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The Nordic Ecodesign Effect Project

Estimating benefits of Nordic market surveillance of ecodesign and energy labelling

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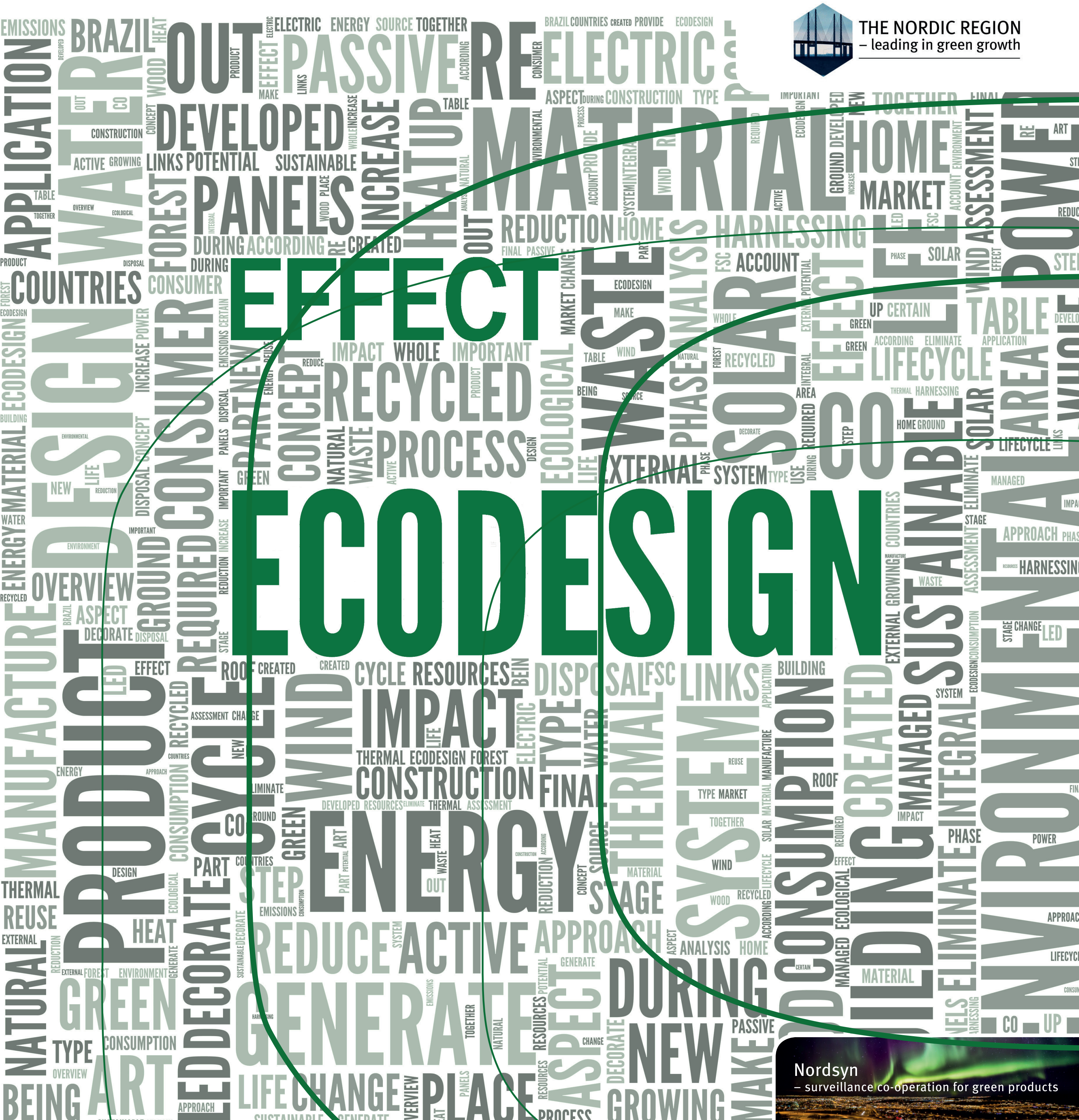

Nordsyn
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Troels Fjordbak Larsen

TemaNord 2015:563

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ISBN 978-92-893-4298-8 (PRINT)
ISBN 978-92-893-4300-8 (PDF)
ISBN 978-92-893-4299-5 (EPUB)

http://dx.doi.org/10.6027/TN2015-563
TemaNord 2015:563
ISSN 0908-6692

Layout: Hanne Lebech
Cover photo: ImageSelect

Print: Rosendahls-Schultz Grafisk
Printed in Denmark

This publication has been published with financial support by the Nordic Council of Ministers. However, the contents of this publication do not necessarily reflect the views, policies or recommendations of the Nordic Council of Ministers.

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A project with the aim of estimating the magnitude of lost energy savings due to non-compliant energy using appliances on the Nordic market (Iceland, Finland, Norway, Sweden and Denmark) and subsequently assess the achieved benefits and costs of market surveillance has been carried out for test data for the period 2011–2013.

The results indicate a saved energy loss measured in EUR at around 28 million for a market surveillance cost of around EUR 2.1 million – i.e. a factor of 13 in the return on investment (ROI). These results are highly depending on assumptions of various kinds – see the discussion chapter.

After a short introduction, a description of the data collection and calculation methods established in the pilot study are given in the second chapter. For more details see Annex I.

In chapter 3, the main project calculation steps are described. Together with the main results, a comprehensive discussion of assumptions is given in the final chapter 4, also including some recommendations to future improvements of the work.

This report addresses professionals with in-depth experience within the fields of evaluation, modelling, market surveillance, ecodesign and energy labelling.

This report is part of Nordsyn and the Nordic Prime Ministers green growth initiative under the Nordic Council of Ministers. See more on www.norden.org/greengrowth

1. Introduction

The Ecodesign and Energy labelling directives are estimated to provide a 5% reduction in energy consumption in Europe by 2020. A condition for this result to be achieved is that all products put on the market comply with the requirements for the actual product group.

The national market surveillance authorities (MSAs) for Ecodesign shall monitor and verify that the products on the market are compliant. Well-functioning market surveillance will guarantee fair competition and protect consumers from defective products.

Alarmingly, the Commission review of the Ecodesign directive in 2011 estimated that 10–20% of products covered by implementing measures are non-compliant. Comprehensive market surveillance would have led to full compliance, so in reality inefficient market surveillance has opened up for this 10–20% non-compliance.

Deriving from the Commission estimations, Sweden has previously made this very simple calculation of what lack of market surveillance can lead to: Ecodesign and Energy Labelling are estimated to save a total of around 400 TWh per year in 2020 on EU-level, regarding adopted regulations. With the Commission estimation that, say 10% of the savings from Ecodesign and Energy labelling can be lost due to lack of market surveillance, energy savings around 2 TWh per year in 2020 will be lost for Sweden in 2020, if the market is not well controlled. (400 * 0.1 * 0.05, where 0.05 is the Swedish part of the electricity use in EU).

1.1 Pilot project

Before a fair conclusion about lost energy savings and the (cost-) effectiveness of market surveillance in the Nordic region could be taken, it was decided that the Swedish figures needed both to be refined and broadened to a Nordic scope. Furthermore, the specific accrued expenses of market surveillance should be collected.

In order to make sure the needed data for these objectives could be collected, it was decided to conduct a pilot project before the main project was carried out, with the objectives to establish a first proof of concept regarding an improved calculation method for the estimating the effects of non-compliance in the Nordic region, and to get an overview of available data sources, i.e. conducted appliance tests and data collected during these tests.

1.2 Main project

The pilot project concluded that data was available, and that an improved calculation method was established, so it was decided to carry out the main project with the objectives to apply the available data and do the effect estimation and compare it with estimated costs.

The final available data was rather sparse, both in terms of lab test results, and the costs of the lab tests, but the project managed to come to conclusions about the effects and cost-benefit ratio after all.

2. Pilot project results

2.1 Calculation method

The estimate for lost savings was as a first approximation set to a simple non-compliance *rate* (10) multiplied by the *estimated savings* (400 TWh for EU). Both of these figures are highly uncertain. And the idea of just multiplying the two introduces a new error, since the non-compliance (NC) rate says something about *how many*, nothing about *how much*, in terms of how much off the efficiency limit, the non-compliant products are.

A more refined calculation approach would in words be: to include an estimate of how big deviation (in annual consumption) the non-compliant appliances introduces, compared to a standard purchase (which has to be defined). Multiplied by the non-compliance rate for the particular product group, and the annual sales volume in the target year (say 2013), the annual energy savings loss per product group will be obtained. Multiplying by product specific lifespan, the total lifespan loss is calculated. Summing up over all product groups and all Nordic countries, a Nordic estimate for lost savings is calculated.

In symbols:

$$\mathrm{E} = \sum_{j=1}^{Countries} \sum_{i=1}^{Products} \left(CNC_{ij} - CC_{ij}\right) * R_{ij} * S_{ij} * L_i$$

E Estimated lost energy savings.
CNC_{ij} Average annual consumption of non-compliant appliances, product group i, country j.
CC_{ij} Average annual consumption of standard purchase (compliant appliances),[1] product group i, country j.
R_{ij} Average non-compliance rate, product group i, country j.
S_{ij} Sales in target year, product group i, country j.
L_i Lifespan, product group i.
i 1..cirka 40 product groups regulated.
j Nordic countries (Sweden, Denmark, Norway, Finland, Iceland).

[1] In fact two levels could be used here; the standard purchase value calculated as a sales weighted value OR a value just meeting the limit, the latter being realistic in terms of what the producers often aim for. Also, the non-compliant purchase is probably a cheap product, for which an alternative purchase probably would have been another cheap product just meeting the limit.

For the main project it was suggested that all 4 combinations of metrics (i.e. standard purchase = limit or average, and with/without full lifespan) should be calculated, in order to see the magnitude of variations.

2.2 Available data

A spread sheet template was circulated amongst the Nordic countries, to draw up a simple list of available data sources and their most important attributes (scope, product group, sample size, year, selection method, discloseable …). Firstly this list would be on conducted laboratory tests (or documentation tests – if quantifiable measures could be extracted, e.g. specified power levels in different operating modes) based on some kind of random selection of appliances within a product group. Secondly, inputs on data sources for average annual consumption of compliant appliances, sales and product lifespans were welcome. And thirdly, indications on availability of market surveillance costs (preferably in the target year(s)) were asked for.

The pilot project resulted in a preliminary metadata collection of some central parameters describing the performed market surveillance activities since 2009 in the Nordic countries. The data were then compiled and discussed at a meeting in December 2013. A problem area was detected at the meeting; the surveillance was often not based on random sampling. The overall results and the way to handle non-random sampling are described in 2.3.

The specific sought parameters were:

Table 2.1: Collected data for each surveillance activity

Parameter	Description
Country	
Scope	If the activity was conduction in (L)aboratory or on product (D)ocumentation
Program	(E)codesign or (L)abelling, or (B)oth
Product group	Dishwashers, Washing machines, etc.
Sample size	The number of elements in the test sample
Year	
Selection method	If it was random, handpicked or a combination
Discloseable	If the collected data could be shared in the group
Known expenses	If the costs of the activity was known
Comments	Any extra comments to the activity

The collection gave these totals:

Table 2.2: Total for conducted surveillance activities

Product group \ Country	DK	FI	IS	NO	SE	Sum
Air conditioning	129				6	135
Air conditioning – air-to-air heatpumps					4	4
Dish Washers	40				6	46
Electric motors	78				20	98
Electric ovens	17				17	34
Electronics			1,077			1,077
External power supplies	77	8			15	100
Freezers				10		10
Refrigerators	147			10	57	214
Standby products	84				5	89
Televisions	70	5	50		15	140
Tumble driers	32	6	70	3	24	135
Washing machines (laundry)	40	56		4	17	117
Washer-driers				1	4	5
Lighting – Ballasts	30					30
Lighting – Light sources	10					10
Lighting – Luminaires	15					15
Lighting – Lamps	15				60	75
Lighting – LED-lamps	20					20
Lighting – Tertiary lighting					16	16
Lighting – Household lamps					15	15
Lighting – CFLs		13		10		23
Lighting – Light bulb			91			91
Sum	804	88	1,288	38	281	2,499

In total almost 2,500 appliances have been tested since 2009 in the Nordic region. The dataset can be sub-setted in many ways, e.g. if it is decided only to use more recent test. Only allowing data from 2011 and on, the samples are reduced to about half:

Table 2.3: Totals, when discarding of surveillance activities before 2011

Product group \ Country	DK	FI	IS	NO	SE	Sum
Air conditioning	119				6	125
Air conditioning - air-to-air heatpumps					4	4
Dish Washers	25				6	31
Electric motors	78				20	98
Electric ovens					6	6
Electronics			300			300
External power supplies	77	8			15	100
Refrigerators	98				23	121
Standby products	84					84
Televisions	70	5	50		15	140
Tumble driers	22	6	70		7	105
Washing machines (laundry)	30	56			7	93
Washer-driers					4	4
Lighting – Ballasts	10					10
Lighting – Luminaires	15					15
Lighting – Lamps	15				60	75
Lighting – LED-lamps	20					20
Lighting – Tertiary lighting					16	16
Lighting – Household lamps					15	15
Lighting – CFLs		8		10		18
Sum	663	83	420	10	204	1,380

Looking only at laboratory tests, the data pool is reduced to these figures:

Table 2.4. Totals for laboratory test since 2011

Product group \ Country	DK	FI	NO	SE	Sum
Air conditioning	21			6	27
Air conditioning – air-to-air heatpumps				4	4
Dish Washers	5			6	11
Electric motors	41			20	61
Electric ovens				6	6
External power supplies	25	8		10	43
Refrigerators	29			23	52
Standby products	19				19
Televisions	30	5		15	50
Tumble driers	10			7	17
Washing machines (laundry)	10			7	17
Washer-driers				4	4
Lighting – Lamps	15			60	75
Lighting – Tertiary lighting				16	16
Lighting – Household lamps				15	15
Lighting – CFLs		8	10		18
Sum	205	21	10	199	435

This means less than 20% of the samples are left. In practice, the documentation-based samples can be valid for the calculations, thus considered conservative contributions to the results, since the producer information must be expected not to be disadvantageous for the appliance performance. Still some breaches of the regulations are seen in from the documentation, since the producers simply do not have sufficient knowledge about the regulations in force.

For more details about the data collection, see Appendix I.

2.3 Dealing with handpicked sampling

Sampling is used to, based on a subset of data, to say something about a whole population. E.g. a sample of washing machines is examined, to say something about all washing machines on the market. *Random sampling* is when the sample is selected randomly, and the probability of picking any given sample can be calculated. When applying a non-random, or handpicked sample, the probability approach is no longer valid (since the sample is pre-determined) and the representativity of the sample for the whole population is destroyed.

In many situations it is still chosen to perform non-random/judgmental/handpicked/targeted sampling. This is often the case for market surveillance, where products suspected to be non-compliant with the regulations are selected. This is because a general picture of the market situation in terms of a non-compliance rate is not the primary goal, but instead a specific wish and obligation to monitor, and eventually get rid of the illegal products through contact to the producers of the non-compliant products that occur.

Still, can this handpicked sample say something about the whole market situation, with regards to compliance rates? The simple answer is no. But in practice, this is the knowledge about the market that is at hand. Assumptions must then be introduced, in order to extract any information about the market from the targeted sampling. Also, in some cases the hand-picked samples are supplemented by a small random sample from the remainder of the market. How can this be included? In the following paragraphs the cases are described and suggestions to calculation methods specified.

2.3.1 Three basic scenarios

The sampling can be divided into three different categories:

1. Pure random sample.
2. Only handpicked.
3. Mixed random and handpicked.

Below is assumed a total population (market) of N elements (i.e. different models on the market that all could be relevant to test), a sample size of s (s_1 and s_2 for the mixed situation) p is the number of elements in the sample found not to be compliant (p_1 and p_2 in the mixed situation) and P is the rate of non-compliance for the whole market, i.e. the targeted estimator we want to be able to calculate.

In each sample the elements are examined with regards to compliance with the regulation. The reason for non-compliance can be different things, but to keep it simple, we are only looking at compliant or not in energy use/efficiency (i.e. only how much the energy use/energy efficiency differ from the ecodesign limit or the given energy label, not considering energy loss due to much standby-usage, failing to go into standby/off-mode quickly enough etc). Other kind of non-compliance like documentation lacks, to high noise levels etc. are not included in this calculation.

1. Pure random sample

In this case, the statistical theory can provide us directly with a predictor, since we have a sample that follows the Binomial distribution (compliant or not). Hence, the estimate for a non-compliance rate for the whole market N is:

P = p/s, p = number of non-compliant elements in the sample size of s, and the total number of non-compliant elements are N*P.

2. Only handpicked

In this situation, the sample cannot be said to follow a probability distribution. We have to introduce an assumption: the handpicking is effective and based on specific knowledge, leading to the assumption that all picked elements are non-compliant as default. The rate P for the whole market N is then:

P = p/N, p is the number of elements in the sample found not to be compliant

Comments to this assumption: if p<s (i.e. not all handpicked elements were non-compliant), this could mean that the handpicking is not fully successful, i.e. some non-compliant elements have escaped the surveillance and are still to be discovered, OR that there is only p non-compliant elements among the N. The latter is the situation expressed in the formula. If p=s (i.e. all in the sample are non-compliant) the first situation, that some could have escaped is emphasized, since all are non-compliant in the sample, and the sample size then could be limiting the picture of how many non-compliant elements there really are. Therefore, if assuming effective handpicking, getting close to all elements being NC in the sample, this somehow weakening the reliability of the predictor formula as it is less and less certain that all NC elements are cap-

tured. In this situation, a supplementary sampling should be conducted (which is often the case in practice).

The total number of non-compliant elements is thus P*N = p.

3. Mixed random and handpicked samples

In the mixed situation, the calculation/estimation formula becomes a bit more complicated. If we build on the previous assumptions and terminology, the situation is now that we still have a presumably effective handpicking of s_1 elements of which p_1 are non-compliant, and then a supplementary random sample of s_2 of which p_2 are non-compliant. So the handpicking is effective, but may leave some out to be caught in the extra sample.

The overall rate of non-compliance for the whole market of N elements, are then still $P=p_1/N$ but now with a contribution from the random part, Q. I.e.:

$$P = p_1/N + Q$$

The situation of the random sampling is now based on $N\text{-}s_1$ elements. For those, the predictor for the rate of non-compliance must be:

$$Q = p_2 / s_2$$

But the random sample only accounts for the share $(N\text{-}s_1)/N$ of the market. In order to add up the two factors, this weight must be applied:

$$P = p_1/N + (N\text{-}s_1)/N^* p_2 / s_2, \text{ or}$$
$$P = (p_1 + (N\text{-}s_1) * p_2 / s_2)/N$$

To test the formula, we can see that the two extremes converge towards the two previous formulas. I.e.:

if no handpicking, $s_1 = 0$, we have:
$P = (0 + (N\text{-}0) * p_2 / s_2)/N = p_2 / s_2$, as we saw earlier, and
if no random sampling we have , $s_2 = 0$, i.e. $p_2 = 0$,
$P = (p_1)/N$ as we saw earlier.

Another extreme situation is when all in the handpicked and random sample are non-compliant. Here we get:

$P = (p_1 + (N\text{-}s_1))/N$, and since $p_1 = s_1$,
$P = 1$

This is exactly what to expect.

The total number of expected non-compliant elements for the market N is then $N * P = p_1 + (N-s_1) * p_2 / s_2$

> **Example**
>
> In a market surveillance test of washing machines, 7 out of 10 handpicked machines were non-compliant. A random sample of 20 out of the remaining 490 machines on the market showed 1 non-compliant machine. The resulting estimate for the overall non-compliance rate for washing machines is then
>
> $P = (7 + 490 * 1 / 20)/500 = 31.5/500 = 0.063$ or 6.3%

2.4 Energy consequences of non-compliance

The non-compliance rate and expected number of appliances for a specific product group can be estimated using the above mentioned formulas. In order to estimate the total energy effects of non-compliant appliances, also the energy deficit between non-compliant and an alternative compliant appliance must be estimated. There are normally two ways an appliance can be energy non-compliant: it can be using more energy (E_{NC}) than a given MEPS (minimum energy performance standard) require (E_{limit}), or it can be labelled wrong, i.e. it consumes more energy than the attached label indicates. For each of these situations, an energy "penalty" (i.e. the actual amount of wasted energy, due to lesser savings than expected) must be settled.

I. Non-compliance with MEPS

In the case of non-compliance according to a minimum limit there are two reasonable scenarios to consider in this situation. Either the alternative, compliant appliance would have been a "standard purchase", i.e. a sales weighted average purchase, with a corresponding annual consumption E_{SP}. The energy "penalty" E_P is then the difference:

$$E_P = E_{NC} - E_{SP}$$

OR the alternative purchase would have been of such a kind that just meets the MEPS limit, the argument being that the non-compliant appliance probably was cheap, and the consumer would have bought another cheap product, just compliant, if the non-compliant appliance was removed from the market. Then the penalty would be:

$$E_P = E_{NC} - E_{limit}$$

This would typically mean a lesser penalty.

It is suggested that both penalty values are calculated where data are available, to get an indication of the robustness of the total loss of energy savings, due to MEPS non-compliance.

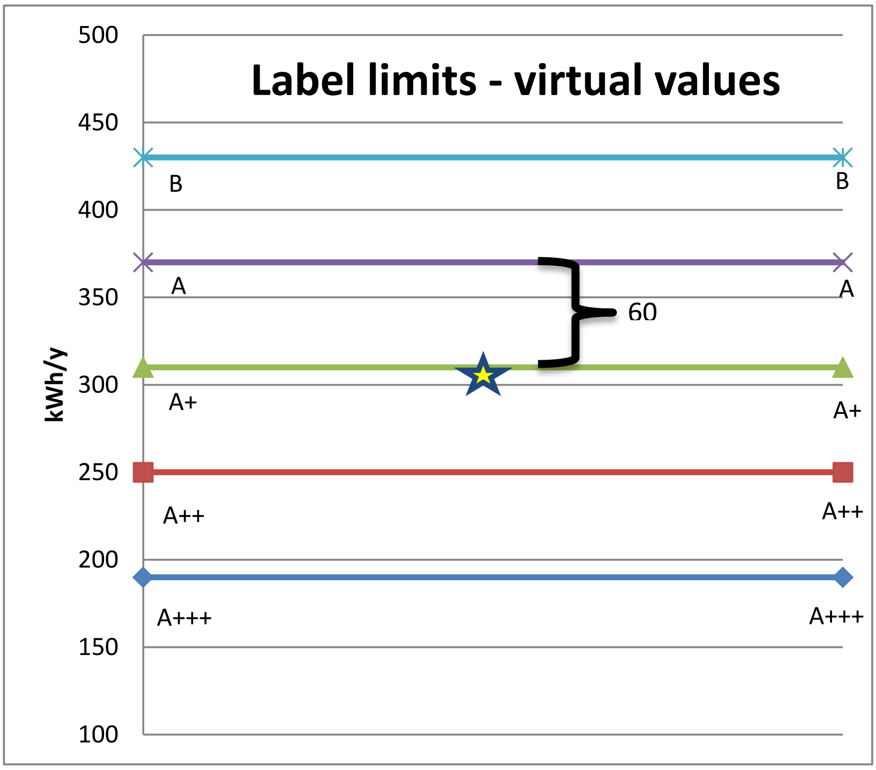
II. Non-compliance with labelling

In case of wrong labeling, the penalty is evidently the difference from the actual measured energy consumption and down to the limit for the declared (but false) class:

$$E_P = E_{NC} - E_{Class\ X\ imit}$$

In case of not having the measured consumption available in the surveillance data, experience suggests that the correct energy class is the lower neighbor energy class, i.e. D instead of C, B instead of A etc. The energy penalty would thus be, as a first approach, the difference between energy midpoints of the two relevant classes. In order to ensure a conservative estimate for the NC effect, it is suggested to use half of the difference, since the actual consumption in principle could be anywhere in the range between the two class limits:

Figure 2.1: Label limits and effect of NC



In the shown figure 1, the NC-appliance has claimed an A+ label (the Star marker), but the lab tests have shown it only qualified for A. The full range between A-limit and A+ limits are 60 kWh. In this example, a fair assumption is to say the real consumption is in average 30 kWh away from being A+ labelled.

So it is decided to use this formula in the main project:

$E_P = (E_{NC} - E_{Class\ X\ imit})/2$

2.5 Lifespans

The effect of a non-compliance purchase has not only an impact in the year of the purchase, but as long as the appliance is in use. Therefore, in the formula for the non-compliance effects, the lifespan of each appliance type is included, in order to capture the effect for all of the years the specific appliance uses energy. In the following, a generalized example of how the stock is affected is presented:

As an example, we have an appliance with sales around 100,000 pieces per year. The average longevity is 4 years with a spread of ½ a year. 6 years later, a regulation is coming into force, leading to a NC-rate of 10% in the annual sales. In numbers this looks like this, for the sales:

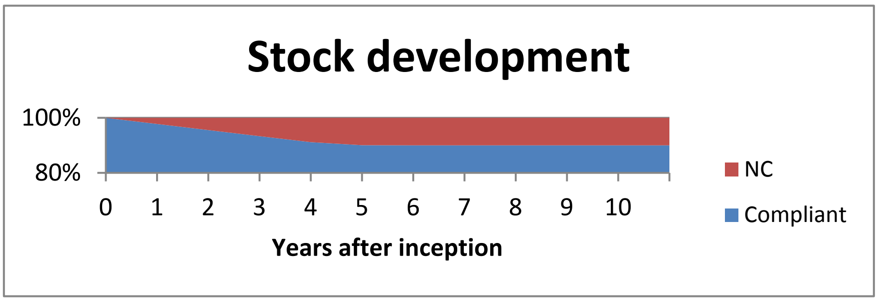
Years after legislation	-6	-5	-4	-3	-2	-1	*0*	1	2	3	4	5	6	7	8	9	10
Compliant	100,000	100,000	100,000	100,000	100,000	100,000	*90,000*	90,000	90,000	90,000	90,000	90,000	90,000	90,000	90,000	90,000	90,000
NC	0	0	0	0	0	0	*10,000*	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000
NC rate	0	0	0	0	0	0	*0.1*	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1

For the stock, this development is seen, in numbers:

Compliant	100,000	200,000	299,997	397,722	447,722	449,997	440,000	430,000	420,000	410,228	405,228	405,000	405,000	405,000	405,000	405,000	405,000
NC	0	0	0	0	0	0	10,000	20,000	30,000	39,772	44,772	45,000	45,000	45,000	45,000	45,000	45,000

And graphically:

Figure2.2: NC-Stock development



So after circa 5 years, depending on the spread of the lifespan, the share of NC's in the *stock* saturates – i.e. the number of NC-appliances being sold outbalances the number disposed from the stock.

Still, this non-compliance effect will not be fully realized until end of the last year of the lifespan, so in order to see realized annual effects, a calculation without the multiplication with lifespans is also needed. But that will then need to be aggregated, according to the figure, since the second year will include NC-appliances sold in both first and second year etc. In the actual case, a simple multiplication with lifespan is used, when calculating the full lifespan effect.

2.6 Cost and benefit calculations

In order to convert the calculated non-compliance effects in terms of lost energy savings into economic effects, some final assumptions about this are made in this chapter.

For the end-user, the cost of purchasing a non-compliant appliance will be the energy price $P_{end\text{-}user}$ multiplied by the identified *energy penalty*. I.e.:

$$C_{end\text{-}user} = E_P * P_{end\text{-}user}$$

where the price may vary from sector to sector and in time (depending on different tax levels). An annual average will be used.

For the society, another price can be calculated. In fact, the marginal extra energy use may cause the need for enlargement of the power supply, infrastructure etc. These costs are very difficult to estimate. A more simple approach is to calculate the more marginal extra costs of the primary fuel needed to produce the energy, and the costs of the extra CO_2 emissions it has led to, depending on the production efficiency. I.e.

$$C_{marginal} = E_P * (k*P_{fuel} + e*P_{CO2})$$

where k is the conversion factor from secondary to primary energy (normally set to 2,5 for electricity), P_{fuel} is the fuel price, e is the average CO_2 emission factor in kg per produced energy, and P_{CO2} is the price for emitting 1 kg of CO_2. All factors can be settled per country. This calculation is however not done within this project.

If it on the other hand is assumed that the market surveillance efforts – in time – leads to full compliance, the costs for the society is only the costs of the market surveillance. I.e.

$$C_{society} = \sum C_{surveillance\ i}$$

And the estimate for the achieved benefits would be exactly the avoided end-user costs. So summing up all end-user costs and surveillance costs can give us an indicative benefit/cost ratio of the market surveillance. Only indicative, since the real effect/benefit of market surveillance should be measured as the difference between having surveillance and not having surveillance. But since the latter situation will not be possible (except for other EU-countries?) the best estimate is as described, using previous symbols. This calculation method is used within this project.

$$R = \frac{Benefit}{Cost} = \frac{P_{end-user} * \sum_{j=1}^{Countries} \sum_{i=1}^{Products} (CNC_{ij} - CC_{ij}) * R_{ij} * S_{ij} * L_i}{\sum_{k=1}^{Surveillances} C_k}$$

E	Estimated lost energy savings.
CNC_{ij}	Average annual consumption of non-compliant appliances, product group i, country j.
CC_{ij}	Average annual consumption of standard purchase (compliant appliances),[2] product group i, country j.
R_{ij}	Average non-compliance rate, product group i, country j.
S_{ij}	Sales in target year, product group i, country j.
L_i	Lifespan, product group i.
i	1..cirka 40 product groups regulated.
j	Nordic countries (Sweden, Denmark, Norway, Finland, Iceland).
$P_{end\text{-}user}$	Energy price for the end-user.
C_k	Total costs of each surveillance effort.

[2] In fact two levels could be used here; the standard purchase value calculated as a sales weighted value OR a value just meeting the limit, the latter being realistic in terms of what the producers often aim for. Also, the non-compliant purchase is probably a cheap product, for which an alternative purchase probably would have been another cheap product just meeting the limit.

3. Main project results

In the following the results of the data collection and application of the decided calculation methods are shown as spread sheet steps.

Only laboratory tests have been included in the first data collection approach due to lack of time and concern about possible uncertainty of the document control penalties. Hence the total number of data points is considerably lower than the optimal 1,380 tests carried out according to the meta data collection in November 2013. Filtering this list to only include laboratory tests gives possible 380 tests. The distribution of received samples is shown on sheet 1:

Tabel 3.1: Lab samples received. R=random, SR=semi-random, HP=Hand picked

1 Actual available Lab samples			Country	DK	DK	DK	FI	FI	FI	IS	IS	IS	NO	NO	NO	SE	SE	SE	All			All	Nov. 2013
Product	**E**	**L**	**Method**	**R**	**SR**	**HP**	**R**	**SR**	**HP**	**R**	**SR**	**HP**	**R**	**SR**	**HP**	**R**	**SR**	**HP**	**R**	**SR**	**HP**	**All**	**Exp**
TV	X	X		0	0	10	0	0	0	0	0	0	0	0	0	5		9	5	0	19	24	50
Standby	X			0	0	25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	25	25	19
EPS	X			0	17	8	0	0	0	0	0	0	0	0	0	0	0	9	0	17	17	34	43
Lighting(light sources)	X	X		0	0	18	0	0	0	0	0	0	0	11	0	40	0	0	40	11	18	69	75
Air-conditioners and comfort fans	X	X		0	0	18	0	0	0	0	0	0	0	0	0	4	0	0	4	0	18	22	31
Electric motors	X			0	0	55	0	0	0	0	0	0	0	0	0	20	0	0	20	0	55	75	61
Fans 125–500kW	X			0	0	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	6	0
Circulators	X			0	0	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8	8	0
Refrigerator/freezers domestic	X	X		0	0	47	0	0	0	0	0	0	0	0	10	30	0	0	30	0	57	87	52
Washing machines	X	X		0	0	10	0	0	0	0	0	0	0	0	0	7	0	0	7	0	10	17	17
Dishwashers domestic	X	X		0	0	7	0	0	0	0	0	0	0	0	0	4	0	0	4	0	7	11	11
Driers, domestic	X	X		0	0	10	0	0	0	0	0	0	0	0	0	7	0	0	7	0	10	17	17
Combined driers /washing machines		X		0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	4	0	0	4	4
SUM				0	17	222	0	0	0	0	0	0	0	11	10	121	0	18	121	28	250	399	380

It is clear that there are many differences compared to the November 2013 assessment of available data. However, not all deviations results at a lower number of cases – in fact the total number of tested appliances are higher than expected. This is mainly due to higher numbers for refrigerators and motors.

Next step is to look at the volume of non-compliance:

Tabel 3.2: Number of non-compliant products in each test

2 Non-Compliance (E) count			Country	DK	DK	DK	FI	FI	FI	IS	IS	IS	NO	NO	NO	SE	SE	SE	All			All
Product	**E**	**L**	**Method**	**R**	**SR**	**HP**	**R**	**SR**	**HP**	**R**	**SR**	**HP**	**R**	**SR**	**HP**	**R**	**SR**	**HP**	**R**	**SR**	**HP**	**All**
TV	X	X		0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	1
Standby	X			0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	5
EPS	X			0	4	3	0	0	0	0	0	0	0	0	0	0	0	2	0	4	5	9
Lighting(light sources)	X	X		0	0	1	0	0	0	0	0	0	0	2	0	0	0	0	0	2	1	3
Air-conditioners and comfort fans	X	X		0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	4
Electric motors	X			0	0	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7	7
Fans 125–500kW	X			0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
Circulators	X			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Refrigerator/freezers domestic	X	X		0	0	*34*	0	0	0	0	0	0	0	0	*8*	*18*	0	0	18	0	42	60
Washing machines	X	X		0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	2	0	0	2
Dishwashers domestic	X	X		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Driers, domestic	X	X		0	0	2	0	0	0	0	0	0	0	0	0	1	0	0	1	0	2	3
Combined driers /washing machines		X		0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	1
SUM				0	4	57	0	0	0	0	0	0	0	2	8	22	0	3	22	6	68	96

Overall not so many non-compliant appliances are found. But surely combined fridge-freezers do not follow that rule. Note that in the following calculation, only non-compliance in terms of energy (i.e. ecodesign infringement or wrong labeling) is included. Some other kinds of non-compliance can also lead to energy loss, but is not included in this calculation.

Applying the formula to handle a combination of random, semi-random and hand picked samples, specified in the pilot project, we can calculate these non-compliance percent rates:

Tabel 3.3: Non-compliance rates according to formula, in percent, pct, %

3 Non-Compliance (E) pct	DK	DK	DK	FI	FI	FI	IS	IS	IS	NO	NO	NO	SE	SE	SE	Avg	Avg	Avg	Formula	Est. market size
Product	**R**	**SR**	**HP**	**R**	**SR**	**HP**	**R**	**SR**	**HP**	**R**	**SR**	**HP**	**R**	**SR**	**HP**	**R**	**SR**	**HP**	**All**	
TV													0.0		0.5			0.5	0.5	1,000
Standby			0.5														0.0	0.5	0.5	1,000
EPS		0.8	0.6												0.4		0.8	1.0	1.8	500
Lighting(light sources)			0.1								0.2		0.0				0.2	0.1	0.3	1,000
Air-conditioners and comfort fans			8.0										0.0				0.0	8.0	8.0	50
Electric motors			0.7										0.0				0.0	0.7	0.7	1,000
Fans 125–500kW			2.0														0.0	2.0	2.0	50
Circulators																	0.0	0.0	0.0	50
Refrigerator/freezers domestic			3.4									0.8	60.0			60.0	0.0	4.2	60.8	1,000
Washing machines														0.3			0.3	0.0	0.3	750
Dishwashers domestic																	0.0	0.0	0.0	1,000
Driers, domestic			0.6											0.3			0.3	0.6	0.9	350
Combined driers /washing machines														6.7			6.7	0.0	6.7	15
SUM																60.0	0.7	1.4	6.3	

We obtain an overall rate of 6.3% non-compliance. Again, this is for the received lab tests only. An interesting note is that only standby is non-compliant due to the ecodesign limit, all the other non-compliances noted are regarding energy label.

As pointed out before, the fridge-freezers seem to be the most interesting product group in terms of proving violations of the criteria – 60% of the tested appliances. In all cases, this is due to wrong labeling. Note how the three percentages for R, SR and HP of 60.0; 0.0 and 4.2 do not add up to more than 60.8 as a results of the special biased-samples formula. I.e. the contributions from random and biased samples are weighted together. Next step is to get and estimate for how severe any of the violations are. Based on the received technical data, these results are obtained:

Tabel 3.4: Estimated energy cost of non-compliance per sample. The calculation background for the values can be found in the spreadsheet

4 Non-Compliance (E) kWh/y	DK	DK	DK	FI	FI	FI	IS	IS	IS	NO	NO	NO	SE	SE	SE	Avg	Comments
Product																	
TV															9.0	9.0	
Standby			5.9													5.9	assumed 4 hours/ day standby
EPS		1.1	3.6												0.1	1.6	assumed 2,000 hours/ y running
Lighting(light sources)			2.9								2.5					2.7	assumed 1,000 hours/ y burning
Air-conditioners and comfort fans			40.0													40.0	1 obs.
Electric motors			118													117.8	assumed 2,000 hours/ y running
Fans 125–500kW			694.0													694.0	1 obs.
Circulators			0.,0													0.0	no NC
Refrigerator/freezers domestic			39.5									32.7	35.5			35.9	Label difference div 2
Washing machines													10.8			10.8	Label difference div 2
Dishwashers domestic			0.0													0.0	no NC
Driers, domestic			31.2										17.8			24.5	Label difference div 2
Combined driers /washing machines													90.0			90,0	Label difference div 2
SUM / AVG																79.4	

Non-compliance was calculated to a typical level of 35 kWh/y for the dominant non-compliant appliances, with a wide spread from 1.6 to 700 kWh/y. Big variations are seen, not least due to the one electric fan. This was not a particularly big fan, so still this result seems fair – many of these industrial fans consumes 20 times the deviation per year.

In the other end of the scale, no NC was found for the tested Circulators and Dishwashers. In average an energy penalty of around 80 kWh/y must be paid for NC, but of course for many of the smaller products, e.g. standby-group appliances, this is a factor of 10 lower.

The calculation principle is both distances to ecodesign limits and labeling differences. For ecodesign, it is only the energy amount that the appliance is off the limit that is used – not the distance to an average alternative purchase – to get a conservative estimate. Also, the labeling difference is calculated as half the distance between actual and claimed (typically neighbor) energy class, thus assuming the appliance in average is in the middle of the observed class. This is for ease only, since the actual point could have been used. But it allows us to claim a conservative estimate for this part too.

The most important figure is the 35.9 kWh/y difference found for fridge-freezers, since the NC ratio for this product group is high.

Before moving to total calculation of the differences, we need some appliance lifespans. These we got from the Danish ELMODEL-bolig , see ref. 1):

Tabel 3.5: Lifespan estimates in years

5 lifespans per product group in years	**Avg**
Product	
TV	7
Standby	4
EPS	4
Lighting(light sources)	5
Air-conditioners and comfort fans	12
Electric motors	15
Fans 125–500kW	15
Circulators	10
Refrigerator/freezers domestic	10
Washing machines	10
Dishwashers domestic	10
Driers, domestic	10
Combined driers /washing machines	10
SUM	

Blue = estimate from Danish data.

Note the use of blue color when working with estimates. This is repeated in the following sheets, here for the sales figures:

Tabel 3.6: Sales figures for the 5 countries

6 sales per year, est. Product	DK	FI	IS	NO	SE	Sum
TV	700,000	560,000	35,000	910,000	1,000,000	3,205,000
Standby	5,000,000	4,000,000	250,000	6,500,000	20,000,000	35,750,000
EPS	12,000,000	9,600,000	600,000	15,600,000	21,600,000	59,400,000
Lighting(light sources)	11,500,000	9,200,000	575,000	14,950,000	20,700,000	56,925,000
Air-conditioners and comfort fans	36,000	28,800	1,800	46,800	6,4800	178,200
Electric motors	100,000	80,000	5,000	130,000	180,000	495,000
Fans 125–500kW	5,000	4,000	250	6,500	9,000	24,750
Circulators	178,000	142,400	8,900	231,400	320,400	881,100
Refrigerator/ freezers domestic	123,000	98,400	6,150	15,900	221,400	608,850
Washing machines	200,000	160,000	10,000	260,000	360,000	990,000
Dishwashers domestic	175,000	140,000	8,750	227,500	315,000	866,250
Driers, domestic	93,000	74,400	4,650	120,900	167,400	460,350
Combined driers/ washing machines	6,000	4,800	300	7,800	10,800	29,700
SUM	30,116,000	24,092,800	1,505,800	39,150,800	64,948,800	159,814,200

The sales are estimated using Danish model data combined with scaling factors:

Tabel 3.7: Scaling factors

Country	Scaling
DK	1
NO	1.3
SE	1.8
FI	0.8
IS	0.05

Also we have a few more certain sales figures for Sweden (TV and standby appliances. Source: ecodesign-effect calculations).

So according to the table some 160 million appliances are sold every year, for the shown product groups, in the Nordic countries together. The NC effects measured for these 160 million appliances are:

Tabel 3.8: Annual effects of NC in GWh

7 annual effects (GWh) Product	DK	FI	IS	NO	SE	Sum
TV	0.03	0.03	0.00	0.04	0.05	0.14
Standby	0.15	0.12	0.01	0.19	0.59	1.06
EPS	0.35	0.28	0.02	0.45	0.62	1.71
Lighting(light sources)	0.09	0.07	0.00	0.12	0.17	0.46
Air-conditioners and comfort fans	0.12	0.09	0.01	0.15	0.21	0.57
Electric motors	0.08	0.07	0.00	0.11	0.15	0.41
Fans 125–500kW	0.07	0.06	0.00	0.09	0.12	0.34
Circulators	0.00	0.00	0.00	0.00	0.00	0.00
Refrigerator/freezers domestic	2.68	2.15	0.13	3.49	4.83	13.29
Washing machines	0.01	0.00	0.00	0.01	0.01	0.03
Dishwashers domestic	0.00	0.00	0.00	0.00	0.00	0.00
Driers, domestic	0.02	0.02	0.00	0.03	0.04	0.10
Combined driers /washing machines	0.04	0.03	0.00	0.05	0.06	0.18
SUM	3.63	2.90	0.18	4.72	6.85	18.28

Around 18 extra GWh/y is used, with the largest contribution from combined fridge-freezers of 13 GWh/y.

Applying a kWh price of EUR 0.26 for Denmark, EUR 0.14 for Finland, 0.10 for Iceland, 0.13 for Norway and EUR 0.17 for Sweden (source: Eurostat, ref. 2, and for Norway/Iceland: estimates), these economic numbers can be found:

Tabel 3.9: Annual effects of NC in Million EUR

7 annual effects (Mio. EUR) Product	DK	FI	IS	NO	SE	Sum
TV	0.01	0.00	0.00	0.01	0.01	0.02
Standby	0.04	0.02	0.00	0.02	0.10	0.18
EPS	0.09	0.04	0.00	0.06	0.11	0.29
Lighting(light sources)	0.02	0.01	0.00	0.02	0.03	0.08
Air-conditioners and comfort fans	0.03	0.01	0.00	0.02	0.04	0.10
Electric motors	0.02	0.01	0.00	0.01	0.03	0.07
Fans 125–500kW	0.02	0.01	0.00	0.01	0.02	0.06
Circulators	0.00	0.00	0.00	0.00	0.00	0.00
Refrigerator/freezers domestic	0.70	0.29	0.01	0.44	0.82	2.28
Washing machines	0.00	0.00	0.00	0.00	0.00	0.00
Dishwashers domestic	0.00	0.00	0.00	0.00	0.00	0.00
Driers, domestic	0.01	0.00	0.00	0.00	0.01	0.02
Combined driers /washing machines	0.01	0.00	0.00	0.01	0.01	0.03
SUM	0.95	0.40	0.02	0.60	1.17	3.14

Remembering that the sales one year leads to consumption as long as the average lifespan allows for, the lifetime effects (multiplying with the lifespan) for one year of sales are:

Tabel 3.10: Effects including full lifespan consumption, in GWh

8 effects (GWh) full lifespan Product	DK	FI	IS	NO	SE	Sum
TV	0.22	0.18	0.01	0.29	0.32	1.01
Standby	0.59	0.47	0.03	0.77	2.36	4.23
EPS	1.38	1.11	0.07	1.80	2.49	6.84
Lighting(light sources)	0.47	0.37	0.02	0.61	0.84	2.31
Air-conditioners and comfort fans	1.38	1.11	0.07	1.80	2.49	6.84
Electric motors	1.24	0.99	0.06	1.61	2.23	6.12
Fans 125–500kW	1.04	0.83	0.05	1.35	1.87	5.15
Circulators	0.00	0.00	0.00	0.00	0.00	0.00
Refrigerator/freezers domestic	26.84	21.47	1.34	34.89	48.31	132.85
Washing machines	0.06	0.05	0.00	0.07	0.10	0.29
Dishwashers domestic	0.00	0.00	0.00	0.00	0.00	0.00
Driers, domestic	0.20	0.16	0.01	0.25	0.35	0.97
Combined driers /washing machines	0.36	0.29	0.02	0.47	0.65	1.78
SUM	33.8	27.0	1.7	43.9	62.0	168.4

Converted into money:

Tabel 3.11: Effects including full lifespan consumption, in Million EUR

8 effects (Mio. EUR) full lifespan Product	DK	FI	IS	NO	SE	Sum
TV	0.06	0.02	0.00	0.04	0.05	0.17
Standby	0.15	0.06	0.00	0.10	0.40	0.72
EPS	0.36	0.15	0.01	0.23	0.42	1.17
Lighting(light sources)	0.12	0.05	0.00	0.08	0.14	0.40
Air-conditioners and comfort fans	0.36	0.15	0.01	0.23	0.42	1.17
Electric motors	0.32	0.14	0.01	0.20	0.38	1.05
Fans 125–500kW	0.27	0.11	0.01	0.17	0.32	0.88
Circulators	0.00	0.00	0.00	0.00	0.00	0.00
Refrigerator/freezers domestic	7.02	2.94	0.14	4.45	8.24	22.78
Washing machines	0.02	0.01	0.00	0.01	0.02	0.05
Dishwashers domestic	0.00	0.00	0.00	0.00	0.00	0.00
Driers, domestic	0.05	0.02	0.00	0.03	0.06	0.17
Combined driers /washing machines	0.09	0.04	0.00	0.06	0.11	0.31
SUM	8.8	3.7	0.2	5.6	10.6	28.9

So circa 168 GWh or EUR 29 Million can be estimated as extra consumption due to NC, from one year of sales, summing up all years the appliances in average exist.

3.1 Costs

The market surveillance does not come by itself, and a good deal of resources is needed to be spent in order to conduct the adequate testing. Precisely how much is spent on each of the testing tasks are often not so easy to get hold off, but some few estimates has been put forward in the data collection process.

These data has been put into the same schema:

Tabel 3.12: Costs in Million EUR

9 Costs per sample (Mio. €)	DK	DK	DK	FI	FI	FI	IS	IS	IS	NO	NO	NO	SE	SE	SE
Product	R	SR	HP	R	SR	HP	R	SR	HP	R	SR	HP	R	SR	HP
TV													0,029		0,018
Standby			0,006												
EPS			0,005												0,009
Lighting(light sources)			0,006								0,1				0,085
Air-conditioners and comfort fans			0,008										0,114		
Electric motors			0,014												0,051
Fans 125-500kW															
Circulators															
Refrigerator/freezers domestic			0,019										0,033		
Washing machines			0,002												
Dishwashers domestic			0,001												
Driers, domestic			0,005												
Combined driers /washing machines															
SUM			0,067								0,05		0,176		0,163
			No Lab costs	Only adm.							All costs		All costs		All costs

R = Random
SR = Semi-Random
HP = Hand Picked

Avg. DK adm. cost in EUR/model: 300,68
Avg. SE adm. cost in EUR/model: 870,33
Total weighted avg. adm. cost in EUR/model: 385,80

	NO SR	SE R	SE HP
Lab + purchase costs, mio. EUR (total minus avg. adm.)	0,047	0,138	0,156
Models included	11	18	48
Lab + p. costs per model, EUR	4251	7668	3244

Avg. lab + purchase costs per model for tests: 5054 EUR
Total average costs per model, incl. adm.: 5440 EUR

All Danish data has been specified as only the administration costs, no costs for the actual testing (or purchasing of the appliance) is included. This gives a chance to estimate the administrative cost in average, and a figure of circa EUR 300 per tested model is obtained. Three cases of Swedish test provided administrative costs of circa EUR 870 per tested appliance. The weighted average is EUR 385.8/appliance, since the volume of Danish tests with known administration costs are much larger.

Other cost samples specified by Sweden and Norway includes all expenses. Subtracting an administrative cost using the weighted average, gives us the possibility to calculate an average for all costs, per tested model of around EUR 5,440.

This figure can then be used as an estimate for all the conducted tests. This gives these results:

Tabel 3.13: Total testing costs

10 Total costs per sample (Mio. EUR)	DK	DK	DK	FI	FI	FI	IS	IS	IS	NO	NO	NO	SE	SE	SE	Sum
Product	**R**	**SR**	**HP**	**R**	**SR**	**HP**	**R**	**SR**	**HP**	**R**	**SR**	**HP**	**R**	**SR**	**HP**	
TV	0.00	0.00	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.029	0.00	0.018	0.1
Standby	0.00	0.00	0.14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.1
EPS	0.00	0.09	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.009	0.1
Lighting(light sources)	0.00	0.00	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.1	0.00	0.22	0.00	0.00	0.4
Air-conditioners and comfort fans	0.00	0.00	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.114	0.00	0.00	0.2
Electric motors	0.00	0.00	0.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.11	0.00	0.00	0.4
Fans 125–500kW	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Circulators	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Refrigerator/ freezers domestic	0.00	0.00	0.26	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.16	0.00	0.00	0.5
Washing machines	0.00	0.00	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.00	0.1
Dishwashers domestic	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.1
Driers, domestic	0.00	0.00	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.00	0.1
Combined driers/ washing machines	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.0
SUM	0.000	0.092	1.208	0.00	0.00	0.00	0.000	0.000	0.000	0.00	0.05	0.05	0.604	0.120	0.009	2.1

Note that these costs adhere from 3 years of testing activities, and do not include Documentation test costs. The costs are therefore divided by 3. So, when looking at the difference between costs and "benefits", a good upside is seen.E.g. for refrigerators in Sweden the benefit is 8.24–0.16/3 = EUR 8.18 Mio. Here is a total overview:

Tabel 3.14: Total benefits in Million EUR

11 total benefits (Mio. EUR) Product	DK	FI	IS	NO	SE	Sum
TV	0.04	0.02	0.00	0.04	0.04	0.14
Standby	0.11	0.06	0.00	0.10	0.40	0.68
EPS	0.32	0.15	0.01	0.23	0.42	1.13
Lighting(light sources)	0.09	0.05	0.00	0.06	0.07	0.27
Air-conditioners and comfort fans	0.33	0.15	0.01	0.23	0.39	1.10
Electric motors	0.22	0.14	0.01	0.20	0.34	0.91
Fans 125–500kW	0.26	0.11	0.01	0.17	0.32	0.87
Circulators	-0.01	0.00	0.00	0.00	0.00	-0.01
Refrigerator/freezers domestic	6.94	2.94	0.14	4.43	8.18	22.63
Washing machines	0.00	0.01	0.00	0.01	0.00	0.02
Dishwashers domestic	-0.01	0.00	0.00	0.00	-0.01	-0.02
Driers, domestic	0.03	0.02	0.00	0.03	0.05	0.13
Combined driers /washing machines	0.09	0.04	0.00	0.06	0.10	0.30
SUM	8.4	3.7	0.2	5.6	10.3	28.1

Note: since the tests have been conducted throughout 3 years, an average annual testing cost is found by dividing the cost by 3.

A good deal of the benefits comes from the fact that market surveillance done in some countries affects the whole market. Thus Finland as an example has saved around EUR 3.7 million on having the Swedish and Danish tests exposing NC in the assumingly common Nordic market.

In total about EUR 28 million can be saved due to optimal market surveillance after a full appliance lifespan, coming from one year of sales.

4. Conclusion, discussion of results, and recommendations

From the results chapter, it can be concluded that:

- circa EUR 28 million can be saved in the Nordic countries through collaborative market surveillance, through an investment of around 2.1 million, or a ROI of 13
- the overall non-compliance rate was 6.3% at a typical level of 35 kWh/y for the dominant non-compliant appliances, with a wide spread from 1.6 to 700 kWh/y in non-compliance
- individual Nordic countries can save a lot of market surveillance expenses when results from other Nordic countries are shared
- in terms of saved electricity 168 GWh in full lifespan savings can be achieved
- costs per appliance tested in lab is around EUR 5,440 in total.

The results are based on quite few data. Both the potential saving effect and the costs estimated could be stronger if more test and cost evidence were provided, especially data containing all lab costs, not only administrative costs.

Methodically, the approach is assuming that the extra consumption from NC is a good estimator for the effects of market surveillance. In fact, the NC's are what we see with the current level of market surveillance. More optimal effect estimations would be to look at differences between the current market surveillance and a region/country where no market surveillance is taking place. On the other hand, *if all NC models are removed instantly from the market when discovered, the estimated potential savings from market surveillance are actually achieved*.

4.1 Discussion

There are a number of assumptions worth commenting since they affect the outcome significantly.

The treatment of the hand-picked samples. This is done so that the number of NC's are compared with the whole market size, since the whole market size is the sample size when hand-picking. But it introduces an underestimation (actually the minimum NC rates are estimated this way), since not all NC's may be tested due to practical limits and therefore the NC rate may be higher. Supplementary *random* sampling should be added in order to avoid this underestimation. Until then, the results must be considered conservative. Random samples are of course favourable in these kind of calculations, but in reality we see more and more hand-picked samples, so how to best use these may be an area to further explore.

The energy "penalty" calculation. This is as described done for labeling, so that only half the distance to the limit for the correct label is used. The argument is that the tested appliance could be placed anywhere between the two limits, and therefore in average will be in the middle, i.e. half the distance. In practice the producers can control the consumption quite accurate, so this assumption may not reflect reality. But using only half the distance places the estimates as conservative. A more exact calculation of the penalty could be reached if the distance between the actual measured energy efficiency and the limit of the class was used.

Also, other losses of energy from e.g. light bulbs not living as long as prescribed, TV sets not shutting off after 4 hours as they should etc., are not included in the estimates. This emphasizes the conservativeness off the estimates.

Represented product groups. Only the product group with actual lab tests have obtained an estimate for the market surveillance effects, and contributes to the total. In reality all product groups with active energy performance legislation are affected by the ongoing market surveillance, since the producers are aware of the risk of being tested. Again this adds to the fact that the estimated effects are conservative.

Other assumptions. It is assumed that lifespans for each product group are equal to estimates used in the Danish stock model ELMODEL-bolig. It is assumed that sales figures from Denmark can be transferred to the other Nordic countries using a scaling from GDP in each country. If more accurate numbers are used you can improve the calculation.

Comparison with earlier estimates. In the introduction of this report a very simple calculation of what lack of market surveillance can lead to was shown, giving that energy savings around 2 TWh per year in 2020 will be lost for Sweden in 2020, if the market is not well controlled (400 * 0.1 * 0.05, where 0.05 is the Swedish part of the electricity use in EU). The results from the calculations within this project give 62 GWh in saved energy in Sweden with current market control. This may give a better estimate, even though the numbers are not exactly comparable. The Commission estimation that, say 10–20% of the savings from Ecodesign and Energy labelling can be lost due to lack of market surveillance, could be compared with the 6.3% non-compliance rate found in the here presented calculations.

Low estimate. As mentioned above the presented calculations underestimate the savings from current market surveillance in a number of ways i.e. the way the hand-picked samples are handled, how the energy penalty is calculated, only inclusion of energy loss from not meeting the limits, only including the loss in the product groups we had available tests for.

4.2 Recommendations

Data collection: it is strongly recommended that more cost data, and also more lab test data are collected, in order to strengthen the data basis for the estimates. Also more accurate data on lifespans, sales figures and electricity prices could strengthen the calculations.

Hand-picking: based on the discussion it is recommended that a small research project about how to utilise the hand-picked data better is carried out. A contact to the Danish Technical University (see ref. 3) has been made, and they recognize the problems, and are willing to participate in such a project.

The calculation of the penalty could be improved, for example by using the distance between the actual measured energy efficiency and the limit of the class.

Sensitivity: In order to see which product groups would be most important to test in future, a simple sensitivity calculation is done. If the NC rates is changes with 1%, the resulting benefits would be higher. The ratio between the two situations suggests which product groups that would contribute the most:

Figure 4.3: Sensitivity test of obtained economic results

Total benefits (Mio. EUR) Product	Sum	+1% NC	Ratio	Share
TV	0.14	0.49	3.48	0.05
Standby	0.68	2.12	3.13	0.22
EPS	1.13	1.78	1.58	0.10
Lighting(light sources)	0.27	1.59	5.82	0.20
Air-conditioners and comfort fans	1.10	1.25	1.13	0.02
Electric motors	0.91	2.41	2.64	0.23
Fans 125–500kW	0.87	1.31	1.51	0.07
Circulators	-0.01	-0.01	1.00	0.00
Refrigerator/freezers domestic	22.63	23.00	1.02	0.06
Washing machines	0.02	0.20	11.15	0.03
Dishwashers domestic	-0.02	-0.02	1.00	0.00
Driers, domestic	0.13	0.33	2.43	0.03
Combined driers /washing machines	0.30	0.34	1.15	0.01
SUM	28.1	34.8	1.24	1.00

The Ratio column indicates what relative change in savings that would be accomplished with a 1% increase in NC-rate, compared to already accomplished for this appliance group. I.e. relative to its own group. Looking at the Share column, we see the relative change, compared to all groups.

So product groups like Standby, Lighting and Electric Motors would contribute most to future savings, provided that NC-rates increase by 1%. Washing machines, Lighting and TVs would give the largest relative change, according to this. But firstly, the product groups with no lab tests for the moment should certainly be prioritized.

References

ELMODEL-bolig. Danish bottom-up model for electricity consumption in the domestic sector. See more on www.elforbrug.dk

Eurostat: http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=nrg_pc_205&lang=en

DTU Compute – Department of Applied Mathematics and Computer Science, Camilla Thyregod.

Ecodesign effects Denmark. See www.ens.dk

Ecodesign effects SE, att. Linn Stengård, Energimyndigheten, Sweden.

Sammanfattning

Ett projekt med syfte att beräkna förlorad energibesparing på grund av att energianvändande produkter inte klarar gällande krav på den nordiska marknaden (Island, Finland, Norge, Sverige och Danmark) och därefter utvärdera kostnad och vinst med marknadskontroll, har genomförts för testdata för perioden 2011–2013.

Resultaten visar på en energibesparing på runt 28 miljoner EUR för en marknadskontrollkostnad på cirka 2.1 miljoner EUR – dvs en faktor 13 i avkastning på investeringen (ROI). Dessa resultat är beroende på antaganden av olika slag – se diskussionskapitlet.

Efter en kort introduktion beskrivs i andra kapitlet datainsamling och beräkningsmetoder etablerade i pilotstudien. För mer information se bilaga I.

I kapitel 3 beskrivs projektets huvudsakliga beräkningar. Slutsatser och diskussion redovisas i kapitel 4, inklusive rekommendationer till framtida förbättringar av beräkningarna.

Rapportens målgrupp är professionella med kunskap kring utvärdering, modellering, marknaskontroll, ekodesign och energimärkning.

Denna rapport är en del av Nordsyn och de nordiska statsministrarnas grön växtinitiativ under Nordiska ministerrådet. Se mer på www.norden.org/greengrowth

Annex I: More about the data collection

In order to get an indication of how big a share of the total consumption that is covered by valid market surveillance, data from recent ecodesign effect studies in Denmark (ref. 4) and Sweden (ref. 5) can be used. In these studies, the total consumption for each of the regulated product groups is estimated. Using table 3 as the basis, and requiring at least 15 elements per sample, these product groups (indicated by green background) are considered covered:

Table 5: Product groups covered by sufficient market surveillance, and the estimated savings and consumption they represent. Rightmost the sample sizes per country. Green background indicates the product group is considered covered by sufficient sampling

Product	E	L	Ecodesign and labeling GWh/y		Baseline cons. GWh/y		Samples				
			2020	2030	2020	2030	DK	FI	IS	NO	SE
TV	X	X	*790*	1,002	2,044	2,238	*70*	*5*	*50*	*0*	*15*
Standby	X		*554*	543	713	702	*84*	*0*	*0*	*0*	*0*
- electronics									*300*		
EPS	X						*77*	*8*	*0*	*0*	*15*
Lighting(light sources)	X	X	*998*	1150	3,600	3,646	*50*	*8*	*0*	*10*	*75*
Lighting (light sources) tertiary	X	X					*0*	*0*	*0*	*0*	*16*
Lighting (fixtures)	X						*10*	*0*	*0*	*0*	*0*
Air-conditioners and comfort fans	X	X	*246*	465	2958	2,959	*119*	*0*	*0*	*0*	*10*
Electric motors	X						*78*	*0*	*0*	*0*	*20*
Fans 125–500kW	X										
Circulators	X		*610*	1288	3220	2,402					
Water pumps	X										
Refrigerator/ freezers domestic	X	X	*175*	300	1141	1,274	*98*	*0*	*0*	*0*	*23*
Washing machines	X	X	*71*	132	712	836	*30*	*56*	*0*	*0*	*7*
Dishwashers domestic	X	X	*90*	169	957	1,126	*25*	*0*	*0*	*0*	*6*
Driers, domestic	X	X	*64*	155	534	771	*22*	*6*	*70*	*0*	*7*
Combined driers/ washing machines		X					*0*	*0*	*0*	*0*	*4*
Ovens		X					*0*	*0*	*0*	*0*	*6*
Simple STB	X										
SUM			*2,988*	3,916	15,879	15,954	663	83	420	10	204
Not covered			610	1,288	3,220	2,402					
Covered			*2,378*	*2,628*	*12,659*	*13,552*			*1360*		
			80%	*67%*	*80%*	*85%*			*54%*		

The E and L columns are indications of regulations in force; E=Eco-design and L=Labeling. The figures in the "Ecodesign and labeling" are the estimated effects of Ecodesign and labeling regulations in Sweden for the different products by 2020 and 2030, and the "Base-line cons." is the estimated consumption in total, without the Ecodesign and labeling schemes.

So according to table 5, the green highlighted rows, about 80% of the expected savings and estimated consumption, where known, can be said to be covered by sufficient market surveillance sampling. This is not a fulfilling description of the coverage, but gives a good indication. I.e. many of the important product groups are covered.

If we look at the sampling method used in the different countries, it is clear that handpicking is a popular approach. Requiring only random selection we have these sample sizes left:

Table 6: Sample sizes, only random selection

Rækkenavne	FI, DK	IS	SE	Sum
Air conditioning			6	6
Air conditioning - air-to-air heatpumps			4	4
Dish Washers			6	6
Electric motors			20	20
Electric ovens			6	6
External power supplies			15	15
Refrigerators			23	23
Televisions		50	15	65
Tumble driers		70	7	77
Washing machines (laundry)	50		7	57
Washer-driers			4	4
Lighting – Lamps			60	60
Lighting – Tertiary lighting			16	16
Lighting – Household lamps			15	15
Lighting – CFLs	8			8
Sum	58	120	204	382

Note that both DK and FI have no pure random selected samples. Also we have as a total for the Nordic region, only 382 samples. Therefore, it is important to be able to use both the handpicked cases, and the ones with a mix of handpicked and random selected samples.

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TemaNord 2015:563

The Nordic Ecodesign Effect Project

The project presents a calculation of the benefits and effects of the current market surveillance of ecodesign and energy labelling in the Nordic countries. The results indicate that market surveillance is cost effective, especially when countries cooperate; market surveillance of 2 million Euro saves about 30 million Euro for the customers. The project is part of Nordsyn under the Nordic Prime Ministers' overall green growth initiative - read more at www.norden.org/greengrowth.

THE NORDIC REGION
– leading in green growth

TemaNord 2015:563
ISBN 978-92-893-4298-8 (PRINT)
ISBN 978-92-893-4300-8 (PDF)
ISBN 978-92-893-4299-5 (EPUB)
ISSN 0908-6692

9 789289 342988