.

2.1.3. Coal consumption

Coal data was primarily derived from Cooper. Attempts to reconcile this data with that of the Minerals Bureaux (Department of Minerals and Energy)[Prevost, 2002] was not possible due to the poor energy reporting of coal mined. Tonnages were estimates, and calorific values are not available.

Coal data for industry was derived from Cooper [Cooper 2000] and Kenny [Kenny 2002]. Coal data for commerce was derived from de Villiers [de Villiers 2001].

Residential coal consumption was derived from several studies, summarised in the 'residential energy consumption' section. Concern about the accuracy of residential data was raised by Lloyd and Qase [Lloyd & Qase 1999]

2.1.4. Biomass consumption

The two manor sectoral users of biomass energy are the industry and residential sectors. The major users in the industrial sector are the pulp and paper industry and the food and tobacco industry. Consumption by the latter was taken from Kenny [Kenny 2002].

Information for this review has been taken from the following sources:

- ERI, background documents for the IEP which draw from industry [Kenny 2002]
- Biomass initiative reports [Gander 1994 and Williams et al. 1996]
- EDRC Domestic energy use database [Trollip 1994 and Afrane Okese 1998].

It is noteworthy to mention that significant uncertainty surrounds fuel-wood consumption and production figures. It is suggested that the revision of domestic energy databases take place regularly, and the data correlated with biomass studies.

2.2. <u>Industrial consumption</u>

The following industrial energy audits and sector studies have been referenced and compared with the figures from the DME database:

- Gold mining (Mining and quarrying)

- Brick making (Non-metallic minerals)
- Pulp and paper (Paper and Pulp)
- Motor Manufacturing (Manufacturing)
- Textiles (Textile and leather)
- And Brewing (Food and tobacco)

Unless otherwise stated:

- Estimates are taken from Cooper [DME 2002] and inflated with growth in the industry. This is normalised against electricity consumption over time.
- Electricity consumption was estimated from Prinsloo [Prinsloo 2002] and electricity end use from the Energy Outlook [Howells et al.].

Sub-sector specific notes are summarised below.

2.2.1. Chemical

- Due to the large and integrated use of coal at SASOL, South Africa's largest chemical plant, it is difficult to establish the accuracy of consumption data that has been gathered by analysts.

2.2.2. Food and Tobacco

- Quantities of Bagasse are burned in sugar mills to provide both heat and power. Industry contact was made in the Energy Outlook [Howells et al] to determine estimates of these. There are differing estimates in the local literature. [NER 2002]

2.2.3. Gold mining

- Electricity consumption was estimated from Prinsloo [Prinsloo 2002] and electricity end use from the Energy Outlook [Howells et al.].
- The end-use split for energy use was similar to that reported in a case study compiled by Energy Consulting Services and the ERI [Howells & Chapman 2000a].

2.2.4. Iron &Steel

- Coke oven coke figures were sourced from the Energy Outlook data which was taken from Cooper [DME 2002].
- Other fuel use was estimated from the Energy Outlook [Howells et al.2002].
- Electricity consumption was estimated from Prinsloo [Prinsloo 2002] and electricity end use from the Energy Outlook [Howells et al.].

2.2.5. Nonferrous metals

- The end-use split for electricity use was similar to that reported by a case study compiled by Energy Consulting Services and the ERI [Chapman 2000 & Howells].

2.2.6. Non-metallic minerals

- Anthracite consumption is included in the coal figures.

2.2.7. Other Industry

- This sector forms a large percentage of energy used in industry. Included under other are all small industries and any fuel used that is not assigned to a specific sub-sector. The implication of this is that data collected and projections made for the sub-sectors are not accurate.

2.2.8. Textile & leather

- The primary data source for the textile industry is Voest [Voest 1997] who describes an in-depth market survey of the textile industry. According to this study, neither Cooper nor Pouris closely estimate energy consumption in the sector, with the exception of electricity use, which shows close correspondence.

2.2.9. Other mining

- Fuels used in other mining were estimated in the Energy Outlook. The total fuel used for the mining and quarrying sector was taken from Cooper

2.2.10. Pulp and Paper

- Coal and Biomass data was derived from the Energy Outlook. The Outlook references industry studies and contact with the industry representatives.
- The data is fairly consistent with an energy audit carried out at the SAPPI Tugela mill in Kwa-Zulu Natal. [Howells & Chapman 2000b].

2.2.11. Transport Equipment

- Data from sources is contradictory in this sector. An energy audit by the ERI [Fawkes et al 2002] of the VW South Africa plant is different to that of Pouris and Cooper.

2.2.12. Machinery

- Pouris gives significantly higher values than Cooper for consumption in this sector.

2.2.13. Construction

- LPG, Kerosene, Diesel and Petrol consumption was taken from Pouris [Pouris 2002]
- Electricity end use was estimated using Prinsloo [Prinsloo 2002] and the Energy Outlook [Howells et al.].

2.2.14. Auto-generation

- Auto-generation estimates were used from Prinsloo [Prinsloo 2002.]

- The Energy Outlook estimate was within a few percent of those of Prinsloo. This document in turn references studies by [Anderson 1993] and communication with the industries involved.

The approach provides a useful indication of current trends but does not produce quantitatively reliable information. The relative contribution of plants in each sub-sector needs to be established i.e. are they typical and representative? This issue needs to be addressed to establish methods for future data capture.

2.3. Commercial consumption

For commercial buildings the following studies and some audits were considered:

- SA Country studies [de Villiers 2000]
- IEP 2002 [Howells, 2002]
- And Cape Town, Durban and Gauteng building energy audits. [de Villiers 1996]

The following table is adapted from de Villiers [2001].

Table 1. Energy use in the commercial sector (PJ)

Source	*Year*	*Elec*	*Coal*	*Piped gas*	*LPG*	*Diesel*	*Paraffin*	*Resid. oil*
De Viliers [de Villiers 2000]	1990	53.1	16.3	0.8	2.0	1.4	0.2	2.8
GHG inventory (Scholes 1997)	1990		126.5	0.6	0.1			0.1
DME (1998)	1996	53.5	7.2-35.1	0.8	2.3	-	0.1	-
SSA (1989, 1992)[b]	1990	53.1						
NER (1995)	1996	47.2						
Dutkiewicz et al (1991)[c]	1990		16.3			0.8	0.2	2.8
Outlook [Howells 2002]	2000	58.5	5.5	1	2.1	1.3	0.2	2.6
This study	**2000**	**58.5**	**15**	**1**	**2.1**	**1.3**	**0.2**	**2.6**

[a] Liquid fuel data was confidential at this time.

[b] Interpolated value from Census figures for 1989 and 1992.

[a] Calculated for boilers only, assuming 70% of oil is residual oil, 25% diesel and 5% paraffin.

It is interesting to note that there was an error in the Outlook figures for coal consumption. A primary information source for the commercial sector of the Energy Outlook was de Villiers.

2.4. Commercial and industrial energy efficiency measures

Energy efficiency measures from several case studies summarised in the Energy Outlook are considered [Howells et al 2002]. It is important to note, that this work is at a national level, based on average values and assumptions, and therefore is indicative. The following is summarised from the Outlook:

2.4.1. Thermal efficiency improvements summary

Energy Outlook [Kenny et al 2002] figures show an improvement in energy consumed of about 15% for solid fuels and about 10% for electrical systems.

2.4.2. Non-thermal electricity consuming technologies

An average value of 60% has been chosen for the conversion of final to useful energy for all non-thermal applications. The only exception is lighting. This value is only used as a standard against which to measure the effect of more efficient technologies. Potential for energy efficiency improvements are detailed below.

Compressed air systems

Compressed air systems around the world have great potential for reducing electricity demand by improved energy efficiency. This can be realised through well-managed compression, treatment, distribution and monitoring.

It was assumed that a 20% improvement was possible for compressed air systems. Indeed estimates from several studies suggest that up to 40% of compressed air could be saved in South African industry by better management [Fawkes et al 2002]. A well-managed compressed air system will have a leak rate of less than 10% [Trikam et al 2000]. These savings were assumed to have a payback of one year. It was further assumed that ten percent of the cost saving per year after the first year would go towards maintaining the improvements. (Again costs chosen here are high estimates).

Variable speed drives (VSDs)

Variable speed drives in some applications can reduce electrical demand and the greenhouse gas emissions associated with electrical generation. This saving is achieved because motor output can closely match demand during times of low output and therefore draw less electricity.

It is reported that savings from fans can amount to up to 30%. In order to not overstate the case potential savings, this was reduced to 25%.

The application of VSDs for pumping, HVAC and other applications such as mining was not considered because of the extra control requirements, which would need to be integrated into the system. There is potential in gold mining for complete automation and VSD control as part of an integrated approach but this has not yet found wide application.

Electrical motors

Technology changes and the drive for increased profits and energy efficiency have resulted in high efficiency motors becoming available both internationally and locally [DOE 2002]. Other potential savings options include motor downsizing, minimising load, cutting the power supply during no load times and the application of variable speed drives (discussed earlier).

The following assumptions were made for the motor stock in South Africa:

- A modest 5% improvement could be realised per motor over the base case over 25 years[DOE 2002],
- The average life of the motor was 10 years,
- The increased capital cost per motor was $7.3 per kW,
- The average load factor was assumed to be 70%,
- The systems that would be affected by introducing high efficiency motors include: 'pumping' and 'motors'.

Lighting

Using higher efficiency lamps, switching them off when not needed and making use of skylights in sunny areas offers significant opportunities for saving electricity and reducing greenhouse gases. Much of the lighting energy is used on the factory floor. The assumptions used to predict energy savings in this area are taken from a recently completed case study [Fawkes et al 2002], which looked in some depth at factory lighting options[1].

Efficient Heating Ventilation and Cooling (HVAC) equipment

Various measures can be implemented to improve the efficient operation of heating, ventilation and cooling systems. These include:[Kenny et al 2000]

- Ensuring minimum hours of operation
- Proper maintenance of heat exchanger surfaces
- Waste heat utilisation
- High efficiency motors and VSD's (this has been discussed in another section, and is not included here.)

A recent report suggests that energy consumption by HVAC could be reduced by 25% in new installations and 37% in old installations compared with the baseline case [de Villiers 2000]. The measures were expected to have a three-year payback, and ten percent of fuel cost savings were dedicated to maintaining the savings. Similar studies in local industry show a one-year payback. The cost estimates used are high and the savings low so as not to overstate the case for energy efficiency.

Energy Star Equipment

Most computers and other office equipment are shipped to South Africa with the energy saving capability de-activated. Savings can amount to 40% of energy consumed per unit. For this work, it was assumed that up to 30% electricity saving was possible.

[1] Of the options investigated (skylights, turning lights off during non-productive hours and high efficiency lighting upgrade) high efficiency upgrades were chosen, as this represents an easily measured option. It also does not represent the full spectrum of savings, and therefore probably understates the potential savings and at a higher cost. This is consistent with the philosophy of the report, which seeks to identify realisable mitigation options.

Solar Hot Water Heating

The potential for solar hot water heating was considered. Costs per installed unit were taken as R462/GJ [de Villiers 2000] of useful energy produced and 3% maintenance costs.

2.4.3. Commercial building design

The Energy Outlook focussed only on options that did not require significant institutional interventions, therefore, the enforcement or consideration of commercial building codes was not included.

In this work it is considered worth quantifying (indicatively) the energy efficiency potential of commercial building design.

3. TRANSPORT ENERGY CONSUMPTION AND EFFICIENCY MEASURES

Transport energy consumption was derived from the Energy Outlook [Howells et al 2002]. In which the following sources were used

- Industry contacts
  - Eksom [Prinsloo] for electricity consumption for trains.
  - Transnet for estimates of diesel consumption.
  - South African bus owners association.
  - And Oil industry analysts.
  - The South African Petroleum industry.
- Early official data from Cooper (1996).

Transport energy saving measures include, amongst others:

- Increased use of public transport,
- Lift clubs,
- Using vehicles smaller more efficient vehicles,
- Reducing drag by design,
- Moving from petrol to diesel vehicles.

South Africa has a low per capita transport energy consumption due to high reliance on public transport (minibus taxi's). Energy consumption will increase over time if people become wealthier and can afford more private vehicles and leisure trips.

A significant observation in the transport sector is that much depends on consumer behaviour. While it is possible to determine potentials for energy conservation based on change in behaviour and vehicle ownership patterns, this is beyond the scope of this report, and not modelled. Some of the measures are modelled in the Energy Outlook [Howells et al. 2002]

4. RESIDENTIAL ENERGY CONSUMPTION AND EFFICIENCY MEASURES

The data for this sector has been compiled from several sources and include:

- EDRC Domestic energy use database and GHG mitigation country study [de Villiers and Matimbe 2000]
- ERI residential energy database
- DME energy statistics

The objective of data collection and analysis in this work is to estimate energy used in the following categories of households:

- Residential urban
  High income suburban areas
- Residential rural
  Low income rural households
- Residential townships
  Low income urban and peri-urban areas
- Residential low cost
  These are considered to be 'RDP housing'.
- And Residential others
  Including high income rural etc.

The fuel split for each of the following services needs to be estimated before determining estimates for particular energy efficiency 'interventions'.

4.1.1. Short residential energy literature survey

Lloyd and Qase [1999] discussed coal consumption in townships in Gauteng, in order to asses the potential for low smoke fuel. There are significant data gaps in residential coal consumption, due to limited accounting of flows from coal mines to households and specific sectors. This has been confirmed by other sector experts [Cooper, 2002]. Interestingly, there appears to be room for improved accounting and a broadening of the tax base, as the costs from the coal mine to the customer increase from about R90/ton to 350-650/ton. It was observed that the average consumption of coal was approximately 1ton/year per household (the average CV of coal suggested by this study was about 26GJ/ton, or more). It is assumed that one million households dependant on coal and the household consumption is not be more than 1Mton (according the Lloyd and Qase, this is a high estimate). According to DME 2002 data, this figure is much higher than this. Assuming a (high estimate) CV of 30GJ/ton a high-end GJ consumption of coal is estimated to be 30TJ pa coal. Other information based on collected data is the observation that during the three coldest winter months three times more coal is used than during the three warmest summer months. Assuming that very little coal is used for space heating during the summer months, the implication is that 70% of coal consumption in winter months is used for space heating. Assuming a linear drop in space heating from winter to summer, it may be roughly approximated that about 50% of coal consumption in this region is for space heating and the same amount for water heating and cooking. Lloyd [2002] suggests that very little coal is used for water heating. If this is true, then, again by a very rough approximation, about 15TJ of coal is used for water heating and 15TJ for space heating. It is very important to note that these approximations are only indicative as further to the assumptions stated the following is also assumed:

- Coal is the predominant heating and cooking fuel in the area surveyed,
- Should people use only limited coal, the ratios used for space heating and cooking remain static
- The area surveyed is not necessarily representative of all the South African coal using areas, for the following reasons:
  - Cultural behaviour (preferred heating / cooking levels),
  - Affordability (coal prices differ in different regions.)
  - Temperature profiles, which according to experts, can be loosely divided into three macro regions, for electricity consumption [Dekenah. 2002], this has also been identified by [Afrane-Okese, 1998]

Other information of interest, in terms of energy efficiency interventions, is the percent split of coal appliance use in the sample area:

- Coal stove: 68.2%
- Mbawala (Adapted 25litre paint drum): 26.7%
- Fireplace: 0.8%

Two related reports produced by the biomass initiative, namely a synthesis report by Williams et al. [Williams et al 1996] and [Gander, 1994] are referenced. In these biomass consumption data was collected from a wide range of sample households, in both rural, urban and peri-urban areas. Interesting points to note include the observation that per-capita consumption varies significantly. While there appears to a be a correlation between the use of space heating and national temperature differences (per person and household), other cultural factors which affect consumption include:

- Preferences toward wood usage, though it is viewed by fuel transition theory as a non-modern fuel [Golding, 2002],
- Household design,
- Family structures,
- Access to affordable and acceptable alternative fuels and devices.
- Access to wood resources in similar wood-dependant communities affects consumption by up to 50% (806 -409kg/cap/yr). This is a significant observation, implying that where energy is easily available (affordable and accessible), more energy is used than necessary. In many efficiency studies, this is referred to as the 'take-back' effect.
- The mean per capita use of fuel wood in rural areas ranges from: 251 to 1120kg/capita. Household use varies from 1387 to 5074kg/yr. This is further complicated by variations in the calorific value of wood. A significant factor in this regard is the moisture content of the wood, which is generally not measured in these surveys.
- The mean per capita use of fuel wood in low income urban areas was as follows:
  - 1056kg /household/yr in the Southern Cape to 18475kg/household/yr in the Gauteng area. The latter's high consumption is due to the high wood fuel use in 'backyard shacks'.
  - Consumption in unplanned shacks, range from 13 to 1210kg/household per year.
- In dung burning households, dung consumption per household per year varies from 100 to 1976 kg/year

In the synthesis report, rural biomass energy use is quoted from three authors and varies from 150 to 444kg/household per month.

In his Masters thesis Afrane-Okese [, 1998] developed ranges for energy consumption data for poor rural and urban households in South Africa using estimates based on data from Thorne [Thorne 1993] and Trollip [Trollip 1993] amongst others. This work draws attention to data shortages, and is based on estimates made by the afore mentioned authors. This data is then projected for various scenarios. The information in this work is useful for generating estimates of energy consumption in low-income rural and urban townships. There is also excellent data available for correlating income with fuel use trends. However, much of this data is limited by the dated estimates upon which it is based. While not mentioned explicitly in the scenario planning, much has changed in terms of income and population distribution. The work bases it's projections on the National Electrification Forum (NELF, 1994) which would be instructive to evaluate, in the light of electrification penetrations, electricity uptake and shifting trends in population movements [Golding 2002]. The study was limited to low income households.

Trollip developed energy demand profiles for several different classifications of households, namely [Trollip 1993]:

- Formal mid-high income (electrified)
- Formal low-income (electrified)
- Formal low-income (non-electrified)
- Backyard shack (electrified)
- Planned shack (non-electrified)
- Planned shack (electrified)
- Unplanned shack (electrified)
- Unplanned shack (non-electrified)
- Rural (non-electrified)
- Rural (electrified)
- Farm (non-electrified)
- Farm (electrified)

The results of Trollip's household population estimates are remarkably accurate.

The Department of Minerals and Energy (DME) produces a national energy database. This contract is carried out by a consultant for the DME, and data can be found on their website www.dme.gov.za. The work is reviewed by an expert committee consisting of academia, government and industry. The two consultants referenced below are Cooper of Rand Afrikaans University and Pouris. Much concern has been expressed by members of the review committee in terms of the accuracy of the current reporting [Prinsloo 2002 & van Wyk 2002].

De Villiers of Eta resources and Matimbe of the EDRC [De Villiers & Matimbe, 2000] summarised work by Flecher and others at the EDRC, the Department of Minerals and Energy and the Energy Research Institute [ERI 1999], to develop a greenhouse gas mitigation study for the residential sector. This study compiles a useful aggregate energy consumption profile for the residential sector, from existing research. It does not however consider the breakdown of households in order to establish appropriate measures per household type. This is overcome by assuming limited penetrations of greenhouse gas mitigation measures in the sector.

Work carried out by the ERI include initial energy modelling and database collection for the Sustainable Energy Programme [ERI 1999] and the national integrated energy planning ‘Energy Outlook 2002’ [Howells et al]. These works included a synthesis of available data, including sources referenced above and informal [Cowen 2001] and formal review by sector experts, during public workshops. Biomass studies carried out by the CSIR were also considered [Scholes & van der Merwe 2000].

4.1.2. Household numbers in South Africa

Table 2 below gives the number of households in South Africa used to reconcile and compile energy consumption estimates. Primary sources for this data were Trollip, Statistics South Africa and the Department of Housing.

Table 2: Household numbers in South Africa

Household types	Trollip [1993]			Statistics South Africa[2] (and this study)	Department of Housing [Rudolph 2002] (and this study)
	2000[3]			2000	2000
Urban	Formal mid-high income (electrified)	2087912	2087912.088	2124134	
Township	Formal low-income (electrified)	626374			
	Formal low-income (non-electrified)				
	Backyard shack (electrified)	1043956			
	Planned shack (non-electrified)	417582	3298118.775	3355335	
	Planned shack (electrified)	1670330			
	Unplanned shack (electrified)				
	Unplanned shack (non-electrified)	730769			
Rural	Rural (non-electrified)	844925	2923076.923	2973787	
	Rural (electrified)	2078152			
Low Cost (RDP)	*Planned shack (non-electrified)*		1190892.214	1 200 000	1 200 000
	Planned shack (electrified)				

[2] Extrapolated using population estimates, using Department of Housing Figures to estimate RDP, which were assumed to be mostly ‘urban’.

[3] Estimated by Trollip, using Department of Housing Figures to estimate RDP, which were assumed to be mostly ‘urban’.

This breakdown is useful in terms of matching average individual household energy patterns with aggregate national figures.

4.1.3. Overall household energy consumption

Estimates of consumption in the residential sector are given in the following table compiled from a variety of sources. Much of this data is dated, and based on estimates which in turn were dated when used by the author quoted below.

Table 3: Energy consumption estimates for the residential sector.

Source	*Year*	*Elec.*	*Coal*	*Paraffin*	*LPG*	*Wood*	*Dung*	*Solar*
de Viliers & Matimbe (2000)	1995	87.4	57.9	26.6	4.3	80.3	4.3	0.2
Energy Research Inst. (1999)	1995	88.0	59.0	24.0	3.4	82.0	0.0	0.1
Dept. of Min. & Energy (1998)	1996	89.0	59.0	28.0	0.5	0.0		
National Electricity Reg. (1996)	1995/96	114.0						
SA National Energy Ass. (1998)	1995	85.0	122.0	30.0	5.0	380.0		
Lloyd & Qase (1999)	1999		30.0					
IEP 1(2002)	1995	87.9	58.1	25.5	4.3	80.6	4.3	0.2
de Villiers & Matimbe (2001)	***2000***	***106***	***58.1***	***26.8***	***4.1***	***62.8***	***3.1***	***0.2***
IEP 1(2002)	***2000***	***106***	***58***	***25.3***	***4.6***	***84.7***	***4.3***	***0.2***
Prinsloo (2002)	***2000***	***106***						
Pouris (2002)	***2000***	***103***	***41***	***22***	***3***	***190***		
For this study (to be included in IEP2)	***2000***							

The estimates for 2000 show (with the exception of Pouris' biomass estimate) considerable consistency. This is however likely to be attributed to the same basic data being used in each case.

4.1.4. Methodology for household estimate

There are essentially two energy data sources to reconcile. These are overall and household consumption data. Changes in consumption due to electrification are estimated by increasing the electrified share of households, in the appropriate category. The shortfalls in taking this approach can be summarised as follows:

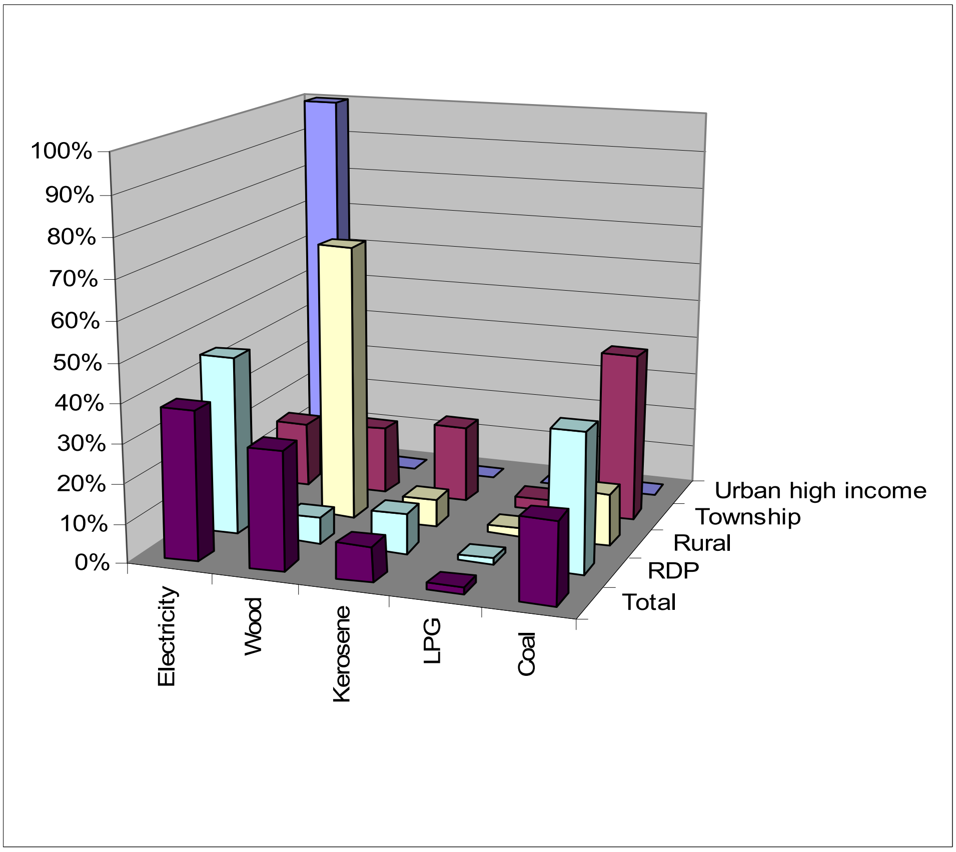
- It is assumed that there is little change in consumption patterns per household. To accurately verify this or describe changes new survey data needs to be collected. There is some evidence that there is a quantifiable lag between the time that a new settlement is electrified, and an increase in electricity uptake that is independent of income. [University of Cape Town, 2002]
- More recent data than that quoted exists, but is not available in the required format.

- The top-down and bottom-up approach used to approximate the data requirements for this study, were not designed with the end of 'reconciliation' in mind.

4.1.5. Household-type energy consumption estimates

Using the methodology described an estimate for percentage energy consumption for each household type considered was derived. The following figure indicates the average percentage fuel use per household.

Figure 1: Percentage fuel carrier consumption per household type



It should be noted, that increasing the desegregation of the residential sector is necessary for accurately determining the effect of future interventions and to province a framework for future data collection.

4.1.6. Household energy efficiency measures

It is important to consider that the more available energy becomes the more it is used. Energy efficiency interventions could result in an increase in energy use. An important benefit may be improved living standards, a high priority policy objective of government.

The following list of measures is taken from the Energy Outlook [Howells et al 2002]

4.1.7. High efficiency stoves-biomass and coal

The effectiveness of high efficiency stoves as an intervention to reduce fuel wood consumption has been questioned in several studies. Increases in fuel wood consumption have been recorded after high efficiency stoves have been introduced.

Reasons for this include:

- Increased 'take back' as more energy service is available,
- Switching to wood from paraffin, as wood was now more affordable (which may actually imply a reduction of total energy consumption.)
- Acceptability has been poor

Reductions of wood consumption have ensued when acceptance has been addressed. Recent observations imply that marketing, including gender considerations (as women do much household cooking), is a vital component of acceptability. A significant factor that should be linked to high efficiency stove use is that of indoor air pollution which can be significantly reduced.

4.1.8. Moving from electricity to Liquid Petroleum Gas (LPG)

While there is little efficiency to be gained by moving from electricity to LPG at end use, the improvement in the system efficiency is significant. In order to produce electricity one unit of electricity, one must burn three energy units of coal, while the production of LPG from crude is about 92% efficient. The same may be concluded from moving from moving away from electricity to coal.

4.1.9. Compact florescent bulbs (CFLs)

Essentially CFLs provide similar lighting levels with lover electricity consumption than incandescent bulbs. CFLs are generally more expensive and have a longer life span.

4.1.10.Solar water heaters (SWHs)

Solar hot water heaters can generally be either stand alone or co-heated with a fuel such as electricity or gas. The systems use solar energy to heat water for geysers. Proponents of SWHs' claim that 90% of the water heating necessary can be achieved by the sun. It was assumed for modelling purposes that 25% of the heating would be supplied by electricity. This assumption was made to simplify the model, and to not overstate the case for Solar Hot Water heaters. Solar hot water heater systems have higher capital and installation costs compared to standard electric geysers.

4.1.11.Insulation of hot water cylinders

A commonly cited measure for reducing water heating costs is to apply insulation to geysers. Surprisingly the savings estimated are relatively low, about 5% [de Villiers 2000].

4.1.12.Thermally efficient housing

There are several ways to increase the thermal efficiency of new and existing houses in South African. A few are summarised below:

- installing a ceiling (Where not already in place)
- Installing insulation

- Chimney installation

For new houses:

- Correct orientation
- Correct window sizing
- Insulated walls

It is assumed that a 15% heating saving is possible by improving roof insulation and 24% saving by installing a ceiling [de Villiers 2002]. An average value of 15% was chosen for this study because the application is limited by climatic considerations.

4.2. Further residential energy data reporting

It is suggested by Trollip [2002] that existing energy models and databases can be carefully upgraded in order to establish residential energy consumption figures accurately. This could include contracting Statistics South Africa [Statistics South Africa, 2002], who have collected household energy use data by dwelling type, but have only compiled macro figures. This data would be useful to determine:

- Health impacts of energy,
- Type and extent of energy efficiency intervention per household category,
- Analysing the consistency between different studies, which have categorised data according to parameters such as income [UCT 2002 and Afrane-Okese, 1998].

Unfortunately much work has been lost including the LEAP modelling work done by both Trollip [Trollip 2002] and Afrane-Okese [Afrane-Okese, 2002]. This may be redone and integrated into the existing national IEP [Surridge et al, 2002] models.

5. SUMMARY OF ENERGY EFFICIENCY IMPROVEMENTS

The following table summarises efficiency improvements considered and the potential savings from the measures discussed. The following comments apply:

- In order to determine when a specific option was economic, the IEP MARKAL model was run with the assumptions as given in the Baseline Optimised scenario [Howells et al 2002].
- While the model shows potential saving for industrial use of biomass, this is unlikely to occur. The biomass used in industry is generally a by-product and competes with commercially bought-in fuel such as coal, oil or gas. Therefore it is likely that more efficiently used biomass would displace coal, oil or gas. The effect will be to reduce greenhouse gas emissions (as industrial biomass is regenerated), and reduce fossil fuel consumption.
- Solar hot water heaters need not be used for electricity systems, but are considered here to mean integrated electricity-solar hot water heaters
- Building design is applied only to new commercial buildings. It is assumed that rate of growth of building space is 3% per annum. The figure quoted for buildings is for the year 2010, which assumes 50% of the new buildings are designed efficiently.
- It is assumed that the target of 20% of compressed air options are realised.
- It is assumed that only 50% of the savings are realisable for the other energy efficiency options described.

- In the case of VSD's it is assumed that these would be applicable only to 25% of air handling fans. The analysis therefore assumes a 12.5% penetration [de Villiers 2000]. HVAC is not considered here since this could replicate measures included in 'efficient HVAC'
- Energy star equipment is assumed to penetrate only 30% of 'other' electrical appliances in the commercial sector.
- It is assumed that only HFO, LPG and Kerosene are used for thermal heating in terms of liquid fuels.
- The modelling assumptions for the input-output model designed by Laitner [Laitner 2002] are detailed in the appendix. The following comments apply:
  - This is for a 10 year period starting in 2003.
  - Apart for the compressed air component, a local content of 60% is assumed.
  - These results are purely indicative and have only been calculated for industrial electricity saving options as a function of payback.
  - It is assumed that the potential saving indicated in the table is achieved during the program.

Table 3: Summary of easily implemented energy efficiency improvements

Measure	Fuel Saving potential	Fuel affected		Fraction of total for that fuel (Industry)	When economic[4]?	Assumed payback period	Jobs-years over a ten year period: Please note this is ***indicative only.*** Assumptions are stated in appendix: I/O model for industry electricity options.	
							80% local	20% local
VSD	30%	Electricity		(<1%)	2000-2010	4 year	3700	-1500
Motors	5%	Electricity		1% (2%)	2006-2010	5 year	7600	-1300
Comp air	20%	Electricity			Immediately	1 year	7500 (100% local)	
Lighting	35%	Electricity		2% (1%)	2002-2006	3 year	3200	900
HVAC includes some VSDs	25%	Electricity		0.5% (0.1%)	2002-2010	3 year	270	60
Energy Star Equipment	30%	Electricity		0.1 (2%)	Immediately			
Commercial building design	40%	Electricity[5]		<1%(3%) [6]	Immediately[7]			
Thermal Fuel: Industry, Agriculture and commerce.	15%	Solid	Bagasse	8%	Immediately			
			Coal	7%	Immediately			
			Vegital waste	10%	Immediately			
			Wood	1%	Immediately			

[4] These results are very sensitive to initial assumptions. A range has therefore been suggested.
[5] Affects other fuels, but the primary effect is for electricity.
[6] Assuming moderate growth as in the IEP, by 2020, 42% of the commercial buildings will be built after 2002. It is assumed that half of these could be efficient due, and this value represents a moderate 2020 potential.
[7] Authors estimate. This has not yet been modelled in the MARKAL IEP model.

	13%	Liquid	HFO	5%	Immediately			
			LPG	3%	Immediately			
			Kerosene	0.5%	Immediately			
	11%	Gas		3%	Immediately			
	10%	Electricity		1%	Immediately	6-9month	4400	3200
(Electricity to coal)	55% system efficiency				Immediately			
(Electricity to NG)	61% system efficiency				2006-2012			
(Electricity to LPG)					Not economic			
Household CFL use	65%	Electricity	1% (6%)		2002-2010			
Efficient stoves	30%	Coal	1% (8%)		Immediately			
		Wood	<1% (7%)		Immediately			
Electricity to LP gas	50% system efficiency.	Electricity			Immediately			
Solar hot water heater (residential)	75%[8]	Electricity	<1% (3%)		2002-2010[9]			
Geyser insulation	5%	Electricity	<1%(1%)		2002-2010[10]			
Add ceilings to RDP houses and insulation to existing houses.	15-40% (15%)[11]	Thermal fuels	<1% (1%)		Immediately[12]			

Using these very modest energy efficiency improvements, it is possible to reduce energy consumption by about 5%. Technically, using the basic principals outlined above about 10% savings can be achieved. Further savings can be achieved by moving from fuels such as electricity to coal, gas or oil for supplying thermal heat. This should not be implemented without considering the increase in local environmental pollution that could occur.

An important point to note from the table above is the importance of local manufacture and involvement in order to maximise the increase of jobs that result from energy efficiency. It should also be noted that these represent limited interventions. 15% of industrial electricity demand could be saved with a payback of three years. This is an achievable task based on local energy audits of industrial facilities. Further, assuming 70% local content the job-year increases are shown to be about 40 000. The model should be reviewed and upgraded to evaluate jobs from efficiency measures in other sectors and for other fuels.

[8] Proponents claim 90% saving of electricity.
[9] Authors estimate. This has not yet been modelled in the MARKAL IEP model.
[10] Authors estimate. This has not yet been modelled in the MARKAL IEP model.
[11] It was assumed that only 50% of households had significant winter heating requirements. A total penetration of 30% was assumed.
[12] Authors estimate. This has not yet been modelled in the MARKAL IEP model.

6. REFERENCES

DME, Energy Balances, www.dme.gov.za/publications/project_research/energy/spreadsheet95.htm, 2002.

Cooper, C, Rand Afrikaans University, Personal communication, January 2002.

Prinsloo, J., excel spreadsheet, Integrated Strategic Electricity Planning Office, Eskom, 2001

Prinsloo, J., Personal communication, Integrated Strategic Electricity Planning Office, excel spreadsheet, Eskom, 2002

DME, Energy Balances, email from Johan van Wyk Department of Minerals and Energy, 2002

Kenny, A, Background to Energy in South Africa, Energy Research Institute, University of Cape Town, 2002

De Villiers, M., Greenhouse gas baseline and mitigation options for the commercial sector, Eta resources for EDRC, Cape Town, 2000

Prevost, X., Personal communication, Minerals Beureax, Department of Minerals and Energy, Pretoria, 2002.

Tatham, G., Analyst for Culula industries, personal communication, Cape Town 2002.

Lloyd P., Energy Research Institute, University of Cape Town, personal communication, 2002

Dekenah, M., Load Research Program, Video conference, personal communication 2002.

Williams, T., Eberhard A. and Dickson, Synthesis report of the Biomass Initiative, Biomass initiative Report PFL-SYN-01, Department of Minerals and Energy Affairs, 1996.

Gander M., Status Report on Biomass Resources, Fuelwood Demand and Supply in South Africa, Biomass initiative Report PFL-SYN-01, 1994.

Golding, A., personal communication, Department of Minerals and Energy, 2002

Department of Minerals and Energy, Energy Statistics number 2, Pretoria 1995.

Rudolph, M., Email, Department of Housing, maria@housepta.pwv.gov.za , 2002

University of Cape Town., 'Options for a Basic Electricity Support Tariff', Eskom & Department of Minerals and Energy, 2002

Pouris, A., , 2000 Energy Balance, Department of Minerals and Energy, (not yet published), 2002

Trollip, personal communication, energy consultant, 2002

Statistics South Africa, www.statssa.gov.za, (1996 census data), 2002.

Afrane-Okese, Y., Domestic Energy Use Database for Integrated Energy Planning, Energy and Development Research Centre, University of Cape Town, 1998.

Afrane-Okese, Y., personal communication, Energy and Development Research Centre, University of Cape Town, 2002.

De Villiers, M. and Matimbe, K., Greenhouse gas mitigation for the residential sector, Energy and Development Research Centre, Cape Town, 2000

Van Wyk, J., Personal communication, Energy Database Director, Department of Minerals and Energy, 2002

Scholes, B., and van der Merwe M., 'South African country study: forestry and land use change report', CSIR, 2000

Voest, J., 'Market survey of the textile industry', Department of Minerals and Energy, 1997

Fawkes H., Shultz, T., and van Es, D., Energy Assesment Report of the Volkswagen SA Plant', Energy Research Institute, University of Cape Town, 2002

NER, www.ner.co.za, National Electricity Regulator, 2002

Lloyd, P., and Qase, N., Potential for Low Smoke Fuel, Energy and Development Research Centre, University of Cape Town, 1999

Laitner, S., Senior Economist, Environmental Protection Agency, Excel Preliminary I/O model for South Africa-Workshop, held at the University of Cape Town, 2002

Howells, M., and Chapman D., Eilandsrand Goldmine Energy Audit, Energy Consulting Services, 2000.

Howells, M., and Chapman D., Sappi Tugela Audit, Energy Consulting Services, 2000.

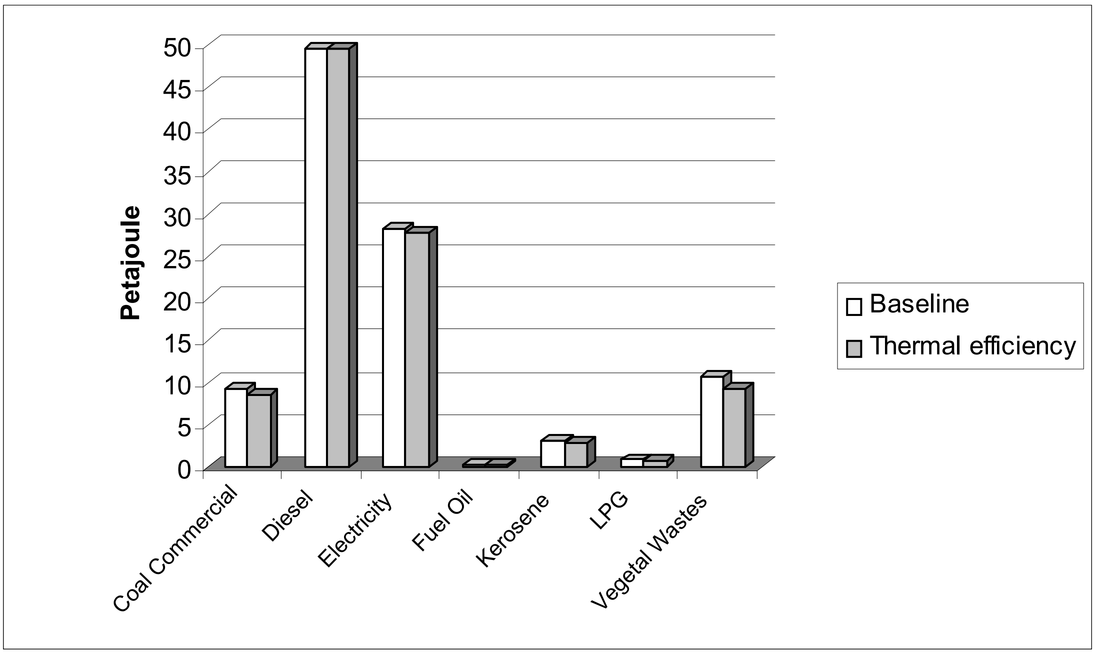
Anderson, R., 'A survey of Co-generation and independent power production worldwide and the potential for its application SA.', Department of Minerals and Energy Affairs, 1993.

Trikam A.J., Howells M.I. and Drummond R.S.H., "How to save energy and money: Compressed air systems" Compiled by Kenny A.R., pp 53, prepared for the European Commission, Netherlands Ministry of Economic Affairs, October 2000.

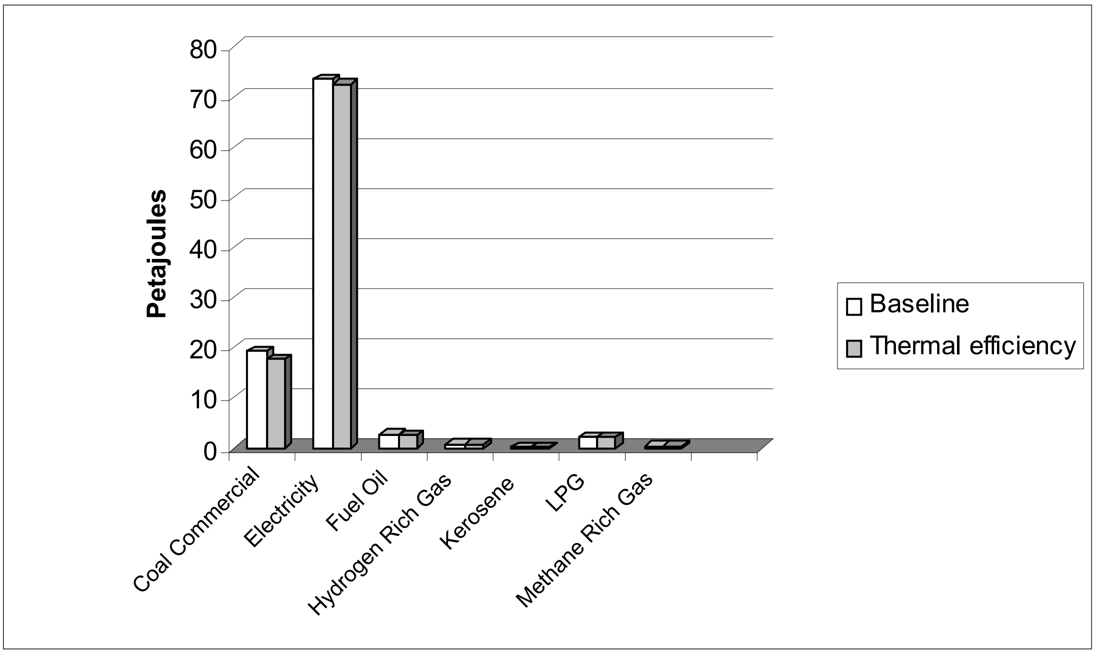
US Department of Energy, 'Motor master' software of the US Department of Energy's Motor challenge programme, 2002

Kenny A.R., Trikam A.J., Howells M.I. and Drummond R.S.H., "How to save energy and money: Refrigeration", prepared for the European Commission, Netherlands Ministry of Economic Affairs, October 2000.

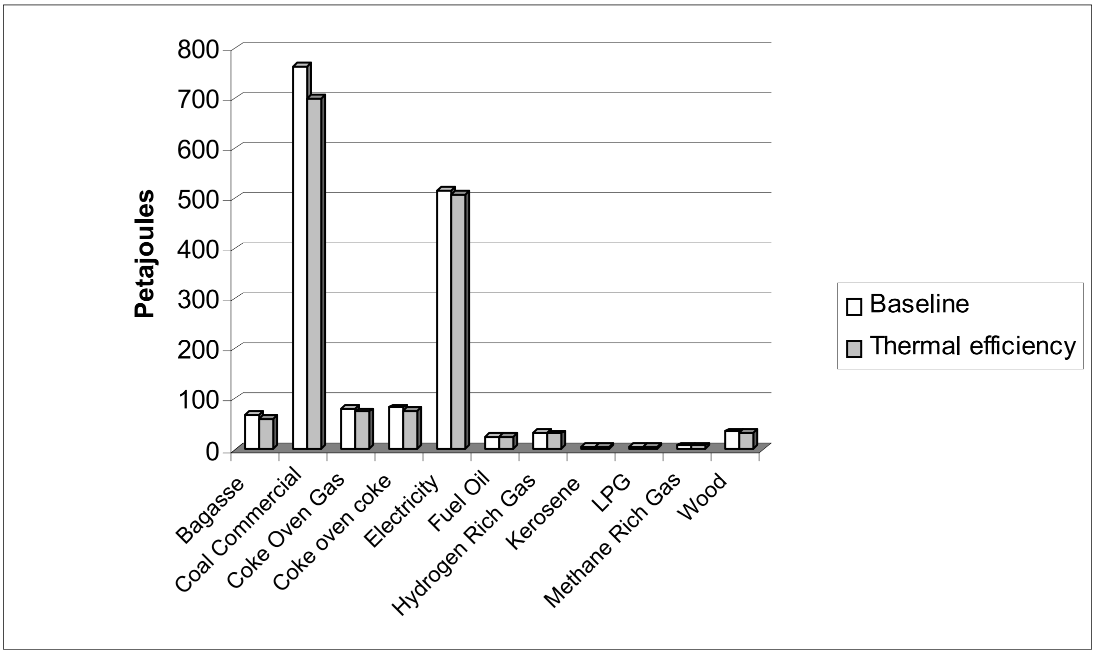
7. APPENDIX 1: SAVINGS FROM SELECTED MEASURES



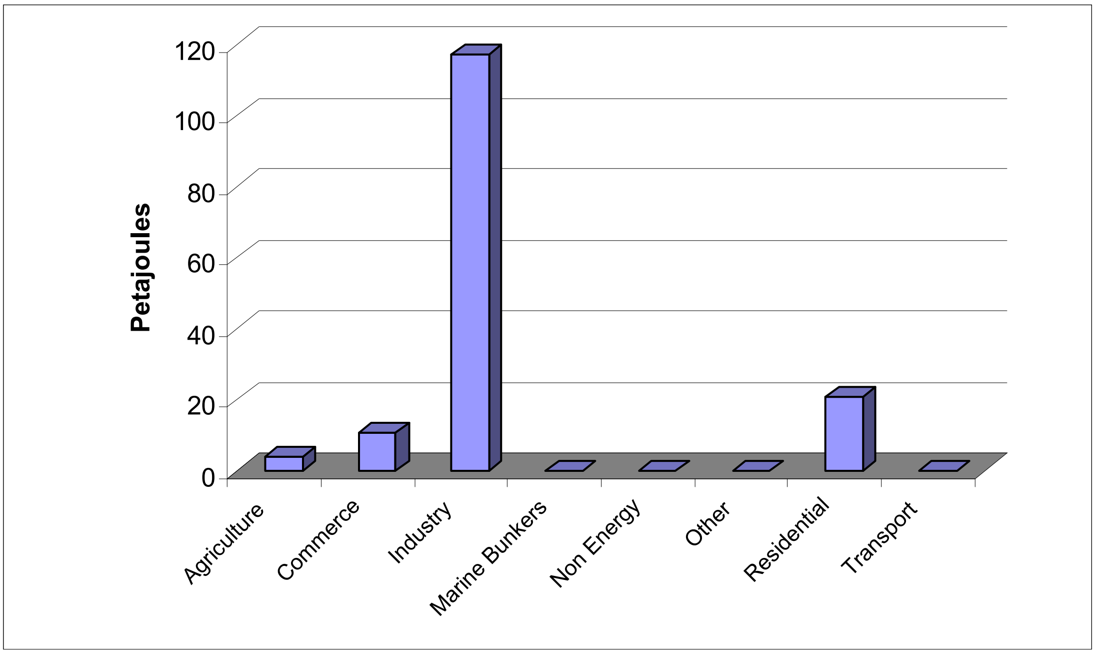
Thermal Energy Saving in Agriculture 2010



Thermal Energy Saving in Commerce 2010



Thermal Energy Saving in Industry 2010



Energy savings by sector for all measures in 2010