Evaluation of realised energy savings with simulation models

A new policy tool for the Netherlands

P.G.M. Boonekamp **(ECN)**

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The results are partly based on work of:
J. Gerdes (PME)
C. Tigchelaar (Households, heating)
P. Vethman (Households, electricity)
J. Sipma (Services/Buildings)
W. Wetzels (Industry & Agriculture).
C.H. Volkers (MONIT)
B. Daniels (NEM)

Abstract

This report describes a new analysis tool for the evaluation of realised energy savings, and effects of savings policy, in the Netherlands. It aims to meet the information needs of policy makers, both at national and EU level, using the monitoring results of Agency NL. The system builds on the Protocol Monitoring Energy Savings to calculate realised savings. The innovation consists of the option to adjust energy models per sector, as already used for scenario analysis, to simulate past developments. The simulations can estimate total savings and assess the contribution of policy measures. The detailed simulation approach also enables the decomposition of energy trends into volume-effects due to growth, structural effects such as fuel substitution and import/exports, and various saving effects. As the modeling system is already used for the analysis of future trends, it enables a good comparison between ex-ante (expected) savings and ex-post (realised) savings. Finally, the system enables a faster delivery of calculation results than presently is the case.

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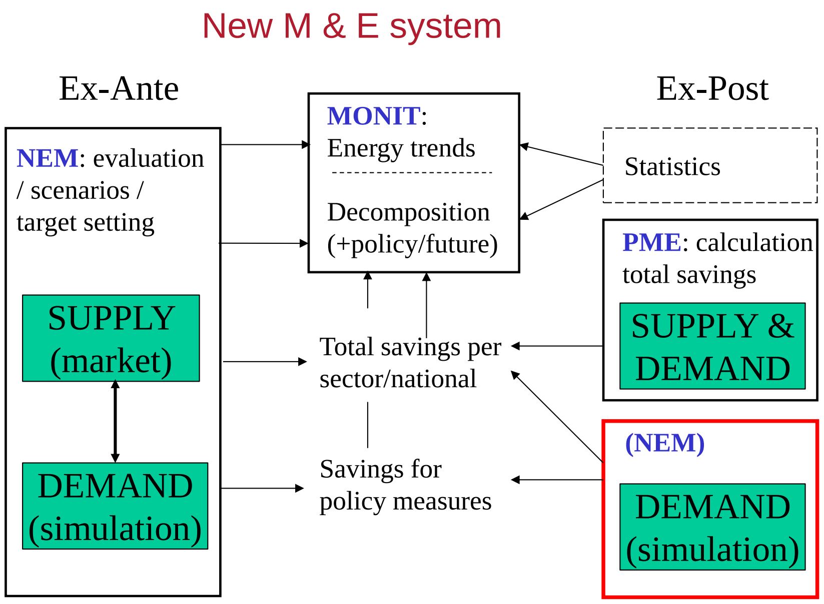
Summary

Why a new M & E system?
Since the eighties ECN is supporting the Dutch government by means of modeling the energy system (*NEM*), developing scenarios and evaluating the effect of policies. Since the nineties realized energy savings are calculated each year according to the Protocol Monitoring Energy savings (*PME*). Results are presented with the *MONIT*-tool. However, the requirements on monitoring & evaluation have increased due to new European legislation on energy savings and GHG emission reduction. Moreover, there are shortcomings in ex-post evaluation: delay in PME reporting on recent saving, no analysis of policy interaction, and lack of comparability for targets and realised savings.

What is new in the M & E tool?
The current system of ex-ante evaluation (scenarios) using the modeling system *NEM* is not changed. But a number of simulation models for end-use sectors are adapted to simulate past energy(savings) developments (see righthand-below in Figure). In this way a much more detailed ex-post evaluation is possible than with the existing *PME*-tool.

Figure 1: New monitoring & evaluation system on energy trends and savings



What does the new tool deliver?

The following results on the *content* are provided:

- Decomposition of energy changes into growth, structure and saving effects.
- Integrated set of total, policy and autonomous savings.
- Saving figures comparable with earlier set targets.
- Interaction effects between policy effects.
- Emission reduction effects of savings.
- Effectiveness for national targets versus savings.
- Cost-effectiveness/efficiency of saving policy (to be implemented).

Results in different *format*s van be provided, e.g.:

- In- or excluding consumption for non-energy uses.
- Split of energy consumption between ETS and non-ETS.
- Savings in final or primary terms (choice in EU directives).
- Energy savings in format of national or various EU targets.
- Intensities per sector (for National Reporting Format of the EU).

Results regarding the *process* are:

- Minimum delay in delivery of recent saving figures.
- Complete coverage of all realized savings (including Services).
- Transparency on quality of the saving figures.

Conclusions

The new M & E tool offers several advantages compared to the current set of tools that does not provide integrated ex-ante and ex-post results in a fast and flexible way. The tool has already proven its usefulness in the evaluation for the second Energy Efficiency Plan, provided in 2011 to the EC.

Moreover, the new application of existing simulation models for the execution of ex-post evaluation of realized savings constitutes also a regular validation of the models, which will also improve the quality of the scenario calculations with these models.

The new tool can also provide results when monitoring data are incomplete and are replaced by expert inputs; however, an acceptable quality of the results demands a minimum amount of effort in gathering monitoring data.

1

Introduction

Evaluations are key part of energy policy formulation

Monitoring & evaluation is an indispensable part of policy making in the field of energy efficiency and savings. Ex-post it helps to understand observed changes in energy consumption and ex-ante to develop (cost)effective energy and climate policies, adapted to changing circumstances.

Since the eighties ECN is supporting the Dutch government by means of modeling the energy system, developing scenarios and evaluating the effect of policies. Several national energy outlooks (e.g. NEV, 1990) have guided the formulation of energy policy. In the nineties support has been extended to monitoring & evaluation of realized energy savings. Each year the savings are calculated according to the Protocol Monitoring Energy savings (PME), described in PME, 2004.

New questions from the EU, better answers needed

After 2000 the requirements on monitoring & evaluation have increased. First of all due to new European legislation on energy savings, such as the Energy Service Directive (ESD, 2007) and the Energy Efficiency Directive (EED, 2012). Secondly, because of the GHG emission reduction target of 20% in 2020 that will require close monitoring of the policies and measures at the MS level (EC, 2009).

Moreover, a number of shortcomings in ex-post evaluations hamper the support to policy makers, such as the delay in reporting on recent saving trends, the difficulty to analyse interaction between different policy measures, and the lack of comparability between targets and realised savings.

New M&E system can solve problems and meet policy demands

These developments have led to the set-up of a new monitoring & evaluation system that is meant to overcome these problems, and is able to meet the national and international demands. The system builds on the existing modeling system and the PME calculation of realized savings.

This report, an update of a Dutch report (Boonekamp, 2010), presents the new evaluation system. It shows which type of results can be obtained and which policy needs can be fulfilled. Chapter 2 describes the current approach and the problems encountered. Chapter 3 describes the structure of the new system, followed by a chapter on examples of possible results. Finally, chapter 5 gives an overview of all policy issues which can be addressed with the new monitoring & evaluation system.

2

Evaluating trends & savings

2.1 Analysis of energy developments

Since the seventies the formulation of energy policy in the Netherlands has been more and more based on systematic monitoring & evaluation approaches. Presently it has become normal government practice (see VBTB, 1999 and RPE, 2006). **Monitoring** regards the observation of actual developments, i.e. WHAT has happened. The focus of **evaluation** is on WHY it happened and developments are valued in relation to goals (effectiveness) and efforts deployed (cost-effectiveness or efficiency).

Monitoring => What,
evaluation => Why

Here the focus is on energy efficiency and energy savings, but always in relation to overall energy consumption trends including growth factors, such as increased BNP, and structural changes, such as a shift from industry to services.

For evaluation a distinction can be made between **ex-ante**, i.e. exploration of future developments including expected energy savings, and **ex-post** which comprises past developments including realised savings.

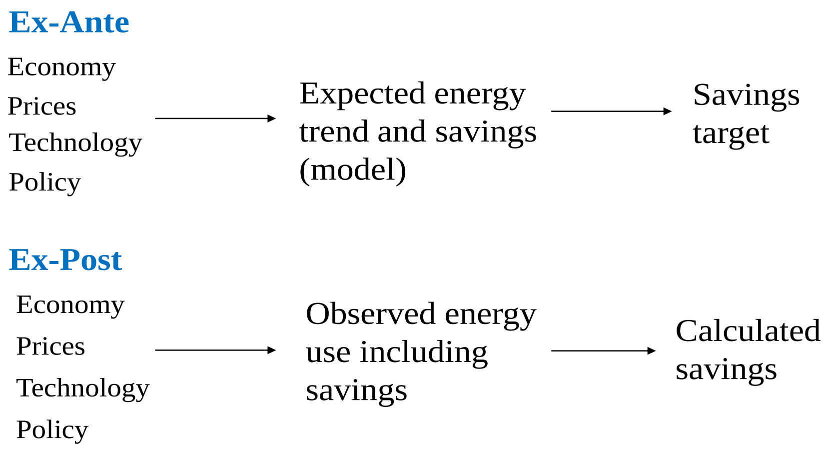
Ex-ante => expected in future
Ex-post => observed in past

2.1.1 Ex-ante evaluation of future developments

Policy makers try to influence future development of energy consumption and the adjacent effects, such as emissions, costs and security of supply. Ex-ante evaluations are performed to explore possible trends and the way policy can influence these trends. Monitoring is not an issue here because there are no observed trends, but only expected ones.

Ex-ante evaluations generally take the form of energy scenarios that show how energy consumption will develop, given assumption about economic growth, the composition of energy using activities and prices of primary energy carriers (e.g. ECN, 2010). Moreover, it is analysed how a package of policy measures can stimulate energy savings, thereby reducing energy consumption and emissions. Often targets for energy savings are formulated, based on the scenario evaluation (see **Figure 2**).

Figure 2: Basic scheme of ex-ante and ex-post evaluation



Scenario evaluations generally are executed with energy **models** that describe the energy system in mathematical terms and calculate the future energy consumption and savings (see section 2.2.3).

2.1.2 Ex-post monitoring & evaluation of the past

The basic scheme for ex-post evaluation is different from that of for ex-ante evaluation. The same factors lead to actual savings, included in the observed energy trends. These savings can only be estimated with calculation methods, using observed data on energy use and drivers (see **Figure 2**).

Ex-post monitoring & evaluation is executed for the following reasons:
- **Observation** of actual developments in the energy system.
- **Insight** in the factors that determine energy consumption trends.
- **Check** whether, and why, the formulated savings target has (not) been met.
- Analysis of the **(cost) effectiveness** of policy measures deployed.

Monitoring regards mainly the first and second issue. Observation of the energy consumption trends, the penetration of energy saving devices, the amount of subsidies, etc. provide the building blocks for the other issues. Decomposition analysis can show how different factors, such as economic growth and energy savings, have contributed to the observed change in energy consumption (see section 2.2.5).

The third and fourth issue are part of **evaluation.** The check on the target for energy savings asks for methods to calculate realised energy savings (see section 2.2.4). The effectiveness analysis should deliver the explaining factors behind the savings, especially the effect of policy measures that influence investments for saving measures and energy using behaviour. Finally, the cost-effectiveness can show at what costs, for energy users, government and the country as whole, the goals have been met.

2.2 ECN contribution and tools

2.2.1 Monitoring & evaluation activities

Outlook centerpiece of ex-ante evaluation

National Energy Outlook

ECN performs at a regular basis ex-ante evaluations of future energy trends and policies. These are published in the form of **National Energy Outlooks** with reference scenarios and policy variants (from NEV, 1990 to ECN, 2010). The results encompass:

- Primary energy consumption trends.
- Final energy consumption per sector.
- Energy savings in end-use and in supply.
- Effect of policy measures on savings and renewable energy production.
- Emissions connected to energy consumption.
- Energy prices, investments and total energy costs to users.
- Cost-effectiveness of policy.

According to the recent Outlook (ECN, 2010) energy savings up to 1.5% per year can be realised, given a package of policy measures.

Annual calculation of realised energy savings

Every year the realised energy saving are calculated in conformity with the Protocol Monitoring Energy savings (PME). PME savings regard the total savings at national level and per sector, which can be due to policy but also due to autonomous developments. The calculation of energy savings is performed by ECN, which serves as the independent policy evaluation institute. Guidance to the method and calculations is provided by a platform consisting of NL Agency, PBL, CBS and ECN. The results show that the high savings rate before 2000 has decreased to less than 1% per year currently.

Evaluation of cost-effectiveness of policy

In cost-effectiveness analysis the energy savings or emission reductions are related to the adjacent costs for the different stakeholders: energy users, government and the country as a whole. In 2005 the cost-effectiveness of energy and climate policy was evaluated, both for the past and the future (ECN, 2005). A more recent ex-ante evaluation is presented in ECN/SEO, 2012; a more recent ex-post evaluation by CE (TK, 2012) concludes that that a thorough evaluation is not possible since 2007.

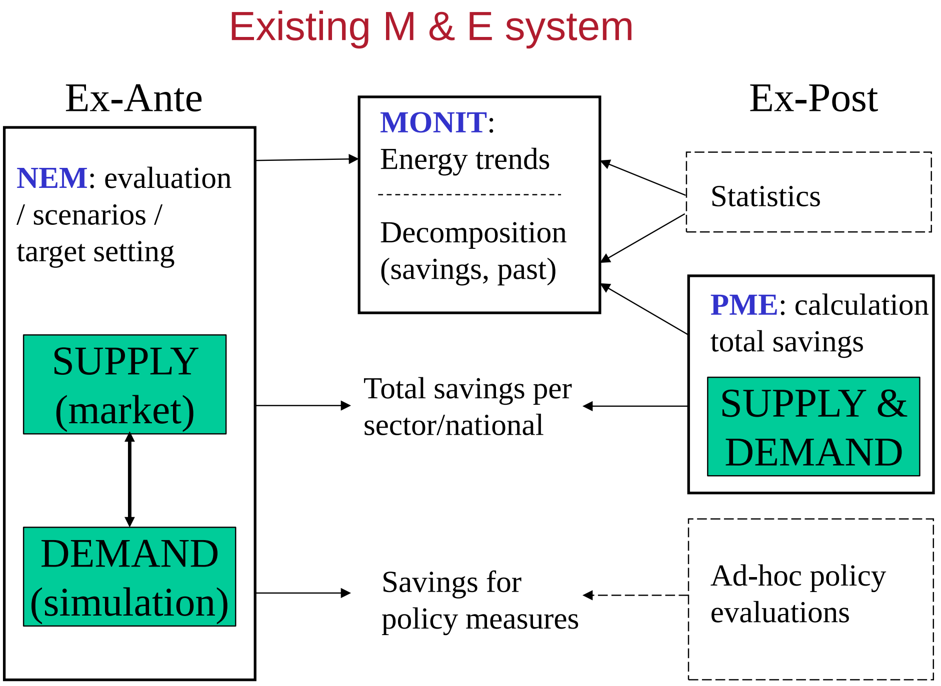
2.2.2 Available evaluation tools

The current monitoring & evaluation tools are shown in **Figure 3**, both for ex-ante evaluations (lefthand side) as well as for ex-post evaluations (righthand side).

For ex-ante evaluations, scenarios and outlooks, the National Energy Modeling system (**NEM)** is applied (Volkers, 2006). The developments at the end-use side are simulated with models per sector (see DEMAND). The developments at the supply side are analysed with energy market models (see SUPPLY). The interaction between the two parts concerns volume and price of deliveries from supply to demand. Results are the total expected energy savings per sector and national, and the saving effect of policy measures. Based on these results saving targets can be formulated (see section 2.2.3).

For ex-post evaluations the Protocol Monitoring Energy savings (**PME**) is applied (Boonekamp et al, 2001). PME provides total savings per sector and national, including the supply side (see section 2.2.4). The results can be compared with saving targets in order to check whether savings policy has been successful.

Figure 3: Existing monitoring & evaluation system on energy trends and savings



NEM = National Energy Modeling system

MONIT = Monitoring of National energy use, Information en Trend analysis

PME = Protocol Monitoring Energy consumption

Ex-post policy evaluation with various ad-hoc studies

The realised savings of policy measures are determined in **ad-hoc studies** based on various evaluation methods. To the extent possible, these results can be compared with the expected contribution of policy (see lower arrows in between). These ex-post evaluations are demanded through a government scheme that is valid for all policy measures (RPE, 2006). An overview of recent evaluation studies in the field of energy and climate is provided in TK, 2012.

The **MONIT system** is meant to present detailed energy trends, both for past (ex-post) and future (ex-ante) years. For past years the trends are based on energy statistics which are corrected for yearly deviations in temperature during the heating season. Energy trends for future years from NEM are already normalized.

MONIT for presenting energy data and decomposition of changes

The current MONIT tool is also able to decompose changes in past energy consumption (see also section 2.2.5). Changes in energy consumption are decomposed into growth effects (GDP), structure effects (sector shifts and substitution between energy carriers) and various saving effects (end-use, combined heat and power and power stations).

The M&E system provides ex-ante as well as ex-post total savings (see **Figure 3**). The savings are comparable because the PME method is also used to calculate ex-ante savings in the NEM. The savings due to policy measures are only available for future years and may differ in format from the policy savings from ad-hoc studies.

2.2.3 NEM for ex-ante evaluations

The National Energy Modeling system (NEM) determines future energy (savings) trends and policy effects. The scope is the national energy system, from end-use to extraction/imports, for the period from 2010 up to 2050. Aspects covered are energy consumption, supply mix, import/export, substitution between energy carriers including renewables, penetration of efficient appliances, energy savings, investments, emissions, energy costs, prices, government expenses including subsidies, etc. (RS, 2006). The NEM system consists of simulation models for the end-use sectors (DEMAND) and market models for the supply side (SUPPLY).

SUPPLY-side
The most important model at the supply side is the Electricity production model POWERS which determines the use of existing power plants for given electricity demand patterns and fuel prices. The model also facilitates the choice of new power plants if extension of capacity is needed. The resulting electricity prices are an input for the demand side models, which in turn deliver an electricity demand to the Electricity production model.

DEMAND-side
At the demand-side sector models are available for:

- Households (dwellings and appliances) – SAWEC and EVA respectively.
- Tertiary sectors – SAVE Services.
- Industry & Agriculture (including CHP) – SAVE Production.
- Transport – TEMPO.

The sector model characteristics are described in section 3.3.1.

2.2.4 PME for ex-post evaluations

The calculation of realised energy savings, which are based on observed trends, is performed with the Protocol Monitoring Energy savings (see PME, 2004). The scope of PME calculations is national and sectoral energy consumption for the period from 2000 up to now. This approach delivers total energy savings, which can originate from autonomous trends, or due to policy measures.

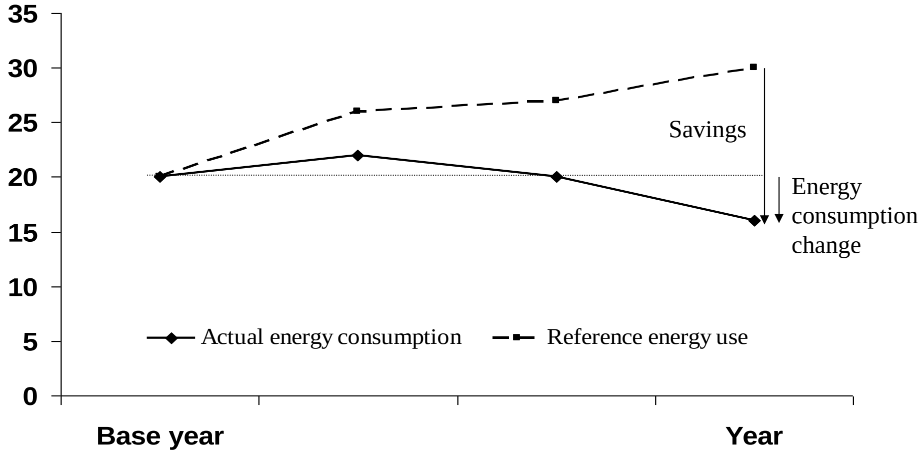
In PME a distinction is made between three saving categories:

- Energy end-use.
- CHP in end-use.
- Supply (power production).

End-use savings are calculated for targeted end-uses, using drivers and indicators. Examples for targeted end-uses are space heating in households, electricity use in Service sectors, energy for paper production and fuel use for road transport of goods. For each targeted end-use a driver is chosen that is assumed to determine energy consumption without savings, the so-called *reference energy consumption* (see **Figure 4**). The development of the reference is calculated from energy consumption in the base year and the change in the driver quantity over time. Through comparison with the *actual energy consumption* the *realised energy savings* are determined.

The savings of Combined Heat and Power (CHP) production are calculated by comparing the fuel input of CHP to the input at power plants, for the replaced electricity, and the input in conventional boilers, for the replaced heat. The increase in savings against the base year provides the CHP savings.

Figure 4: Savings determined from reference versus actual energy consumption



The savings in **power production** are calculated per fuel type. In this way substitution from e.g. gas to coal, leading to a lower average conversion efficiency, will not emerge as negative savings. For each fuel type the fuel input is calculated with actual electricity production and the conversion efficiency of the base year. The difference with actual fuel input constitutes the savings due to higher conversion efficiency.

2.2.5 Decomposition using the MONIT tool

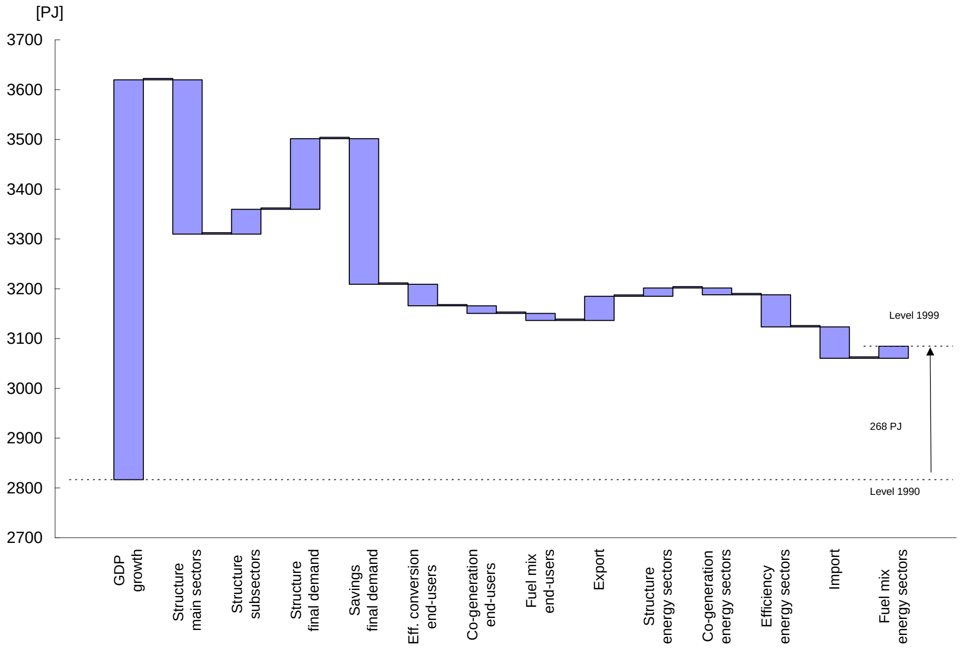
The observed change in energy consumption can be explained by decomposing it into different driving factors, such as:

- Volume, due to growth of activities.
- Structure, due to changes in the type of activities.
- Substitution between energy carriers.
- Import and export of energy.
- Energy savings.

The decomposition of changes in energy consumption is done with MONIT (Monitoring Of National energy use, Information en Trend analysis), described in MONIT, 2004. Starting point for the MONIT system are the energy balances of the Central Bureau of Statistics (CBS). Next, these balances are modified in several steps, to account for the changes in volume, structure, substitution, import/export and savings. The differences between the balances provide the decomposition results. The decomposition can be done both for past and future developments.

Figure 5 shows how the change in total energy consumption is decomposed into overall growth effects (GDP), structure effects such as sector shifts, and various saving effects (end-use, combined heat and power and power stations). If substitution between energy carriers and import/export changes are seen as special cases of structure effects, the change in energy consumption can be attributed to three factors: volume-, structure- and saving-effects.

Figure 5: Decomposition of the change in total energy consumption for 1990-1999



2.2.6 International evaluation requirements

NEEAP for the European Commission

Due to the Energy Service Directive (ESD, 2006) the Netherlands has formulated National Energy Efficiency Action Plans (NEEAP, 2007 and NEEAP, 2011). The NEEAP provides information on realised and expected energy savings in end-use sectors (excluding energy use under the ETS). For the NEEAP savings may be calculated *top-down*, but at least part of the savings must be calculated *bottom-up*. Top-down calculations use the change in an indicator, e.g. average gas consumption per dwelling, to estimate the total savings (in this example gas savings for dwellings). Bottom-up calculations calculate savings for a (policy) measure by multiplying the number of

NEEAP: evaluation of national savings (policy) for the European Commission actions (e.g. high-efficiency boilers) with the unitary savings per action (see also EMEEES, 2009.

The *expected* savings, both top-down and bottom-up, are derived from scenarios, set up with the NEM system. The *realised top-down* savings are derived from the PME calculations; the *realised bottom-up* savings stem from monitoring by Agency NL (e.g. for transport in HNR, 2006).

The Energy Efficiency Directive (EED, 2012) extends the reporting obligations both in time (up to 2020) and in scope (also saving figures for energy supply sectors and ETS-industry).

Odyssee indicators and top-down savings

Odyssee energy indicators used for calculation of savings for all EU countries

In the European Odyssee project on energy indicators the realized energy savings are calculated for each year and for all EU countries (Odyssee). This so-called top-down method, based on indicators, provides total savings per sector and at national level. ECN participates in the project and takes care of the inputs for the Netherlands. Because the Odyssee method sometimes differs from the PME approach it is not always possible to compare the results.

UNFCCC explanation of emission trends

The Netherlands has to report, through the EC, on GHG emissions and underlying factors to the UNFCCC (EC, 2005). One of the obligations is to explain the observed and expected emission trends, for which information on energy savings is vital. Expected savings are derived from the scenarios set up with the NEM system; realised savings are derived from the PME calculations.

IEA energy data

The IEA provides a database on energy consumption for OECD countries (IEA/stats). ECN provides MONIT figures that are based on CBS data but have been adapted to IEA definitions. Recently IEA also presented a database on energy indicators (IEA/indicators) where the inputs for the Netherlands are supplied through the Odyssee project.

2.3 Limitations current evaluation methods

Problems with current monitoring & evaluation mainly regard the ex-post evaluation, using the PME method. For the ex-ante evaluation sometimes the same problems are valid, e.g. when drafting the base year situation. The following problems are the most important ones.

Match of total and policy savings

The calculated PME savings at sector and national level concern only total savings. No distinction can be made between the two components, autonomous savings and savings due to policy measures. Therefore, it is not possible to provide information to policy makers on the effectiveness of their efforts.

Policy effects are determined only on an ad-hoc basis. The studies differ in scope and format of the results, and often do not take account of interaction with other policy measures. Therefore, they cannot be easily fitted into the overall picture of energy trends and total savings.

Delay in provision of ex-post saving figures

Total savings according to the PME format become only available two years after the last year presented in the analysis. For instance, the PME-report of 2010 contains savings results up to 2008 (PME, 2010). This delay is due to the need for many detailed data at lower aggregation levels, for which some final data become available only after 2 years. Final data are needed because the saving results over the whole period are dependent on the figures for the previous year.

No recent PME saving figures due to delayed data

Incomplete coverage for ex-post evaluation

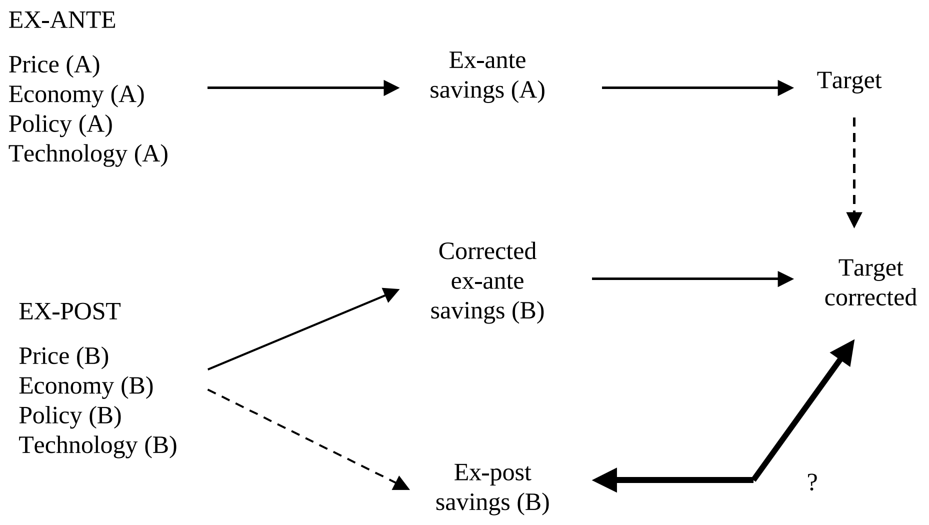
In the PME calculation of total savings no figures are presented for the end-use sectors Services and Chemistry. This is due to the lack of reliable energy consumption data or lack of information on drivers that can be used to construct a reference energy use (‘ without savings’). The first problem could be solved by (re)introducing suitable energy consumption surveys. To solve the driver problem quantities must be found that explain energy consumption trends from volume-trends (such as number of employees or Value Added) en structure effects (such as more floor space per employee or more ICT in the workplace).

No savings for Chemistry and Services calculated with PME

Difficult comparison of savings and target

Ex-post savings are often calculated in order to assess whether saving targets have been met (see **Figure 6**). However, saving targets often have been derived from ex-ante evaluations using different inputs (A), instead of the actual data (B).

Figure 6: Comparison of ex-ante (target) and ex-post (realized) energy savings



Because the targets were based on circumstances, such as economic growth and energy prices, that have changed since, realized savings and targets are hardly comparable with each other. One solution would be to correct the target for changing circumstances (see ‘corrected ex-ante savings’), after which it can be compared with the realized savings.

With regard to the format problems are already solved. The targets are based on the results of simulation models, while ex-post results are based on statistical data and indicators. However, the detailed simulation results can be converted into savings according to the PME format which are fairly comparable with the historic PME results.

Interaction between policy effects

Effects of different policy measures do not add up due to overlap

In order to stimulate energy savings, most countries apply a set of policy measures, e.g. efficiency standards for cars and appliances, subsidies for insulation measures, voluntary agreements with industry and overall energy taxes. The impact of the whole set is not equal to the sum of the effects of each separate measure. This is due to interaction, e.g. strict standards on the efficiency of new cars diminish the effect of higher petrol prices due to a petrol tax, because the car uses less petrol due to the standard. In some cases the interaction can increase savings, e.g. the combination of labels and a subsidy for specific appliances proved to more effective than the sum of both policy measures apart (ADEME, 2009).

In the analysis of policy effects interaction poses more and more a problem due to the introduction of EU policies, on top of national policies. Just summing up the saving effects of all policy measures will overestimate the overall effect. An analysis of the interaction is needed to assess the real policy effect. Moreover, this enables policymakers to develop a more effective policy package.

Uncertainty margins for saving figures

For **PME saving figures** the reliability is dependent on:

- The margins in the input data used.
- The length of the period.
- The aggregation level.

Savings based on indicators are by definition uncertain

Sectoral energy consumption data from annual statistical surveys have a margin of at least 1%, but often much more. For targeted energy uses inside sectors, e.g. electric motors in industry, this margin is even larger. There is also a margin for the data on drivers, such as Value Added per sector of km driven by cars. Together this leads to margins for calculated yearly savings that are (much) higher than the 0.5% to 2% yearly savings normally found. For a period of five years the savings found accumulate to 5-10%, which is comparable to the uncertainty margin. When aggregating different savings to the sector or national level, the margin in aggregated figures becomes relatively smaller. But in general, it remains difficult to conclude on realised year-to-year savings.

Policy savings are calculated differently in the many ad-hoc evaluations of the effect of a particular policy measure. Here the same problems arise as to reliable detailed data. But on top of that comes the uncertainty in the saving effect of a policy measure when there is interaction with other policy measures. For instance, the effect of an energy tax on energy consumption will be lower if there are already stringent standards for energy using devices.

3

New evaluation approach

3.1 Requirements to be met

Requirements as to content, format and process define new evaluation system

The new evaluation approach should cope with the observed problems with current evaluation tools, additional international requirements and new evaluation issues. The requirements regard only the ex-post evaluation as the ex-ante evaluation functions already satisfactory. The requirements concern content, format and process.

Content

The following results on the content are needed:

- Decomposition of energy changes into growth, structure and saving effects.
- Integrated set of total, policy and autonomous savings.
- Saving figures in different formats (national, EED).
- Interaction effects between policy effects.
- Emission reduction effects of savings.
- Effectiveness for national targets versus savings.
- Cost-effectiveness/efficiency.

Format

The users of M&E results need results in different formats for energy and savings, e.g.:

- In- or excluding consumption for non-energy uses.
- Split of energy consumption between ETS and non-ETS.
- Final or primary energy consumption (EED).
- Energy savings in conformity with 1.5% obligation (EED).
- Intensities per sector (National Reporting Format of the EU).

Process
Requirements regarding the process are:

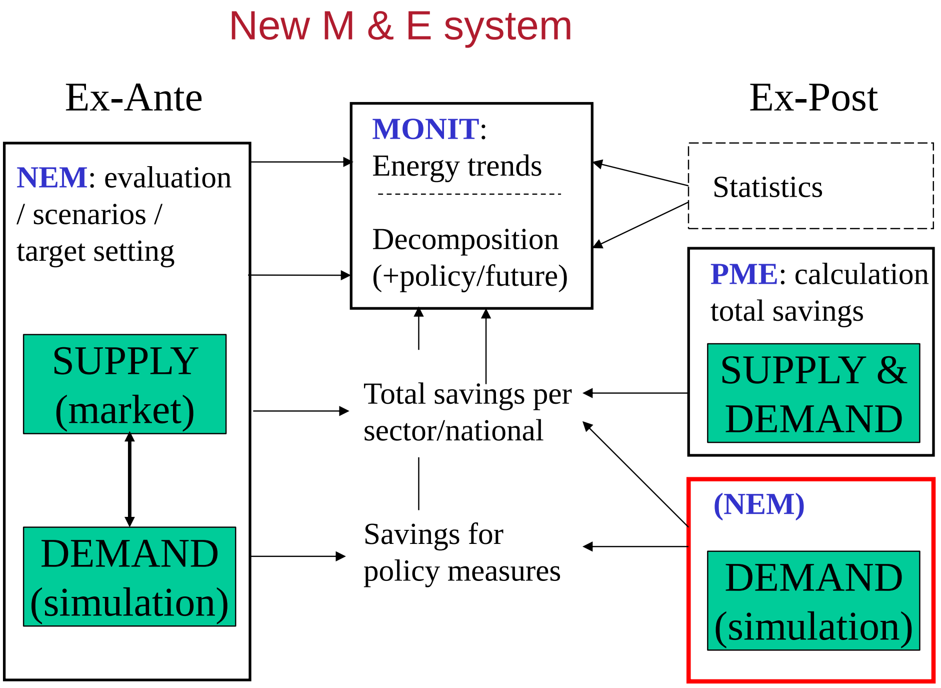
- Minimum delay in delivery of recent saving figures.
- Full coverage of the scope for savings.
- Better (known) quality of the saving figures.

3.2 The adapted evaluation system

Adaptation of M&E system mainly at the ex-post side

In the new system the existing parts Ex-ante/NEM and Ex-post/PME are still valid (see **Figure 7**). The new part regards the application of **simulation models** from NEM also for the **ex-post evaluation** of energy savings in end-use sectors (see '(NEM)' on right side). In the following section this new part is described.

Figure 7: New monitoring & evaluation system on energy trends and savings



NEM = National Energy Modeling system
MONIT = Monitoring of National energy use, Information en Trend analysis
PME = Protocol Monitoring Energy consumption

In the new approach the total savings ex-post are now a combination of the PME results and NEM results in historic years for end-use sectors. The ex-post savings due to policy measures are now derived from historic NEM simulations, instead of the various external studies.

Ex-post evaluation now executed with same tool as ex-ante evaluation

For the ex-post situation both total savings and policy savings are now provided by the same modeling system. Therefore, it is possible to present an integrated set of total and policy savings. And because the ex-ante and ex-post savings are calculated with the same system, the comparison of saving targets and realized savings will be easier.

The overview of all results, to be provided by the new M&E tool, in the ANNEX shows that all requirements mentioned in the previous section can be met with the adapted evaluation system.

3.3 Simulation of past trends with models

3.3.1 Sector models used for scenarios

Sector models

Simulation with existing models, used for scenario analysis, is at the heart of the new approach. At the demand-side the NEM system contains the following sectors:

- Households.
- Tertiary sectors.
- Industry (incl. CHP).
- Agriculture (incl. CHP).
- Transport.

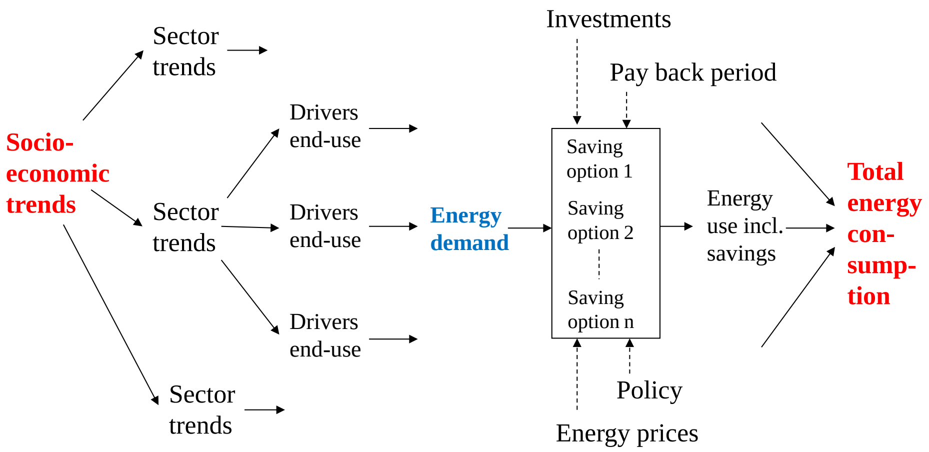
For Households two different models, on dwellings (**SAWEC**) and on appliances (**EVA**), are available. For Tertiary sectors the **SAVE-Services** model is applied. The sectors Industry and Agriculture are combined in one model (**SAVE-Production**). The model for the sector Transport (**TEMPO**) regards only technical developments for vehicles; in order to provide the overall picture for transport it must be supplemented with external information on mobility trends.

General model characteristics

The simulation models for the different sectors all have a different detailed set-up. However, the general approach is about the same (see **Figure 8**). Socio-economic trends, such as population and GDP growth translate into sectoral trends, which are converted to drivers that define energy demand per targeted end-use, e.g. heated floor area in offices, ownership of appliances, production of cement and transport of persons or goods. This results in an energy demand (without savings) per targeted end-use.

Simulation models differ per sector but have same structure

Figure 8: General structure of sectoral simulation models



The demand is met by energy using devices that can be more or less efficient depending on the choice of saving options. The models contain all known saving options, such as increased or high efficiency boilers, various insulation measures, variable speed electric motors, efficient cars, etcetera. The choice is dependent on energy prices, investment costs and policy measures, such as subsidies, which define the attractiveness of saving options. Given the profitability requirements in a sector, this results in more or less penetration of these options.

Based on the constructed energy demand trends and the penetration of saving options expected trends for energy consumption and savings are found. Most models also provide investments needed and the overall costs of saving measures (except EVA and TEMPO). In combination with the modelling of the supply side in NEM it is also possible to provide the emission reductions due to savings policy.

3.3.2 From validation to historic simulation

Validation

Validation of models can be seen as sort of historic simulation

Normally, simulation models must validated as to their ability to simulate future energy trends and related developments in the right way. This test is accomplished by simulating the past with the model and look at the fit with observed developments. If the model results match with the actual trends it is believed that the model will also function well for future situations. Detailed simulation models do not have an unlimited time horizon; generally the maximum of the future period should be in line with the length of the validation period.

Historic simulation

The validation approach is extended in such a way that it enables to simulate past energy trends and to analyse the effects of policy measures. Having a good fit with observed trends enables to provide various saving results (see section 3.3.4). However, once this has been accomplished the simulation models are used to simulate alternative historic developments, e.g. without the applied policies, or with other energy prices of economic growth. The differences between the simulation cases can show the effects that have contributed to the observed trends (see section 3.3.5).

3.3.3 Model adaptations for simulation

Adaptation of model structure

For relevant quantities the model will incorporate the actual value next to the calculated value. In this way it is possible to compare model results with actual developments at every level:

- Socio-economic trends defining energy demand.
- Penetration of saving options.
- Developments for targeted energy uses.
- Overall energy consumption.

The model parameters for behaviour that define penetration of saving options are made flexible in order to fit the model results to the actual trends.

Adaptation of inputs

The following main inputs are adjusted in historic simulations:

- Expected socio-economic trends > realised trends.
- Expected stock of energy using devices > observed stocks.
- Expected prices > actual prices.
- Intended policies > actual policy measures.

Fit of model results to actual trends

A first simulation is made with the adapted inputs and the results are compared with observed data specified above. Normally the fit is not complete, especially at lower aggregation levels. The fit for penetration of saving options is improved by adjusting the parameters that define the relation between energy prices, investment costs and penetration. The fit for targeted end-uses can be improved by adjusting the relationship between socio-economic quantities and energy demand. This will also improve the fit with overall energy consumption. However, a perfect fit with statistical energy figures is not by definition attainable or even desirable (see example case in Chapter 4).

For ex-post simulation the assumed model inputs must be replaced by actual inputs

3.3.4 Results for the base case simulation

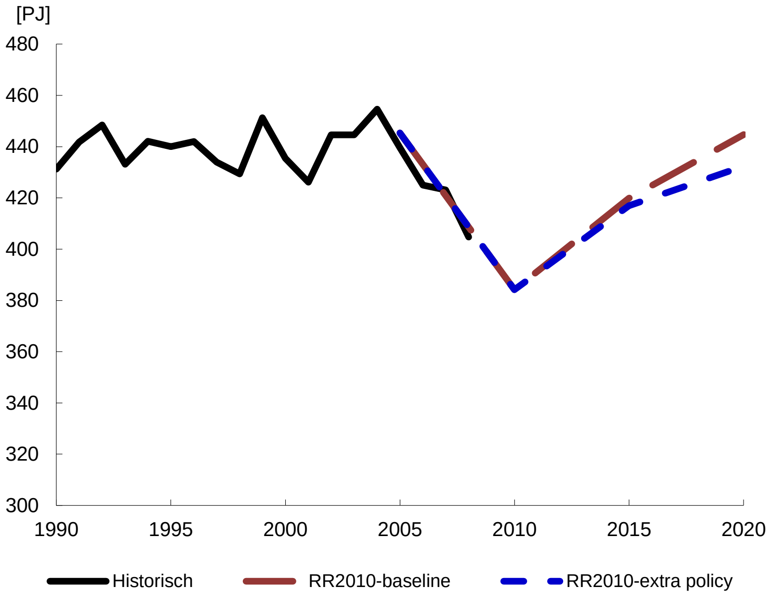
The result of fitting the models to historic trends is a base case simulation with information on energy demand, penetration of saving options, total and policy savings, final and primary energy consumption, emissions, investments and energy costs.

Historic simulation provides the trends and energy savings

Energy consumption trends

The base case simulation provides energy trends for both the historic years and for years to come. For historic years the simulation trend should match with the observed trend; for the expected trend no such check is possible. As an example **Figure 9** shows results for the sector Industry in the period 1990 to 2020 in ECN, 2010. The recent dip (black line) was expected to continue up to 2010 and then reverse again, and end up at the same or lower level in 2020, depending on the amount of policy deployed.

Figure 9: Historic and future thermal energy trends for the sector Industry



Source: ECN, 2010.

Total energy savings

Total energy savings are calculated from the difference between the energy consumption trend and the trend for frozen efficiency. Frozen efficiency means that the average efficiency of all energy using systems remains at the base year level. **Table 1** presents saving results for the Netherlands as provided in the second National Energy Efficiency Action Plan (NEEAP) to the European Commission. The results comprise both historic figures (2008-2010) and future/expected figures (2011-2016).

Table 1: Total energy savings per sector and year provided for the second NEEAP

PJ change	2008	2009	2010	2011	2012	2013	2014	2015	2016
	Historic				Future				
Households	-9.8	-9.9	-9.6	-16.2	-13.4	-13.5	-13.7	-13.6	-7.5
Services	-6.2	-5.1	-5.2	-4.9	-4.6	-4.1	-4.5	-4.5	-4.4
Industry	-4.7	-3.2	-5.6	-3.1	-7.8	-9.4	-10.2	-9.1	-10.7
Transport	-4.6	-3.9	-11.3	-5.2	-5.2	-5.2	-5.2	-5.2	-4.7
Agriculture	-13.1	-3.4	-4.8	-7.9	-7.8	-2.7	-3.5	-3.4	-2.9
Total end-use	-38.3	-25.4	-36.4	-37.3	-38.8	-34.9	-37.0	-35.9	-30.2

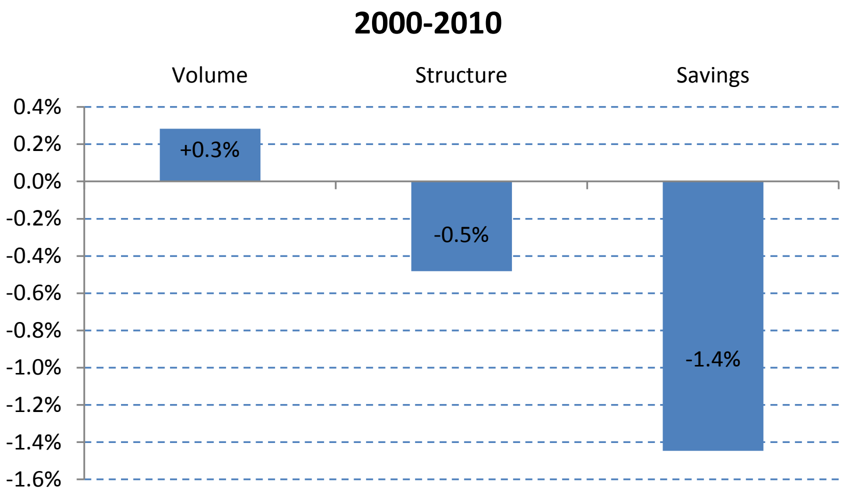
Changes in energy use can be decomposed in factors, using the simulation results

Decomposition of change in energy consumption

The trend for energy consumption is not only influenced by savings, but also by the growth of energy using activities and shifts in the type of activities, e.g. from energy intensive production of steel to energy-extensive services. Therefore, changes in energy consumption can be decomposed into a volume-effect (growth), a structure-effect (shift between activities) and a saving-effect.

A decomposition example for the observed change in gas consumption for Households is shown in **Figure 1**. The volume-effect of +0.3%/year is the increase in number of households. The structure-effect of -0.5% is due to all other factors not being savings, such as a lower occupation rate (due to more woman doing work outside the house). The savings-effect of -1.4% is due to very efficient new dwellings and insulation measures and high efficiency boilers in existing dwellings. All effects together lead to 1.6% lower gas consumption for households.

Figure 10: Decomposition of the change in historic Household gas consumption (%/year)



3.3.5 Results from multiple simulations

Simulation variants next to the base case can show effects of policy measures

Once a base case simulation is available, other simulations can be executed, e.g. a simulation without policy measures, or a simulation with different drivers (growth).

The following historic variants can be simulated next to the base case simulation:

- Variant 1: frozen technology (without penetration of saving options).
- Variant 2a, 2b, 2c, ….: without policy measure a, b, c, …
- Variant 3: without all (extra) policy.

Total and policy savings

From the differences between the variants the following results can be obtained:

- **Total savings** = Base case - variant 1.
- **Effect of specific policy** measure x = base case - variant 2x.
- **Total policy effect** = Base case - variant 3.

For each case the adjacent emission reductions can be calculated.

Interaction between policy measures

The interaction between policy measures can be quantified by comparing the effect of variant 3 with that of the sum for variants 2a, 2b, …. Because the sum of effects for all separate variants does not contain interaction results, but that of variant 3 does, the difference shows the interaction effect.

Comparison of target and realized savings only possible with adaptations, using extra simulations

Effectiveness of policy

The effectiveness concerns the question whether the realized savings meet the target. Earlier it has been shown that direct comparison between the two is hardly possible (see **Figure 6**). Effectiveness can be assessed in two ways:

- Recalculating the original scenario with the model using current socio-economic inputs, adjusting the target in conformity with changes in model savings, and comparison with the savings in the base-case.
- Simulating the base case with the inputs used in the original scenario and comparing this variant with the base case.

Efficiency of savings policy

The efficiency (or cost-effectiveness) is calculated from the ratio between saving effects and the adjacent changes in costs (investment, variable costs and energy costs). The costs can be calculated in three ways:

- National perspective: without taxes in energy prices and without subsidies, and relatively low profitability demands (discount rates).
- End-user perspective: energy prices including taxes and investments corrected for subsidies, but with short pay-back periods customary for end-users.
- Government perspective: saving effects traded against budget effects (spending on subsidies or reductions on tax-income).

Provided that these different costs are available from the model simulations, the efficiency can be calculated from the differences between the base case and variants. However, this has not been implemented yet, nor are all historic cost data available. In the ANNEX an overview is presented of all possible types of results that the new M&E tool can provide.

4

Unique results from simulation

In the following sections a number of examples will show what historic simulation is capable of. They cover different sectors and various subjects relevant to evaluation.

4.1 Correction of statistical trend breaks

A basic condition for ex-post evaluation is the availability of reliable data on energy consumption. This is especially true for the PME calculation of savings, based on indicators and energy statistics. If recent statistical data are not available the simulation approach may provide a solution.

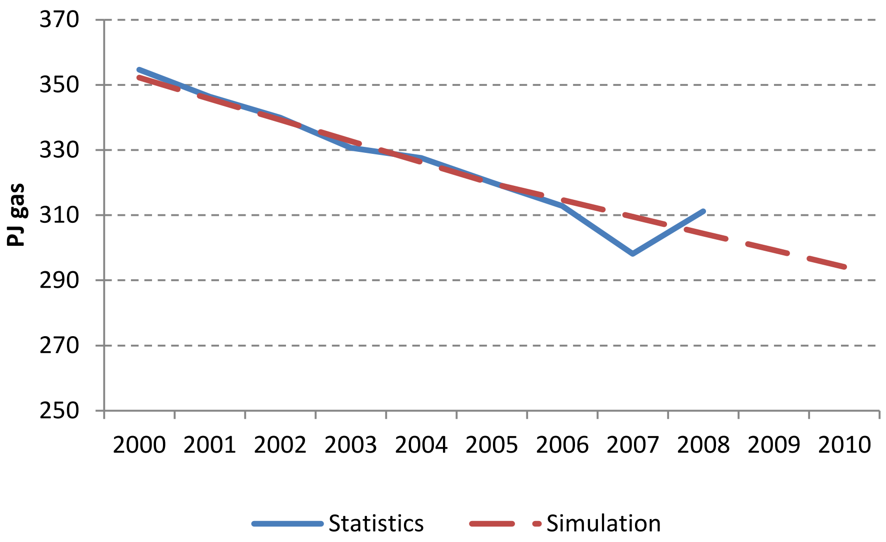
Trend-breaks in statistics can be ‘repaired’ with historic simulations

Statistics on Household energy consumption in the Netherlands are not directly observed but based on trends according to a survey for a few thousand families. Due to a change in the survey set-up a trend break in statistical data emerged (see **Figure 11**, solid blue line). Calculated savings using the PME-tool show an erratic year-to-year pattern for 2006-2008.

In the simulation approach with the SAWEC model an energy consumption trends is based on many bottom-up trends, such as number of households, dwellings and energy using systems and penetration of saving options. Normally the overall trend matches with the long term energy trend according to statistics, and statistical figures can be used indeed. But in case of a ‘dip’ in the statistical trend this is not the case, unless it can be explained by large and fast changes in the underlying drivers. Given the known and stable developments for these drivers between 2006 and 2008, the real energy consumption trend should follow the blue line in the figure.

The top-down savings, calculated on the basis of simulated past energy consumption, provide a more reliable saving figure than the one based on statistical data.

Figure 11: Gas consumption according to statistics or model simulation



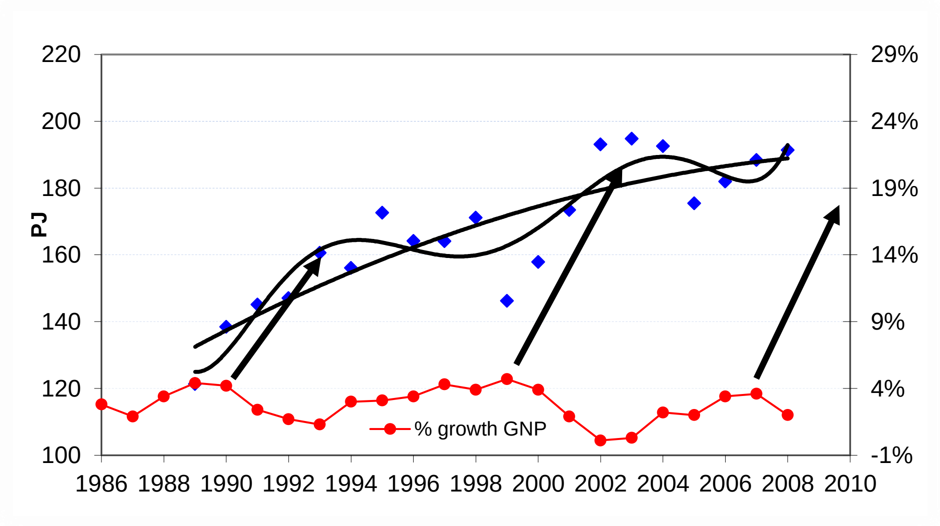
4.2 Cyclical trends in the services sector

Observed cyclical energy trends can be explained from socio-economic variations

The simulation model SAVE-Services has been fitted on historical socio-economic developments, such as employment and floor space, the penetration of energy using devices and overall energy consumption according to statistics.

The statistical gas consumption (see blue dots in **Figure 15**) shows at first sight a rather erratic pattern. However, further analysis from Sipma, 2012 reveals a regular pattern that is connected, with some delay, to variations in GDP growth. The more or less straight line shows a first-order regression line for gas consumption in case of a smooth economic trend. The second-order regression line shows an up and down pattern that can be connected to the pattern in economic growth, with some delay.

Figure 12: Statistical gas consumption and business cycles for Services



This example shows that the availability of energy consumption trends and historic trends for explaining factors in one framework allows the analysis of the causes and relationships for observed developments.

4.3 Interaction between policy measures

Since 1990 simulations have been executed for the household sector, as part of ex-ante evaluations for policy makers. After 2000 it became possible to use the same model for an ex-post analysis for the period 1990-2000. Past trends were simulated with the known actual inputs, such as number of dwellings, appliances, penetration of insulation and high-efficiency boilers, etcetera. This base case simulation was executed with SAVE-Households, an earlier version of current household models (see Boonekamp,2006).

Interaction between policy measures: combined effect lower than sum of effects

To analyse policy measure interaction the following variants have also been calculated:

- Base-case without **energy tax.**
- Base-case without investment **subsidies** on saving options.
- Base-case without **regulation** for space heating.
- Base-case without **package** of all three policies.

Regulation for space heating concerns mandatory application of insulation measures in new dwellings up to 1995 and an overall energy performance standard afterwards.

The differences between base-case and the first three variants show the effect of each of the separate policy measure types; the difference for the last variant shows the combined effect (see **Table 2**). The sum of the effects of the three separate policy measures prove to be higher than the combined effect (lowest row in table). The interaction for the three measures limits savings with 13% for gas and 4% for electricity in 2000. Assuming a continuation of the three policy measures after 2000 the interaction could be as high as 30% (Boonekamp, 2006).

Table 2: Energy savings for separate and combined policy measures for households

	1995		2000	
	Gas [PJ]	Electricity [PJe]	Gas [PJ]	Electricity [PJe]
Policy measures:				
Tax only	0.0	0.0	8.5	1.6
Subsidies only	10.1	1.5	18.1	2.7
Regulation only	6.1	0.0	19.3	0.0
(sum policy effects)	(16.2)	(1.5)	(45.9)	(4.3)
Combination of tax, subsidies and regulation	15.3	1.5	41.5	4.2

This application shows that it is possible to analyse interaction between policy measures and that interaction is not to be disregarded.

4.4 Combined ex-post/ex-ante evaluation

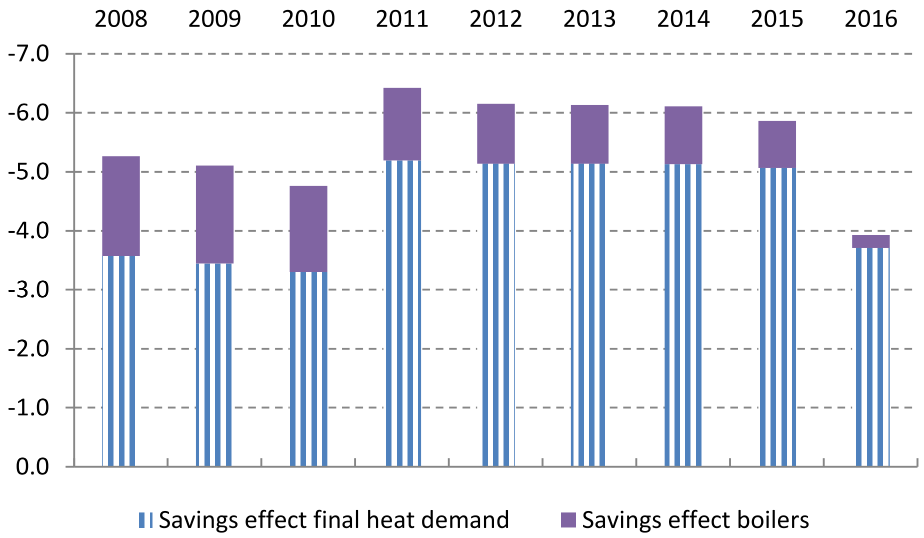
Simulation provides continuous trend for ex-post and ex-ante results

Under the ESD, EU Member States had to provide a National Energy Efficiency Action Plan in 2011 to the European Commission. The NEEAP regards savings in end-use sectors for the period 2008-2016 (excluding ETS companies), to be proven with so-called top-down methods (total savings) and bottom-up methods (additional savings).

The reporting for 2011 (NEEAP, 2011) encompasses both **ex-post** (2008-2010) and **ex-ante** (2011-2016) evaluations, which must be **combined** in order to show that the overall savings target (9% for the period 2008-2016) has been met.

A first challenge was the ex-post evaluation using the PME tool, with only complete data for 2008, but lacking statistical data for 2009 and 2010. A second challenge was posed by the recent economic crisis which might have large effects on annual savings through changes in socio-economic trends and changes in investment behaviour. Both challenges have been met by using the simulation model SAWEC. Household gas consumption for space heating was analysed, both for past (2008-2010) as well as future years (2011-2016). The savings are shown in **Figure 13**, split into savings on demand and savings for conversion in boilers.

Figure 13: Realized/expected gas savings in the residential sector



Because of the crisis the expectation was that savings would decrease due to fewer new dwellings. Normally they contribute considerably to the savings, because their gas consumption is much lower than that of the average dwelling. However, analysis of the dwelling stock revealed that there was indeed a dip in 2010, but in 2008 and 2009 actually more new dwellings were built compared to earlier years. This was due to a special program to compensate for the crisis effect on employment in the building sector. Another stabilising factor was the continued replacement of old boilers by new ones in existing dwellings. Together these developments resulted in overall historic energy savings that remained almost stable.

The same simulation showed that savings are expected to increase again from 2011 on, provided that the dip in 2010 for new dwellings would end. However, by 2014 the savings from replaced boilers are expected to decrease because the old boilers were already efficient too.

Thus the simulation approach solved the problem of statistical data not yet available for the PME savings calculations, brought new insights about savings in a crisis situation, and could couple ex-post and ex-ante results in a consistent manner.

4.5 National versus EU policy

New directive asks for national savings on top of savings due to EU policies

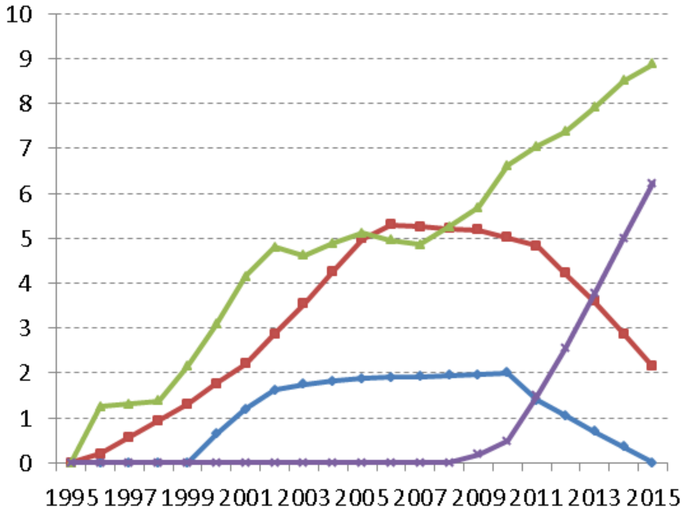
The Energy Efficiency Directive states that the realised savings in countries should be *additional*, meaning only due to national savings policy, on top of already present EU policy. Therefore, account should be taken of EU policies such as the minimum efficiency standards for appliances (Eco-design) or cars (CO_2 standards for new cars). The effect of these EU policies must be accounted for when determining the eligible national savings.

As an example, electricity consumption for households has been analysed with the EVA model and an extension that takes account of the effect of economic instruments. The electricity savings are influenced by:

- EU Directive with minimum **efficiency standards** (Ecodesign, 2009).
- Nationally introduced **Energy tax**.
- Nationally introduced **Premiums** (subsidies on selected A-label appliances).
- **Label scheme,** EU instigated but nationally endorsed.

Figure 14 shows the effects in case each policy measure were the only one present.

Figure 14: Savings of EU and national policy measures for household appliances (PJ)



The effect of the energy tax is derived from the higher electricity price and a price-elasticity, based on earlier simulations (Boonekamp, 2007). The premiums triggered a one-time market transformation for some appliances, until these appliances were replaced again. The effect of the label system increased with each vintage of new appliances but decreased when the label-appliances were again replaced (without extra savings). The Eco-design directive has a fast increasing effect from 2009 on due to the step-by-step application to new appliance types.

From 2009 on substantial overlap between EU and national policy for electricity savings of Households

The focus of this analysis is on the period 2009-2015, because interaction between EU and national policy only is present after implementation of the Eco-design Directive. From 2009 on the overlap mainly regards energy taxes that still increases after 2009 (the effect of premiums and labels is already decreasing). The standards on minimum efficiency require much more efficiency than taxes could accomplish by only influencing purchasing behaviour of households. Therefore, the additional effect of national energy taxes is zero for the appliances with Eco-design standards. There is still a saving effect for other appliances, but the additional (national) savings will decrease anyway with full implementation of the Eco-design directive.

The exact overlap between EU and national policy will be calculated after the extension to the EVA model has been implemented. However, the approach taken shows that simulation of energy use in the presence of both EU and national policy measures can take account of overlap and deliver eligible savings that are much lower than calculated without the overlap.

4.6 Electric appliances bottom-up

Efficient electric appliances are among the most important focal points of EU energy efficiency policy. From the nineties on, mandatory efficiency labels have been introduced and by 2009, minimum efficiency standards are set due to the Eco-design directive (Ecodesign, 2009).

The effects of these two policies are calculated for households with the detailed model EVA (briefly described in (EVA, 2011) that contains all electricity appliances and other devices (lighting, boiler pumps). The annual electricity consumption per appliance/device is determined by three factors:

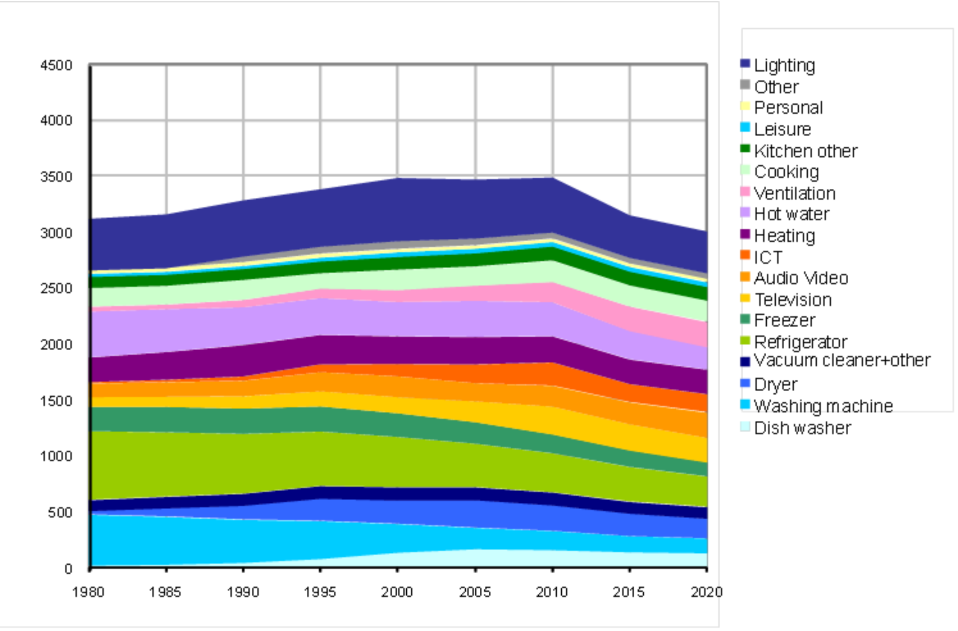
- Ownership.
- Intensity of use and performance (changes).
- Efficiency improvements.

Electricity use of households modeled in EVA by split over many appliances

Ownership is related to socio-economic trends; the intensity of use and changes in performance are only relevant for few appliances.

Because replacement of old appliances by new more efficient ones is the most important mechanism for realising savings, the model uses a vintage approach where appliances are replaced every number of years depending on the lifetimes. Therefore the simulation starts already in the past (see **Figure 15**).

Figure 15: Simulated electricity consumption per household appliance



Electricity use defined by increased ownership, replacement schedule and standards for new appliances

The detailed EVA modelling shows the diversity in the trends:

- **Stable** ownership / **large** savings: lighting, washing machines, refrigerator.
- **Stable** ownership / **limited** savings: cooking, room heating, vacuum cleaner.
- **Increasing** ownership / **large** savings: dish washers.
- **Increasing** ownership / **limited** savings: ICT, audio/video, ventilation, dryers.
- **Decreasing** ownership / **limited** savings: hot water preparation.
- **Decreasing** ownership / **large** savings: freezers.
- **Stable** ownership / **better** performance / **large** savings: TV.

The savings are dependent on development of ownership and the gradual effect of policy through replacement by more efficient new appliances. These developments are different for the past (e.g. mainly increasing ownership) and for the future (mainly savings due to standards).

This case shows that only simulation with much detail and a vintage approach can describe possible development of household electricity use.

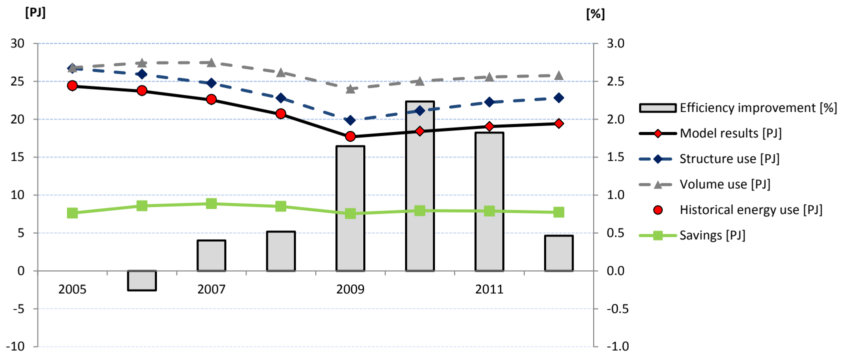
4.7 Industrial production and savings

The simulation model 'SAVE-production' simulates energy consumption of industrial sectors, such as cement, paper, iron & steel and chemicals (Daniëls en van Dril, 2007). Economic growth scenarios are converted in physical production and a demand trend per energy function (heating, drives, etc.). This provides the energy consumption trend in case no savings would be realised.

For the calculation of energy savings a 'bottom up' approach is applied with all relevant saving technologies and stocks of energy using systems that are replaced once and again. The choice for replacement with more energy efficient options is dependent on investment costs, energy prices and usual pay back times, but also on market distortions such as lack of knowledge or lack of capital. On the other hand the choice can be influenced by policy, such as subsidies or agreements that mitigate barriers.

Figure 16 shows the developments for heat demand in the Paper industry. The upper line 'Volume use' represents energy consumption if only defined by production. The difference with 'Structure use' is due to dematerialization, a decoupling between economic and physical output due to changes in the product mix.

Figure 16: Recent developments for heat demand in the Paper industry



The ‘Model results’ line is the simulated actual energy consumption, which matches observed energy consumption data. The difference with ‘Structure use’ constitutes the savings, which are separately shown.

The production of most paper products has decreased since 2005. No new paper plants, which are more efficient in general, have been built. The total number of paper plants has even decreased. The production volume of uncoated paper and writing paper was halved in 2008 following the closure of three paper plants in 2008 (VNP, 2009). This has led to a reversal of the dematerialization trends as more energy intensive/low value added production remained, leading to an increase in energy intensity, e.g. more energy use per Euro.

Savings are also dependent on changes in production (not only energy consumption)

This example illustrates that the energy savings are also influenced by increasing or decreasing production trends. A detailed simulation model is needed to show these interaction between production, structural changes and energy savings.

4.8 Up- and downward CHP saving trends

Energy savings, cumulated from year to year, normally show a non-declining pattern because realized savings cannot disappear again. For instance, insulation for existing dwellings will not be removed when energy prices decrease substantially. For most saving options the investments, once done, are ‘sunk costs’ which cannot be lowered by a reversal of the saving option.

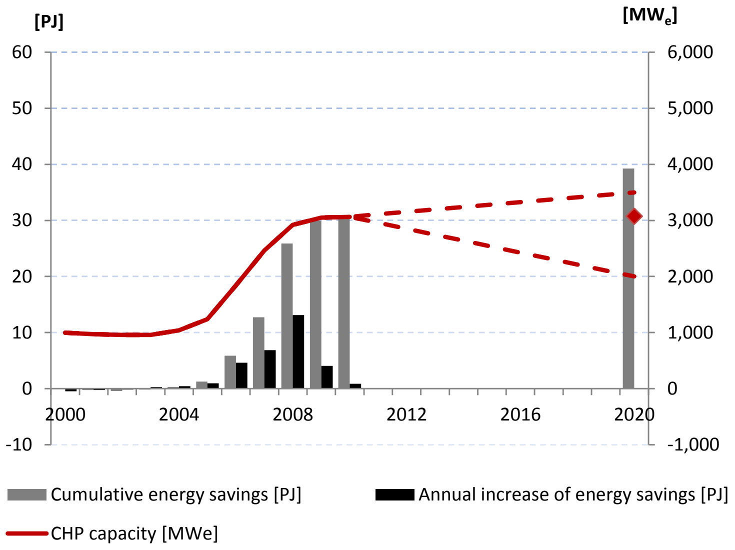
The mechanism of ‘sunk costs’ does not hold for combined heat and power (CHP) production where the cost savings can become negative if fuel costs are higher than the revenues of the production of electricity and heat. In that case it might be rational to switch back to using a boiler for heat production and purchase electricity from the grid.

An example of these dynamics is given for CHP production in the Horticulture sector in the Netherlands, analysed with the CHP-part of the SAVE-Production model. **Figure 17** shows the strong growth of CHP capacity in recent years, based on CBS, 2012. An important reason for the upward trend was the very profitable electricity production in peak hours, which could be combined with providing heat over the day by using a heat storage vessel. The extra CHP savings (black bar) have decreased since 2008 and the increase of cumulative savings (grey bars) halted in 2010[1].

CHP savings can increase fast, but can also decrease again

In the coming years negative savings can occur when the existing gas engines are removed or their electricity production reduced. Only in favourable circumstances (high electricity prices and low gas prices) the CHP capacity will increase (upper red dotted line in **Figure 17**). For low electricity prices and high gas prices the CHP capacity will decrease (lower red dotted line). The most probable trend is a stable capacity (see red marker in 2020). The most probable savings in 2020 (see grey bar) show a more favorable picture with a slight increase against 2010.

Figure 17: Capacity and savings for CHP in Horticulture in the Netherlands



The CHP case shows that for this specific saving options realised savings can disappear again due to a changing market situation. A simulation which takes account of these market situation, both for already existing and new CHP capacity, can explain the opposing trends in the past and the future for CHP savings.

4.9 Product choice coupled to savings

Energy intensity of crop types varies substantially in Horticulture

The relation between crop choice, energy consumption and energy savings in the Dutch greenhouse horticulture sector has been analysed with the SAVE-Production model. Up to 2010 the total glass area remained relatively constant (see **Figure 18**, black line). The production expressed in physical units per m^2 (see blue line) has grown since 2003 (vd Velden en Smit, 2011) and the scale of companies was increasing (CBS, 2012).

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[1] CHP savings calculated with an efficiency for electricity generation of 42.5% and for heat generation of 95%.

Within the sector, the trends depend on the type of crop. The area used for the production of vegetables (red dotted line) has grown in recent years, while the area used for growing flowers (yellow dotted line) has decreased.

There is also a continuous shift from cheaper to more expensive products (vd Velden, 2012). The larger added value of cultivation was accompanied by a higher energy intensity.

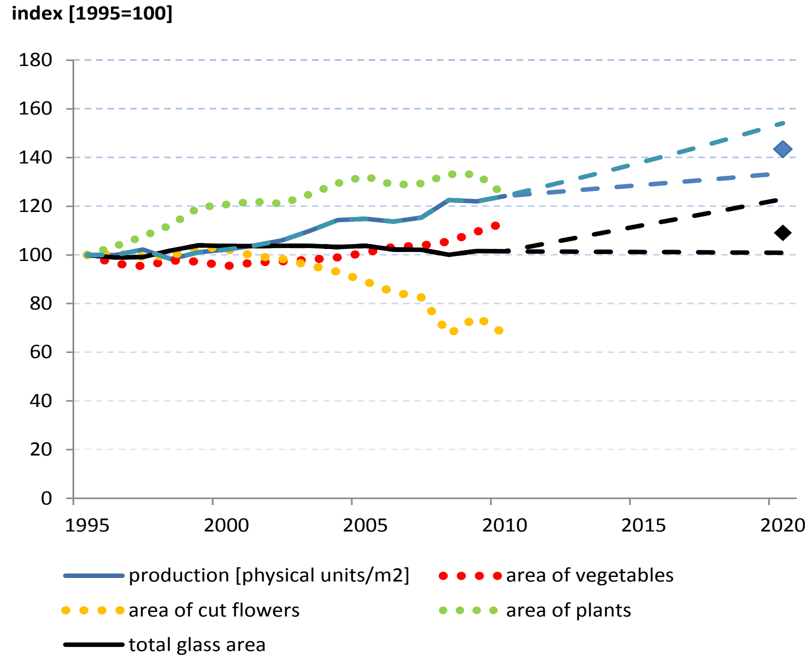
For the future, a stabilization in total glass area as well as further growth are possible (see lower and upper dotted black lines), with a slight increase for 2020 as best estimate (see black marker). The production is expected to grow, also in the case of stabilizing glass area.

The future trends, and the uncertainty margins, are the result of various factors:

- Savings options (given energy prices, investment costs and savings policy).
- Availability of (profitable) CHP for artificial lighting.
- Crop choice in relation to market opportunities.
- Crop scheduling (and lighting) during the year.

The first set of factors is valid for energy savings analysis in general, but the other factors have to do with energy supply (CHP) or with the production process.

Figure 18: Development of greenhouse glass area per crop type and production in horticulture

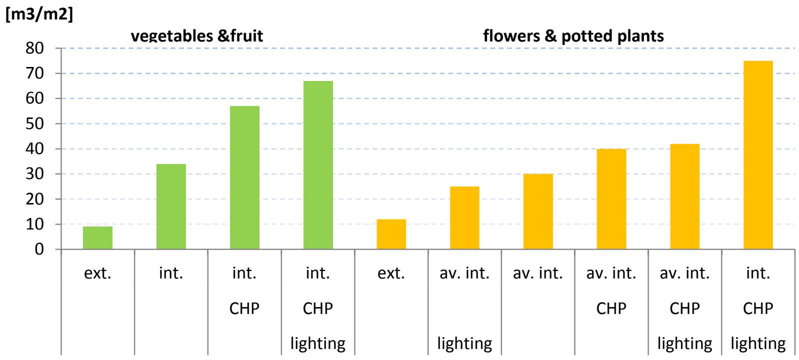


* Indices, 1995=100, source: CBS, 2012 and LEI, 2012

The energy consumption not only varies widely between crop types, but also depends on the way crops are cultivated. **Figure 19** illustrates the large differences in natural gas consumption, depending on:

- Schedule of cultivation, energy-intensive or extensive (ext/int/av.int bars).
- Use of CHP for heating (int + CHP bars).
- Use of CHP for artificial lighting (int + CHP +lighting bars).

Figure 19: Use of natural gas for different greenhouse cultivation categories



* m^3 gas per m^2
Source: Van der Velden, 2008

Product choice and energy savings intertwined in horticulture

Because there are so many factors defining energy consumption and savings, and these factors are intertwined, the analysis of trends is complex. An energy savings option, such as CHP, can have a large impact on the net energy costs. This can influence the choice of crops to be produced, which in turn will influence the energy intensity of the total production in horticulture. Only a model that not only incorporates the savings-factors, but also other relevant (production) factors can explain the past or future developments for energy savings in horticulture.

4.10 Summary contributions of simulation

Simulation not only provides energy saving figures in a different way compared to conventional methods, but it adds as well to better quality of the energy savings figures in the following ways:

- Check on statistical data and improved consumption data (section 4.2 and 4.3).
- Interaction between the effects of policy measures (section 4.4).
- Consistency for ex-post and ex-ante evaluation (section 4.5).
- National versus EU policy effects (section 4.6).
- Savings for divergent cases, through a detailed approach (section 4.7).
- Relationship between production pattern and savings (section 4.8 and 4.10).
- Negative energy savings (section 4.9).

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Appendix A. Evaluation needs that can be met

Evaluation asks for many types of results which can be met with the new M&E system

In the preceding chapters a new ex-post evaluation system and examples of possible results have been presented. It is meant to meet almost all needs of stakeholders with regard to the evaluation of energy trends and energy savings. The stakeholders constitute:

- The Dutch Government (Ministries of EZ, BZK and I&M).
- The EC (DG ENER/NEEAP and DG CLIMA/NRF).
- European projects (Odyssee indicators).
- International organisations (IEA and UNFCCC).

Results that can be provided with the new M&E system

1. **Energy balances:** historical figures for all combinations of sectors and energy carriers, original statistics or figures corrected for yearly climate variations.
2. **Trends:** for historic energy consumption, for a flexible period from 1990 on. For each combination of (sub)sector and energy carrier, statistics or corrected for yearly climate variations
3. **Decomposition** of the change in historic energy consumption to show underlying causes: volume (growth), sector structure (composition of economic activity), fuel substitution and energy savings (end-use, CHP and supply side)
4. **Intensities:** relation between energy consumption and socio-economic quantities, such GDP (national), Value Added (industry) or person-km/ton-km (transport)
5. **Total savings** realized savings at sector and national level: compared to a chosen base year, including demand/supply interaction (see PME)
6. **Missing indicator-based savings:** calculation of savings for targeted energy uses where no appropriate indicators are available (e.g. sector Services)
7. **Saving figures in different formats:** in final or primary terms, for ETS and non-ETS sectors, in format of Odyssee-project, IEA-indicators, EEA-reporting, etc.
8. **Renewables as savings**: counting of renewables-behind-the-meter (e.g. PV) as part of savings (on delivered energy) or separate.
9. **Broader defined savings:** choice between ‘technical’ savings and ‘system’ savings including dematerialization (thinner beer cans), behavior (lower thermostat setting) or societal norms (less car driving)
10. **Savings fitting to a specific target**: National target for *total savings*, ESD target of *end-use savings* of 9% in 2008-2016 (excluding ETS sectors , savings to meet the EED *energy consumption ceiling* for 2020 (-20% against BU trend for the EU) or the EED target of 1.5% *additional savings* per year as part of the savings obligation)
11. **Emission reduction due to savings**: integrated picture of energy consumption, savings and emission reductions (CO_2)
12. **Policy savings**: effect of individual policy measures or a set of implemented measures with their interaction

13. **Autonomous savings**: difference between total savings and policy savings, to be defined in agreement with users of the results.
14. **EU- versus national savings**: separate effect of implemented EU policies versus national policy measures
15. **Total versus policy savings**: consistent results for total, policy and autonomous savings
16. **Corrections on savings:** corrections on the gross savings of implemented policy measures for free riders (subsidized saving measures that would have been taken anyway), free drivers (ongoing effect of ended subsidy scheme due to market transformation) and rebound/take back effect (spending part of lower energy bill due to savings on new activities that use energy)
17. **Common format for ex-ante and ex-post results**: same <u>format</u> for expected savings (target) and realised savings
18. **Comparable ex-ante and ex-post results**: adaptation of target, or realized savings, to compare original target and realized savings when the situation has changed in the meanwhile.

Improvements for the evaluation process.
Next to the content the new evaluation system also contributes to improvements for the evaluation process.

Faster results:
realised savings, calculated with indicator-based methods like PME, are only available almost two years after the most recent year with figures has ended. The new evaluation system based on simulation could provide results one year earlier.

Stable saving figures:
the intrinsic uncertainty in year-to-year saving figures, calculated with indicator-based methods, often leads to strongly varying or negative year-to-year savings. This can be avoided through the detailed bottom-up simulation approach, where year-to-year savings can only vary in accordance with changes in the penetration of concrete saving measures (which is often not the case).

Trade-off costs – usefulness:
current monitoring and evaluation methods rely strongly on data collection. Without a complete data set it is hardly possible to provide results on realized savings. The new evaluation system uses simulation models which incorporate much expert knowledge on trends at every level: penetration of saving measures, subsector activities and energy demand, energy consumption per sector, etc. Even without complete yearly monitoring data on every item mentioned it is possible to estimate realized savings. However, the more monitoring data are available, the higher the quality of the saving figures provided. In this way the trade-off between effort for monitoring & evaluation and quality of results can be made visible.

ECN
Westerduinweg 3
1755 LE Petten
The Netherlands

P.O. Box 1
1755 LG Petten
The Netherlands

T +31 88 515 4949
F +31 88 515 8338
info@ ecn.nl
www.ecn.nl