Department of Minerals and Energy Pretoria

Capacity Building in Energy Efficiency and Renewable Energy

Report No. 2.3.4-30(D)

MONITORING OF ENERGY EFFICIENCY TARGETS:

Review of International Best Practice

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July 2005

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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 2015. 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.

Given the relatively small number of countries that have set quantified energy efficiency targets, there has been little experience worldwide in the comprehensive monitoring of energy efficiency progress at the economy-wide and sectoral level. However, what little experience there is should form the foundation upon which the South African protocols and processes are based. Somewhat greater in extent is the body of international experience concerned with the monitoring of specific energy efficiency programmes. Examining the approaches adopted in this area can provide useful guidance in the design of a South African system for monitoring energy efficiency targets. The purpose of this paper is therefore to review international best practice in energy efficiency monitoring, and identify those elements that are most applicable in the South African context.

The first step in the process was to conduct a survey in order to derive an overview of the attitudes and opinions of experts worldwide. The results of this survey are presented in Section 2 below. In addition to the survey, a literature review backed up by telephone and e-mail interviews was conducted to discover the key features of systems that are currently in place around the world. These results are presented in Section 3, with more detailed case studies for countries that can provide useful lessons for South Africa, and short summaries of other countries. Section 4 draws conclusions and makes recommendations for the design of a South African system.

2 Survey of Expert Opinion

2.1 Survey questions

The questions asked in the survey are as follows:

1. Monitoring systems:

   In your experience, do most countries have formal systems in place to monitor progress or targets in energy efficiency?

   Does your country have such a system?

   How well, in your experience, do national energy efficiency monitoring systems generally work?

2. Name examples of some countries that are doing well in terms of monitoring their energy efficiency efforts.
3. How are the monitoring activities funded and how many staff would you consider appropriate for carrying them out.
4. Setting up indicators:

   What kind of targets or indicators are most effective in terms of tracking or evaluating the impact / effect of energy efficiency policies?

   Based on your experience, how are indicators best organized (e.g., by sector, by technology, by energy intensity?)

   How is the energy efficiency monitoring best organized and implemented? (E.g. by government agencies or contracted out).

5. What are the main barriers to establishment and implementation of an effective energy efficiency monitoring scheme?
6. Indicators by sector:

   What kind of indicators would you recommend for practical monitoring of energy efficiency progress in the residential Sector?

   What kind of would you recommend for practical monitoring of energy efficiency progress in the commercial Sector?

   What kind of would you recommend for practical monitoring of energy efficiency progress in the industrial Sector?

   What kind of would you recommend for practical monitoring of energy efficiency progress in the transport Sector?

7. Are there particular issues and difficulties related to measuring and estimating end-use efficiency that you would like to highlight? And how can these issues be addressed? Considerations as to which type of data sources are most efficient to use would be especially interesting.
8. Further to the previous question, are there any special issues or considerations related to data collection/verification/quality control that you would like to highlight? Comments pertaining to data, which relates to the underlying driving forces that tell you not only “where you are” but rather why you are where you are, would be particularly appreciated.

2.2 Survey results

Since only 18 responses were received, caution must be exercised in attaching statistical significance to these results, except in cases where there is a clear consensus. Over half of the responses received (10 out of 18) concerned the experiences of Asian countries, three responses related to EU countries, two to the USA, two to developing countries in general and one response related to Africa. In all except three cases, the respondent's answers related to their own country.

A clear majority of respondents believed that most countries do not yet have in place a formal system for monitoring progress in energy efficiency, or energy efficiency targets. However, over half of the respondents claimed that their country (or the country on which they were providing information) has in place a system for monitoring energy efficiency progress, although in many cases the system in question is only a partial one, or is not functioning effectively. When asked how well national energy efficiency monitoring systems function, only five respondents were positive (answering either 'well, without question' or 'generally well').

When questioned about examples of countries that are doing well in terms of monitoring their energy efficiency efforts, a number of countries emerged as being cited on several occasions by different respondents. These were: Japan, USA, EU, Germany and Thailand. However, in many cases it seems the respondent was referring more to the monitoring on a programme by programme basis of specific energy efficiency initiatives, rather than the comprehensive monitoring of energy efficiency improvements at an economy-wide and sectoral level.

Of those who expressed a positive opinion, a significant number felt that the staffing level required to implement a comprehensive monitoring system was high – above 15 full-time staff members. However, the general consensus was that the required staffing level depended on how ambitious the monitoring system was to be, with general agreement that staffing levels needed to be higher at the outset, while initial difficulties are ironed out. There was a general consensus that the monitoring system should be funded either out of general government budget, or from energy taxes / levies introduced specifically for this purpose.

A very clear majority of respondents felt that sector-wise monitoring was necessary to develop a clear picture of energy efficiency progress, with indicators based on energy intensity (either economic or physical). A few respondents favoured a system based on technology-specific indicators (e.g. penetration rates of technologies classified according to their energy efficiency). A few respondents also highlighted the need for monitoring the activity levels of energy efficiency efforts (e.g. number of energy audits carried out, number of personnel trained in energy awareness).

With regard to the question of whether energy efficiency monitoring should be carried out 'in-house' by the respective government agency, or contracted out to an external body, opinion was equally divided. About one third of respondents favoured a joint effort between government and external bodies, where although much of the actual work would be carried out by outside contractors, the process would remain under the close direction and supervision of the relevant government department.

The most commonly cited barrier to the implementation of an effective energy efficiency monitoring system was the lack of funding / available staff. Lack of awareness of energy efficiency was also frequently mentioned, as was poor availability of data.

On the sector-specific questions regarding the most appropriate indicators to use, a clear majority favoured energy-intensity based indicators. For the residential, industrial and transportation sectors, a smaller, but significant number of respondents favoured using technology-based indicators. These would take the form of penetration and replacement rates for energy efficient appliances, equipment and vehicles. Very few respondents favoured these technology-based indicators for the commercial sector.

3 Country studies

A literature search was conducted, followed up where appropriate with telephone and e-mail conversations, to develop a picture of which countries had particularly valuable experiences from which South Africa could learn, in the areas of monitoring energy efficiency progress and setting up national energy efficiency monitoring systems. Three countries – New Zealand, Canada and The Netherlands – emerged as being the most significant, and these are described in detail in the following sections. The European Union is also included, as decisions made at the EU level impinge upon all member countries. Less detailed discussions are also included on a number of other countries which have energy efficiency monitoring systems that are designed for a more specific purpose. Finally, a number of one-off energy efficiency studies are described where the methodology used and the lessons learned could inform the development of a national monitoring system for South Africa.

3.1 New Zealand[1]

3.1.1 Background

Energy efficiency targets in New Zealand became part of official policy in 2000, with the passing of the Energy Efficiency and Conservation Act. This Act required the preparation of a National Energy Efficiency and Conservation Strategy (NEECS), which was required to contain targets for the achievement of the objectives of the strategy. In 2001, a target was set of "…at least 20% improvement in economy-wide energy efficiency by 2012". Unlike in South Africa, sectoral targets were not specified in general, with the exceptions of the government sector (a 15% reduction in energy use per employee or per unit of floor area), and the commercial sector.

Another difference with South Africa is that NEECS did not specify whether the energy efficiency target referred to primary energy demand or final energy consumption. Following a period of discussion and consultation with the Energy Efficiency and Conservation Authority (EECA, the body charged with monitoring energy efficiency performance), it was decided that the target should be interpreted as referring to primary energy demand. In the South African case, however, targets are explicitly expressed in terms of final energy demand.

3.1.2 Conceptual and methodological framework

A conceptual framework for monitoring progress towards energy efficiency targets was recommended by consultants engaged for the purpose[2]. The framework recommended was centred on the 'Driving Force – State – Response' model. This framework already formed the basis of the conceptual framework adopted by the Ministry of Environment, and its recommendation here was largely a result of a wish to harmonise with the Ministry.

Under this model, the actual energy efficiency at any given time represents the 'state' of the system. The 'driving forces' are the factors that have an impact on energy efficiency; these may be economic factors, or they may relate to the current regulatory environment. These driving forces cause a change in the state of the system which, assuming it is observed and understood, elicit a response. This response may include policy measures or the introduction of energy efficiency programmes, which in turn become driving forces themselves. The consultants acknowledge that the 'state' part of the model needs to receive the greatest attention, as this is what provides the primary indication of whether the energy efficiency targets have been met. However, they emphasise that attention must also be paid to the 'driving force' and 'response' components:

[1] Unless otherwise stated, the sources for this section are Lermit & Jollands (2001) and Luxmoore (2005).

[2] Lermit & Jollands (2001)

> "... for a rich picture of energy efficiency in New Zealand, EECA must monitor 'driving forces' and 'responses' as well. These will assist with answering the question of 'why' energy efficiency changed as it did."[3]

Within this framework, the driving forces also include factors such as the awareness of, and attitudes to energy efficiency among energy users. These more qualitative and subjective variables are important not only in explaining the 'why' of energy efficiency changes, but also in anticipating possible future problems. Future changes in energy efficiency are a function of investment decisions made today, which are in turn influenced by current attitudes and awareness.

EECA have attempted to monitor some of these more subjective elements by looking at experiences at the level of individual firms. However, they lack the resources to conduct any large-scale surveys of attitudes towards energy efficiency, so the data they receive is patchy and inconsistent. In particular, it is very easy to obtain information on 'good news' stories, which firms are keen to share. Conversely, it is virtually impossible to collect information on firms and businesses having a more negative attitude to energy efficiency.

The EECA methodological framework is basically a top-down approach, where a suite of macro-level indicators are defined, and a process of decomposition is used to separate out the different causal components of the observed change in energy consumption. Following the recommendations of the consultants appointed to advise on the methodology best suited to monitoring energy efficiency improvements, EECA chose to adopt the Divisia decomposition technique[4]. Changes in the energy intensity indicator are broken down into component parts corresponding to changes in activity levels, structural effects and efficiency changes – the last of these is the quantity of interest. Several other countries that have used decomposition previously as a way of separating out the underlying causes of changes in energy intensity have used the Laspeyres technique. New Zealand was one of the first countries to formally adopt the methodologically superior Divisia technique.

Decomposition techniques allow for an 'energy quality effect' (the effect of changes in the mix of energy carriers) to be considered as one of the components of changes in energy intensity. EECA decided not to incorporate this into their analysis at this stage, but have kept open the possibility of incorporating it at a later date. Another underlying cause of changes in energy intensity, the weather, can be taken into account in decomposition. In EECA's case, they made the assumption that the weather effect would be zero for the productive (i.e. non-residential) sectors. For the residential sector, they compensated for the effect of changes in the weather before performing the decomposition. However, the impact of this variable is very small.

Initially, the analysis performed by EECA in the residential sector included a breakdown of efficiency changes by end-use (using the categories of space-heating, water-heating and 'other'). More recently, this breakdown has been dropped from the analysis, as it was felt that the assumptions and inferences upon which it was based were difficult to substantiate.

One of the greatest challenges facing EECA in tracking energy efficiency performance is the inconsistency over time of the data set. Much of the data is derived from the same sources as that on which the International Energy Agency (IEA) energy balances are based. The IEA is concerned primarily with whether the energy balance does indeed balance, and are less concerned with inconsistencies between the current year's energy balance and previous ones. There is a constant pressure to improve the quality of the data provided, but unless improvements in data quality can be

[3] Lermit & Jollands (2001)

[4] See 'Monitoring of Energy Efficiency Targets: Theoretical Review' for a description of the various methodological options.

back-cast over previous years, every improvement constitutes a discontinuity. This makes the tracking of progress over time very problematic.

3.1.3 Institutional framework

Monitoring of progress towards achieving the NEECS targets is the responsibility of the Energy Efficiency and Conservation Authority (EECA). EECA is a Crown Entity, established under the Energy Efficiency and Conservation Act 2000, as the principal body responsible for assisting in the delivery of the government's energy efficiency agenda. EECA were jointly responsible, with the Ministry of the Environment, for drawing up NEECS. It is estimated that the equivalent of approximately six full-time staff positions are devoted to monitoring progress towards energy efficiency targets.

Monitoring of energy efficiency progress in New Zealand relies on already existing data sources. EECA do not have sufficient resources to conduct surveys or otherwise generate new sources of data. There was an attempt recently to lobby for the introduction of a government funded biennial energy survey that would provide a much more comprehensive data set, but this was unsuccessful. There is a statutory requirement on industries and businesses to provide the data required by government agencies. However, the full force of this instrument is very rarely needed, as data is usually provided voluntarily. The main data sources are as follows:

- ***Statistics New Zealand*** provide census data, demographic data, national accounts and production surveys
- ***Ministry for Economic Development*** provide data on energy use, which is the basis upon which the annual energy balances for the IEA are created.
- ***Property Council*** provide data on floor area in the commercial sector

Data storage and processing are the sole responsibility of EECA, who are also responsible for preparing and presenting the results annually.

3.1.4 Communicating results

EECA reports annually on the progress made towards achieving the energy efficiency targets. Results are reported both as a year-on-year change and as a cumulative change since the base year. The following figures are reported on the economy-wide analysis and the analyses of the productive sectors:

- total energy demand in current year
- change in total energy demand since previous year
- energy:GDP ratio in current year
- change in energy:GDP ratio since previous year
- energy per capita in current year
- change in energy per capita since previous year
- change in total energy demand since previous year attributable to efficiency changes
- change in efficiency since previous year
- cumulative change in efficiency since base year

For the residential sector, the following figures are reported:

- total residential energy demand in current year
- change in residential energy demand per capita since previous year

- change in residential energy demand per household since previous year
- change in residential energy demand attributable to efficiency changes
- change in efficiency since previous year
- cumulative change in efficiency since base year

Graphical representation of the key findings is also used. For the top-level economy-wide analysis, overall progress towards the national target is presented as a trend line, shown alongside the required trends. An example is shown in Figure 0 below. The blue line represents the progress required to meet the 2012 target assuming a constant percentage-point improvement each year, while the red line represents a geometric progress towards the target. The green line represents actual progress made. The graph shows that while good progress was made in the first year, the second year results were very disappointing. Energy efficiency actually fell significantly over the second year, such that the cumulative improvement over the first two years was only about 1% - well below the required rate of progress.

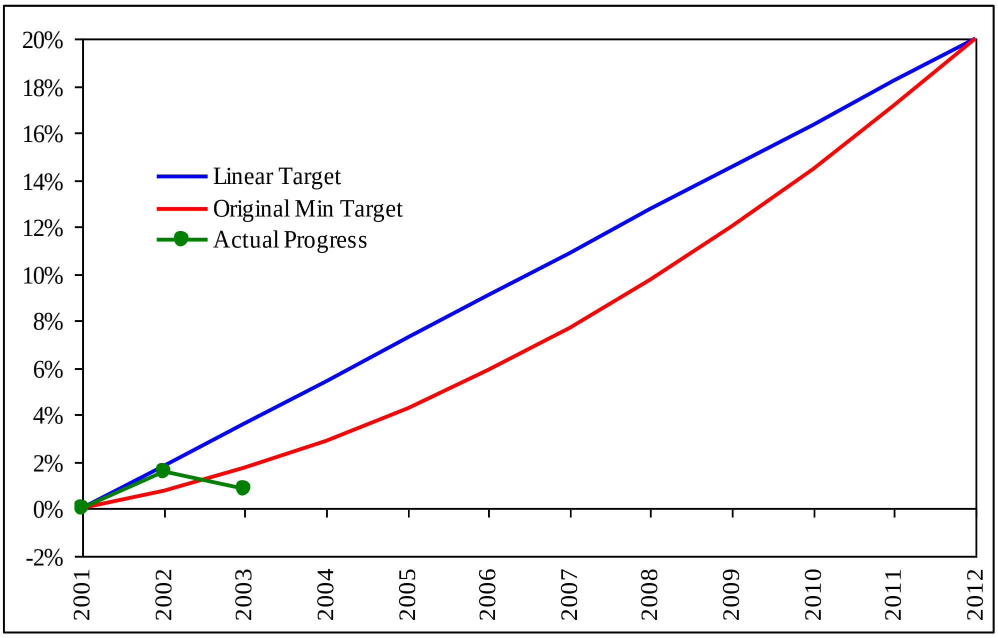

Figure 1 EECA's presentation of annual progress against New Zealand's national target (EECA, 2004)

In addition to presenting progress towards the national target, EECA's annual reports also illustrate, on a sector-by-sector basis, the main factors underlying the observed changes in overall energy consumption. An example of this is presented in Figure 0 below, which shows the breakdown of changes in industrial sector energy consumption for each year starting from 1996-97. The black trace represents the actual observed change in overall energy consumption for that year, while the coloured bars represent the factors making up that change. For example, in 1996-97, the observed change in industrial sector energy consumption was close to zero, but underlying that change was an increase of approximately 10 PJ (caused by activity increases, structural changes and energy quality changes), which was offset by a decrease of about 10 PJ (caused by efficiency gains). Conversely, for 2002-03, the black trace shows that total sectoral energy consumption increased by approximately 8 PJ, made up

of an approximately 9 PJ increase (due to increased activity, falling efficiency and energy quality effects) offset by a decrease of about 1 PJ resulting from structural effects.

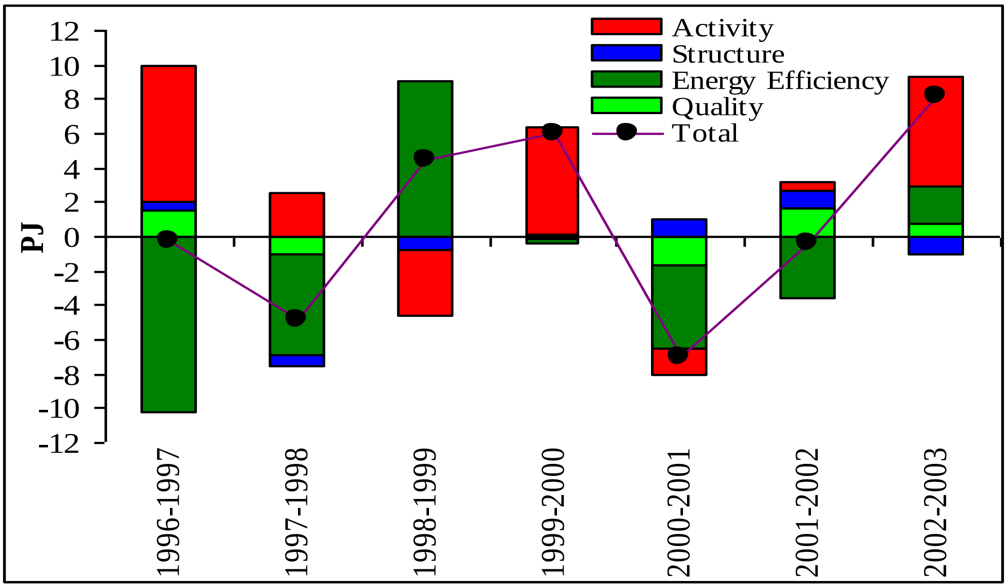

Figure 2 **EECA's presentation of the breakdown of sectoral energy consumption changes in New Zealand (EECA, 2004)**

3.2 Canada[5]

3.2.1 Background

Unlike in South Africa, there is no specific legislative background behind the monitoring of energy efficiency in Canada, and no energy efficiency targets have been defined at the economy-wide or the sectoral level. Natural Resources Canada (NRCan) is the federal government department responsible for sustainable development and the management of natural resources. The Office of Energy Efficiency (OEE) within NRCan has a range of responsibilities, which include the development and implementation of energy efficiency programmes. It is a requirement of the funding portfolio that NRCan-OEE report on the impacts of the programmes they manage to the Treasury Board Secretariat, who are responsible for the allocation of funding.

The current system for monitoring energy efficiency progress was developed in response to a 1997 report by the Auditor General, which required NRCan-OEE to improve the programme performance information it provides to Parliament and the public. This requirement to monitor programme performance could have been fulfilled with a relatively narrow bottom-up project-based monitoring system, as used in the EU (see Section 3.4.1 below). However, in order to produce a more comprehensive picture of performance, particularly with regard to greenhouse gas emission targets, NRCan decided to combine programme performance monitoring with a top-down indicators-based monitoring of overall sectoral trends. The Canadian system is therefore probably the most complete and comprehensive of any in the world.

[5] Unless otherwise stated, the sources for this section are Nanduri (2005), McNabb (2005), Bilodeau (2005) and Hulan (2005).

3.2.2 Conceptual and methodological framework

Since the purpose of this review is to examine best-practice as applicable to the monitoring of sectoral and economy-wide targets, it is the monitoring of sectoral trends in Canada that is of most interest here. The methodology adopted was a top-down indicators-based approach, where a Laspeyres decomposition was performed on total energy consumption to determine the effects of structural change, activity-level changes and efficiency changes.

A characteristic of the Laspeyres methodology is the appearance of 'residual' terms in the decomposition analysis (referred to as 'interaction terms' in the NRCan methodology documentation). These residual terms become significant when the fractional change in the various indicators is large relative to their base year values. Since NRCan base their analysis on the year 1990, the magnitudes of the residual terms have begun to be problematic[6]. Simply changing the base year to a more recent year would reduce the magnitude of the residual terms, but this would make it difficult to use the results as the basis for assessing progress against Kyoto Protocol targets (1990 is the base year for the Kyoto Protocol). Instead therefore, considerable attention has been paid to developing a methodology for correctly allocating these residuals to the factors of decomposition. However, this methodology will soon become redundant as a decision has recently been made within NRCan to change over to using a Log-Mean Divisia approach to decomposition, which does not result in residual terms.

As alluded to above, one of the incentives behind the setting-up of the Canadian energy efficient monitoring effort was to assist in tracking progress towards meeting commitments under the Kyoto Protocol. As such, there is a strong focus in the Canadian methodology on translating changes in energy efficiency into corresponding changes in greenhouse gas emissions. For each sector, as well as for the economy as a whole, the total change in greenhouse gas emissions is calculated, which is then disaggregated into a portion due to the change in energy consumption itself, and a portion due to a change in the greenhouse gas intensity of the sector (i.e. the effect of fuel mix). This analysis is carried out both with and without including the greenhouse gas emissions attributable to electricity generation.

3.2.3 Indicators and data sources

Generally speaking, the availability of data to support the monitoring of energy efficiency is very good in Canada. Detailed data on activity levels for all sectors is available, and energy consumption data is available at a relatively detailed level of disaggregation. Much of this data comes from the data resources that Statistics Canada routinely collect. However, in the residential sector, a significant volume of the data required is generated specifically for the purpose of energy efficiency monitoring, through surveys that NRCan-OEE commission Statistics Canada to carry out.

For the transport sector, high quality data on activity levels (tonne-km and passenger-km) and energy consumption is available. However, some 'beneficiation' of energy consumption data has to be performed by NRCan-OEE, as the data provided by Statistics Canada is disaggregated by mode (road, rail, air) but not by sub-sector (freight versus passenger). From the most recent year onwards, greatly improved data on vehicle occupancy rates is available, enabling the activity-level indicator for passenger transport (passenger-km) to be determined more accurately.

Within the commercial / public sector, NRCan-OEE use floor space as the main activity level indicator, but use an additional indicator to take into account the 'service level' in terms of auxiliary equipment (primarily air conditioning, but also computers, photocopiers etc.). From this year onwards, they have access to more detailed data on air-conditioned floor space versus non-air-conditioned, so the effect of air conditioning has been removed from the service level indicator. As a result, the impact of service level on energy consumption is now much smaller, but a more detailed picture can be constructed of

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6 By 2003, the residual terms for the industrial sector exceeded the structural effect (Bilodeau, 2005).

how the increased use of air conditioning is impacting on overall energy consumption. In the most recent analysis, improved data on floor space has become available, following a request by NRCan-OEE to Informetrica Ltd. to improve the methodology they employ to estimate floor space.

In recognition of the fact that the availability of detailed data on residential energy use was likely to be essential for many purposes, NRCan instigated the Survey of Household Energy Use (SHEU) as long ago as 1993. The survey is actually carried out by Statistics Canada, and was commissioned as part of the development of the wider National Energy Use Database, which itself is one of the initiatives introduced by NRCan to monitor progress towards stabilising and reducing greenhouse gas emissions. On Statistics Canada's recommendation, SHEU was designed to tie in closely with the Labour Force Survey, which Statistics Canada were already conducting monthly. This greatly reduced the cost of developing SHEU, as the sampling methodology was already in place and there already existed a panel of interviewers experienced in questioning householders.

SHEU is extremely detailed, covering all aspects of household energy use and taking approximately an hour per household to complete. It has been conducted three times in total, the most recent being in 2004, for which the data is still being prepared for publication. About 15,000 households are covered by SHEU, and the approximate total cost is CAN$ 2.1 million. Interviewers conduct the survey with the assistance of a questionnaire containing a total of over 400 questions. A picture of the level of detail can be gained from the fact that there are ten questions on the subject of freezers. The extent of the survey makes it too costly to conduct more frequently, but NRCan are exploring the possibility of developing a simpler survey, and securing the budget allocation needed to conduct this on an annual basis. It is currently too early to say whether these plans will come to fruition.

For analysis of the residential sector, NRCan-OEE makes use of two different indicators for the level of activity, depending on the variable in question. For heating and lighting (and also for space cooling), they use floor area as the activity-level indicator. For household appliances (including cooking) and water heating, activity-level is represented by the number of households. The rationale behind the choice of these activity-level indicators is clear, but it leads to an additional complexity in the analysis. Effectively, the residential sector is divided into two sub-sectors, one consisting of services that are proportional to floor-area and the other consisting of services that relate to the number of households. In fact, the number of *individuals* could have been used as a third activity-level indicator in the case of water-heating, since this energy service is probably more closely related to population than to number of households. However, this would have led to an additional level of complexity that is probably not justifiable given the limited additional benefit.

3.2.4 Institutional framework

The responsibility for undertaking energy efficiency monitoring, both at the sectoral level and at the programmatic level, resides entirely with NRCan. NRCan are answerable to the Treasury Board Secretariat and the Auditor General in terms of accountability with regard to the spending of public funds, but these two bodies do not usually play a role in determining the monitoring procedures or the content of the monitoring reports.

The data underpinning the monitoring of energy efficiency comes predominantly from Statistics Canada, either from standard datasets or from surveys specially commissioned by NRCan. NRCan also have partnerships with industry bodies such as the Canadian Appliance Manufacturers Association, who provide useful data on the characteristics of new equipment entering the market. A close relationship with other government departments is also useful with regard to generating data – for example, the Department of Transport agreed to add energy-related questions to a comprehensive vehicle survey they were commissioning.

Within NRCan, it is estimated that approximately 20 staff are involved in energy efficiency monitoring, with an annual budget of $5 million[7]. However, this allocation of resources covers all aspects of monitoring, including both the top-down sectoral analyses and the detailed monitoring of individual energy efficiency programmes. Programme monitoring requires the equivalent of about 2.5 full-time staff positions, with a core budget of about $100,000 plus an additional $100-200 k for each programme study undertaken. It can therefore be inferred that the resources devoted to tracking, analysing and reporting on sectoral trends in energy efficiency and greenhouse gas emissions amount to about 17-18 staff and just below $5 million.

3.2.5 Communicating results

The results of NRCan-OEE's sectoral analyses of energy efficiency are published annually in the document 'Energy Efficiency Trends in Canada'. The style and language of the document is pitched at the level of the sophisticated lay-person, and extensive use is made of graphical presentation of results. For the economy as a whole and for each sector, data is presented graphically on trends in total energy consumption, and on the portion of the total change that can be attributed to each of the main factors in the decomposition analysis (see Figure 0). In each case, these changes are also translated into changes in greenhouse gas emissions. Results are presented only as a cumulative total change since the base year, rather than as year-on-year changes.

The 'Energy Efficiency Trends in Canada' report also presents a graph of the trend over time of the 'energy efficiency index', which related cumulative improvements in energy efficiency to the base year (1990). For example, an energy efficiency index of 1.15 means that, if all other factors had remained unchanged, energy efficiency improvements alone would have resulted in total energy consumption being 15% lower than in the base year. Figure 0 shows the graphical presentation of the trends in energy efficiency index from 1990-2003. The graph illustrates that, with the exception of a single year (1996), energy efficiency improved steadily between 1990 and 2001, after which it has levelled off and then started to decline. The main reasons for this levelling off were an increase in the energy intensity of mining, smelting and refining, and an overall fall in capacity utilisation across the industrial sector.

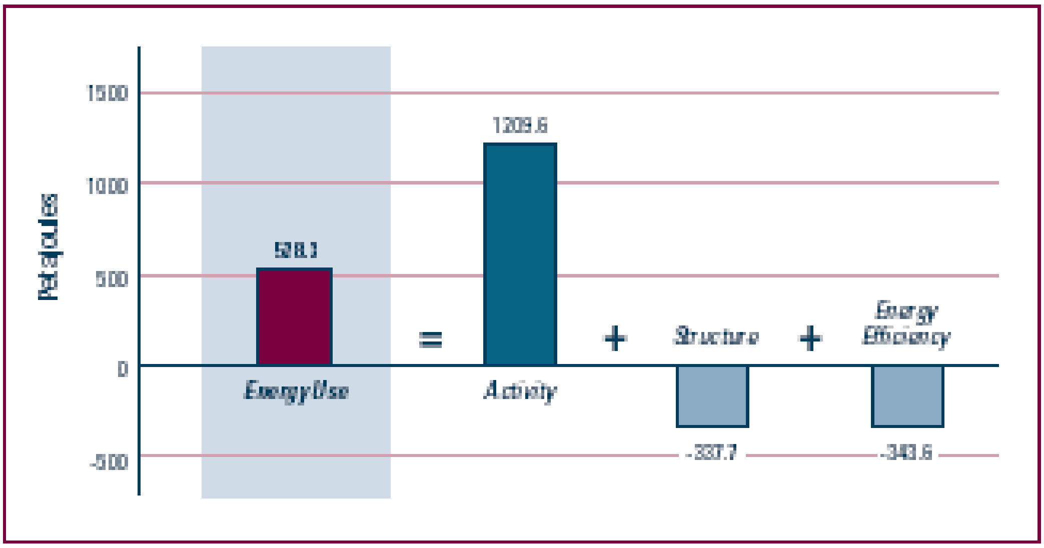

Figure 3 NRCan's presentation of the breakdown of changes in industrial sector energy consumption between 1990-2003 (NRCan 2005).

7 Dollars in this context are Canadian dollars (CAD 1 = ZAR 5.41)

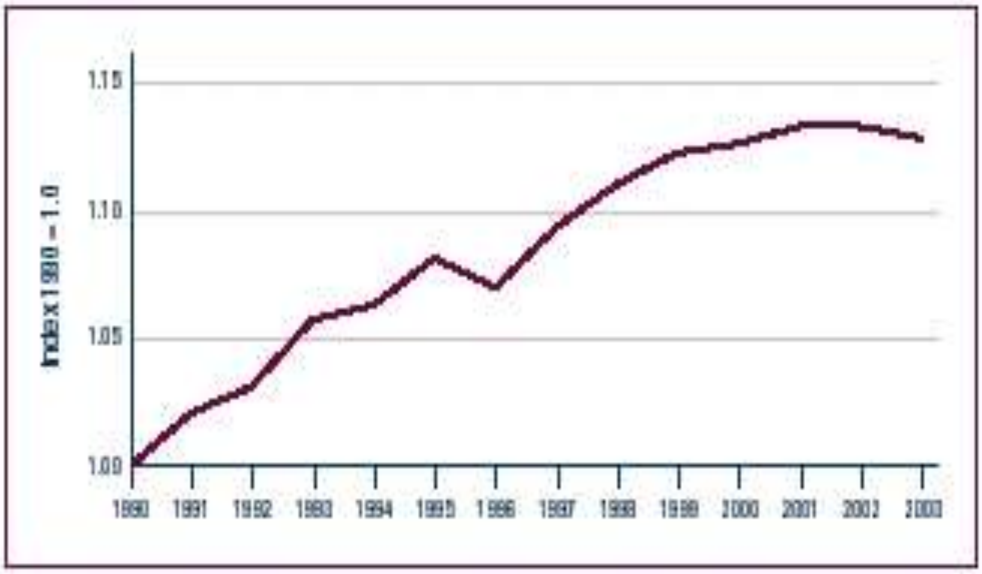

Figure 4 NRCan's presentation of the change in energy efficiency index between 1990-2003 (NRCan 2005).

In addition to the presentation of the main results, 'Energy Efficiency Trends in Canada' also presents some detailed case studies on specific 'driving forces'. Examples include the impact of air-conditioning in the residential sector, the impact of changes in capacity utilisation in the industrial sector, and an assessment of the criteria upon which consumers base car-purchasing decisions.

3.3 Netherlands[8]

3.3.1 Background

The Dutch government has published a number of energy-related White Papers and action plans over recent years, which together serve to define energy efficiency targets for the economy as a whole and for individual sectors. The Dutch overall long-term goal is for an economy-wide improvement in energy efficiency of 33% between 1995 – 2020. Shorter term targets were set for the period between 1990-2000, which amounted to an overall improvement in energy efficiency of 1.7% per year. For the period post-2000, sectoral energy efficiency targets were set of 19% for the industrial sector, 23% for the residential and services sectors, 10% for the transport sector, 26% for agriculture and 40% for electricity generation.

During the mid-1990s, the emphasis in the Netherlands shifted from direct regulation to voluntary agreements as a means of achieving improvements in environmental performance. In the context of energy efficiency, these voluntary agreements mainly took the form of 'Long-Term Agreements' (LTAs). LTAs are covenants between government and individual firms or industry associations, under which the company voluntarily agrees to a particular energy efficiency target and, in return, the government undertakes to provide support in the form of information, training and technical assistance. Signatories to LTAs are also promised exemption from related future regulatory measures. The first generation of LTAs ended successfully in 2000, having achieved efficiency improvements of over 22%.

The second generation of LTAs covers only the non-energy intensive industries, and non-industry sectors. As of 2003, signatories to second generation LTAs accounted for about 90% of the total energy

[8] The main sources of information for this section were Boonekamp (2004) and Boonekamp (2001)

consumption of the non-energy intensive industries. The energy intensive industries are now covered by 'Benchmarking Covenants', under which industries agree to become world leaders[9] with regard to energy efficiency as quickly as possible, and in any case before 2012.

From a monitoring perspective, the requirements of LTAs and Benchmarking Covenants are for detailed tracking of energy efficiency at the level of the individual firm. Signatories to LTAs and Benchmarking Covenants are responsible for reporting on their own performance, subject to verification by the SenterNovem[10] and the Benchmarking Verification Agency. However, it was also felt desirable to understand how the LTA / Benchmarking Covenant programme impacted on energy efficiency at a national level. For this reason, the Dutch Ministry of Economic Affairs requested a group of institutions[11] to work with the Netherlands Statistics Service (CBS) to devise a system for monitoring energy savings at the sectoral and economy-wide level. It is this system that is of most interest here, as some of the Dutch experiences may provide guidance for the setting up of a similar system in South Africa.

3.3.2 Conceptual and methodological framework

The Dutch team adopted a top-down indicators-based methodology they refer to as the 'Protocol Method'. This approach appears to be broadly similar to other decomposition approaches, in that it apportions the overall observed change in energy consumption to factors attributable to activity level changes, structural changes and efficiency changes. As described in the accompanying paper 'Monitoring of Energy Efficiency Targets: Theoretical Review', decomposition methods differ in the weighting factors they use to apportion the variable being analysed between the components of the analysis. The 'Protocol method' appears to use the energy intensity in Year 0 as the weighting factor in calculating the activity effect, and the activity level in Year t as the weighting factor in calculating the efficiency effect. This has the effect of eliminating the residual, which many other decomposition approaches suffer from. However, the arithmetical justification for using these weightings does not appear to be as robust as that behind the log-mean Divisia approach.

Rather than treating the energy conversion sectors separately, the Dutch system decomposes primary energy consumption (as opposed to final consumption), and uses changes in energy conversion efficiency as one of the explanatory variables. This includes taking into account the impact of changes in the usage and efficiency of cogeneration. This leads to a much more complex decomposition analysis, particularly at the national level, where on-site cogeneration and utility cogeneration (combined heat and power) are treated separately. The economy-wide disaggregation of changes in primary energy consumption thus considers a total of seven factors: GDP effect, inter-sectoral structural effect, intra-sectoral structural effect, end-user (on-site) cogeneration saving, utility cogeneration (CHP) saving, efficiency gains in the energy conversion sector and finally end-user efficiency gains.

One strength of the Dutch methodology is the calculation of the margins of error in the results produced, giving policy-makers an impression of the robustness of the figures and highlighting areas of the analysis that need strengthening. Rather than attempting to calculate these margins of error analytically, which would have been prohibitively complex, a stochastic Monte Carlo simulation was used. At a national level, the margin of error was estimated to be about 0.3 percentage points for the 2002 data, which amounts to about one-quarter of the total observed percentage change in primary energy

9 Defined as being within the top 10% internationally in their sphere.

10 The national implementing agency for energy and environment policies

11 The institutions in question were: Netherlands Bureau for Economic Policy Analysis (CPB); Energy Research Centre of The Netherlands (ECN); Netherlands Agency for Energy and the Environment (SenterNovem); National Institute for Public Health and the Environment (RIVM); Netherlands Environmental Assessment Agency (MNP).

consumption. For the services sector, the margin of error was considered so high that it would be misleading even to present data on efficiency gains.

An interesting feature of the Dutch methodology is the thorough way in which structural effects are analysed. A conventional decomposition analysis conducted at the economy-wide level attributes a portion of the observed change in energy consumption to structural changes, and a portion to changes in energy intensity. However, the portion attributed to structural changes includes only inter-sectoral structural changes, but not the structural changes that are taking place *within* the main sectors. The effect of these *intra*-sectoral structural changes actually shows up as a component of the energy intensity effect when a top-level analysis is conducted. A simple top-level analysis will not therefore provide a true picture of the effects of efficiency changes. The Dutch methodology avoids this problem, correctly attributing lower-level structural effects in the top-level analysis.

3.3.3 Indicators

The choice of indicators was made to mirror as closely as possible the range of data available from the national statistical service, Statistics Netherlands. ECN perform some corrections to the data they receive from Statistics Netherlands, to account for variations in outdoor temperature and to re-allocate industrial cogeneration from the energy conversion sector to the industrial sector. They also calculate conversion factors that relate delivered energy to primary energy demand for fossil fuels. These are effectively the weighted means of the individual conversion efficiencies of all fossil fuel conversion plants in operation during the year in question.

The activity-level indicators are referred to as ‘energy-relevant variables’ in the ECN terminology. Wherever possible, physical indicators are used, and in the residential sector, different indicators are used for different activities. For space heating, the number of households is used for the activity-level indicator, whereas for water heating, the number of individuals is used. For the commercial / public sector, ECN use value-added as the main activity-level indicator, but for comparison also perform a parallel analysis where the number of employees is used as the indicator for activity level.

Data availability for the transport sector appears to have been very good, with full data on passenger-km for passenger transport and tonne-km for freight transport being available. Rather than analysing freight transport and passenger transport separately, the Dutch team appear to derive an aggregate activity-level indicator for the transport sector as a whole, by taking a weighted mean of the indicators for each of the two main sub-sectors. It is not clear why this is done, given the apparently good availability of data, and it seems to have the effect of introducing a meaningless additional ‘structural’ effect corresponding to a shift in relative importance of passenger versus freight transport.

3.3.4 Communicating results

The results from the Netherlands analysis of energy efficiency changes are presented in the form of an ECN report, in a somewhat academic format. Unlike in the case of New Zealand and Canada, the results do not appear to be reported in a style and format that is designed to be accessible to the lay person. The report presents a brief description of the ‘Protocol’ methodology, before presenting economy-wide and sectoral analysis results. For each sector, data is presented on the trends over time in total energy consumption and on the energy intensity (energy per unit of activity) for each important energy carrier.

In common with the other countries studied in detail here, the key results from the analysis are presented graphically. However, only the average annual changes over the period from 1995 are presented, rather than year-on-year changes. Figure 0 shows an example of the graphical representation of the analysis results for a single sector – in this case, the residential sector. The graph shows that, between 1995-2002, an increase in the number of households accounted for an average annual increase of approximately 0.9% in final energy consumption (‘volume effect’), structural changes accounted for a

further average annual increase of about 0.6%, while efficiency improvements ('saving effect end use') accounted for an average annual reduction of about 1.2% in final energy consumption. The effect of savings in cogeneration was negligible, resulting in an overall observed average annual change in final energy consumption ('mutation consumption') of about +0.3%.

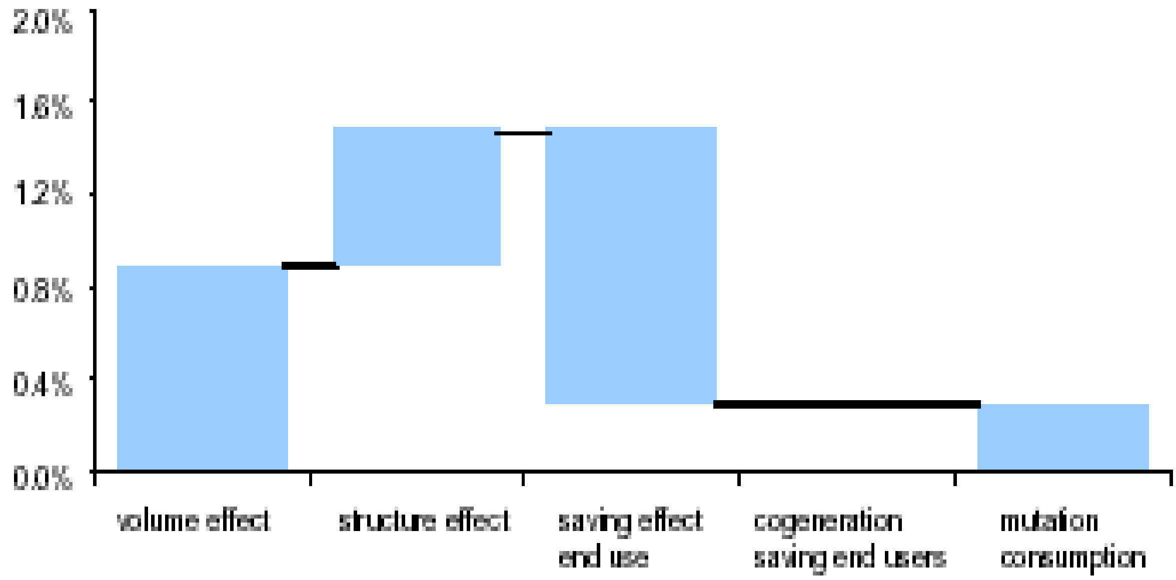

Figure 5 ECN's presentation of the factors underlying the change in residential sector energy efficiency between 1995-2002 (Boonekamp 2004).

3.4 European Union

The activities of the European Union have an impact on the monitoring methodologies applied within individual member countries. This may be a direct impact, through EU Directives that require particular methodologies to be adopted, or an indirect impact through the harmonisation in the type and format of data collected in different countries (usually to facilitate cross-border comparisons) as embodied in initiatives such as MURE and ODYSSEE. So, although there are differences in the approaches adopted by EU member states, it is instructive to examine the activities of the European Union with regard to energy efficiency monitoring.

3.4.1 Draft Directive on Energy End-Use Efficiency and Energy Services

In December 2003, the European Commission tabled a Draft Directive on Energy End-Use Efficiency and Energy Services[12] that would have imposed binding targets for energy efficiency improvements on member states. The targets under the Commission's original Draft Directive would have amounted to a 9% improvement in energy efficiency by 2015. Subsequently, the European Parliament backed this proposal and tightened the original targets to the equivalent of an 11.5% improvement in energy efficiency by 2015. However, when the bill came before the Council of Ministers for final approval, all binding targets were completely removed, to be replaced by indicative targets amounting to a 6% reduction in energy consumption over a 6 year period[13].

[12] European Commission (2003)

[13] EurActiv (2005)

Although the terms of the Draft Directive have been softened somewhat, and mandatory targets are no longer included, other parts of the Draft Directive define the conceptual framework within which monitoring of the indicative targets will take place in member states. For example, the Draft Directive specifies[14] that a bottom-up approach should be adopted for monitoring the savings resulting from policies, programmes and measures introduced in response to the Directive[15]. Existing programmes can also be counted, providing only energy savings actually achieved after the Draft Directive comes into force are included.

A detailed account of how a bottom-up project-based methodology should be developed and applied is provided by the Wupperthal Institute for Climate, Environment, Energy[16]. The paper provides a simple example concerning a programme to promote the adoption of super-efficient household refrigerators. The annual energy saving per unit is easily estimated from data on typical usage patterns of refrigerators. Sales figures for different models of refrigerator are available from retailers, and market research techniques are then used to establish how many of the additional sales of efficient appliances are attributable to the programme itself, and how many are due to the 'free-rider' effect. For some energy efficient technologies, particularly in the household sector, data must also be gathered to determine the extent of the 'rebound' effect. This is where consumers demand a higher level of energy service in response to the improvement in energy efficiency, for example thermal insulation of homes resulting in higher indoor temperatures rather than (or as well as) energy savings.

3.4.2 The Odex index

Over the past ten years, a methodology has been developed under the EU ODYSSEE project[17] for monitoring economy-wide and sectoral energy efficiency changes in the EU member countries. This methodology uses an 'aggregated bottom-up energy efficiency index' termed Odex. By adopting a consistent methodology and uniform data sets across all countries, Odex permits cross-country comparisons to be made.

For each sector, a number of sub-sectors / activities are defined, for which energy intensity indicators are calculated. A total of 26 sub-sectors / activities are used in the full Odex system, although some of these are omitted or modified for particular countries. Where possible, physical units are used for the energy intensity indicators (e.g. energy consumption per tonne of product). The sub-sectors / activities and the intensity indicators used are as follows:

Industry: steel, cement, pulp & paper (all use GJ / tonne); chemicals, food & beverages, textiles & leather, equipment & machinery, non-ferrous metals, non-metallic minerals except cement (all use GJ / €).

Residential: space heating (MJ / m^2 normalised for weather); water heating, cooking (both use MJ per household); refrigerators, freezers, washing machines, dishwashers, televisions (all use MJ / year per appliance in normal usage).

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[14] See Annex IV of the Draft Directive; European Commission (2003)

[15] This does not preclude the use by member countries of top-down methodologies for their own purposes. However, top-down methodologies will not be acceptable as evidence that the indicative targets enshrined in the Draft Directive have been met.

[16] Thomas (2005)

[17] ODYSSEE has been running since 1993, and is a collaborative initiative of all the national energy agencies of the EU-15 countries (i.e. the EU member countries prior to May 2004), which aims to develop and use a comprehensive database of disaggregated energy end-use data and energy inetnsity indicators.

Transport: cars (specific consumption in litres / km); trucks & light commercial vehicles (GJ / tonne-km); domestic air passenger transport (GJ / passenger-km); rail, inland & inshore water (both use GJ / tonne-km or passenger-km depending on whether freight or passenger); motorcycles, buses (both use GJ / year per vehicle).

Commercial / public: no further disaggregation – GJ / year per employee is the intensity indicator used.

Energy transformation: not currently included in the Odex methodology, but there are plans to extend it in future to include energy transformation.

The Odex index for each sector is calculated by taking a weighted aggregate of the sub-sectoral intensity indicators, where the weighting factor is the share of that sub-sector in the total sectoral energy consumption. It appears that the base-year shares are used for these weighting factors, which makes the Odex methodology equivalent to the reciprocal of the Laspeyres approach to decomposition[18]. An economy-wide Odex index is calculated in the same way, by taking a weighted sum of the sectoral Odex indices.

Since all countries participating in the ODYSSEE project have been working together for some time to develop a harmonised set of indicators, there are no problems with regard to data availability. The set of indicators used has evolved over many years to take account of data availability, and thus provides the optimum compromise between usefulness and availability. The institutional arrangements for the collection of indicators data are up to individual countries to determine, but generally the national energy agency of each country leads the process of data collection.

3.5 Other countries

The three countries described in detail above have been singled out because they most closely mirror the South African situation, where a comprehensive system of monitoring economy-wide and sectoral energy efficiency changes was requested at an official level. A number of other countries have conducted energy efficiency monitoring studies, either at the request of government departments or as purely academic studies, but these tend to be more specific in their purpose and scope. Also, many EU countries have placed binding targets on suppliers of electricity and gas for achieving energy savings among end-users, in response to EU Directives on energy market liberalisation. In most cases, these savings targets can be achieved with the help of tradable certificates (usually referred to as ‘white certificates’), for which a rigorous monitoring and validation process is required.

3.5.1 Italy[19]

Energy efficiency targets in Italy represent the national implementation of the European Directives on the liberalisation of gas and electricity markets, in a way that is coherent with the Directive on Energy End-Use Efficiency and Energy Services. The process is therefore project / programme driven, and places an onus on gas and electricity suppliers to achieve end-use efficiency gains. Targets are equivalent to a cumulative saving of 2.9 Mtoe over the five year period 2005-09 inclusive, and are binding only on suppliers with a customer base of more than 100,000.

Targets may be met through in-house energy efficiency projects, through projects developed jointly with third parties, or through buying tradable certificates from other suppliers who have exceeded their targets. Suppliers who fail to meet their targets through any of these routes must pay a non-compliance penalty. Energy efficiency gains therefore carry a definite economic value to those who achieve them,

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[18] As described in the accompanying paper ‘Monitoring of Energy Efficiency Targets: A Theoretical Review’, aggregation and decomposition methodologies are essentially reciprocals of each other, with each pair of methodologies being characterised by the weighting factors that are used.

[19] Pavan (2005)

which places a heavy burden on the system for monitoring the savings achieved. The system for monitoring and verification of energy savings was developed and is implemented by AEEG, the Italian Regulatory Authority for Electricity and Gas.

Three levels of monitoring energy savings are considered in the Italian system: ‘deemed savings’, engineering estimates and energy monitoring plans. ‘Deemed savings’ are ex ante inferences about the savings achieved, suitable for projects whose expected savings are reasonably well understood. They are cheap and simple to apply, as they require no on-site measurement, relying instead on assumptions of key variables (e.g. hours of operation, level of free-rider effect etc.). Surveys have shown these assumptions to be sufficiently accurate for the purpose. A typical programme where the deemed savings approach might be applicable is the transformation of the domestic refrigerator market through an appliance labelling scheme.

Engineering estimates represent the next level of monitoring complexity. The approach is still relatively cheap and simple, and is used for projects where the energy saving depends on a limited number of well-defined parameters, which have to be measured on a case-by-case basis (for example, hours of operation). This approach might be applicable, for example, in a programme to promote the purchase of energy efficient motors in the industrial sector.

Energy monitoring plans are the highest level of complexity in the monitoring and verification of energy savings. They involve the direct measurement on a case-by-case basis of before and after energy consumption, and are necessary for projects where energy savings depend on several parameters that change on a case-by-case basis. The exact methodology has to be developed and approved for each project individually.

3.5.2 United Kingdom

UK energy suppliers have been obliged to implement programmes aimed at achieving improvements in energy efficiency since 1994, when the first ‘Energy Efficiency Standards of Performance’ (EESoP) programme was introduced[20]. The programme has operated more or less continuously since then, with modifications to take account of the gradual opening up of the energy supply markets, and has now become the Energy Efficiency Commitment (EEC). EEC requires all energy suppliers with more than 15,000 residential customers to achieve household energy savings amounting to a total of 62 TWh, with the total commitment being apportioned to each supplier according to their size. There are further requirements that savings must be ‘additional’ (i.e. beyond what is already mandated in other regulations, or better than the market average) and that 50% of the savings must be achieved in low-income households.

Although there is no tradable certificates market yet in place, obligations can be traded between suppliers, providing each trade is approved by Ofgem, the Office of Energy Regulation. The system for monitoring and verifying savings must therefore, like the Italian system, be very robust and reliable. Because binding targets are only set for household energy use, the monitoring system can adopt an approach similar to the ‘deemed savings’ approach used in Italy (see Section 3.5.1 above). In this way, the costs of monitoring can be kept to a minimum – in EESoP3 for example, monitoring costs were less than 2% of the total programme costs. Individual suppliers are responsible for monitoring their own schemes, and reporting the savings achieved to Ofgem on a quarterly basis. Ofgem also performs random audits (through an independent auditor) of the schemes of each supplier to ensure that the savings estimates being claimed are realistic.

[20] The first phase of EESoP placed an obligation only on electricity suppliers. It was only in 2000 that EESoP3 placed an obligation on both gas and electricity suppliers.

An important tool in the monitoring of energy efficiency progress in the UK will be the Home Energy Efficiency Database (HEED), currently under development by the Energy Saving Trust. This database will contain information about purchased household energy efficiency measures, and has the capacity to store information about the physical characteristics and installed energy efficiency measures for every one of the UK's 25 million homes. Data for HEED will initially come from schemes being operated by energy suppliers under EEC, but ultimately it is hoped that energy efficiency data from proposed 'Home Information Packs'[21] will be fed into HEED.

3.5.3 One-off studies

An extensive body of literature exists in which one-off studies are conducted on countries or groups of countries, to determine trends in end-use energy efficiency over particular periods of time. Although these studies do not constitute systems for monitoring energy efficiency progress *per se*, the methodologies adopted and the data sets utilised can provide useful lessons for the setting up of a monitoring system in South Africa. Clearly, for retrospective studies of this type, the generation of new data is not an option, so in all the following cases use was made of existing data sets.

APEC Countries

Perhaps the most extensive of these one-off studies is that conducted by the Asia Pacific Energy Research Centre in 2000-01[22]. In this long-term study, a top-down indicators-based approach is used to analyse the energy intensity trends in all 21 APEC member countries. A key feature of the study is the attempt to devise a common methodology and a common set of indicators that can be used across all APEC countries, thereby facilitating cross-country comparisons. The study applies a Laspeyres decomposition methodology.

Partly because of the desire to compare intensity trends across countries, it was important to normalise for temperature effects. However, this normalisation was hindered somewhat by the fact that there is no standardised methodology for defining the number of degree-days, with each APEC country adopting a slightly different definition. This need not be a major drawback, as it is the *fractional change* in degree-days from one year to the next which is the key variable, not the absolute number of degree-days. However, the choice of degree-day elasticities[23] of 1.0 for the residential sector and 0.75 for the services sector would appear to be somewhat arbitrary.

In the services sector, the study explored two approaches. The preferred approach, using a physical indicator (floor space) for activity levels, was not possible for the vast majority of the countries covered by the study, because floor space data was not available. The second approach used energy consumption per worker as the proxy indicator for energy intensity, which then required a factor relating to labour productivity to be introduced in order to relate this indicator to aggregate energy intensity.

In the transport sector, again the preferred approach of using passenger-km and tonne-km as activity level indicators had to be forgone, because of a lack of available data on these indicators. Instead, the intensity indicators used were freight and passenger transport energy consumption per capita.

China

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21 Proposed legislation currently being considered would make it mandatory for sellers of homes to compile standardised 'Home Information Packs' to inform potential buyers. Several stakeholders, including the Energy Saving Trust propose including energy efficiency data in these packs.

22 Asia Pacific Energy Research Centre (2001)

23 The degree-day elasticity is the ratio between the percentage change in degree-days and the corresponding percentage change in space heating / cooling energy consumption

The University of Groningen in the Netherlands conducted a study of China's industrial sector through the 1990s to determine the contribution of efficiency gains to the observed changes in energy consumption[24]. The study also proposes a decomposition methodology that aims to eliminate the residual component, which is a characteristic of the commonly used Laspeyres approach. The methodology proposed actually has elements of both the Laspeyres and the Divisia approaches, but is somewhat contrived. It uses the sub-sectoral energy intensity in Year 0 as a weighting factor for calculating structural effects, and the sub-sectoral share of output in Year t as a weighting factor for calculating intensity effects. While this does have the desired effect of eliminating the residual, there does not appear to be any rigorous mathematical basis for choosing these weighting factors. There would therefore appear to be no reason for favouring this methodology over the log-mean Divisia approach used in New Zealand.

The study improves upon earlier studies conducted on China's industrial sector by using value-added (as opposed to gross output) as the activity level indicator, thereby avoiding double counting. Data for value-added was available for 37 to 40 sub-sectors (depending on the year in question) whereas data on sub-sectoral energy consumption was available only for 31 sub-sectors. In order to reconcile the two data-sets, the analysis itself was conducted with a disaggregation into 29 sub-sectors. The study used only data that was already available from existing sources.

Norway

A study of long-term trends in manufacturing energy use in Norway was conducted by the Institute for Energy Technology in partnership with the IEA[25]. Covering a period of 20 years, the study adopted a Laspeyres decomposition methodology to examine the evolution of the structure and intensity of manufacturing energy use. Nine other OECD countries were also examined in this study. To ensure international compatibility, the disaggregation was limited to seven sub-sectors, one of which was a catch-all 'Other' sub-sector. Data was obtained from the official industrial statistics and energy balances of the countries studied.

Indonesia

The University of New South Wales conducted a study on Indonesia's manufacturing sub-sector, covering the period 1980-2000[26]. The study focussed mainly on CO_2 emissions, and used the adaptive-weighting Divisia approach[27] to determine the relative importance of activity levels, structural factors, energy intensity effects and CO_2 intensity of fuels in the aggregate change of CO_2 emissions from the manufacturing sector. The data used was that which was already available from the Indonesian Central Bureau of Statistics. The total number of industries into which the manufacturing sub-sector was disaggregated was not reported.

[24] Zhang (2000)

[25] Unander and Schipper (1997)

[26] Sitompul and Owen (2004)

[27] This is a generic term for a set of approached that minimise the residual component by using weighting factors that differ from year to year and from sub-sector to sub-sector. The log-mean Divisia approach, which removes the residual component completely, is one form of the adaptive-weighting Divisia approach. No information was available to indicate which adaptive-weighting approach was used in this particular study.

4 Conclusions and recommendations for South Africa

4.1 Relative merits of different methodological approaches

Many different approaches have been adopted to the task of monitoring progress made towards achieving energy efficiency targets. There are two ways in which these approaches can be characterised:

top-down versus bottom-up

indicators-based versus project-based

Top-down monitoring is, by definition, indicators-based. The systems in use in Canada and New Zealand appear to be the most complete examples of top-down, indicators-based systems currently in operation. The focus is on macro-level indicators for changes in energy consumption, which are analysed according to their various causal components, one of which is the change in the efficiency with which energy is used. The top-down analysis takes the observed change in overall energy consumption, attributes portions of this to factors such as changes in activity level and structural changes, then assumes that the residual change in energy consumption is due to changes in the efficiency with which energy is used. It requires macro-level data on total energy consumption and total activity levels in each of the sectors analysed.

Bottom-up approaches may be either project-based or indicators-based. Project-based bottom-up monitoring, as expounded by the European Commission and a number of EU member-countries, focuses on energy efficiency policies and programmes in place, and attempts to attribute changes in energy consumption to these policies and programmes. Most policies and programmes are in any case required to have a monitoring component built into them, to ensure cost-effectiveness. The approach simply sums up the energy saving impacts attributable to all policies and programmes, and assumes that this total is the overall energy saving due to efficiency changes. It requires micro-level data on impact per participant and number of participants for each policy or programme currently active.

Indicators-based bottom-up monitoring is the basis of the Odex indicators developed under the EU Odyssee project. Conceptually, indicators-based approaches are the same whether they be top-down or bottom-up, and the data requirements for each are similar[28]. Because of this, the distinction that will be focussed on here is that between project-based and indicators-based approaches.

The key difference between the project-based approach and the indicators-based approach is perhaps best illustrated by referring to the ‘Driving Force-State-Response’ model adopted by New Zealand (see Section 3.1.2 above). In the context of this model, the indicators-based approach to monitoring <u>observes</u> the change in the state of the system, and <u>infers</u> what driving forces may have caused this change. Conversely, the project-driven approach <u>observes</u> the driving forces, and <u>infers</u> how the state of the system must have moved as a result.

This distinction highlights the most critical shortcoming of the project-based approach. Generally speaking, the project-based approach looks only at a limited number of the driving forces at work – specifically, those that take the form of energy efficiency policies, programmes and projects. However, there are many other driving forces that are either unknown, or at least are difficult to quantify and analyse. Some of these unobserved or unquantified driving forces may actually be pulling energy efficiency downwards, rather than improving it. Referring to Figure 0, a project-based approach such as that prescribed in the EU Draft Directive on End Use Energy Efficiency and Energy Services, and

[28] In order to aggregate sub-sectoral and industry-level energy intensity data in the bottom-up approach, a set of weighting factors must be used in what is effectively a weighted mean calculation. These weighting factors are exactly the same as those that must be used for decomposing sectoral or economy-wide energy intensity data in the top-down approach.

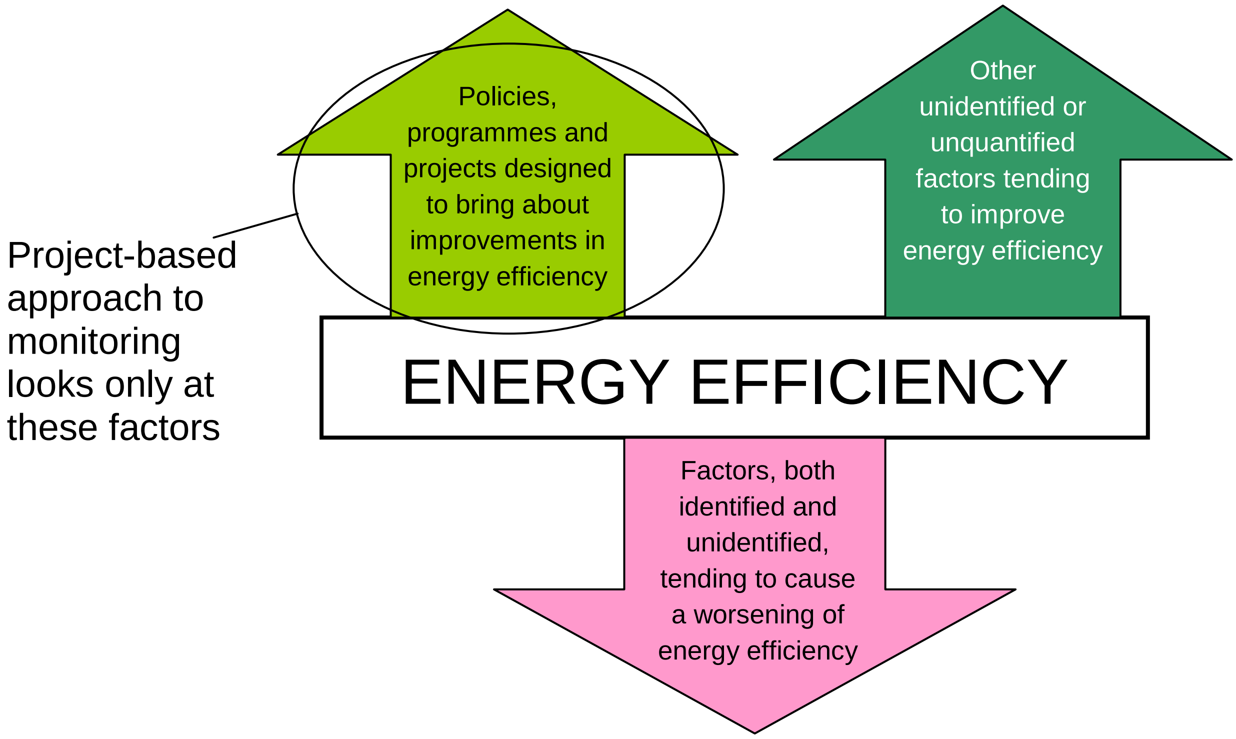

Figure 6 Illustration of the focus of a project-based approach to monitoring energy

elaborated by the Wupperthal Institute (see Section 3.4.1 above), essentially ascribes all the arrows apart from the highlighted one to part of the 'business as usual' scenario. In other words, business as usual encompasses all factors affecting energy efficiency apart from specific policies, programmes and projects that are designed to improve energy efficiency.

While this approach is probably satisfactory in a situation where energy efficiency is improving, it presents difficulties in a situation where the energy efficiency of an economy, sector or sub-sector is falling. Where energy efficiency is deteriorating, a project-based approach to monitoring provides no indication as to what driving forces might be causing the deterioration – information which is essential if policy-makers are to respond appropriately. Only an indicators-based approach can allow attention to be focussed on factors that may be causing energy efficiency to fall.

Another difficulty with a project-based approach is how to deal with awareness-raising programmes. It is notoriously difficult to determine accurately what effect raising awareness of energy efficiency has on actual end-use efficiency, a difficulty that is compounded when an awareness-raising programme interacts with other programmes such as those providing subsidies or other incentives to purchase energy efficient equipment.

However, a project-based approach to monitoring also has several advantages over an indicators-based approach. The data requirements are minimal, since all energy efficiency projects, programmes and policies will (or at least, should!) already have in place a component for monitoring their impact and effectiveness. A project-based approach is also necessary in situations where an energy efficiency target is imposed on energy suppliers (as in the case of many European countries), as they need to demonstrate meeting their target by counting the kWh savings in the various initiatives and programmes that they have implemented. These individual contributions can then be summed across all suppliers to derive a national figure for energy efficiency improvements.

However, in South Africa energy efficiency targets are general, and are not imposed on particular energy suppliers. Thus energy efficiency improvements that are not tied to particular projects or programmes nevertheless also count towards the meeting of overall energy efficiency targets. In this circumstance, a project-based approach is less useful, as it would miss many of the factors that have contributed towards an improvement in energy efficiency and, more importantly, would also fail to identify the key influences in the event that energy efficiency had deteriorated.

In an ideal world, a complete system would include both indicators-based and project-based components. In the South African context, an indicators-based approach is probably more appropriate initially, so it is recommended that the setting up of a working system focus initially on this approach. This system can then be supported by project-based data as this becomes available. It should be mandated that any energy efficiency policies, programmes and projects receiving official support are required to provide data on energy saving impacts to the energy efficiency monitoring system. Thus, as time goes by, the indicators-based system will be backed up by increasingly detailed data on specific initiatives.

4.2 Data requirements and availability

Both in the survey and in the country-specific studies, poor availability of data was cited as a significant impediment to the creation of a comprehensive and effective energy efficiency monitoring system. This issue is closely linked to that of resourcing, as data collection is clearly very resource intensive. There are two possible responses to gaps in the available data – one is to generate new data flows to fill the gaps, while the other is to make do with the data that is available, modifying the monitoring system if necessary to accommodate the sub-optimal data set.

EECA in New Zealand lobbied for the introduction of regular comprehensive surveys that would have plugged many of the data gaps, but this was refused on budgetary grounds. Conversely, NRCan in Canada were able to generate new data sets in the residential sector and transport sectors. For the transport sector, they approached the Department of Transport, who agreed to add an energy-related component to the survey questions in the comprehensive Canadian Vehicle Survey. In the residential sector, they had sufficient resources available to commission Statistics Canada to carry out a comprehensive household survey on energy end-use. Although this survey will only be carried out approximately every four years, the level of detail is very high.

The Canadian experience is particularly interesting for South Africa, as they made use of the already existing Labour Force Survey as a vehicle on which the household energy survey could be carried. South Africa’s own Labour Force Survey, conducted every six months by Statistics South Africa, could serve a similar purpose. It covers over 32,000 households, achieves a response rate in excess of 88% and already contains questions relating to dwelling type, which could provide useful information on expected demand for space heating. Statistics South Africa’s General Household Survey, conducted annually, is another potential vehicle for additional questions relating to household energy use.

More generally, the experiences of Canada and New Zealand strongly suggest that part of the remit for the body responsible for conducting monitoring of energy efficiency targets in South Africa should be to maintain very close relationships with any government departments and external bodies that are engaged in any form of data collection and surveys. The addition of well-targeted additional questions into existing surveys provides a very low-cost means of collecting additional data.

With regard to modifying the methodology to accommodate less-than-ideal data sets, a number of points can be learned from the country-specific studies. In the APEC study (see Section 3.5.3 above), energy per worker was used as a proxy indicator for energy intensity in the services sector, in lieu of the preferred energy per unit of floor space, for which data was not available. This probably provides a reasonably good approximation as, within any given sub-sector, the number of workers is likely to

correlate fairly well with floor space[29]. However, the methodology employed in the APEC study uses GDP as the overall activity level indicator, which then necessitates the use of a labour productivity factor to relate GDP to work-force. In the event that data on floor area is not available for South Africa, a similar approach can be adopted for South Africa. However, it is recommended that sectoral and sub-sectoral GDP be removed from the analysis by using the number of workers as the main activity level indicator. A decomposition analysis can then be based on a disaggregation into main sub-sectors, with the following factors used: energy per worker in the sub-sector (intensity effect); fraction of total workforce accounted for by the sub-sector (structural effect); total sectoral workforce (activity effect).

The transport sector is likely to present problems in terms of data availability in South Africa, so it is instructive to observe the methodologies employed in other countries. In New Zealand, Canada and the Netherlands, data on tonne-km for freight transport and passenger-km for passenger transport was available, so these figures could be used as the activity level indicators for this sector. However, the New Zealand analysis also provided, for comparison, data on energy intensities where the activity level indicators were number of passengers for passenger transport and value-added (contribution to GDP) for freight transport. Although not ideal as activity level indicators, they are probably the next-best option if the ideal data on passenger-km and tonne-km is not available. In the case of private car transport only, the Odex index methodology employed by EU countries appears to use km travelled as the activity level indicator. The advantage of this indicator is that it is likely to be more easily obtainable from existing vehicle registration databases.

4.3 Detailed methodological issues

A notable feature of the Dutch methodology is the reporting of second-level structural effects in the top-level economy-wide analysis. A simple analysis conducted at the economy-wide level results in a portion of the change in total energy consumption being attributed to changes in energy intensity. However, this energy intensity effect actually includes the effects of structural changes *within* the main sectors. In order to correctly report the impacts of energy intensity changes and structural changes, these second-level (and even third-level) effects should be taken into account in the top-level analysis.

The New Zealand analysis used household income as one of the explanatory variables for changes in residential energy consumption. However, wealth is only a useful indicator inasmuch as it is a proxy for ownership and usage levels of energy-using appliances. This may not be appropriate in the South African context, where a large number of households operate outside of the officially recorded economy, with the result that official figures for household income may not serve as a good proxy for appliance ownership levels. A better solution would therefore be to by-pass the proxy indicator and use regular household surveys to provide direct data on the quantity of interest, namely the ownership and usage levels of appliances.

In the residential sector, the New Zealand methodology uses population as the indicator for total activity level in the decomposition analysis, while the Canadian methodology uses number of households. The approach adopted by the Netherlands team uses a combination of the two, using population as the activity level indicator for water heating, but number of households as the corresponding indicator for other end-uses. Even where the main indicator used is number of households, it is certainly true that total population (and hence average household size) is also a significant explanatory variable. In the New Zealand methodology, the effects of changes in household size appear to be subsumed into a ‘structural change’ factor. In the case of South Africa, most energy-using household activities probably correlate more closely with number of households than with population, so it is recommended that the monitoring system use number of households as the main activity level indicator.

[29] Note that, in this methodolgy, it does not matter that the number of workers per unit of floor space differs widely <u>between</u> sub-sectors.

The New Zealand and Canadian methodologies use weather as an explanatory variable, for the residential sector only in the case of New Zealand, and for the residential and commercial / public sectors in the case of Canada. The basis for this is that lower average temperatures result in an increased demand for space heating. However, although weather can have a significant impact on changes in energy consumption in an individual year, its relative impact diminishes as cumulative changes over a number of years are observed. This is because variations in average temperature tend to cancel out over sufficiently long periods. Results for New Zealand indicate that weather accounted for only 0.5% of the total cumulative change in total energy consumption over the period 1996-2003, even though for certain individual years within that period, its influence was very strong. The impact of differences in the weather in South Africa is likely to be weaker than in either New Zealand of Canada, since the number of heating degree-days is significantly smaller[30]. Unless there is reason to believe that there are long-term movements in average temperature that are significant over the monitoring period, it is therefore recommended that weather is not used as an explanatory variable in performing a decomposition analysis for South Africa. However, if sufficiently reliable data on average heating degree-days is available, it is recommended that this be used to perform an initial normalisation of energy consumption data for the residential and commercial / public sectors.

All of the three countries studied in detail appear to have used the relative share of different household activities in total household energy consumption as a factor in the decomposition analysis, referring to this as a ‘structural’ effect. However, this is somewhat artificial, and is not really analogous to the structural effect in the productive sectors, because household activities are not substitutes for one another in the same way as activities in the productive sectors. All productive activities are means of generating value-added, and so it is largely a matter of collective choice as to which activities are undertaken in a particular economy. Household activities, however, are governed by the need for particular energy services, so this choice is constrained. For example, an economy can ‘choose’[31] to create wealth by focussing more on financial services at the expense of manufacturing, whereas a household cannot realistically choose higher lighting levels as a substitute for cooking food. It is therefore not recommended that this approach be used in the South African context.

4.4 Institutional structures and resources

With only three examples to choose from of comprehensive systems for the monitoring of sectoral and economy-wide energy efficiency trends, it is somewhat difficult to draw general conclusions about institutional structures and resourcing levels. The three countries studied in detail here place responsibility for implementing monitoring systems in three different types of body: a government department in Canada’s case, a parastatal authority in New Zealand and an independent research organisation in the Netherlands. In most of the European countries where project or programme-based monitoring is carried out, this is done by (or at least audited by) parastatal authorities.

Of these three types of body, the independent research organisation is perhaps least well equipped to report on results in a style that is accessible to the public and to key policy-makers. Some concern was expressed, both in the international survey of expert opinion and in the local stakeholder consultation, that placing responsibility for monitoring with a government department may lead to a lack of credibility and suspicions of ‘spin’. The most broadly acceptable type of body for implementing a monitoring system would therefore seem to be the parastatal authority.

With regard to resourcing levels, again the examples from which to draw conclusions are very limited in number. No information was available from ECN regarding the resources provided for the energy

30 Although South Africa has more cooling degree-days than New Zealand, this is not relevant for residential sector energy consumption, since only a tiny fraction of dwellings have air-conditioning.

31 Of course, ‘choose’ in this context does not imply any form of central planning or decision-making; it merely reflects the collective response to market forces of many individuals and firms.

efficiency monitoring they performed. The conclusion from the other two countries studied in detail is that the Canadian system was adequately resourced, whereas the New Zealand system was somewhat under-resourced.

Although the level of resourcing required for operating a monitoring system is probably relatively constant for different economies, the likely availability of resources will certainly depend on the size of the economy. The Canadian economy is just over twice the size of that of South Africa, so if the assumption is made that available resources are in proportion to the size of the economy, this suggests a reasonable level for South Africa would be a permanent staff of about 8-9 and an annual budget of about ZAR 13.5 million. However, it is likely that the requirements in the initial period will be somewhat higher, as more resources are needed to launch a new system than to operate a mature system.

4.5 Reporting of results

Very few countries have formalised systems under which there is regular reporting of economy-wide and sectoral energy efficiency trends, so conclusions about the relative merits of different approaches to reporting are based on a very small number of examples. Both New Zealand and Canada produce an annual report pitched at the level of the sophisticated lay-person, which describes the main results in considerable detail. These main reports are backed up by more technical reports on methodological issues, aimed more at the specialist wishing to understand the details of the analytical techniques. This form of reporting would seem to be completely adequate for fulfilling the two aims of informing the public and guiding policy-makers, while also providing transparency. It is therefore recommended that the South African system for monitoring energy efficiency adopt a similar style of reporting.

The particular method of displaying the decomposition results differs slightly between New Zealand, Canada and the Netherlands. The most obvious difference is that Canadian and Dutch results are presented only as a cumulative change in the impact of energy efficiency from the base year, whereas the New Zealand results are presented as year-on-year changes. It is felt that the method of representing results chosen by the Netherlands team is somewhat confusing (notwithstanding their superior treatment of structural impacts – see Section 4.3). In the South African case, both year-on-year changes and cumulative progress towards achieving the overall targets should be presented both for the whole economy and for each sector. It is recommended that changes over the most recent year are presented in a similar way to the Canadian style (Figure 0), which is easily understood by non-specialists. For cumulative progress towards meeting sectoral and economy-wide targets, it is recommended that the nEw Zealand style of presentation (Figure 0) be used.

5 References

Asia Pacific Energy Research Centre; 'Energy Efficiency Indicators: a study of energy efficiency indicators in APEC economies'. March 2001.

Bilodeau J-F. (Natural Resources Canada, Office of Energy Efficiency); personal communication, September 2005.

Boonekamp P. *et al*; 'Protocol Monitoring Energiebesparing'. Published by ECN as ECN-C--01-129 (December 2001).

Boonekamp P., Gijsen A., Vreuls H.; 'Realised Energy Savings 1995-2002 According to the Protocol Monitoring Energy Savings'. Published by ECN as ECN-C--04-085 (October 2004).

Energy Efficiency and Conservation Authority (EECA); 'Energy Efficiency and Renewable Energy Performance in New Zealand - March 2002/03 Year Two Report on the National Energy Efficiency and Conservation Strategy' (October 2004).

European Commission (2003); 'Proposal for a DIRECTIVE OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL on energy end-use efficiency and energy services'. COM(2003) 739 – final. (http://europa.eu.int/eur-lex/en/com/pdf/2003/com2003_0739en01.pdf)

EurActiv; 'EU states reject binding energy efficiency targets'. EurActiv.com Energy Outlook, 29 June 2005. (http://www.euractiv.com/Article?tcmuri=tcm:29-141683-16&type=News)

Hulan I. (Natural Resources Canada, Office of Energy Efficiency); personal communication, September 2005.

Lermit J., Jollands N.; 'Monitoring Energy Efficiency Performance in New Zealand: A Conceptual and Methodological Framework'. Prepared for EECA, September 2001.

Luxmoore I. (Energy Efficiency and Conservation Authority); personal communications, March-April 2005.

McNabb D.(Natural Resources Canada, Office of Energy Efficiency); personal communication, July 2005.

Nanduri M. (Natural Resources Canada, Office of Energy Efficiency); personal communication, September 2005.

Natural Resources Canada (NRCan); 'Energy Efficiency Trends in Canada, 1990-2003'. (June 2005).

Pavan M.; 'Italian Energy Efficiency Obligation and White Certificates: Measurement and Evaluation'. Paper presented at the workshop on 'Case Studies of Current European Schemes for the Measurement and Verification of Energy Efficiency Improvements' organised by Eurpean Commission, European Parliament and ECEEE (Brussels, March 2005).

Sitompul R., Owen A.; 'Decomposition of energy-related CO_2 emissions in the Indonesian manufacturing sector'. School of Economics, University of New South Wales (2004).

Thomas S.; 'The quantitative targets for energy savings proposed by the draft directive on energy end-use efficiency and energy services – how to define, how to monitor them'. Wupperthal Institut für Klima, Umwelt, Energie GmbH (January 2005).

Unander F., Schipper L.; 'Long Term Manufacturing Energy Use in Norway: an international perspective'. ECEEE Summer Study Proceedings (1997).

Zhang, ZhongXiang; ‘Why Had the Energy Intensity Fallen in China’s Industrial Sector in the 1990s? The Relative Importance of Structural Change and Intensity Change’. Faculty of Economics and Faculty of Law, University of Groningen, Netherlands (2000).