Uncertainty analysis in energy savings calculations

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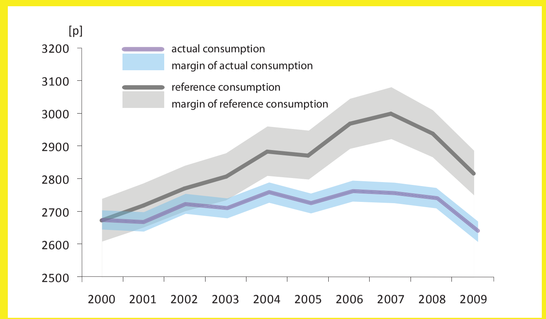
Calculating savings top down

Calculating top down savings is based on comparing reference (based on the development of activies) and actual energy consumption. The absolute savings are the difference between the actual and reference consumption in a certain year. The average annual relative savings are calculated using the ratio between the absolute savings and the reference consumption.



Both reference and actual energy consumption have statistical uncertainty margins.

Three possible causes for uncertainty

The way energy savings are calculated, by comparing the development of energy consumption to the related activity, leads to three possible types of uncertainty:

1. Uncertainty in energy **usage data**
2. in **activity data**
3. and in the **appropriateness** of the selected activity as a measure of energy consumption

The uncertainty in the appropriateness has been estimated and applied in the past, but the current calculation only takes the error in statistics into account.

Why calculate uncertainty?

- Savings can only be said to be statistically significant if reference and actual energy consumption are far enough apart
- Getting an idea of the precision of the result. This is important for monitoring if a target needs to be met.
- Discovering where the largest uncertainties originate

How to calculate uncertainty margins?

Errors are assumed to be independent. With this, the applied formulas for error propagation can be written as follows:

Function	Variance
f = aA	$\sigma_f^2 = a^2\sigma_A^2$
f = aA ± bB	$\sigma_f^2 = a^2\sigma_A^2 + b^2\sigma_B^2$
f = AB or f = A/B	$\left(\frac{\sigma_f}{f}\right)^2 = \left(\frac{\sigma_A}{A}\right)^2 + \left(\frac{\sigma_B}{B}\right)^2$
$f = aA^{\pm b}$	$\left(\frac{\sigma_f}{f}\right)^2 \cong b\left(\frac{\sigma_A}{A}\right)^2$

Where A and B are variables with standard deviations σ_A and σ_B, and a and b are precisely known constants.

The second rule shows that adding sectoral results leads to a lower uncertainty at the national level.

The last rule leads to lower uncertainty for the average yearly savings. Here, A is the ratio between the reference and actual energy consumption, and b is a number smaller than 1, namely 1 divided by the number of years since the base year.

Uncertainties for savings in the Netherlands

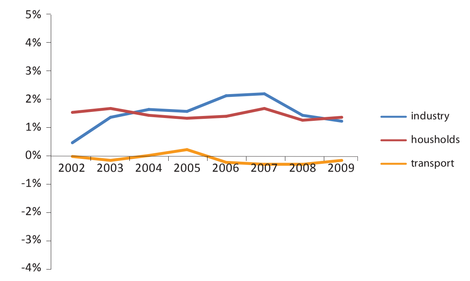
The Protocol Monitoring Energy Savings encompasses all aspects of the Dutch energy system: demand side, supply side and CHP.

The largest uncertainties are found in the end use sectors.

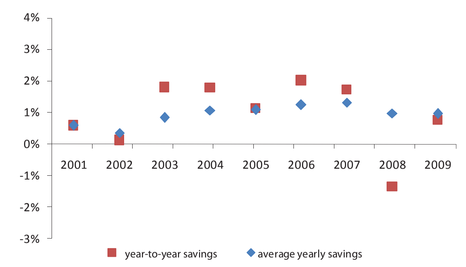
Uncertainties in source data (95% confidence interval):

Sector	Final consumption	Activity in sub sectors
Industry	1.6%	3-10%
Transport	2.0%	2-7%
Agriculture	6.2%	2-7%
Services	6.2%	- (no savings calculated)
Households	2.9%	3-7%

Dealing with uncertainty



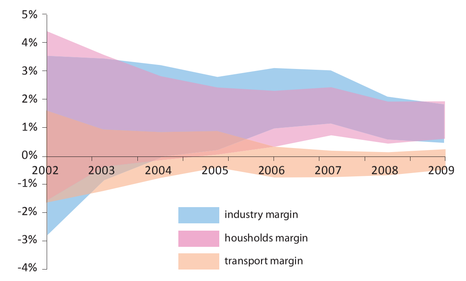
Calculated yearly average savings per sector – are savings really different?



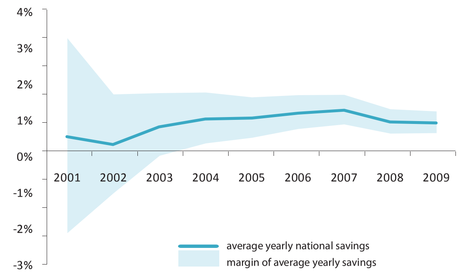
National year-to-year savings and average yearly savings

Averaging leads to a more stable and reliable picture

Results



Margins of yearly average savings per sector



National savings with uncertainty margin

Margins decrease because of averaging, see rule 4 at the top right

Conclusion and Discussion

- Uncertainty analysis shows that, due to the magnitude of the margins in both energy consumption and activity data, savings only become significant after a couple of years past the base year
- The further from the base year, the lower the uncertainty margins in the energy savings figures become
- As an indication of the order of magnitude: about 7 years after the base year 2000, the margin of the Dutch energy savings figure is +/- 0.3%, compared to around 1% average annual savings.
- Only after a couple of years can it be shown that Transport savings are significantly lower than savings in Industry and Households

- Meaningful statements about better or worse energy savings compared to earlier results are only possible when taking uncertainty margins into account. In practice year-to-year changes are most often not significant.
- Comparing savings results between sectors or countries should include uncertainty margins
- It would be useful to include uncertainty margins in reported savings results, as an indication of the probability that a target has been met.

Where to find the source data margins?

- Expert judgement by Statistics Netherlands (CBS)
- Largest uncertainties are found in end use sector data, not in supply side data

Effects of the error propagation rules

- The national savings figure has a lower uncertainty than sector figures because aggregation diminishes uncertainty
- Averaging savings over a longer period leads to lower uncertainty because of the way uncertainty behaves in exponential growth

Acknowledgements

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References

- Protocol Monitoring Energy Savings (Boonekamp et al., ECN-C—01-129, in Dutch)
- Uncertainty in energy savings figures (Gijsen, Boonekamp, RIVM report 773001030/2004, in Dutch)