



Department of Minerals and Energy Pretoria

Capacity Building in Energy Efficiency and Renewable Energy

Report No. 2.3.4-30(E)

MONITORING OF ENERGY EFFICIENCY TARGETS:

Methodology Handbook

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July 2005



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Prepared Ian Househam

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Abbreviations and Acronyms

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

1 Introduction

1.1 Background

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

The accompanying papers ‘Monitoring of Energy Efficiency Targets: Theoretical Review’ and ‘Monitoring of Energy Efficiency Targets: Review of International Best Practice’ outline the basis for choosing the top-down ‘Divisia Decomposition’ methodology as the main quantitative approach for analysing available data. The purpose of this paper is to translate the theoretical language of the accompanying papers into a more practical language that can be used by analysts charged with the task of implementing and operating data processing systems. In doing so, it is hoped that this paper can serve as an “operator’s manual” for the Divisia Decomposition methodology.

1.2 Terminology

In the following sections, certain terms are used to convey specific meanings necessary to keep the discussion clear. These terms and the meanings implied are described as follows:

Unit of analysis. The same decomposition techniques can potentially be applied at any level in the economy. The ‘unit of analysis’ is the item whose total energy consumption is being decomposed, whether it be the whole economy, a particular sector, an individual industry, or even a single activity.

Component. In order to perform the decomposition, a unit of analysis has to be divided into smaller entities. These are referred to as ‘components’. Where the unit of analysis is the whole economy, the components will be the main economic sectors. Where the unit of analysis is, for example, the freight transport sub-sector, the components would be the various modes (e.g. road, rail, air).

Factor. A decomposition analysis always aims to attribute the observed change in the total energy consumption to a number of influences. These are referred to here as ‘factors’, and may include changes in population, structural shifts or, most importantly for this discussion, changes in the efficiency of energy use.

2 Economy-wide decomposition

2.1 Data requirements

For an economy-wide decomposition to be performed, the following data-set is required:

- total energy consumption for the whole economy in base year
- total energy consumption for the whole economy in current year
- energy consumption for each sector in base year
- energy consumption for each sector in current year
- share of GDP for each sector in base year
- share of GDP for each sector in current year
- number of households in base year
- number of households in current year

2.2 Procedure

The procedure described below will be illustrated at each step using the following hypothetical data:

		Base year	Current year
ECONOMY TOTAL	Energy consumption (TJ)	3492232	3378892
	GDP	707810	734205
Agriculture	Energy consumption (TJ)	85380	87661
	GDP	20850	25850
Industry	Energy consumption (TJ)	2891732	2786031
	GDP	225845	227671
Commercial / public	Energy consumption (TJ)	124280	107321
	GDP	402192	418146
Transport	Energy consumption (TJ)	197481	200941
	GDP	58923	62538
Residential	Energy consumption (TJ)	193359	196938
	Number of households	10310000	10140000

After each step in the calculations below, the above table will be reproduced with the newly calculated numbers included. These derived numbers will be presented in shaded cells, while the original data will always be in unshaded cells.

To assist the reader in following the calculations, an accompanying Excel spreadsheet ('Worked examples.xls') is provided. The sheet 'Economic-wide analysis' should be selected to accompany this section. With each calculation described below, a reference to the corresponding cell in the Excel spreadsheet is provided.

Step 1: Calculate weighting factors

The weighting factors are calculated by taking the logarithmic mean of the energy consumption figures for the base year and the current year. Weighting factors must be calculated for each component. The logarithmic mean is defined as follows:

$$\text{logarithmic mean of } x \text{ and } y = (x - y) \div \ln(x / y)$$

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NB: for this methodology, the natural logarithm (ln) function must be used, rather than the common logarithm (log) function.

Using the sample data, the following weighting factors are thus calculated:

Agriculture weighting factor = $(85380-87661) \div \ln(85380/87661) = 86515$ [Cell C10]

Industry weighting factor = $(2891732-2786031) \div \ln(2891732/2786031) = 2838554$ [Cell C15]

Commercial / public weighting factor = $(124280-107321) \div \ln(124280/107321) = 115593$ [Cell C20]

Transport weighting factor = $(197481-200941) \div \ln(197481/200941) = 199206$ [Cell C25]

Residential weighting factor = $(193359-196938) \div \ln(193359/196938) = 195143$ [Cell C29]

		Base year	Current year
ECONOMY TOTAL	Energy consumption (TJ)	3492232	3378892
	GDP	707810	734205
	Weighting factor	3239868.216	
Agriculture	Energy consumption (TJ)	85380	87661
	GDP	20850	25850
	Weighting factor	86515.48847	
Industry	Energy consumption (TJ)	2891732	2786031
	GDP	225845	227671
	Weighting factor	2838553.503	
Commercial / public	Energy consumption (TJ)	124280	107321
	GDP	402192	418146
	Weighting factor	115593.2326	
Transport	Energy consumption (TJ)	197481	200941
	GDP	58923	62538
	Weighting factor	199205.992	
Residential	Energy consumption (TJ)	193359	196938
	Number of households	10310000	10140000
	Weighting factor	195143.03	

Step 2: Calculate shares of each productive sector in total GDP

The next step is to calculate the share of each productive sector in the total GDP. Using the sample data, the following shares of total GDP can be calculated:

Agriculture base year share = $20850 / 707810 = 0.0295$ [Cell C8]

Agriculture current year share = $25850 / 734205 = 0.0352$ [Cell D8]

Industry base year share = $225845 / 707810 = 0.3191$ [Cell C13]

Industry current year share = $227671 / 734205 = 0.3101$ [Cell D13]

Commercial / public base year share = $402192 / 707810 = 0.5682$ [Cell C18]

Commercial / public current year share = $418146 / 734205 = 0.5695$ [Cell D18]

Transport base year share = $58923 / 707810 = 0.0832$ [Cell C23]

Transport current year share = $62538 / 734205 = 0.0852$ [Cell D23]

		Base year	Current year
ECONOMY TOTAL	Energy consumption (TJ)	3492232	3378892
	GDP	707810	734205
	Weighting factor	3239868.216	
Agriculture	Energy consumption (TJ)	85380	87661
	GDP	20850	25850
	Share of GDP	0.029457058	0.03520815
	Weighting factor	86515.48847	
Industry	Energy consumption (TJ)	2891732	2786031
	GDP	225845	227671
	Share of GDP	0.319075741	0.310091868
	Weighting factor	2838553.503	
Commercial / public	Energy consumption (TJ)	124280	107321
	GDP	402192	418146
	Share of GDP	0.568220285	0.569522136
	Weighting factor	115593.2326	
Transport	Energy consumption (TJ)	197481	200941
	GDP	58923	62538
	Share of GDP	0.083246917	0.085177845
	Weighting factor	199205.992	
Residential	Energy consumption (TJ)	193359	196938
	Number of households	10310000	10140000
	Weighting factor	195143.03	

Step 3: Calculate energy intensities

Energy intensities for each sector must now be calculated, simply by dividing the energy consumption by the GDP in each year for the productive sectors, and by the number of households for the residential sector. Thus, for the sample data, the following energy intensities can be calculated:

Agriculture base year energy intensity = $85380 / 20850 = 4.09496$ [Cell C9]

Agriculture current year energy intensity = $87661 / 25850 = 3.39114$ [Cell D9]

Industry base year energy intensity = $2891732 / 225845 = 12.80406$ [Cell C14]

Industry current year energy intensity = $2786031 / 227671 = 12.23709$ [Cell D14]

Commercial / public base year energy intensity = $124280 / 402192 = 0.30901$ [Cell C19]

Commercial / public current year energy intensity = $107321 / 418146 = 0.25666$ [Cell D19]

Transport base year energy intensity = $197481 / 58923 = 3.35151$ [Cell C24]

Transport current year energy intensity = $200941 / 62538 = 3.21310$ [Cell D24]

Residential base year energy intensity = $193359 / 10310000 = 0.018755$ [Cell C28]

Residential current year energy intensity = $196938 / 10140000 = 0.019422$ [Cell D28]

		Base year	Current year
ECONOMY TOTAL	Energy consumption (TJ)	3492232	3378892

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	GDP	707810	734205
	Weighting factor	3239868.216	
Agriculture	Energy consumption (TJ)	85380	87661
	GDP	20850	25850
	Share of GDP	0.029457058	0.03520815
	Energy intensity	4.094964029	3.391141199
	Weighting factor	86515.48847	
Industry	Energy consumption (TJ)	2891732	2786031
	GDP	225845	227671
	Share of GDP	0.319075741	0.310091868
	Energy intensity	12.80405588	12.23709212
	Weighting factor	2838553.503	
Commercial / public	Energy consumption (TJ)	124280	107321
	GDP	402192	418146
	Share of GDP	0.568220285	0.569522136
	Energy intensity	0.309006644	0.256659157
	Weighting factor	115593.2326	
Transport	Energy consumption (TJ)	197481	200941
	GDP	58923	62538
	Share of GDP	0.083246917	0.085177845
	Energy intensity	3.351509597	3.213102434
	Weighting factor	199205.992	
Residential	Energy consumption (TJ)	193359	196938
	Number of households	10310000	10140000
	Energy intensity	0.01875451	0.019421893
	Weighting factor	195143.03	

Step 4: Calculate activity-level change factor

We are now ready to begin calculating the contributions to the total change in energy consumption that are attributable to the main factors. First, we calculate the contribution due to changes in overall activity level. This is calculated as follows:

Step 4.1

Calculate the ratio:

$$(\text{current year total GDP}) \div (\text{base year total GDP})$$

For the sample data, this is equal to $734205 / 707810 = 1.037291$ [Cell E4]

Step 4.2

Calculate the natural logarithm of the ratio from Step 4.1. For the sample data, this is equal to:

$$\ln(1.037291) = 0.036613$$
 [Cell F4]

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Step 4.3

Calculate the **sum of the weighting factors from Step 1 excluding the residential sector**.
For the sample data, this is equal to:

$$86515 + 2838554 + 115593 + 199206 = 3239868 \dots\dots\dots [\text{Cell C5}]$$

Step 4.4

Calculate the product:

logarithm from Step 4.2 x sum of weighting factors from Step 4.3

For the sample data, this is equal to:

$$0.036613 \times 3239868 = 118620 \dots\dots\dots [\text{Cell G4}]$$

Step 4.5

Calculate the ratio:

(current year number of households) ÷ (base year number of households)

For the sample data, this is equal to $10140000 / 10310000 = 0.983511 \dots\dots$ [Cell E27]

Step 4.6

Calculate the **natural logarithm of the ratio from Step 4.5**. For the sample data, this is equal to:

$$\ln(0.983511) = -0.016626 \dots\dots\dots [\text{Cell F27}]$$

Step 4.7

Calculate the product:

logarithm from Step 4.6 x weighting factor for residential sector from Step 1

For the sample data, this is equal to:

$$-0.016626 \times 195143 = -3244.507 \dots\dots\dots [\text{Cell G27}]$$

Step 4.8

Calculate the sum:

product from Step 4.4 + product from Step 4.7

For the sample data, this is equal to:

$$118620 + -3244.507 = 115375 \dots\dots\dots [\text{Cell G30}]$$

The result is the contribution to the overall change in energy consumption attributable to changes in total activity level. The result is positive, meaning that activity level changes accounted for an increase in energy consumption.

Activity level changes accounted for a 115375 TJ increase in the total observed change in energy consumption

Step 5: Calculate structural change factor

The next step is to calculate the contribution of structural changes to the total change in energy consumption. Note that structural change is defined only in terms of the productive sectors, and does not include the residential sector. It is calculated as follows:

Step 5.1

For each productive sector, calculate the ratio:

$$(\text{current year share in GDP}) \div (\text{base year share in GDP})$$

For the sample data, these are as follows:

Agriculture: $0.0352 / 0.0295 = 1.1952$	[Cell E8]
Industry: $0.3101 / 0.3191 = 0.9718$	[Cell E13]
Commercial / public: $0.5695 / 0.5682 = 1.0023$	[Cell E18]
Transport: $0.0852 / 0.0832 = 1.0232$	[Cell E23]

Step 5.2

For each productive sector, calculate the natural logarithm of the ratio from Step 5.1. For the sample data, this gives:

Agriculture: $\ln(1.1952) = 0.1783$	[Cell F8]
Industry: $\ln(0.9718) = -0.0286$	[Cell F13]
Commercial / public: $\ln(1.0023) = 0.0023$	[Cell F18]
Transport: $\ln(1.0232) = 0.0229$	[Cell F23]

Step 5.3

For each productive sector, calculate the product:

$$\text{logarithm from Step 5.2} \times \text{weighting factor for component from Step 1}$$

For the sample data, this is equal to:

Agriculture: $= 0.1783 \times 86515 = 15430$	[Cell G8]
Industry: $= -0.0286 \times 2838554 = -81069$	[Cell G13]
Commercial / public: $= 0.0023 \times 115593 = 265$	[Cell G18]
Transport: $= 0.0229 \times 199206 = 4568$	[Cell G23]

Step 5.4

Calculate the **sum of all the products from Step 5.3**. For the sample data, this is equal to:

$$15430 + -81069 + 265 + 4568 = -60807 \text{$$
 [Cell G31]

The result is the contribution of structural changes to the observed change in total energy consumption. The result is negative, meaning that structural changes accounted for a decrease in energy consumption.

Structural changes accounted for a 60807 TJ decrease in the total observed change in energy consumption

Step 6: Calculate efficiency change factor

The next step is to calculate the contribution of efficiency changes to the total change in energy consumption. This is calculated as follows:

Step 6.1

For each sector, calculate the ratio:

$$(\text{current year energy intensity}) \div (\text{base year energy intensity})$$

For the sample data, these are as follows:

Agriculture: $3.3911 / 4.0950 = 0.8281$	[Cell E9]
Industry: $12.2371 / 12.8041 = 0.9557$	[Cell E14]
Commercial / public: $0.2567 / 0.3090 = 0.8306$	[Cell E19]
Transport: $3.2131 / 3.3515 = 0.9587$	[Cell E24]
Residential: $0.0194 / 0.0188 = 1.0356$	[Cell E28]

Step 6.2

For each sector, calculate the natural logarithm of the ratio from Step 6.1. For the sample data, this gives:

Agriculture: $\ln(0.8281) = -0.1886$	[Cell F9]
Industry: $\ln(0.9557) = -0.0453$	[Cell F14]
Commercial / public: $\ln(0.8306) = -0.1856$	[Cell F19]
Transport: $\ln(0.9587) = -0.0422$	[Cell F24]
Residential: $\ln(1.0356) = 0.0350$	[Cell F28]

Step 6.3

For each sector, calculate the product:

$$\text{logarithm from Step 6.2} \times \text{weighting factor for sector from Step 1}$$

For the sample data, this is equal to:

Agriculture: $= -0.1886 \times 86515 = -16316$	[Cell G9]
Industry: $= -0.0453 \times 2838554 = -128559$	[Cell G14]
Commercial / public: $= -0.1856 \times 115593 = -21456$	[Cell G19]
Transport: $= -0.0422 \times 199206 = -8401$	[Cell G24]
Residential: $= 0.0350 \times 195143 = 6824$	[Cell G28]

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Step 6.4

Calculate the **sum of all the products from Step 6.3**. For the sample data, this is equal to:

$$-16316 - 128559 - 21456 - 8401 + 6824 = -167908 \dots\dots\dots [\text{Cell G32}]$$

The result is the contribution of efficiency changes to the observed change in total energy consumption. The result is negative, meaning that efficiency changes accounted for a decrease in energy consumption (i.e. efficiency improved).

Efficiency changes accounted for a **167908 TJ decrease** in the total observed change in energy consumption

Step 8: Cross check

The sum of the factors calculated in Steps 5-7 above should equal the total observed change in energy consumption for the whole unit of analysis. A cross-check should be performed to ensure that this is the case, indicating that no errors have been made.

$$115375 - 60807 - 167908 = -113340 \dots\dots\dots [\text{Cell G33}]$$

The observed change in total energy consumption from the original data is indeed a decrease of 113341 TJ, indicating that the results obtained are consistent and no errors have been made.

NOTE: The impacts of efficiency changes and structural changes in the economy-wide analysis described above do not provide a full and true picture. The structural change factor describes only the impact of structural shifts *between* sectors, but not the impact of structural shift *within* sectors. These *intra*-sectoral structural changes are actually subsumed into the efficiency factor in the simple economy-wide analysis described. If the decomposition analysis is being conducted only at the economy-wide level, then this first-order approximation of the impacts of structural and efficiency changes is the best that is possible. However, if a decomposition analysis is also to be performed on each of the major sectors, then a truer picture of the economy-wide factors should be obtained by taking into account these intra-sectoral effects. This is done by adding together the structural change factors for the main sectors, and subtracting the total from the economy-wide efficiency factor. The economy-wide decomposition then yields four factors: activity effect, inter-sectoral structural effect, intra-sectoral structural effect and efficiency effect. For an example of this calculation, see Appendix A.

3 Sectoral decomposition in the industrial and commercial / public sectors

This section describes the methodology to use where the unit of analysis is either industrial sector or the commercial / public sector, and the components are the main sub-sectors. Note that a similar methodology can be adopted in cases where a more detailed analysis is being performed, using an individual industrial sector as the unit of analysis, and the firms / industries that make it up as the components.

3.1 Data requirements

For each unit of analysis upon which a decomposition is to be performed, the following data-set is required:

- total energy consumption for the unit of analysis in base year
- total energy consumption for the unit of analysis in current year
- energy consumption for each component in base year
- energy consumption for each component in current year
- activity level indicator for the unit of analysis in base year
- activity level indicator for the unit of analysis in current year
- activity level indicator for each component in base year
- activity level indicator for each component in current year

The activity level indicators may be in the form of economic units (e.g. million Rand of value-added) or they may take the form of physical units (e.g. million tonnes of cement produced). Depending on the type of activity level indicator available, one of three different scenarios is possible:

- ***Economic units only*** – where the activity level indicators for all components are in economic units, use the methodology outlined in Section 3.2.
- ***Physical units only*** – where the activity level indicators for all components are in physical units. A brief description is provided in Section 3.3 but, since this situation is extremely unlikely to occur in reality, a worked example is not provided.
- ***Mixed units*** – where the activity level indicators for some, but not all components are in physical units, use the methodology outlined in Section 3.4.

Note 1: for a top level analysis, where the unit of analysis is the whole economy and the components are the main economic sectors, the activity level indicators will always be in economic units only.

Note 2: an analysis conducted in physical units only would be extremely unusual since, in reality, there will almost always be a residual component ('Other' or 'Unspecified') for which data on physical activity levels is, by definition, unavailable.

Note 3: where an analysis is to be conducted using mixed units, economic activity level indicators must be available for *all* components, even those for which physical-based indicators are available.

3.2 Activity level indicators in economic units only

This analysis does not use any physical units for activity levels. The procedure described below will be illustrated at each step using the following hypothetical data:

		Base year	Current year
SECTOR TOTAL	Energy consumption	790 TJ	830 TJ
	Value-added	870 million	1120 million
Sub-sector 1	Energy consumption	240 TJ	196 TJ
	Value-added	300 million	252 million
Sub-sector 2	Energy consumption	240 TJ	342 TJ
	Value-added	360 million	630 million
Sub-sector 3	Energy consumption	190 TJ	195 TJ
	Value-added	160 million	175 million

After each step in the calculations below, the above table will be reproduced with the newly calculated numbers included. These derived numbers will be presented in shaded cells, while the original data will always be in unshaded cells.

To assist the reader in following the calculations, an accompanying Excel spreadsheet ('Worked examples.xls') is provided. The sheet 'Economic activity indicators' should be selected to accompany this section. With each calculation described below, a reference to the corresponding cell in the Excel spreadsheet is provided.

Step 1: If necessary, calculate any 'Other, unspecified' component

Unless the components for which data is available already account for the entire of the unit of analysis, it is necessary to calculate an additional component, designated 'Other' or 'Unspecified' to ensure complete coverage. This is done simply by, for each variable, summing across the components for which data is available and subtracting the sum from the total for the whole unit of analysis.

For the example used here, a new sub-sector 'Sub-sector 4 (Other)' is defined, with the following indicators:

Base year energy consumption = $790 - (240 + 240 + 190) = 120$ TJ [Cell C21]

Current year energy consumption = $830 - (196 + 342 + 195) = 97$ TJ [Cell D21]

Base year value-added = $870 - (300 + 360 + 160) = 50$ million [Cell C22]

Current year value-added = $1120 - (252 + 630 + 175) = 63$ million [Cell D22]

		Base year	Current year
SECTOR TOTAL	Energy consumption	790 TJ	830 TJ
	Value-added	870 million	1120 million
Sub-sector 1	Energy consumption	240 TJ	196 TJ
	Value-added	300 million	252 million
Sub-sector 2	Energy consumption	240 TJ	342 TJ
	Value-added	360 million	630 million
Sub-sector 3	Energy consumption	190 TJ	195 TJ
	Value-added	160 million	175 million
Sub-sector 4 (Other)	Energy consumption	120 TJ	97 TJ
	Value-added	50 million	63 million

Step 2: Calculate weighting factors

The weighting factors are calculated by taking the logarithmic mean of the energy consumption figures for the base year and the current year. Weighting factors must be calculated for each component. The logarithmic mean is defined as follows:

$$\text{logarithmic mean of } x \text{ and } y = (x - y) \div \ln(x / y)$$

NB: for this methodology, the natural logarithm (ln) function must be used, rather than the common logarithm (log) function.

Using the sample data, the following weighting factors are thus calculated:

Sub-sector 1 weighting factor = $(240-196) \div \ln(240/196) = 217.2579$ [Cell C10]

Sub-sector 2 weighting factor = $(240-342) \div \ln(240/342) = 287.9958$ [Cell C15]

Sub-sector 3 weighting factor = $(190-195) \div \ln(190/195) = 192.4892$ [Cell C20]

Sub-sector 4 (Other) weighting factor = $(120-97) \div \ln(120/97) = 108.0925$ [Cell C25]

		Base year	Current year
SECTOR TOTAL	Energy consumption	790 TJ	830 TJ
	Value-added	870 million	1120 million
Sub-sector 1	Energy consumption	240 TJ	196 TJ
	Value-added	300 million	252 million
	Weighting factor	217.2579	
Sub-sector 2	Energy consumption	240 TJ	342 TJ
	Value-added	360 million	630 million
	Weighting factor	287.9958	
Sub-sector 3	Energy consumption	190 TJ	195 TJ
	Value-added	160 million	175 million
	Weighting factor	192.4892	
Sub-sector 4 (Other)	Energy consumption	120 TJ	97 TJ
	Value-added	50 million	63 million
	Weighting factor	108.0925	

Step 3: Calculate shares of each component in total value-added

The next step is to calculate the share of each component in the total value-added for the unit of analysis. Note that the total value-added for an economy is exactly equivalent to GDP, so term 'contribution to GDP' could be used instead of the term 'share of value-added'.

Using the sample data, the following shares of total value-added can be calculated:

Sub-sector 1 base year share = $300 / 870 = 0.3448$ [Cell C8]

Sub-sector 1 current year share = $252 / 1120 = 0.2250$ [Cell D8]

Sub-sector 2 base year share = $360 / 870 = 0.4138$ [Cell C13]

Sub-sector 2 current year share = $630 / 1120 = 0.5625$ [Cell D13]

Sub-sector 3 base year share = $160 / 870 = 0.1839$ [Cell C18]

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Sub-sector 3 current year share = $175 / 1120 = 0.1563$ [Cell D18]Sub-sector 4 (Other) base year share = $50 / 870 = 0.0575$ [Cell C23]Sub-sector 4 (Other) current year share = $63 / 1120 = 0.0563$ [Cell D23]

		Base year	Current year
SECTOR TOTAL	Energy consumption	790 TJ	830 TJ
	Value-added	870 million	1120 million
Sub-sector 1	Energy consumption	240 TJ	196 TJ
	Value-added	300 million	252 million
	Share of value-added	0.3448	0.2250
	Weighting factor	217.2579	
Sub-sector 2	Energy consumption	240 TJ	342 TJ
	Value-added	360 million	630 million
	Share of value-added	0.4138	0.5625
	Weighting factor	287.9958	
Sub-sector 3	Energy consumption	190 TJ	195 TJ
	Value-added	160 million	175 million
	Share of value-added	0.1839	0.1563
	Weighting factor	192.4892	
Sub-sector 4 (Other)	Energy consumption	120 TJ	97 TJ
	Value-added	50 million	63 million
	Share of value-added	0.0575	0.0563
	Weighting factor	108.0925	

Step 4: Calculate energy intensities

Energy intensities for each component must now be calculated, simply by dividing the energy consumption by the value-added for each component in each year. Thus, for the sample data, the following energy intensities can be calculated:

Sub-sector 1 base year energy intensity = $240 / 300 = 0.8000$ [Cell C9]Sub-sector 1 current year energy intensity = $196 / 252 = 0.7778$ [Cell D9]Sub-sector 2 base year energy intensity = $240 / 360 = 0.6667$ [Cell C14]Sub-sector 2 current year energy intensity = $342 / 630 = 0.5429$ [Cell D14]Sub-sector 3 base year energy intensity = $190 / 160 = 1.1875$ [Cell C19]Sub-sector 3 current year energy intensity = $195 / 175 = 1.1143$ [Cell D19]Sub-sector 4 (Other) base year energy intensity = $120 / 50 = 2.4000$ [Cell C24]Sub-sector 4 (Other) current year energy intensity = $97 / 63 = 1.5397$ [Cell D24]

		Base year	Current year
SECTOR TOTAL	Energy consumption	790 TJ	830 TJ
	Value-added	870 million	1120 million
Sub-sector 1	Energy consumption	240 TJ	196 TJ

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	Value-added	300 million	252 million
	Share of value-added	0.3448	0.2250
	Energy intensity	0.8000	0.7778
	Weighting factor	217.2579	
Sub-sector 2	Energy consumption	240 TJ	342 TJ
	Value-added	360 million	630 million
	Share of value-added	0.4138	0.5625
	Energy intensity	0.6667	0.5429
	Weighting factor	287.9958	
Sub-sector 3	Energy consumption	190 TJ	195 TJ
	Value-added	160 million	175 million
	Share of value-added	0.1839	0.1563
	Energy intensity	1.1875	1.1143
	Weighting factor	192.4892	
Sub-sector 4 (Other)	Energy consumption	120 TJ	97 TJ
	Value-added	50 million	63 million
	Share of value-added	0.0575	0.0563
	Energy intensity	2.4000	1.5397
	Weighting factor	108.0925	

Step 5: Calculate activity-level change factor

We are now ready to begin calculating the contributions to the total change in energy consumption that are attributable to the main factors. First, we calculate the contribution due to changes in overall activity level. This is calculated as follows:

Step 5.1

Calculate the ratio:

$$(\text{current year total value-added}) \div (\text{base year total value-added})$$

For the sample data, this is equal to $1120 / 870 = 1.2874$ [Cell E5]

Step 5.2

Calculate the natural logarithm of the ratio from Step 5.1. For the sample data, this is equal to:

$$\ln(1.2874) = 0.2526$$
 [Cell E6]

Step 5.3

Calculate the sum of the weighting factors from Step 2. For the sample data, this is equal to:

$$217.2579 + 287.9958 + 192.4892 + 108.0925 = 805.8354$$
 [Cell C5]

Step 5.4

Calculate the product:

logarithm from Step 5.2 x sum of weighting factors from Step 5.3

For the sample data, this is equal to:

$$0.2526 \times 805.8354 = 203.5540 \dots \dots \dots \text{[Cell G5]}$$

The result is the contribution to the overall change in energy consumption attributable to changes in total activity level. The result is positive, meaning that activity level changes accounted for an increase in energy consumption.

Activity level changes accounted for a **203.55 TJ increase** in the total observed change in energy consumption

Step 6: Calculate structural change factor

The next step is to calculate the contribution of structural changes to the total change in energy consumption. This is calculated as follows:

Step 6.1

For each component, calculate the ratio:

$$(\text{current year share in value-added}) \div (\text{base year share in value-added})$$

For the sample data, these are as follows:

$$\text{Sub-sector 1: } 0.2250 / 0.3448 = 0.6525 \dots \dots \dots \text{[Cell E8]}$$

$$\text{Sub-sector 2: } 0.5625 / 0.4138 = 1.3594 \dots \dots \dots \text{[Cell E13]}$$

$$\text{Sub-sector 3: } 0.1563 / 0.1839 = 0.8496 \dots \dots \dots \text{[Cell E18]}$$

$$\text{Sub-sector 4: } 0.0563 / 0.0575 = 0.9788 \dots \dots \dots \text{[Cell E23]}$$

Step 6.2

For each component, calculate the natural logarithm of the ratio from Step 6.1. For the sample data, this gives:

$$\text{Sub-sector 1: } \ln(0.6525) = -0.4269 \dots \dots \dots \text{[Cell F8]}$$

$$\text{Sub-sector 2: } \ln(1.3594) = 0.3070 \dots \dots \dots \text{[Cell F13]}$$

$$\text{Sub-sector 3: } \ln(0.8496) = -0.1630 \dots \dots \dots \text{[Cell F18]}$$

$$\text{Sub-sector 4: } \ln(0.9788) = -0.0215 \dots \dots \dots \text{[Cell F23]}$$

Step 6.3

For each component, calculate the product:

$$\text{logarithm from Step 6.2} \times \text{weighting factor for component from Step 2}$$

For the sample data, this is equal to:

$$\text{Sub-sector 1: } = -0.4269 \times 217.2579 = -92.757 \dots \dots \dots \text{[Cell G8]}$$

$$\text{Sub-sector 2: } = 0.3070 \times 287.9958 = 88.4219 \dots \dots \dots \text{[Cell G13]}$$

$$\text{Sub-sector 3: } = -0.1630 \times 192.4892 = -31.3716 \dots \dots \dots \text{[Cell G18]}$$

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Sub-sector 4: = $-0.0215 \times 108.0925 = -2.3217$ [Cell G23]**Step 6.4**Calculate the **sum of all the products from Step 6.3**. For the sample data, this is equal to: $-92.757 + 88.4219 - 31.3716 - 2.3217 = -38.0284$ [Cell G27]

The result is the contribution of structural changes to the observed change in total energy consumption. The result is negative, meaning that structural changes accounted for a decrease in energy consumption.

Structural changes accounted for a **38.03 TJ decrease in the total observed change in energy consumption**

Step 7: Calculate efficiency change factor

The next step is to calculate the contribution of efficiency changes to the total change in energy consumption. This is calculated as follows:

Step 7.1

For each component, calculate the ratio:

$$(\text{current year energy intensity}) \div (\text{base year energy intensity})$$

For the sample data, these are as follows:

Sub-sector 1: $0.7778 / 0.8000 = 0.9722$ [Cell E9]Sub-sector 2: $0.5429 / 0.6667 = 0.8143$ [Cell E14]Sub-sector 3: $1.1143 / 1.1875 = 0.9383$ [Cell E19]Sub-sector 4: $1.5397 / 2.4000 = 0.6415$ [Cell E24]**Step 7.2**

For each component, calculate the **natural logarithm** of the ratio from Step 7.1. For the sample data, this gives:

Sub-sector 1: $\ln(0.9722) = -0.0282$ [Cell F9]Sub-sector 2: $\ln(0.8143) = -0.2054$ [Cell F14]Sub-sector 3: $\ln(0.9383) = -0.0636$ [Cell F19]Sub-sector 4: $\ln(0.6415) = -0.4439$ [Cell F24]**Step 7.3**

For each component, calculate the product:

$$\text{logarithm from Step 7.2} \times \text{weighting factor for component from Step 2}$$

For the sample data, this is equal to:

Sub-sector 1: = $-0.0282 \times 217.2579 = -6.1204$ [Cell G9]Sub-sector 2: = $-0.2054 \times 287.9958 = -59.1670$ [Cell G14]

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Sub-sector 3: = $-0.0636 \times 192.4892 = -12.2494$ [Cell G19]Sub-sector 4: = $-0.4439 \times 108.0925 = -47.9814$ [Cell G24]**Step 7.4**Calculate the **sum of all the products from Step 7.3**. For the sample data, this is equal to: $-6.1204 - 59.1670 - 12.2494 - 47.9814 = -125.5180$ [Cell G28]

The result is the contribution of efficiency changes to the observed change in total energy consumption. The result is negative, meaning that efficiency changes accounted for a decrease in energy consumption (i.e. efficiency improved).

Efficiency changes accounted for a **125.52 TJ decrease** in the total observed change in energy consumption

Step 8: Cross check

The sum of the factors calculated in Steps 5-7 above should equal the total observed change in energy consumption for the whole unit of analysis. A cross-check should be performed to ensure that this is the case, indicating that no errors have been made.

 $203.55 - 38.03 - 125.52 = 40.00$ [Cell G29]

The observed change in total energy consumption from the original data is indeed 40 TJ, indicating that the results obtained are consistent and no errors have been made.

3.3 Activity level indicators in physical units only

Although an analysis using only physical units for activity levels is theoretically possible, it is extremely unlikely to occur in reality. Firstly, unless exactly the same physical units are used for all components, data on value-added would also necessary for each component, in order to be able to describe the relative shares of each component in the total. The only circumstance under which exactly the same physical units could be used for describing the activity levels of all components would be in a detailed analysis of a single industry, where the components would be individual plants, each of which produces essentially the same product.

Secondly, unless the available data on the individual components is sufficiently comprehensive to cover the whole unit of analysis, there will always be a residual component for which data on physical activity levels is, by definition, unavailable. In this circumstance, the only meaningful way to quantify the activity level of the residual component is with a economic indicator, so the resulting analysis will therefore be based on mixed indicators, as described in Section 3.4 below.

In the unlikely event that an analysis based purely on physical indicators of activity is performed, the procedure is exactly the same as in Section 3.2 above, except that the energy intensities are calculated by dividing the energy consumption by the physical activity level indicator for each component in each year. Similarly, the shares of each component would be calculated for each year based on physical outputs.

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3.4 Activity level indicators in a mixture of economic and physical units

Where data on physical levels of activity is available, its use is generally preferable to relying solely on economic indicators for activity levels. The analysis described here deals with situations where physical indicators are available for some but not all of the components of the analysis. The procedure will be illustrated at each step using the following hypothetical data:

		Base year	Current year
SECTOR TOTAL	Energy consumption	790 TJ	830 TJ
	Value-added	870 million	1120 million
Sub-sector 1	Energy consumption	240 TJ	196 TJ
	Value-added	300 million	252 million
	Physical output (million tonnes)	30	28
Sub-sector 2	Energy consumption	240 TJ	342 TJ
	Value-added	360 million	630 million
	Physical output (million items)	120	180
Sub-sector 3	Energy consumption	190 TJ	195 TJ
	Value-added	160 million	175 million
	Physical output	not known	not known

Note that, for Sub-sectors 1 & 2, physical activity level indicators are available, but no physical activity level indicator is available for Sub-sector 3.

After each step in the calculations below, the above table will be reproduced with the newly calculated numbers included. These derived numbers will be presented in shaded cells, while the original data will always be in unshaded cells.

In the accompanying Excel spreadsheet ('Worked examples.xls'), the sheet 'Physical activity indicators' should be selected to accompany this section. With each calculation described below, a reference to the corresponding cell in the Excel spreadsheet is provided.

Step 1: If necessary, calculate any 'Other, unspecified' component

Unless the components for which data is available already account for the entire of the unit of analysis, it is necessary to calculate an additional component, designated 'Other' or 'Unspecified' to ensure complete coverage. This is done simply by, for each variable, summing across the components for which data is available and subtracting the sum from the total for the whole unit of analysis. Since physical activity level indicators are not available for all components, or are in different units for different components, it is not possible to meaningfully define physical activity level indicators for this residual component.

For the example used here, a new sub-sector 'Sub-sector 4 (Other)' is defined, with the following indicators:

Base year energy consumption = $790 - (240 + 240 + 190) = 120$ TJ [Cell C30]

Current year energy consumption = $830 - (196 + 342 + 195) = 97$ TJ [Cell D30]

Base year value-added = $870 - (300 + 360 + 160) = 50$ million [Cell C31]

Current year value-added = $1120 - (252 + 630 + 175) = 63$ million [Cell D31]

	Base year	Current year
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SECTOR TOTAL	Energy consumption	790 TJ	830 TJ
	Value-added	870 million	1120 million
Sub-sector 1	Energy consumption	240 TJ	196 TJ
	Value-added	300 million	252 million
	Physical output (million tonnes)	30	28
Sub-sector 2	Energy consumption	240 TJ	342 TJ
	Value-added	360 million	630 million
	Physical output (million items)	120	180
Sub-sector 3	Energy consumption	190 TJ	195 TJ
	Value-added	160 million	175 million
	Physical output	not known	not known
Sub-sector 4 (Other)	Energy consumption	120 TJ	97 TJ
	Value-added	50 million	63 million
	Physical output	not known	not known

Step 2: Calculate weighting factors

The weighting factors are calculated by taking the logarithmic mean of the energy consumption figures for the base year and the current year. Weighting factors must be calculated for each component. The logarithmic mean is defined as follows:

$$\text{logarithmic mean of } x \text{ and } y = (x - y) \div \ln(x / y)$$

NB: for this methodology, the natural logarithm (ln) function must be used, rather than the common logarithm (log) function.

Using the sample data, the following weighting factors are thus calculated:

Sub-sector 1 weighting factor = $(240-196) \div \ln(240/196) = 217.2579$ [Cell C13]

Sub-sector 2 weighting factor = $(240-342) \div \ln(240/342) = 287.9958$ [Cell C21]

Sub-sector 3 weighting factor = $(190-195) \div \ln(190/195) = 192.4892$ [Cell C29]

Sub-sector 4 (Other) weighting factor = $(120-97) \div \ln(120/97) = 108.0925$ [Cell C37]

		Base year	Current year
SECTOR TOTAL	Energy consumption	790 TJ	830 TJ
	Value-added	870 million	1120 million
Sub-sector 1	Energy consumption	240 TJ	196 TJ
	Value-added	300 million	252 million
	Physical output (million tonnes)	30	28
	Weighting factor	217.2579	
Sub-sector 2	Energy consumption	240 TJ	342 TJ
	Value-added	360 million	630 million
	Physical output (million items)	120	180
	Weighting factor	287.9958	
Sub-sector 3	Energy consumption	190 TJ	195 TJ
	Value-added	160 million	175 million
	Physical output	not known	not known

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	Weighting factor	192.4892	
Sub-sector 4 (Other)	Energy consumption	120 TJ	97 TJ
	Value-added	50 million	63 million
	Physical output	not known	not known
	Weighting factor	108.0925	

Step 3: Shares of each component in total value-added

The next step is to calculate the share of each component in the total value-added for the unit of analysis. Note that the total value-added for an economy is exactly equivalent to GDP, so term 'contribution to GDP' could be used instead of the term 'value-added'.

Using the sample data, the following shares of total value-added can be calculated:

Sub-sector 1 base year share = $300 / 870 = 0.3448$ [Cell C10]

Sub-sector 1 current year share = $252 / 1120 = 0.2250$ [Cell D10]

Sub-sector 2 base year share = $360 / 870 = 0.4138$ [Cell C18]

Sub-sector 2 current year share = $630 / 1120 = 0.5625$ [Cell D18]

Sub-sector 3 base year share = $160 / 870 = 0.1839$ [Cell C26]

Sub-sector 3 current year share = $175 / 1120 = 0.1563$ [Cell D26]

Sub-sector 4 (Other) base year share = $50 / 870 = 0.0575$ [Cell C34]

Sub-sector 4 (Other) current year share = $63 / 1120 = 0.0563$ [Cell D34]

		Base year	Current year
SECTOR TOTAL	Energy consumption	790 TJ	830 TJ
	Value-added	870 million	1120 million
Sub-sector 1	Energy consumption	240 TJ	196 TJ
	Value-added	300 million	252 million
	Physical output (million tonnes)	30	28
	Share of value-added	0.3448	0.2250
	Weighting factor	217.2579	
Sub-sector 2	Energy consumption	240 TJ	342 TJ
	Value-added	360 million	630 million
	Physical output (million items)	120	180
	Share of value-added	0.4138	0.5625
	Weighting factor	287.9958	
Sub-sector 3	Energy consumption	190 TJ	195 TJ
	Value-added	160 million	175 million
	Physical output	not known	not known
	Share of value-added	0.1839	0.1563
	Weighting factor	192.4892	
Sub-sector 4 (Other)	Energy consumption	120 TJ	97 TJ
	Value-added	50 million	63 million
	Physical output	not known	not known

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	Share of value-added	0.0575	0.0563
	Weighting factor	108.0925	

Step 4: Calculate energy intensities

Energy intensities for each component must now be calculated. For those components where a physical activity level indicator is available, the energy intensity is:

$$\text{energy consumption} \div \text{physical output}$$

For those components where no physical activity level indicator is available, the energy intensity is:

$$\text{energy consumption} \div \text{value-added}$$

Thus, for the sample data, the following energy intensities can be calculated:

Sub-sector 1 base year energy intensity (physical) = 240 / 30 = 8.0000 [Cell C11]

Sub-sector 1 current year energy intensity (physical) = 196 / 28 = 7.0000 [Cell D11]

Sub-sector 2 base year energy intensity (physical) = 240 / 120 = 2.0000 [Cell C19]

Sub-sector 2 current year energy intensity (physical) = 342 / 180 = 1.9000 [Cell D19]

Sub-sector 3 base year energy intensity (economic) = 190 / 160 = 1.1875 [Cell C28]

Sub-sector 3 current year energy intensity (economic) = 195 / 175 = 1.1143 [Cell D28]

Sub-sector 4 (Other) base year energy intensity (economic) = 120 / 50 = 2.4000 [Cell C36]

Sub-sector 4 (Other) current year energy intensity (economic) = 97 / 63 = 1.5397 [Cell D36]

		Base year	Current year
SECTOR TOTAL	Energy consumption	790 TJ	830 TJ
	Value-added	870 million	1120 million
Sub-sector 1	Energy consumption	240 TJ	196 TJ
	Value-added	300 million	252 million
	Physical output (million tonnes)	30	28
	Share of value-added	0.3448	0.2250
	Physical energy intensity	8.0000	7.0000
	Weighting factor	217.2579	
Sub-sector 2	Energy consumption	240 TJ	342 TJ
	Value-added	360 million	630 million
	Physical output (million items)	120	180
	Share of value-added	0.4138	0.5625
	Physical energy intensity	2.0000	1.9000
	Weighting factor	287.9958	
Sub-sector 3	Energy consumption	190 TJ	195 TJ
	Value-added	160 million	175 million
	Physical output	not known	not known
	Share of value-added	0.1839	0.1563
	Economic energy intensity	1.1875	1.1143
	Weighting factor	192.4892	

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Sub-sector 4 (Other)	Energy consumption	120 TJ	97 TJ
	Value-added	50 million	63 million
	Physical output	not known	not known
	Share of value-added	0.0575	0.0563
	Economic energy intensity	2.4000	1.5397
	Weighting factor	108.0925	

Step 5: Calculate activity intensities

For those components for which physical activity level indicators are available, it is necessary to calculate 'activity intensities', defined as the amount of physical output per unit of value-added. They are calculated as follows:

$$\text{physical output} \div \text{value-added}$$

Thus, for the sample data, the following activity intensities can be calculated:

Sub-sector 1 base year activity intensity = $30 / 300 = 0.1000$ [Cell C9]

Sub-sector 1 current year activity intensity = $28 / 252 = 0.1111$ [Cell D9]

Sub-sector 2 base year activity intensity = $120 / 360 = 0.3333$ [Cell C17]

Sub-sector 2 current year activity intensity = $180 / 630 = 0.2857$ [Cell D17]

Note that activity intensities are not defined for Sub-sectors 3 & 4, as these sub-sectors do not have physical activity level indicators.

		Base year	Current year
SECTOR TOTAL	Energy consumption	790 TJ	830 TJ
	Value-added	870 million	1120 million
Sub-sector 1	Energy consumption	240 TJ	196 TJ
	Value-added	300 million	252 million
	Physical output (million tonnes)	30	28
	Activity intensity	0.1000	0.1111
	Share of value-added	0.3448	0.2250
	Physical energy intensity	8.0000	7.0000
	Weighting factor	217.2579	
Sub-sector 2	Energy consumption	240 TJ	342 TJ
	Value-added	360 million	630 million
	Physical output (million items)	120	180
	Activity intensity	0.3333	0.2857
	Share of value-added	0.4138	0.5625
	Physical energy intensity	2.0000	1.9000
	Weighting factor	287.9958	
Sub-sector 3	Energy consumption	190 TJ	195 TJ
	Value-added	160 million	175 million
	Physical output	not known	not known
	Share of value-added	0.1839	0.1563
	Economic energy intensity	1.1875	1.1143

	Weighting factor	192.4892	
Sub-sector 4 (Other)	Energy consumption	120 TJ	97 TJ
	Value-added	50 million	63 million
	Physical output	not known	not known
	Share of value-added	0.0575	0.0563
	Economic energy intensity	2.4000	1.5397
	Weighting factor	108.0925	

Step 6: Calculate activity-level change factor

We are now ready to begin calculating the contributions to the total change in energy consumption that are attributable to the main factors. First, we calculate the contribution due to changes in overall activity level. This is calculated as follows:

Step 6.1

Calculate the ratio:

$$(\text{current year total value-added}) \div (\text{base year total value-added})$$

For the sample data, this is equal to $1120 / 870 = 1.2874$ [Cell E4]

Step 6.2

Calculate the natural logarithm of the ratio from Step 6.1. For the sample data, this is equal to:

$$\ln(1.2874) = 0.2526$$
 [Cell F4]

Step 6.3

Calculate the sum of the weighting factors from Step 2. For the sample data, this is equal to:

$$217.2579 + 287.9958 + 192.4892 + 108.0925 = 805.8354$$
 [Cell C5]

Step 6.4

Calculate the product:

$$\text{logarithm from Step 6.2} \times \text{sum of weighting factors from Step 6.3}$$

For the sample data, this is equal to:

$$0.2526 \times 805.8354 = 203.5540$$
 [Cell G4]

Step 6.5

For each component that has a physical activity level indicator, calculate the ratio:

$$(\text{current year activity intensity}) \div (\text{base year activity intensity})$$

For the sample data, these are as follows:

$$\text{Sub-sector 1: } 0.1111 / 0.1000 = 1.1111$$
 [Cell E9]

$$\text{Sub-sector 2: } 0.2857 / 0.3333 = 0.8571$$
 [Cell E17]

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Step 6.6

For each component that has a physical activity level indicator, calculate the natural logarithm of the ratio from Step 6.5. For the sample data, this gives:

Sub-sector 1: $\ln(1.1111) = 0.1054$ [Cell F9]

Sub-sector 2: $\ln(0.8571) = -0.1542$ [Cell F17]

Step 6.7

For each component that has a physical activity level indicator, calculate the product:

logarithm from Step 6.6 x weighting factor for component from Step 2

For the sample data, this is equal to:

Sub-sector 1: $= 0.1054 \times 217.2579 = 22.8904$ [Cell G9]

Sub-sector 2: $= -0.1542 \times 287.9958 = -44.3948$ [Cell G17]

Step 6.8

Calculate the sum:

product from Step 6.4 + sum of products from Step 6.7

For the sample data, this is equal to:

$203.5540 + 22.8904 - 44.3948 = 182.0422$ [Cell H4]

The result is the contribution to the overall change in energy consumption attributable to changes in total activity level. The result is positive, meaning that activity level changes accounted for an increase in energy consumption.

Activity level changes accounted for a **182.04 TJ increase** in the total observed change in energy consumption

Step 7: Calculate structural change factor

The next step is to calculate the contribution of structural changes to the total change in energy consumption. This is calculated as follows:

Step 7.1

For each component, calculate the ratio:

$(\text{current year share in value-added}) \div (\text{base year share in value-added})$

For the sample data, these are as follows:

Sub-sector 1: $0.2250 / 0.3448 = 0.6525$ [Cell E10]

Sub-sector 2: $0.5625 / 0.4138 = 1.3594$ [Cell E18]

Sub-sector 3: $0.1563 / 0.1839 = 0.8496$ [Cell E26]

Sub-sector 4: $0.0563 / 0.0575 = 0.9788$ [Cell E34]

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Step 7.2

For each component, calculate the natural logarithm of the ratio from Step 7.1. For the sample data, this gives:

Sub-sector 1: $\ln(0.6525) = -0.4269$ [Cell F10]

Sub-sector 2: $\ln(1.3594) = 0.3070$ [Cell F18]

Sub-sector 3: $\ln(0.8496) = -0.1630$ [Cell F26]

Sub-sector 4: $\ln(0.9788) = -0.0215$ [Cell F34]

Step 7.3

For each component, calculate the product:

logarithm from Step 7.2 x weighting factor for component from Step 2

For the sample data, this is equal to:

Sub-sector 1: $= -0.4269 \times 217.2579 = -92.757$ [Cell G10]

Sub-sector 2: $= 0.3070 \times 287.9958 = 88.4219$ [Cell G18]

Sub-sector 3: $= -0.1630 \times 192.4892 = -31.3716$ [Cell G26]

Sub-sector 4: $= -0.0215 \times 108.0925 = -2.3217$ [Cell G34]

Step 7.4

Calculate the sum of all the products from Step 7.3. For the sample data, this is equal to:

$-92.757 + 88.4219 - 31.3716 - 2.3217 = -38.0284$ [Cell G39]

The result is the contribution of structural changes to the observed change in total energy consumption. The result is negative, meaning that structural changes accounted for a decrease in energy consumption.

Structural changes accounted for a **38.03 TJ decrease** in the total observed change in energy consumption

Step 8: Calculate efficiency change factor

The next step is to calculate the contribution of efficiency changes to the total change in energy consumption. This is calculated as follows:

Step 8.1

For each component, calculate the ratio:

(current year energy intensity) ÷ (base year energy intensity)

For components where a physical activity level indicator is available, use the physical energy intensity. For components where no physical activity level indicator is available, use the economic energy intensity. For the sample data, these ratios are as follows:

Sub-sector 1: $7.0000 / 8.0000 = 0.8750$ [Cell E11]

Sub-sector 2: $1.9000 / 2.0000 = 0.9500$ [Cell E19]

Sub-sector 3: $1.1143 / 1.1875 = 0.9383$ [Cell E28]

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Sub-sector 4: $1.5397 / 2.4000 = 0.6415$ [Cell E36]**Step 8.2**

For each component, calculate the **natural logarithm** of the ratio from Step 8.1. For the sample data, this gives:

Sub-sector 1: $\ln(0.8750) = -0.1335$ [Cell F11]Sub-sector 2: $\ln(0.9500) = -0.0513$ [Cell F19]Sub-sector 3: $\ln(0.9383) = -0.0636$ [Cell F28]Sub-sector 4: $\ln(0.6415) = -0.4439$ [Cell F36]**Step 8.3**

For each component, calculate the product:

logarithm from Step 8.2 x weighting factor for component from Step 2

For the sample data, this is equal to:

Sub-sector 1: $= -0.1355 \times 217.2579 = -29.0108$ [Cell G11]Sub-sector 2: $= -0.0513 \times 287.9958 = -14.7723$ [Cell G19]Sub-sector 3: $= -0.0636 \times 192.4892 = -12.2494$ [Cell G28]Sub-sector 4: $= -0.4439 \times 108.0925 = -47.9814$ [Cell G36]**Step 8.4**

Calculate the **sum of all the products** from Step 8.3. For the sample data, this is equal to:

$$-29.0108 - 14.7723 - 12.2494 - 47.9814 = -104.0138$$
 [Cell G40]

The result is the contribution of efficiency changes to the observed change in total energy consumption. The result is negative, meaning that efficiency changes accounted for a decrease in energy consumption (i.e. efficiency improved).

Efficiency changes accounted for a **104.01 TJ decrease in the total observed change in energy consumption**

Step 9: Cross check

The sum of the factors calculated in Steps 6-8 above should equal the total observed change in energy consumption for the whole unit of analysis. A cross-check should be performed to ensure that this is the case, indicating that no errors have been made.

$$182.04 - 38.03 - 104.01 = 40.00$$
 [Cell G41]

The observed change in total energy consumption from the original data is indeed 40 TJ, indicating that the results obtained are consistent and no errors have been made.

4 Sectoral decomposition in the residential sector

4.1 Analysis by LSM

One possible approach for analysing the residential sector is to use the ‘Living Standards Measure’ (LSM) stratification as the basis for the disaggregation of the sector. Using this analysis, relative shifts in the populations of LSMs would be analogous to the structural effects in the industrial and commercial / public sectors. This ‘structural’ effect in the residential sector would indicate the extent to which changes in energy consumption were due to changes in the average standard of living (i.e. changes in the relative share of different LSM categories). The ‘activity’ factor would indicate the extent to which changes in the total number of household had influenced energy consumption, while the third factor – the ‘efficiency’ factor – would correspond to changes in household energy intensity that were *not* the result of changes in living standard (i.e. technical and behavioural changes in energy efficiency).

A worked example of an analysis based on LSMs will not be provided here, as it is very closely analogous to the analyses described in Sections 2 & 3 above. For more details on analysis by LSM, refer to the accompanying paper ‘Monitoring of Energy Efficiency Targets: A Theoretical Review’. The data requirements for an analysis based on LSMs are described in the accompanying paper ‘Monitoring of Energy Efficiency Targets: Selection and Availability of Indicators’.

4.2 Analysis by end-use activity

The analysis methodology described here decomposes changes in residential energy consumption into four factors: number of households (population effect); number of households carrying out each end-use activity (appliance ownership level); energy efficiency with which activities are carried out (efficiency factor); level at which activities are carried out (usage factor). The last of these factors is effectively a residual, corresponding to that portion of the total change in sectoral energy consumption that cannot be explained by the other factors given the likely availability of data. Data on ownership levels of appliances is relatively easy to obtain, but ownership of an appliance does not provide any information about how much that appliance is used. It is unlikely that detailed and reliable data on usage levels will become available in the foreseeable future, so the only option is to use ownership level as a proxy indicator, and assume that any portion of energy consumption left unexplained is due to changes in usage levels.

At least initially, it is also unlikely that data on specific energy consumptions will be available. The step-by-step description of the methodology presented below describes how the analysis should be conducted both with and without data on specific energy consumption.

4.2.1 Data requirements

The data requirements for this analysis are as follows:

- Total number of households, from StasSA’s ‘General Household Survey’
- Total energy consumption in residential sector, from DME data.
- Fraction of total energy consumption accounted for by: cooking; space heating; water heating; refrigeration; lighting; clothes washing/drying. This information is used to derive the weighting factors, so approximate estimates from the literature are adequate in the first instance, although it is recommended that annually updated estimates are obtained for analyses in subsequent years. For the purposes of the step-by-step description of the methodology presented below, the following hypothetical figures are used: 45% cooking, 20% water heating, 10% refrigeration, 10% space heating, 8% lighting, 3% clothes washing / drying, 4% other.

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- Total ownership level of appliances / total number of households carrying out each activity. This quantity requires some elaboration:
 - Space heating: this is the fraction of households that use space heating, obtainable from StatsSA's 'General Household Survey'.
 - Water heating and cooking: this should be set to 100%, as it can be assumed that virtually all households cook and heat water.
 - Lighting: ideally, this should be the average number of electric lamps in use per household. However, in the absence of this data, the number of rooms in the dwelling can be used as a proxy, obtainable from StatsSA's 'Labour Force Survey'.
 - Other activities: the ownership levels of the relevant appliances should be used. This data is available annually from SAARF's 'All Media and Products Survey'.
- Average specific energy consumption of appliances. In general, this data is not yet available in a sufficiently detailed and reliable form for conducting a full analysis. The step-by-step description of the methodology provided below describes how the analysis should be conducted in the absence of this data. As and when this specific energy consumption data becomes available, its details require some elaboration:
 - Space heating: this should be the average energy per unit floor area for heating a dwelling to a given indoor air temperature. It therefore depends only on the type and material of construction of the dwelling (including whether a ceiling is present), and the level of insulation. Some data on construction material is available from StatsSA's 'Labour Force Survey', although additional survey questions will be required to obtain all the necessary data. Additional research will also be required to convert the data on dwelling construction to figures for specific space heating consumption.
 - Cooking and water heating: this should be the energy requirement to provide a given level of energy service using the fuel / technology combination employed in the household. StatsSA's 'General Household Survey' provides data on the energy source used for cooking, but not water heating. It also does not provide information on the particular technology employed (e.g. paraffin primus versus wick stove), which has a strong influence on the specific energy consumption. Additional surveys will therefore need to be conducted in order to obtain this missing data, which should include information on insulation levels of water heating devices and hot water pipes. Again, additional research will be required to convert survey data into estimates for specific energy consumption.
 - Lighting and other applications: this should simply be the power rating of the appliance in question.

4.2.2 Step-by-step instructions

The procedure will be illustrated at each step using the following hypothetical data. Note that if data on specific energy consumption is not available, Step 5 is omitted.

		Base year	Current year
SECTOR TOTAL	Energy consumption	193360	196940
	Number of households	11780	12546

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Space heating	Fraction of households doing	0.919	0.922
	Specific energy consumption	987	955
Cooking	Fraction of households doing	1	1
	Specific energy consumption	1222	1165
Water heating	Fraction of households doing	1	1
	Specific energy consumption	2565	2377
Lighting	Lamps per household	3.82	3.95
	Specific energy consumption	88	79
Refrigeration	Appliances per household	0.799	0.802
	Specific energy consumption	520	510
Clothes washing	Appliances per household	0.501	0.514
	Specific energy consumption	201	208
Other	Appliances per household	1	1

In the accompanying Excel spreadsheet ('Worked examples.xls'), the sheet 'Residential sector analysis' should be selected to accompany this section. With each calculation described below, a reference to the corresponding cell in the Excel spreadsheet is provided.

Step 1: Calculate the energy consumption of each activity

For each activity, the energy consumption is calculated by multiplying the total energy consumption by the fractional share of total energy consumption for the activity in question. For the purposes of this example, the following hypothetical fractional shares are used: 45% cooking, 20% water heating, 10% refrigeration, 10% space heating, 8% lighting, 3% clothes washing / drying, 4% other. Energy consumption by activity is therefore calculated as follows:

Base year space heating energy consumption = $193,360 \times 0.1 = 19,336$ TJ [Cell C6]

Current year space heating energy consumption = $196,940 \times 0.1 = 19,694$ TJ [Cell D6]

Base year cooking energy consumption = $193,360 \times 0.45 = 87,012$ TJ [Cell C10]

Current year cooking energy consumption = $196,940 \times 0.45 = 88,623$ TJ [Cell D10]

Base year water heating energy consumption = $193,360 \times 0.2 = 38,672$ TJ [Cell C14]

Current year water heating energy consumption = $196,940 \times 0.2 = 39,338$ TJ [Cell D14]

Base year lighting energy consumption = $193,360 \times 0.08 = 15,469$ TJ [Cell C18]

Current year lighting energy consumption = $196,940 \times 0.08 = 15,755$ TJ [Cell D18]

Base year refrigeration energy consumption = $193,360 \times 0.1 = 19,336$ TJ [Cell C22]

Current year refrigeration energy consumption = $196,940 \times 0.1 = 19,694$ TJ [Cell D22]

Base year clothes washing energy consumption = $193,360 \times 0.03 = 5,801$ TJ [Cell C26]

Current year clothes washing energy consumption = $196,940 \times 0.03 = 5,908$ TJ [Cell D26]

Base year other energy consumption = $193,360 \times 0.04 = 7,734$ TJ [Cell C30]

Current year other energy consumption = $196,940 \times 0.04 = 7,878$ TJ [Cell D30]

		Base year	Current year
SECTOR TOTAL	Energy consumption	193360	196940

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	Number of households	11780	12546
Space heating	Energy consumption	19336	19694
	Fraction of households doing	0.919	0.922
	Specific energy consumption	987	955
Cooking	Energy consumption	87012	88623
	Fraction of households doing	1	1
	Specific energy consumption	1222	1165
Water heating	Energy consumption	38672	39388
	Fraction of households doing	1	1
	Specific energy consumption	2565	2377
Lighting	Energy consumption	15469	15755
	Lamps per household	3.82	3.95
	Specific energy consumption	88	79
Refrigeration	Energy consumption	19336	19694
	Appliances per household	0.799	0.802
	Specific energy consumption	520	510
Clothes washing	Energy consumption	5801	5908
	Appliances per household	0.501	0.514
	Specific energy consumption	201	208
Other	Energy consumption	7734	7878
	Appliances per household	1	1

Step 2: Calculate weighting factors

The weighting factors are calculated by taking the logarithmic mean of the energy consumption figures for the base year and the current year. Weighting factors must be calculated for each activity. The logarithmic mean is defined as follows:

$$\text{logarithmic mean of } x \text{ and } y = (x - y) \div \ln(x / y)$$

NB: for this methodology, the natural logarithm (ln) function must be used, rather than the common logarithm (log) function.

Using the sample data, the following weighting factors are thus calculated:

Space heating: $(19,336-19,694) \div \ln(19,336/19,694) = 19514.45$ [Cell C9]

Cooking: $(87,012-88,623) \div \ln(87,012/88,623) = 87815.04$ [Cell C13]

Water heating: $(38,672-39,338) \div \ln(38,672/39,338) = 39028.91$ [Cell C17]

Lighting: $(15,469-15,755) \div \ln(15,469/15,755) = 15611.56$ [Cell C21]

Refrigeration: $(19,336-19,694) \div \ln(19,336/19,694) = 19514.45$ [Cell C25]

Clothes washing: $(5,801-5,908) \div \ln(5,801/5,908) = 5854.34$ [Cell C29]

Other: $(7,734-7,878) \div \ln(7,734/7,878) = 7805.78$ [Cell C33]

		Base year	Current year
SECTOR TOTAL	Energy consumption	193360	196940
	Number of households	11780	12546
Space heating	Energy consumption	19336	19694

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	Fraction of households doing	0.919	0.922
	Specific energy consumption	987	955
	Weighting factor	19514.4527	
Cooking	Energy consumption	87012	88623
	Fraction of households doing	1	1
	Specific energy consumption	1222	1165
	Weighting factor	87815.03715	
Water heating	Energy consumption	38672	39388
	Fraction of households doing	1	1
	Specific energy consumption	2565	2377
	Weighting factor	39028.9054	
Lighting	Energy consumption	15469	15755
	Lamps per household	3.82	3.95
	Specific energy consumption	88	79
	Weighting factor	15611.56338	
Refrigeration	Energy consumption	19336	19694
	Appliances per household	0.799	0.802
	Specific energy consumption	520	510
	Weighting factor	19514.4527	
Clothes washing	Energy consumption	5801	5908
	Appliances per household	0.501	0.514
	Specific energy consumption	201	208
	Weighting factor	5854.337031	
Other	Energy consumption	7734	7878
	Appliances per household	1	1
	Weighting factor	7805.778627	

Step 3: Calculate 'number of households' factor

The next step is to calculate the change in total energy consumption that is attributable to changes in the number of households. This is calculated as follows:

Step 3.1

Calculate the ratio:

$$(\text{current year number of households}) \div (\text{base year number of households})$$

For the sample data, this is equal to $12546 / 11780 = 1.065025$ [Cell E4]

Step 3.2

Calculate the natural logarithm of the ratio from Step 3.1. For the sample data, this is equal to:

$$\ln(1.065025) = 0.062999$$
 [Cell F4]

Step 3.3

Calculate the sum of the weighting factors from Step 2. For the sample data, this is equal to:

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19514.45 + 87815.04 + 39028.91 + 15611.56 + 19514.45 + 5854.34 + 7805.78 = 195144.53.....[Cell C5]

Step 3.4

Calculate the product:

logarithm from Step 3.2 x sum of weighting factors from Step 3.3

For the sample data, this is equal to:

0.062999 x 195144.53 = 12293.85..... [Cell G4]

The result is the contribution to the overall change in energy consumption attributable to changes in total number of households. The result is positive, meaning that changes in the number of households accounted for an increase in energy consumption.

Changes in the number of households accounted for a **12293.85 TJ increase in the total observed change in energy consumption**

Step 4: Calculate 'appliance ownership' factor

The next step is to calculate the change in total energy consumption that is attributable to changes in the level of ownership of appliances, or changes in the proportion of households who carry out the range of energy-using activities covered. This is calculated as follows:

Step 4.1

For each activity, calculate the ratio:

(current year appliances per household) ÷ (base year appliances per household)

For the sample data, these are as follows:

Space heating: 0.922 / 0.919 = 1.003264 [Cell E7]

Cooking: 1 / 1 = 1..... [Cell E11]

Water heating: 1 / 1 = 1 [Cell E15]

Lighting: 3.95 / 3.82 = 1.034031 [Cell E19]

Refrigeration: 0.802 / 0.799 = 1.003755 [Cell E23]

Clothes washing: 0.514 / 0.501 = 1.025948 [Cell E27]

Other: 1 / 1 = 1 [Cell E31]

Step 4.2

For each activity, calculate the natural logarithm of the ratio from Step 4.1. For the sample data, this gives:

Space heating: $\ln(1.003264) = 0.003259$ [Cell F7]Cooking: $\ln(1) = 0$ [Cell F11]Water heating: $\ln(1) = 0$ [Cell F15]

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Lighting: $\ln(1.034031) = 0.033465$ [Cell F19]Refrigeration: $\ln(1.003755) = 0.003748$ [Cell F23]Clothes washing: $\ln(1.025948) = 0.025617$ [Cell F27]Other: $\ln(1) = 0$ [Cell F31]**Step 4.3**

For each activity, calculate the product:

logarithm from Step 4.2 x weighting factor for component from Step 2

For the sample data, this is equal to:

Space heating: $0.003259 \times 19514.45 = 63.59958$ [Cell G7]

Cooking: 0 [Cell G11]

Water heating: 0 [Cell G15]

Lighting: $0.033465 \times 15611.56 = 522.4434$ [Cell G19]Refrigeration: $0.003748 \times 19514.45 = 73.13357$ [Cell G23]Clothes washing: $0.025617 \times 5854.34 = 149.9715$ [Cell G27]

Other: 0..... [Cell G31]

Step 4.4

Calculate the sum of all the products from Step 4.3. For the sample data, this is equal to:

 $63.59958 + 0 + 0 + 522.4434 + 73.13357 + 149.9715 + 0 = 809.1481$ [Cell G35]

The result is the contribution of appliance ownership levels to the observed change in total energy consumption. The result is positive, meaning that changes in appliance ownership levels accounted for an increase in energy consumption.

Changes in appliance ownership levels accounted for a 809.15 TJ increase in the total observed change in energy consumption

Step 5: Calculate efficiency change factor

The efficiency change factor can only be calculated if data on specific energy consumption is available. If this data is not obtainable, this step should be omitted.

The efficiency change factor is calculated as follows:

Step 5.1

Calculate the specific energy consumption for the activity 'Other'. This is equal to the ratio:

(energy consumption of activity 'Other') ÷ (number of households)

Base year 'Other' specific energy consumption: $7734 / 11780 = 0.6565$ [Cell C32]Current year 'Other' specific energy consumption = $7878 / 12546 = 0.6279$ [Cell D32]

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Step 5.2

For each activity (including 'Other'), calculate the ratio:

$$\frac{\text{(current year specific energy consumption)}}{\text{(base year specific energy consumption)}}$$

For the sample data, these are as follows:

Space heating: 955 / 987 = 0.9676	[Cell E8]
Cooking: 1165 / 1222 = 0.9534.....	[Cell E12]
Water heating: 2377 / 2565 = 0.9267	[Cell E16]
Lighting: 79 / 88 = 0.8977	[Cell E20]
Refrigeration: 510 / 520 = 0.9808	[Cell E24]
Clothes washing: 208 / 201 = 1.0348	[Cell E28]
Other: 0.6279 / 0.6565 = 0.9564	[Cell E32]

Step 5.3

For each activity, calculate the natural logarithm of the ratio from Step 5.2. For the sample data, this gives:

Space heating: $\ln(0.9676) = -0.03296$	[Cell F8]
Cooking: $\ln(0.9534) = -0.04777$	[Cell F12]
Water heating: $\ln(0.9267) = -0.07612$	[Cell F16]
Lighting: $\ln(0.8977) = -0.10789$	[Cell F20]
Refrigeration: $\ln(0.9808) = -0.01942$	[Cell F24]
Clothes washing: $\ln(1.0348) = 0.03423$	[Cell F28]
Other: $\ln(0.9564) = -0.04454$	[Cell F32]

Step 5.4

For each activity, calculate the product:

logarithm from Step 5.3 x weighting factor for component from Step 2

For the sample data, this is equal to:

Space heating: $-0.03296 \times 19514.45 = -643.17$	[Cell G8]
Cooking: $-0.04777 \times 87815.04 = -4194.73$	[Cell G12]
Water heating: $-0.07612 \times 39028.91 = -2970.85$	[Cell G16]
Lighting: $-0.10789 \times 15611.56 = -1684.32$	[Cell G20]
Refrigeration: $-0.01942 \times 19514.45 = -378.93$	[Cell G24]
Clothes washing: $0.03423 \times 5854.34 = 200.41$	[Cell G28]
Other: $-0.04454 \times 7805.78 = -347.68$	[Cell G32]

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Step 5.5

Calculate the **sum of all the products from Step 5.4**. For the sample data, this is equal to:

$$-643.17 + -4194.73 + -2970.85 + -1684.32 + -378.93 + 200.41 + -347.68 = -10019.27 \text{.. [Cell G36]}$$

The result is the contribution of efficiency changes to the observed change in total energy consumption. The result is negative, meaning that efficiency changes accounted for an decrease in energy consumption.

Changes in efficiency accounted for a 10019.27 TJ decrease in the total observed change in energy consumption

Step 6: Calculate the unattributed factor

The final step is to calculate the remaining unattributed portion of the total observed change in energy consumption. If data on specific energy consumption was available and an efficiency factor has been calculated, this remaining unattributed factor is due to behavioural changes, including changes in appliance usage levels. If data on specific energy consumption was not available, and an efficiency factor has not been calculated, the unattributed factor is that portion of the change in energy consumption that is due to a combination of behavioural changes and technical efficiency changes.

The unattributed factor is equal to:

(change in total energy consumption) - (sum of all calculated factors)

Where data on specific energy consumption allowed the calculation of an efficiency factor, this is equal to:

$$196940 - 193360 - 12293.85 - 809.15 - -10019.27 = 496.27$$

Where data on specific energy consumption was not available, and an efficiency factor was not calculated, this is equal to:

$$196940 - 193360 - 12293.85 - 809.15 = -9523$$

Depending on whether or not an efficiency factor was calculated, one or other of the following conclusions can be drawn:

Behavioural changes accounted for a 496.27 TJ increase in the total observed change in energy consumption

OR

A combination of behavioral changes and changes in efficiency accounted for a 9523 TJ decrease in the total observed change in energy consumption

APPENDIX A Intra-sectoral structural effects in an economy-wide analysis

Table A1 below shows the results of a simple economy-wide decomposition analysis on a hypothetical economy with three sectors. The results indicate that structural effects accounted for a decrease in energy consumption of 4,401.64 TJ, while reductions in energy intensity accounted for a decrease of 8,640.63 TJ in total energy consumption. However, the structural factor in this analysis includes only inter-sectoral structural shift, while the intensity factor actually includes intra-sectoral structural shifts that are nothing to do with real changes in energy efficiency. For example, examining Table A2 shows that Sector 2 appears to be contributing a 197.35 TJ improvement to the overall figure for the intensity factor. However, a detailed decomposition analysis of Sector 2, presented in Table A3 below, shows that the energy intensity of this sector has actually deteriorated by 170.27 TJ. The apparent improvement in intensity that showed in the economy-wide analysis was actually due to intra-sectoral structural changes.

To provide a true representation of the effects of structural changes versus genuine efficiency improvements in an economy-wide decomposition analysis, the intra-sectoral structural effects should be included. For the hypothetical data presented here, this involves summing the structural factors for the individual sectors:

$$\text{total intra-sectoral structural factor} = -568.04 + -367.57 + 534.08 = -401.53$$

This intra-sectoral structural factor wrongly shows up as part of the intensity factor in the economy-wide analysis, so the economy-wide intensity should be reduced accordingly:

$$\text{true intensity factor} = -8640.63 - -401.53 = -8239.10$$

Thus the observed decrease in total energy consumption of 4072 TJ is made up of four factors:

- Activity changes accounted for an increase of 8970.275 TJ
- Inter-sectoral structural changes accounted for a decrease of 4401.641 TJ
- Intra-sectoral structural changes accounted for a decrease of 401.53 TJ
- Efficiency changes accounted for a decrease of 8239.10 TJ

Of course, for a complete picture, this approach should be cascaded down through all levels, including intra-sub-sectoral and intra-industry structural effects. In practice, however, the improved accuracy resulting is unlikely to merit the additional effort involved.

Table A1 Economy-wide analysis

		Sector 1	Sector 2	Sector 3	Total
Energy	Year 0	295,415.000	35,022.000	51,520.000	381,957.000
	Year 1	289,046.000	35,585.000	53,254.000	377,885.000
Activity	Year 0	24,360.000	43,359.000	132,968.000	200,687.000
	Year 1	24,560.000	44,303.000	136,619.000	205,482.000
Log-mean weighting function		292,218.932	35,302.752	52,382.217	379,903.901
Intensity	Year 0	12.127	0.808	0.387	
	Year 1	11.769	0.803	0.390	
Share	Year 0	0.121	0.216	0.663	
	Year 1	0.120	0.216	0.665	
Activity effect					8,970.275
Structural effect		-4,510.486	-73.213	182.058	-4,401.641
Intensity effect		-8,758.375	-197.354	315.095	-8,640.634

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Table A2 Sector 1 analysis

		Sub-sector 1.1	Sub-sector 1.2	Sub-sector 1.3	Total
Energy	Year 0	13,075.000	281,273.000	1,067.000	295,415.000
	Year 1	18,374.000	269,168.000	1,504.000	289,046.000
Activity	Year 0	6,339.000	15,910.000	2,111.000	24,360.000
	Year 1	6,332.000	16,013.000	2,215.000	24,560.000
Log-mean weighting function		15,574.547	275,176.127	1,273.023	292,023.697
Intensity	Year 0	2.063	17.679	0.505	
	Year 1	2.902	16.809	0.679	
Share	Year 0	0.260	0.653	0.087	
	Year 1	0.258	0.652	0.090	
Activity effect					2,387.779
Structural effect		-144.556	-474.296	50.811	-568.041
Intensity effect		5,316.208	-13,880.725	375.779	-8,188.738

Table A3 Sector 2 analysis

		Sub-sector 2.1	Sub-sector 2.2	Sub-sector 2.3	Total
Energy	Year 0	3,075.000	21,273.000	10,674.000	35,022.000
	Year 1	3,374.000	21,168.000	11,043.000	35,585.000
Activity	Year 0	6,339.000	15,910.000	21,110.000	43,359.000
	Year 1	6,332.000	15,813.000	22,158.000	44,303.000
Log-mean weighting function		3,222.188	21,220.457	10,857.455	35,300.100
Intensity	Year 0	0.485	1.337	0.506	
	Year 1	0.533	1.339	0.498	
Share	Year 0	0.146	0.367	0.487	
	Year 1	0.143	0.357	0.500	
Activity effect					760.297
Structural effect		-72.960	-586.821	292.214	-367.567
Intensity effect		302.560	24.773	-157.063	170.270

Table A4 Sector 3 analysis

		Sub-sector 3.1	Sub-sector 3.2	Sub-sector 3.3	Total
Energy	Year 0	18,945.000	20,456.000	12,119.000	51,520.000
	Year 1	19,433.000	20,331.000	13,490.000	53,254.000
Activity	Year 0	94,456.000	28,592.000	9,920.000	132,968.000
	Year 1	96,551.000	29,333.000	10,735.000	136,619.000
Log-mean weighting function		19,187.966	20,393.436	12,792.258	52,373.660
Intensity	Year 0	0.201	0.715	1.222	
	Year 1	0.201	0.693	1.257	
Share	Year 0	0.710	0.215	0.075	
	Year 1	0.707	0.215	0.079	
Activity effect					1,418.673
Structural effect		-98.823	-30.617	663.521	534.081
Intensity effect		67.069	-646.791	360.968	-218.754