Dishwashers:
Testing the energy variability related to different uses

Final report

- Could dishwashers be recognising test situations and adapting their performance accordingly?
- How much can energy consumption deviate from the declared values under use patterns different from those applied in the lab?
- What are main reasons for the differences?
- How could energy declarations in dishwashers be improved?

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Anette Michel,
Eric Bush,
Jürg Nipkow,
Topten International

Acknowledgements

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[1] https://europeanclimate.org/
[2] http://www.bfe.admin.ch/index.html?lang=en

Content

1 Summary

Three dishwasher models were selected for the tests representing different price levels, energy efficiency classes, number of place settings and from three different brands: Beko DFN 26220S (A++), Bosch SMS63N22EU (A++) and Miele G6300-SCU (A+++). A total of 62 tests were performed with the three models. The tests followed a simplified measurement procedure compared to the measurement standard EN 50242, focusing on measuring the energy consumption. Various test parameters were changed to investigate a) if the dishwashers might be recognising a test situation and adapting their performance accordingly, and b) to quantify the difference between the declared energy consumption on the Energy Label and the one that can occur when used differently.

Key results

- **No compliance issues or hints of circumvention:** The test results did not reveal any compliance issues and no hints that the dishwasher models under test might be recognising a test situation and adapting their performance accordingly. Related research however revealed that circumvention has been an issue with dishwashers: standardisation bodies have already taken steps to improve the measurement standards. With the new standards, measurement of cleaning and drying performance will be combined and measured in the same test runs and the sound power will no longer be established with clean dishes. These changes will make circumvention less likely.
- **Different programmes and extra functions can increase energy consumption by 70% or lower it by 30%:** The tests showed that if dishwashers are used differently from the way they are measured for the Label declaration, they can consume up to 70% more energy than declared – or up to 30% less. Different loads or soiling had only a minor effect on energy consumption. The most important aspect contributing to energy differences is the programme diversity offered by the products (different programmes and extra functions). Many programmes different from the Eco programme used 25%-35% more energy than the Label programme, Intensive programmes recommended for heavily soiled dished used 50%-70% more energy. The result is not surprising: manufacturers' manuals provide correct information on the energy consumption of different programmes.

  Not so transparent is the effect of extra functions on the energy consumption: combining the Label programme with extra functions such as 'Short' or 'better drying' can increase the energy used by 30% to 50%.

  Different use can also lead to a lower energy consumption: The Short programmes use around 20% less energy than the Eco programme, in some cases even up to 30% less. Short programmes are recommended for lightly soiled dishes and operate at lower temperatures. Hence, for lightly soiled dishes, the Eco programme is not the most eco choice.
- **Not loading dishwashers to their full capacity wastes a lot of energy**. When loaded to 50% of the full capacity, the energy consumption reduces only by around 10%, even when choosing a 'half load' extra function.
- **Hot Fill can save a lot of energy:** If a household's hot water is heated in an energy-efficient way and the pipe between water tank and dishwasher is short, then Hot Fill can save 20% of energy with most programmes. With special Hot Fill programmes that renounce on additional heating, energy savings can reach 90%. However, dishwasher models could be more optimised to really save energy when connected to hot water: in

one of the models, a water tank may be hindering energy savings in some programmes; the other one used excess water in the most energy-saving programme.

- **Functioning of energy-saving features not enough transparent:** Energy-saving features such as a water tank may not always be active, and energy consumption can be higher than declared. The activation and deactivation of energy-saving features should be made transparent in the manual. Otherwise users with specific habits may not profit of their energy-saving effect.

The situation with dishwashers – and assumedly other home appliances – is not comparable with what was revealed for diesel cars during the 2015 Volkswagen scandal. It is far less dramatic:

- Test standards are already being improved to make circumvention less likely. No hints on circumvention could be found in the dishwasher tests for this study. VW on the contrary had admittedly used a software to detect test situations.
- If used differently than according to the standard, NOx emissions in diesel cars were found to be on average 7 times, for the worst performer even 25 times higher (ICCT, 2014). In the dishwasher tests, energy consumption was up to 70%. This difference is much smaller than with diesel cars.
- While for cars it is about emissions exceeding a maximum permissible value, for dishwashers it is about exceeding a declared value.
- NOx emissions by cars directly harm human health, electricity consumption by dishwashers does not directly impact people's health.

Recommendations

1. **Combination of testing of different aspects**
   Simultaneously testing as many combinations of functions (such as cleaning and drying efficiency) or aspects (e.g. energy and water consumption) as possible that a product normally provides could be a general rule for measurement standards to make circumvention less likely. If products are able to perform well in different aspects or provide different functions at the same time in real-life, they should also do so in the lab – as far as possible.

2. **'Normal' programme should be the Label programme**
   The name 'Eco' for the Label programme is misleading – there are other programmes that use less energy. The Label programme must be suitable to clean normally soiled dishes, and should communicate this in its name. Also, the 'Normal' programmes are the most used ones. Clearly, today's contradiction between regulations (referring to a 'standard programme') and the measurement standard (saying that the Eco programme should be tested) should be removed by having both referring to the 'Normal' programme.

3. **Better consumer / user information**
   Users should be able to inform themselves in the manual that not filling the dishwasher wastes a lot of energy and water, if energy-saving features may be deactivated, and when a connection to a hot water tank makes sense.

4. **Promotion of Hot Fill**

   The high potential savings by Hot Fill justify better communication to make sure that those consumers having the right conditions in their home are aware of it. An icon on the Label could show if a dishwasher model can be connected to hot water, while at the same time raising awareness among consumers. More detailed information about when a hot water connection makes sense would have to be in the manual and/or the Label Fiche.

5. **New approach to testing and declaring should be discussed**

   The vast range of possible ways to use products is challenging to address with declarations that need to guarantee a fair comparability among models. A new approach to testing and declaring may be needed to account for the programme diversity in dishwashers and other home appliances. An idea, inspired by the developments in testing of cars, could be to introduce a maximum consumption limit, giving more freedom to testers. Additionally, manufacturers could declare how much their most energy-saving programme saves compared to the declared value.

   More research and discussions are needed to find out if there are ways to introduce such a new approach without increasing the testing burden too much. And if it's worth it to add more complexity to testing and declaring, while the differences found in energy consumption are within expectations, and interested users can inform themselves in the manual.

6. **Smart product design needed – and smaller dishwashers?**

   To realise the potential savings by Hot Fill, it is key that dishwashers are designed in an appropriate way: models with a water tank should deactivate this at first installation if connected to a hot water pipe. Hot Fill programmes should also use water in an efficient way. It is up to manufacturers to consider the different ways their products may be used and design them in a smart way, so that energy savings are not hindered.

   Additional research could consider the question if smaller dishwashers could reduce the waste of energy and water due to under-loading. Cycles that run with not fully loaded dishwashers, waste a lot of energy and water.

2 Objectives: why dishwashers?

The goal of the project is to achieve greater CO_2 emission reductions in Europe from product standards and Energy Labelling through:

a) identifying issues and potential failures in standardised product testing,
b) quantifying discrepancies between real-life and declared performance, and
c) suggesting improvements to standards and declarations.

In a pre-study, Topten gathered evidence to find out whether dishwashers would be suitable for in-depth testing. The pre-study considered the following questions:

- Are there potential inadequate measurement methods and regulatory loopholes?
- Is non-compliance an issue?
- Are there cases of suspected cheating devices?

The pre-study found that cases of non-compliance for dishwashers had been discovered in the Market Watch project in 2016 (cleaning and drying efficiency class were wrong for all five models tested, for one also the energy class was wrong), as well as in the Ecopliant project in 2015 (high non-compliance with documentation / information requirements). No hints on cheating devices were found.

Dishwashers were selected for in-depth testing for the following reasons:

- Dishwashers address the aspect of programme diversity: large number of programmes offered to users (usually 5 to 10), while the test and declaration can refer to only one of these. Dishwashers share this aspect with washing machines, washer-dryers and tumble driers.
- There is a contradiction between the regulations, which state that the relevant programme should be named ‘standard programme’, and the measurement standard, saying that it is the Eco programme to be tested (see below).
- Results from a recent user survey show that users prefer programmes different from the label programme (Eco) for most cleaning cycles. This means that for most of the dishwashing cycles happening in reality, the energy consumption is unknown.
- Considerable differences in energy consumption between different programmes are expected, but there is no independent data on this available. Since heating up the water accounts for most of the energy consumed in dish washing, different water temperatures used by different programmes can lead to big energy differences. Research of declared energy consumption values for programmes other than the standard programme hinted at differences of 30% to 50% for ‘normal’ and ‘daily’ programmes, and up to 100% for ‘intensive’ programmes, compared to the declaration based on the Eco programme.
- Ecodesign and Energy Labelling regulations currently under revision provide occasion for input.
- Results might be to some extent valid also for washing machines, washer-dryers and tumble driers. The Ecodesign and Energy Labelling regulations for these product categories are also currently (washing machines, washer-driers) or soon (tumble driers) being revised.

Focus: programme diversity

The most obvious discrepancy between declared and possible performance is linked to the programme diversity offered by dishwashers. While the label declaration is based on the test of one single programme, users can choose up to around 50 possible ways to operate their dishwasher.

Key questions to be investigated with the tests were:

- How large is the deviation in energy consumption if programmes different from the Eco programme are used?
- Which programmes consume more, which less? Are there similarities between different models?
- Do other programmes consume more energy, or can they also consume less?
- How can extra features influence energy consumption, especially when combined with the label programme?

Also, other parameters that can be different in people's homes from the lab test can influence the energy consumption: the amount and type of dishes loaded into the dishwasher or how strongly these are soiled. More soiling and a higher mass of dishes is expected to lead to higher consumption. Water with different characteristics on the other hand should not influence the energy consumed. While measuring according to the test standard, it may be possible to detect any circumvention based on these parameters:

- Does a change to the dish load and soiling increase or decrease the energy consumption as expected, and not at all for a change to the water characteristics?
- Or is the consumption with the standard conditions lowest, even with a high mass of dishes and heavy soiling? This would certainly be suspicious and could hint at a model detecting the test situation and operating at 'artificially' low energy consumption just for the test. The same is true if the water type leads to a change in a model's behaviour.

Additional questions were the saving potential of 'hot fill' and the energy reduction if a dishwasher is only partly loaded:

- Some dishwasher models have an extra feature for 'half load'. By how much is the energy consumption reduced, if the dishwashers are only half loaded (with the extra button pressed or not)?
- If a household is heating up its water with renewables, it makes sense to supply a dishwasher directly with this. But how much electricity can be saved if the dishwasher models are linked directly to hot water?

3 Introduction

3.1 Product regulations and measurement standards

Ecodesign requirements and Energy Label: under revision

Energy Labelling regulation No 1059/2010 and Ecodesign regulation No 1016/2010 are defining the energy declaration and minimum energy performance for household dishwashers since 2010.

Both regulations are currently under review. The JRC is about to finalise the review preparatory study soon (http://susproc.jrc.ec.europa.eu/Dishwashers/index.html).

Ecodesign requirements

Ecodesign tier 3 applies since December 2016: since then, also medium dishwashers must be in energy efficiency classes A+ or better. Now only small dishwashers (≤ 7 place settings (ps)) can still be in class A. Large dishwashers (≥ 11 ps; 10 ps + width > 45cm) already had to be in A+ since December 2013. Table 1 provides an overview on the Ecodesign requirements currently applying.

Table 1: Current Ecodesign requirements for dishwashers

Requirement	Current level	Exceptions
Energy efficiency	Class A+ (EEI < 63)	Small DWs*: A (EEI < 71)
Cleaning efficiency	> 1.12 (old class A)	
Drying efficiency	> 1.08 (class A)	Small DWs*: > 0.86 (class B)

*Small DWs: ≤ 7ps

Regarding the programme relevant for the declaration, the Ecodesign regulation states the following:

"For the calculation of the energy consumption and other parameters for household dishwashers, the cycle which cleans normally soiled tableware (hereafter standard cleaning cycle) shall be used. This cycle shall be clearly identifiable on the programme selection device of the household dishwasher or the household dishwasher display, if any, or both, and named 'standard programme' and shall be set as the default cycle for household dishwashers equipped with automatic programme selection or any function for automatically selecting a cleaning programme or maintaining the selection of a programme." (EC, 2010)

The Ecodesign regulation also asks manufacturers to indicate to users that the standard programme is the most efficient one. And they have to provide information on duration and energy and water consumption for all 'main cleaning programmes':

(2) The booklet of instructions provided by the manufacturer shall provide:

(a) the standard cleaning cycle referred to as 'standard programme' and shall specify that it is suitable to clean normally soiled tableware and that it is the most efficient programme in terms of its combined energy and water consumption for that type of tableware;

(b) the power consumption of the off-mode and of the left-on mode;

(c) indicative information on the programme time, energy and water consumption for the main cleaning programmes.

(From: EC, 2010)

Energy Label

The Energy efficiency classification is based on an Energy Efficiency Index (EEI), which compares the annual energy consumption of a dishwasher model to that of a reference machine with the same number of place settings.

Figure 1: Energy Label for dishwashers

Table 2: Energy Label classification

Energy class	EEI
A+++	EEI < 50
A++	50 ≤ EEI < 56
A+	56 ≤ EEI < 63
A	63 ≤ EEI < 71

Apart from the energy efficiency class, the Energy Label also displays annual water consumption, drying efficiency, number of place settings, sound power level and annual energy consumption.

In the label fiche, additional information must be provided regarding the energy consumption and programme time of the 'standard cleaning cycle', power consumption of off-mode and left-on mode (and duration of the latter), and the indication that the 'standard programme' is the standard cleaning cycle to which the information in the label and the fiche relates, that this programme is suitable to clean normally soiled tableware, and that it is the most efficient programme in terms of combined energy and water consumption.

Revision

Today's minimum efficiency requirements leave only classes A to A+++ on the market. The most efficient dishwasher model has an integrated a heat pump and is 40% more efficient

than the A+++ class threshold[3]. Clearly a new Label is needed, and there is also sufficient room for more ambitious MEPS.

Key discussion points in the preparation meetings of the revision are:

- Which programme should be the Label and Ecodesign programme?
  Today there is a contradiction between the regulations, which state that the relevant programme should be named 'standard programme', and the measurement standard, saying that it is the Eco programme to be tested. Effectively, today it is the Eco programme that is used for the Label declarations. It seems that the contradiction has been created by CEN/CENELEC, who introduced the name 'Eco' for the standard programme[4]. The 'Omnibus study from VHK (March 2014) reaches the same conclusion. The Eco programme is not used a lot: a survey has shown that for 80% of all cycles, programmes different from the Eco programme are used (Hook, Schmitz, Stamminger, 2015; more on user behaviour see in chapter 4.2).
- Dishwasher label programmes have long duration times of 3, 4 or even up to 5 hours. The long programme time allows the dishwashers to reduce the wash temperature and to save energy. But are these long programme durations user-friendly, or do they get users to select other, shorter but more energy-consuming programmes? Should programme duration of the label programme be limited, or be declared on the label? Or are dishwashers mostly used during the night, when duration is not a problem, but the noise level might be?
- Should hot fill be promoted? In households where the water is heated up with renewables (e.g. solar power), dishwashers ready for hot fill (nearly all are) can be linked directly to the hot water. Since heating up the water is the most energy-consuming process in dish washing, this has a high electricity-saving potential. But it depends on the infrastructure in the household: next to renewable hot water production, a short pipe length is needed to avoid large amounts of cooled water to be filled into the dishwasher. And how large is the energy saving from hot fill with today's efficient dishwashers using and heating up only small amounts of water? Is it worth promoting this, while the message is quite complex?
- A change from consumption declarations per year (kWh/year, l/year) to a per cycle declaration is recommended (kWh/cycle, l/cycle). This would leave out Left-On (and Off) mode consumption, should there be a power cap instead? And for delayed-start, too?

Measurement standard: new version available

Dishwashers are tested according to the European standard EN 50242 'Electric dishwashers for household use – methods for measuring the performance' from 2008.

In 2016, CENELEC has updated the EN standard, based on mandate M481 by the EC (2012), and at the same time aligning it to changes that have been made in the IEC standard

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[3] V-ZUG Adora GS60SLWPVi, EEI = 29.3, www.topten.eu

[4] There is one problematic formulation in the Ecodesign regulation, possibly supporting the standardisers' contradictory interpretation: "*The booklet of instructions (…) shall specify that (…) the standard cleaning cycle referred to as 'standard programme' is the most efficient programme in terms of combined energy and water consumption.*" (EC, 2012)
This formulation is not needed and might have supported the contradiction between regulations and measurement standard. In the current revision industry is aiming at changing the wording in the regulation, to 'officially' have the label and Ecodesign regulations refer to the 'ECO' programme. Coolproducts / Topten are strictly opposing this, because in our views the label and Ecodesign should refer to an 'average' programme instead of the best case (Topten / Coolproducts, 2015).

(IEC 60436:2015). The mandate was also including the following task*: "To ensure that the prospective harmonised standard(s) includes a procedure that avoids an appliance being programmed to recognize the test cycles, and reacting specifically to them.*" (EC, 2012)
With the new standard, the test load should better reflect consumer use, also including plastic items, coffee mugs, stainless pots and glass bowls. The total mass of the new test load is 2.5 to 3kg lower (depending on number of place settings); hence energy consumption can be expected to be a bit lower for most dishwashers when tested with the new load.
Another change is combined cleaning and drying (CCD): today cleaning and drying performance are assessed in different test runs, and energy and water consumption is only measured for the cleaning performance test runs. With the new measurement standard, both cleaning and drying performance will be assessed at the same time, and energy and water consumption will be measured with these combined test runs.
Also, the detergent used for the test changes, from IEC reference detergent type B to IEC Type D, which is supposed to be closer to popular detergents offered on the market. The standards contain exact prescriptions of the composition of the reference detergents.
The new measurement standard will be compulsory from 2018, but can be applied already now.

Large variation within standard test series possible
According to the testing engineer, in some dishwasher models, the diagrams and results of each of the five test cycles used for calculating average energy consumption and cleaning performance can be totally different. Hence, even with totally standardised use and conditions, water and energy consumption can vary between cycles. Reasons may be turbidity sensors that are steering the exact programme course.

Dishwasher test: time-consuming and expensive
A full compliance test of a dishwasher model takes around two weeks and costs around 9'000 Euros. It includes

- 3 preparation runs, to wash out any production remains,
- 5 test cycles of the unit under test to measure cleaning efficiency, energy and water consumption,
- 5 test cycles of the reference machine to compare the measured cleaning efficiency, energy and water consumption with,
- 5 test cycles of the unit under test to measure drying efficiency,
- 5 test cycles of the reference machine to compare the measured drying efficiency with,
- 1 test cycle of the unit under test in the acoustic lab to measure the sound power level.

If the standard deviation of the average result is too large, the tests can be continued to up to 8 test cycles for energy / cleaning / drying. Preparing the soiled dishes and assessing the cleaning result is especially time-consuming. Dishes are soiled with milk, tea, minced meat, eggs, oat flakes, spinach and margarine. The standardised, even soiling of all items takes around 2 hours, then the soiled dishes are dried for 2 hours in a hot cupboard (which is loaded according to a loading scheme, depending on the number of place settings, to achieve similar drying levels for all items). Before the dishes can be loaded into the dishwasher model to be tested, they need to cool down for around 40 minutes. This all sums up to around 5 hours for the preparation only.

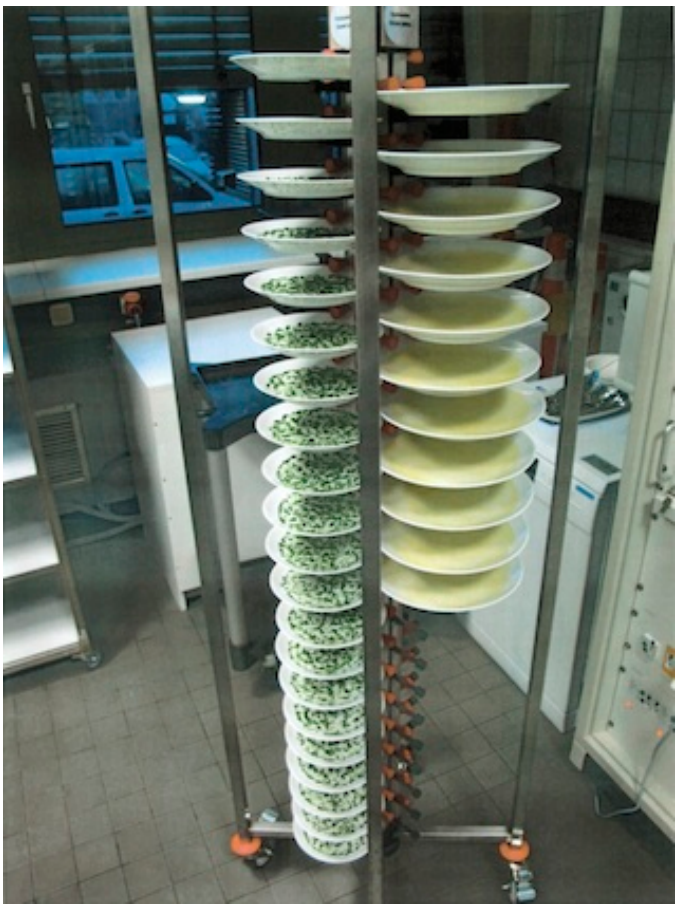


Figure 2 : Plates prepared with spinach and egg yolk (picture: VDE)

Figure 3 **:** Platters, glass bowls and pots prepared with minced meat and spinach (picture: VDE)

The programme which is tested usually takes around 3 hours or more. After any test cycle the unit under test needs to completely cool down before a next test cycle can be performed. Cool-down usually takes around 2.5 hours, but can also be much longer (e.g. for models with a water tank that stores hot rinsing water).
After the cleaning performance has been assessed by the lab staff, all the test dishes are re-cleaned by a professional dishwasher at up to 90°C.

All these time-consuming processes mean that usually not more than one test cycle per day is possible for the unit under test. So, the cleaning and drying performance tests sum up to ten days, preparation and acoustic tests add 2-3 more days.
Dishwashers that are intended to be inbuilt are also tested in a cavity. According to the testing engineer, this has a slight insulating effect, and so the conditions are more favourable for inbuilt dishwashers.

3.2 Dishwasher programmes

Typical dishwashing cycle
A dishwashing cycle normally consists of the following phases (JRC, 2015):

- Pre-rinse with cold water
- Main cleaning phase with warm to hot water (around 40°C – 70°C) and detergent
- Intermediate rinse with tepid water, to rinse out all detergent
- Hot rinse, normally at higher temperature than the cleaning phase (usually around 45°C – 60°C), to facilitate the drying
- Drying phase

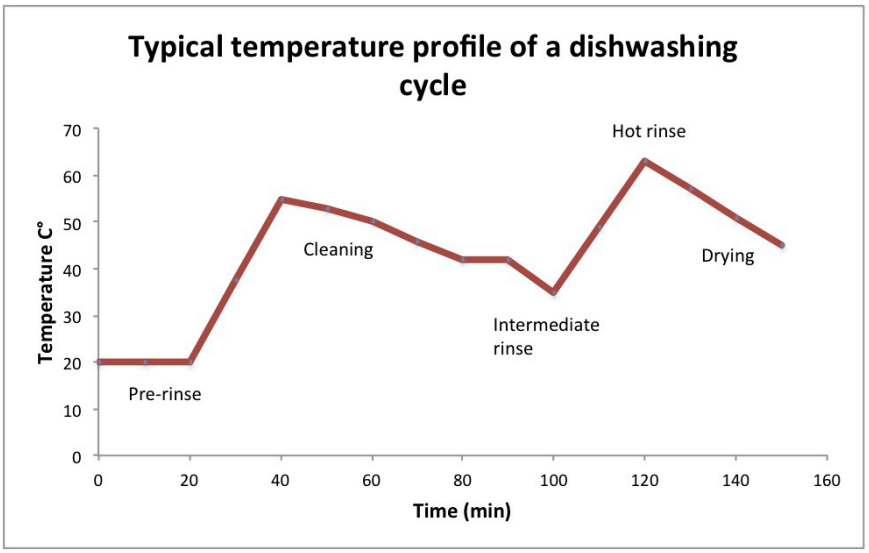


Figure 4: Typical temperature profile of a dishwashing cycle

The energy consumption for a cycle is roughly 1 kWh, the water consumption roughly 10 litres. Programme duration can be between 30 minutes and 6 hours, but will normally be around 2 hours.

Saving energy by long programme duration
The most energy consuming process in a dishwashing cycle is the heating up of the water. Lower water temperatures are the most effective options to save energy.
Energy consumption, programme duration and cleaning efficiency are interlinked by the Sinner cycle. The Sinner cycle is key for understanding energy consumption of dishwashers.

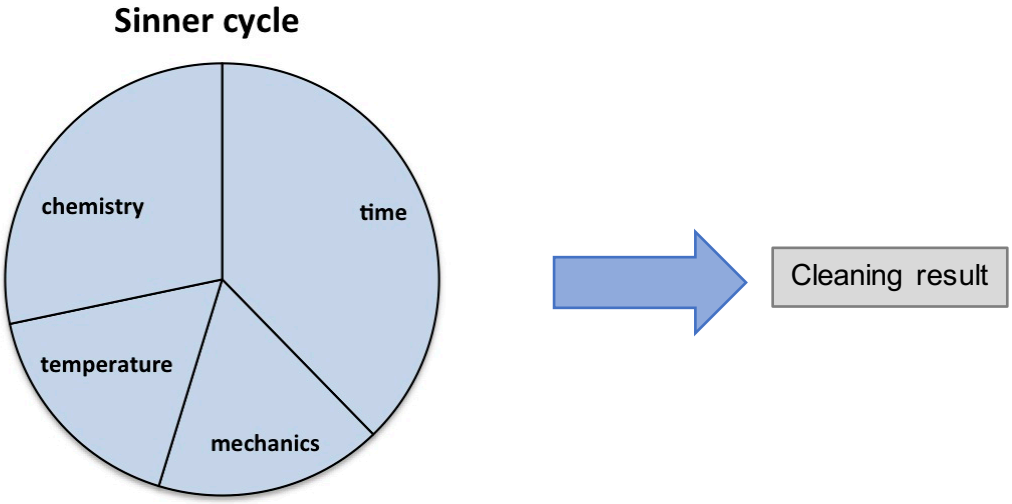


Figure 5 : According to the 'Sinner cycle' the cleaning result depends on the four factors chemistry, mechanics, temperature and time, which can replace each other.

The 'Sinner cycle' means that the cleaning result is dependent on the four factors: time (programme duration), mechanics, temperature and chemistry (detergent). To some extent, these factors can be replaced by each other. Dishwasher manufacturers have little influence on the detergent that is used (chemistry) and on mechanics (which is of high importance in hand dishwashing, but not in dishwashers). Temperature and time are the 'free variables' that influence the cleaning result.

For the Label programme, a high cleaning performance (cleaning efficiency > 1.12) must be reached, leaving only temperature and time as free variables. This means that to achieve a low energy consumption by lowering the water temperature, programme duration must be increased.

This is the reason why the Eco programme, which is optimised to be energy-efficient while achieving a good cleaning performance, usually lasts 3 hours or more in most dishwasher models.

Dishwasher programme diversity

Online research of dishwasher user manuals revealed that most dishwashers offer 5 – 7 different programmes, such as Eco, Normal, Intensive, Short, Glass. Most of today's dishwasher models also offer an 'Auto' programme, which is supposed to be adapting the cleaning process based on the degree of soiling detected by turbidity sensors.

Most dishwasher models offer 2 – 5 extra functions the programmes can be combined with (e.g. 'short', extra drying'), a separate pre-wash and a self-cleaning function. In some cases, programmes can be combined with more than one of the extra functions; on the other hand, some combinations might not be possible.

This gives users the possibility to select from around 30 to more than 50 combinations of programmes and extra functions.

The Energy Label is referring to only one of these. Clearly this can possibly lead to a discrepancy between declared and real energy consumption.

3.3 User behaviour

A recent Uni Bonn consumer survey (Hook, Schmitz, Stamminger et al., 2015) showed that the Eco programme is used for only 19% of all dishwashing cycles. Next to the Eco

programme, users prefer the normal / regular 45°C, 50°C or 55°C programmes (22%), for normal /regular 60°C or 65°C (17%), or for Short / Quick etc. programmes (11%). If the normal programmes of all temperatures are grouped together, these account for 39% of all cycles. The Eco programme is used more often with newer machines, but 30% of the households with a new machine (3 years or less) never use the Eco programme. The survey also showed that users believe to save energy and water with the short programme. Four key graphs copied from the Uni Bonn study visualise these results.

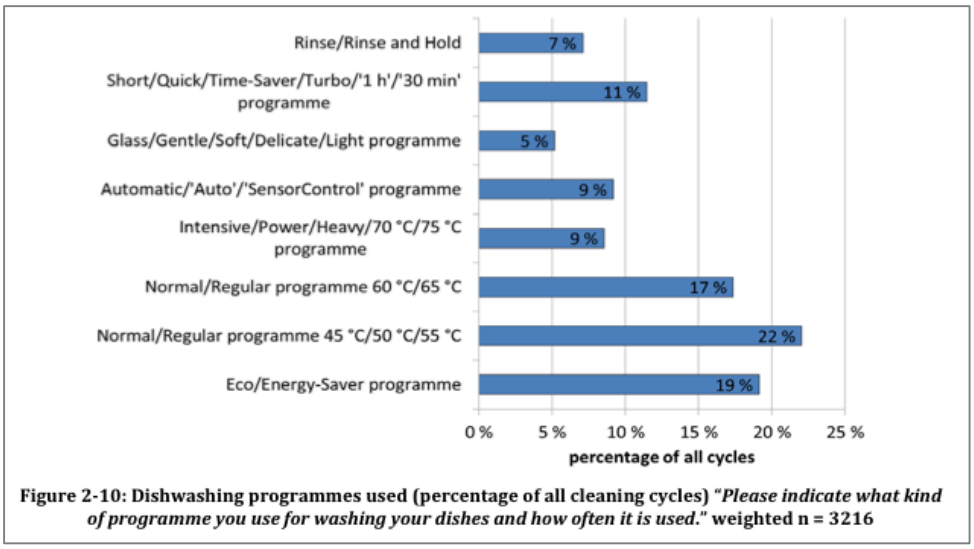


Figure 2-10: Dishwashing programmes used (percentage of all cleaning cycles) ***"Please indicate what kind of programme you use for washing your dishes and how often it is used."*** **weighted n = 3216**

Figure 6 : Dishwasher programmes used. Source: Hook, Schmitz, Stamminger et al., 2015

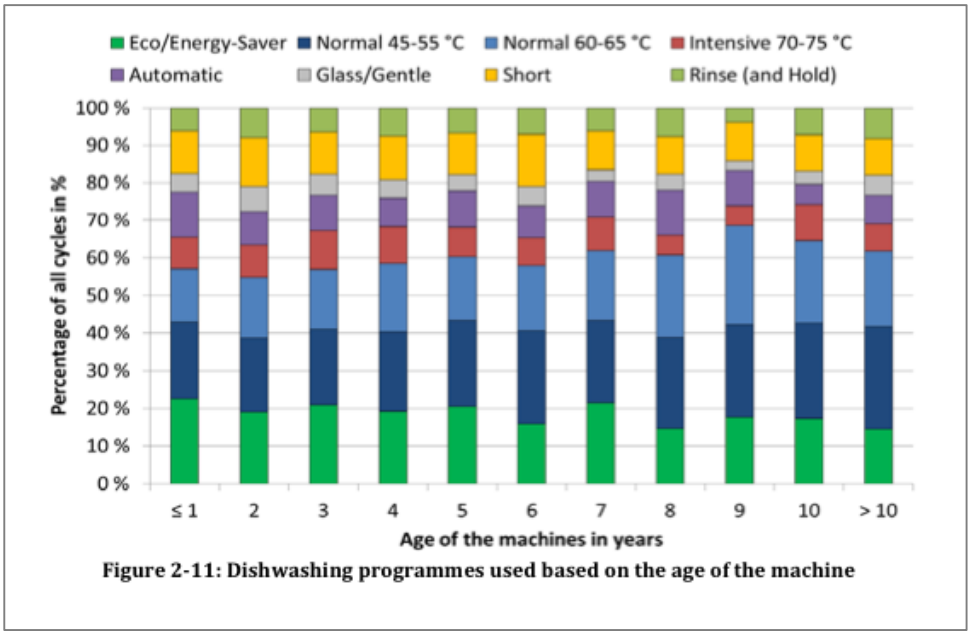


Figure 2-11: Dishwashing programmes used based on the age of the machine

Figure 7: Dishwasher programmes used and age of the machines. Source: Hook, Schmitz, Stamminger et al., 2015

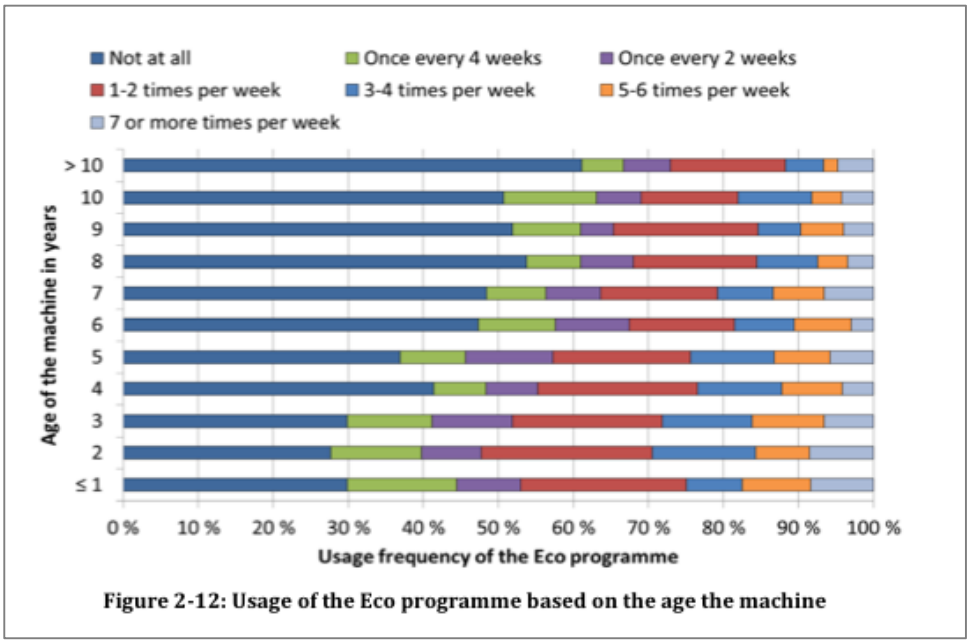


Figure 8: Usage of the Eco programme. Source: Hook, Schmitz, Stamminger et al., 2015

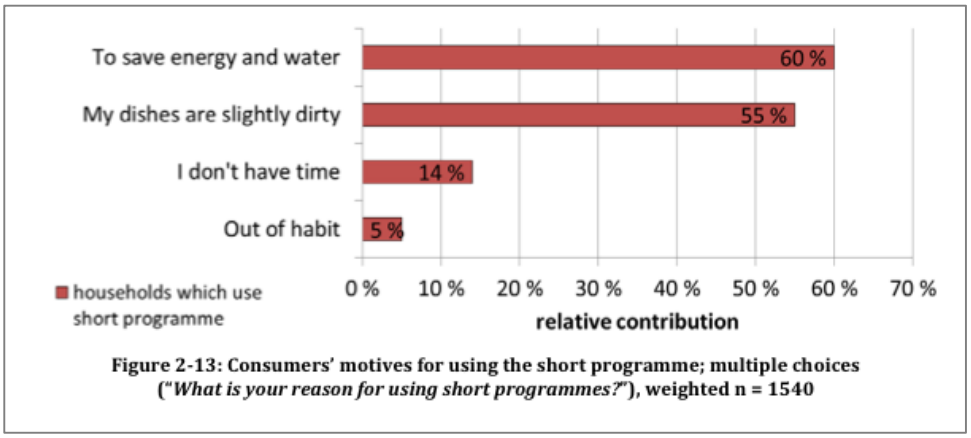


Figure 9: Why do consumers choose short programmes? Source: Hook, Schmitz, Stamminger et al., 2015

Reasons for the low usage of the Eco programme might be that users think that the Eco programme is not suitable for normal everyday use, or they consider the duration of the Eco programme as too long.

It is also possible that users who indicated using the Eco programme, alter it by choosing an additional function such as 'short'. Then, also the energy consumption will most probably be higher than declared. The average use of an unchanged Eco programme can therefore be (a lot) lower than the 19% that have resulted from the Uni Bonn's study.

4 Methodology

4.1 Model selection and purchase

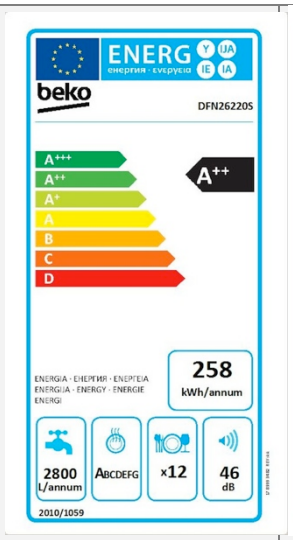
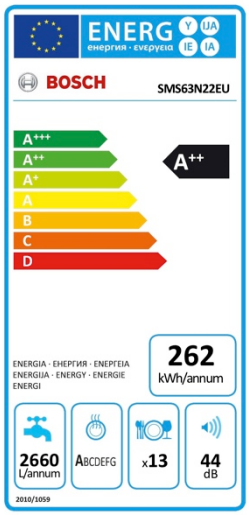
Three dishwasher models from three different brands, that were available on the market at the time of the study, were chosen. The models were selected based on the following criteria:

- Representing different brands, price levels (low / medium / high), energy efficiency classes and different numbers of place settings
- User manual available online
- User manual contains information on different programmes and extra functions
- Offered for sale online in Germany or Switzerland

The selected models and their specifications are shown in Table 3.

Table 3: Dishwasher models selected for the tests and their specifications and price

Brand	**Beko**	**Bosch**	**Miele**
Model	**DFN 26220S**	**SMS63N22EU**	**G6300-SCU**
Type	Freestanding	Freestanding	Inbuilt
No. of place settings	12	13	14
Energy class	A++	A++	A+++
Energy (kWh/year)	258	262	237
Energy (kWh/cycle)	0.90	0.92	0.84
Water (l/year)	2800	2660	2716
Water (l/cycle)	10	9.5	9.7
Drying efficiency class	A	A	A
Sound power (dB)	46	44	44
Programme duration (min)	202	210	190
Purchase price (EUR)	260	440	800
	 (Image: VDE)	 (Image: VDE)	 (Image: VDE)

			
Comments			This model has an ‚EcoFeedback' function: users can choose to see the energy and water consumption after a cycle or have it summed up.

The models were ordered in online shops (mybauer.de, alternate and e-shoppen) and delivered to the testing institute. The purchase from Switzerland proved to be a challenge. Most retailers exclude Swiss consumers from orders out of Switzerland. The Miele model in the end had to be bought by the testing institute at MediaMarkt Frankfurt.
In early October 2016, all three dishwasher models were at the testing institute.

Selected models: programmes available

Models were selected for which information on the programme portfolio was available online. The programmes and extra functions available in each of the models are shown below in tables 2 – 4.

Table 4: Programme portfolio of the BEKO DFN26220S

Programmes	Extra functions
Eco	Halbe Beladung (half load)
Auto	Schnell+ (faster)
Intensiv	SteamGloss (better drying)
Schnell&Sauber (quick & clean)	Tray Wash
Mini 30°C	
Vorspülen (pre-rinse)	
Selbstreiningung (self-cleaning)	

Table 5: Programme portfolio of the Bosch SMS63N22EU

Programmes	Extra functions
Intensiv	VarioSpeed (Zeit sparen) (time saver)
Auto	IntensivZone
Eco	
Glas (glass)	
Schnell (Short)	
Vorspülen (pre-rinse)	

Table 6: Programme portfolio of the Miele G-6300 SCU

Programmes	Extra functions
Eco	AutoOpen
Automatic	Einweichen (soak)
Normal 55°C	Vorspülen (pre-rinse)
Intensiv 75°C	Kurz (short)
Fein (glass)	ExtraSparsam (super saving)
Schnell 40°C (Short)	
ExtraLeise (quiet)	
SolarSpar (SolarSave)	
Maschinenreinigung (self-cleaning)	

4.2 Measurements

VDE testing and certification institute

The measurements were performed by the VDE testing and certification institute in Offenbach[5], Germany. It is a well-known, independent and accredited laboratory testing electrical products for energy, safety, electromagnetic compatibility and other product performance aspects. The VDE mark certifies product safety. VDE performs tests for energy labelling household appliances, lighting products, consumer electronics and building components. VDE experts also provide input to standardisation in IEC, CENELEC or ETSI technical committees.

All tests were performed in October and November 2016.

Sixty-two simplified energy tests

The dishwasher tests were simplified compared to the complex and costly method according to the standard:

- Only energy consumption, water consumption and duration were measured,
- We renounced on testing sound power, cleaning and drying efficiency,
- The performance was not compared to tests with a reference model,
- For each test, only one cycle was performed instead of five,
- Most test runs were performed with simplified soiling.

Thanks to the simplified tests, costs per test could be reduced. This allowed for a total of sixty-two tests to be performed. Since the cleaning performance was not assessed, a commercially available 1-phase tab detergent was used for all test cycles.

[5] https://www.vde.com/tic-en

The following parameters were varied for the tests, to assess their impact on energy consumption:

1. different programmes
2. combination with extra functions
3. different dish load
4. half load
5. different soiling
6. water with different hardness
7. with hot fill

How exactly these parameters were varied is explained below. The exact combination of the parameters for all three models can be found in the detail results table in Annex 2.

1. Testing of different programmes

For assessing the performance of dishwashers according to the Energy Label and Ecodesign, only the Eco programme is tested. A 2015 consumer survey however revealed that for more than 80% of all cycles other programmes are used. Therefore, all programmes that had shown to be relevant for users were tested. For each of the three models that were selected, 'user-relevant' programmes were selected to for the test. According to the 2015 user survey, 'glass' programmes are used only rarely (5%). These were therefore not tested. Also, self-cleaning programmes were not considered. The pre-rinse, which is not a complete programme, was measured only in one case.

According to the Ecodesign regulation, manufacturers must provide 'indicative information on the programme time, energy and water consumption for the main cleaning programmes'. For the three selected models, also the cleaning temperature is indicated for each programme, and manufacturers provide usage recommendations for all programmes (type of dishes and soiling level). This detail information can be found in the below tables and in Annex 1.

All dishwashers have an **Eco** programme, since the measurement standard defines that this is the programme to be tested for the Label declarations. At the same time, the Ecodesign and Labelling regulations require manufacturers to indicate that the 'standard' programme is the most efficient programme. Manufacturers do provide this information in the booklet of instructions, using different formulations (copies of these can be found in the Annex), and always referring to the eco programme. The regulation further requires the 'standard' programme to be 'set as the default cycle' in dishwashers with automatic programme selection. All manufacturers state this in their user instructions. Only for the Miele model, there is also an explanation how this pre-selection of the eco programme can be deactivated to pre-select the last used programme instead ('Memory' function).

All three dishwasher models have an **Auto** programme. Manufacturers inform users that this programme is adapting temperature, water consumption and duration to the level of soiling that is detected by internal sensors. Therefore, manufacturers indicate a range of consumption values for this programme.

All three selected models also offer an **Intensive** programme. This is recommended to use for heavily soiled dishes, with old and dry soiling, and is also suitable for pots and pans. The Intensive programme cleans at high temperature and is the most energy-intense cleaning programme, according to manufacturers' information.

Also, offered by all three models is a **Short** programme for lightly soiled dishes (Beko: 'Mini 30°C', Bosch: 'Schnell'), not reaching high temperatures. According to manufacturers' information, this programme uses even less energy than the eco programme, and has short duration of 30 to 46 minutes.

While the Bosch model does not offer a **Normal** programme, the two other models do (Beko: 'Schnell & Sauber' – 'Quick & Clean'). This programme is suitable for medium soiled dishes for everyday use. It reaches higher temperatures than the Eco programme and has a shorter duration. Energy and water consumption are accordingly higher, according to manufacturers' indications.

The following programmes have been tested:

Table 7: Tested programmes of the **BEKO DFN26220S** and manufacturer's indications

Programme	Recommended for which soiling level?	Cleaning temperature	Energy consumption (kWh)	Water consumption (l)	Duration (min)
Eco	Medium	50°C	0.9	10	202
Auto	Medium to heavy	40°C – 65°C	0.9 – 1.45	10.2 – 14.4	110 – 200
Intensiv	Heavy	70°C	1.43	16.2	156
Schnell & Sauber	Medium	70°C	1.3	10.2	58
Mini 30°	Light	35°C	0.8	10.4	30
Pre-rinse	-		-	4	15

Table 8: Tested programmes of the **Bosch SMS63N22EU** and manufacturer's indications

Programme	Recommended for which soiling level?	Cleaning temperature	Energy consumption (kWh)	Water consumption (l)	Duration (min)
Eco	Medium	50°C	0.92	9.5	210
Auto	Medium to heavy	45°C – 65°C	0.95 – 1.5	7 - 18	90 - 160
Intensiv	Heavy	70°C	1.45 – 1.5	12 - 15	125 - 135
Schnell	Light	45°C	0.8	10	29

Table 9: Tested programmes of the **Miele G-6300 SCU** and manufacturer's indications

Programme	Recommended for which soiling level?	Cleaning temperature	Energy consumption (kWh)	Water consumption (l)	Duration
Eco	Medium	52°C	0.84	9.7	198
Auto	Any	47°C – 65°C	0.7 – 1.3	6.5 – 16	85 – 155
Intensiv	Heavy	75°C	1.45	15	119
Normal	Medium	55°C	1.1	14	174
Short	Light	40°C	0.65	11	46
ExtraQuiet	Medium	46°C	1.1	10.5	288
SolarSave	Medium	-	0.05	27.5	89

ExtraQuiet is a special programme of the Miele model. According to the information given in the instructions booklet, it is very quiet and has a long duration (4:38 hours). Suitable for medium soiled dishes.
SolarSave is another special programme of the Miele model. Like the Bosch model, it can be directly connected to a hot water tank (Hot fill). With the SolarSave programme, the dishwasher will not additionally heat up the water. Since heating up the water normally accounts for most of dishwasher energy consumption, energy consumption of this programme is therefore very low.

2. Testing of extra functions

The three dishwasher models offer extra function that can be combined with all or most programmes. Some of these functions can also be combined with each other. In the instructions booklet manufacturers state that extra functions can change duration (and consumption) of the programmes. All extra functions available on our models were tested in combination with different programmes. Not all extra functions can be combined with any programme, some programmes also cannot be combined with any extra function. The possible combinations cannot be found in the manuals, but had to be defined once the test models had arrived at the lab.
Combination with the Eco programme was of highest interest, because it might change the consumption values of the Label programme.
Below a list of the different tested extra functions, and manufacturers' explanations:

BEKO DFN26220S

- **Half load**: this function allows saving water and energy if the dishwasher is not completely filled.
- **Schnell+ (Short)** shortens the programme duration and lowers the water consumption by applying higher pressure.
- **SteamGloss:** better drying.

Bosch SMS63N22EU

- **Zeit sparen/ time saver (VarioSpeed):** Duration can be shortened by 20% - 50%. Energy and water consumption is higher.
- **IntensivZone:** higher pressure and slightly higher temperature allows cleaning mixed types of dishes, including pots and pans.

Miele G-6300 SCU

- **AutoOpen Off**: in the default settings, the door is opened automatically after the drying phase (except 'ExtraQuiet') to improve drying. In the Eco programme, the door is already opened during the drying phase. Automatic door opening can be disabled.
- **Short**: reduces programme duration by around 30%. Energy consumption can be slightly higher. If used with the Short programme, there will be no drying phase (and hence no auto door opening).
- **ExtraSaving**: reduces the energy consumption up to 20%. Programme duration will be prolonged to achieve a good cleaning result.

3. Testing with a different type of dishes

The standard load in the current measurement standard (EN50242:2008) contains specific plates, cups, glasses, spoons, forks, etc. For each number of place settings, the number of each of these items is defined. Theoretically it is thinkable that a dishwasher can detect the weight of the standard load and thus recognize a test situation. Therefore, the load type and weight was varied.

The new version of the European standard, aligned with the IEC standard, is introducing new items to the test load (mugs, pots, bowls, plastic items). The new load is supposed to better reflect typical load at peoples' homes. The new standard dishes were available at the lab, so the future standard dishes were used to vary the load type.

Manufacturers often provide detail advice to test institutes on how the dishes are to be loaded into the appliance. Since these instructions were not available for the new standard load, testing engineers loaded the dishwashers under test according to the information that was available.

There are larger items in the new test load, but the overall weight is slightly lower than that of the current standard load. Since with the new loading scheme, a slightly lower total mass of dishes needs to be heated up, this could lead to a slightly lower energy consumption.

If instead the energy consumption with the new load showed to be clearly higher than with the current standard load, this might indicate an adaptation to the standard load.

Since the new load is considered to be more consumer-relevant, more cycles were run with the new load (39) than the current standard load (22).

4. Testing with a different amount of dishes

All three dishwasher models were tested with full load, but also with half load. One cycle was run with no load at all. Expected results were that the lower the mass of the dishes, the lower the energy consumption would be.

The half load tests were aiming at two questions:

- Might some dishwashers be detecting the standard load and adapting their behaviour to achieve better results when being under test? If the energy consumption with half load were not lower than with full standard load, this could indicate detection and adaption happening.
- How much is the energy consumption reduced if dishwashers are only half filled? Expectations are that the reduction is less than 50%, and not filling the dishwasher fully is not an efficient was of use.

5. Testing with different soiling

According to the standard, dishes are heavily soiled, and the soil is dried (see above). Apart from a few tests with standard soiling, 'simple' soiling was used for most test runs. For the simple soiling, a mixture of 15g of spinach, 15g of minced meat and 7.4g of margarine was applied to the inside of the dishwasher's door. In addition to this, one of the glasses contained 150ml of frozen milk.

A glass of frozen milk is also used for acoustic test according to IEC 60436:2015. The objective of adding this to the simple soiling was to have turbidity sensors, if present, activated for some time during a cycle, because the milk would take some time to melt. The mixture of spinach, minced meat and margarine on the other hand would activate any sensor already in the pre-wash phase, while being washed away quite quickly.

Heating up and melting the frozen milk uses some extra energy, approximately 0.015 kWh (55 kJ[6]).
This simple soiling was used for most of the test runs, because the time-consuming soiling is an important cost factor. Using a simpler soiling for most of the tests allowed for more test runs being performed, and thus investigating the impact on dishwashing energy consumption of more parameters.

6. Testing with water of different hardness

The preparation of water used for testing appliances is prescribed in EN 60734:2012 Household electrical appliances – Performance – Water for testing. For dishwashers, the water quality is defined regarding total hardness, the ratio of Calcium/Magnesium ions, and the maximum concentration of chloride, as well as iron, copper and manganese ions.
For one test run per model, the water hardness was varied and softer water instead of standard test water was used. The dishwasher models' water hardness setting was not changed for this. First, this setting normally only influences the frequency regeneration occurs (more often with harder water), but not energy use. Second, changing this setting may become active after several cycles only. So, for just one cycle it would not make sense.
This test was investigating if some dishwasher models might be detecting a test situation by recognising the standard water. If the energy consumption with soft water was higher than expected based on other test results, this could indicate a possible detection and adaptation.

7. Testing the saving potential of hot fill

Two of the dishwasher models, the Bosch and Miele models, can be connected to a hot water tank. If a household's water is heated with renewables (e.g. solar power), hot fill can save electricity.
For the two models suitable for hot fill, hot fill was tested with the Eco and one other programme. For the Miele model, additionally the 'SolarSave' programme was tested in combination with hot fill. For all hot fill tests, 45°C hot water was used.
These tests were aiming at quantifying the energy saving potential of hot fill.

[6] The specific energy needed to melt ice is 333 kJ/kg. Melting of 150ml of milk thus requires roughly 50 kJ. The specific heat capacity of ice is 2.06 kJ/(kg*K). To heat up the 150ml of milk from -18°C to 0°C thus needs an additional 5.5 kJ.

5 Results and discussion

Main results were obtained with the sixty-two dishwasher cycle tests. Other findings were obtained from online research and discussions with the testing institute. These are mentioned below.

It must be noted that all tests followed a simplified test method. While compliance tests use the statistical average results of five test runs (and the five individual results can be quite different), each combination was measured only once. Non-compliance can only be proved based on tests with four different units of the same model. Dishwasher tests for the present study were done with just one unit of three different models. So, there is some degree of uncertainty in the test results. Also, the tests did not consider performance aspects like cleaning and drying efficiency, nor noise. Water consumption was measured, but not systematically assessed. For declaration and compliance tests, all of these aspects have to be considered.

An overview on all test results (energy and water consumption) is provided in Annex 2.

In Annex 3, one diagram for each of the three models showing the course of a tested cycle is included, serving as an example.

5.1 Test results: energy consumption

No compliance issues

These dishwasher test results are not valid compliance test results (only one run measured, not all performance aspects, only one unit per model tested). Still, the energy consumption results of the measurements that were performed in line with the EN 50242 standard (programme selection, load, soiling, water according to EN 50242) can be compared with the value declared on the Energy Label.

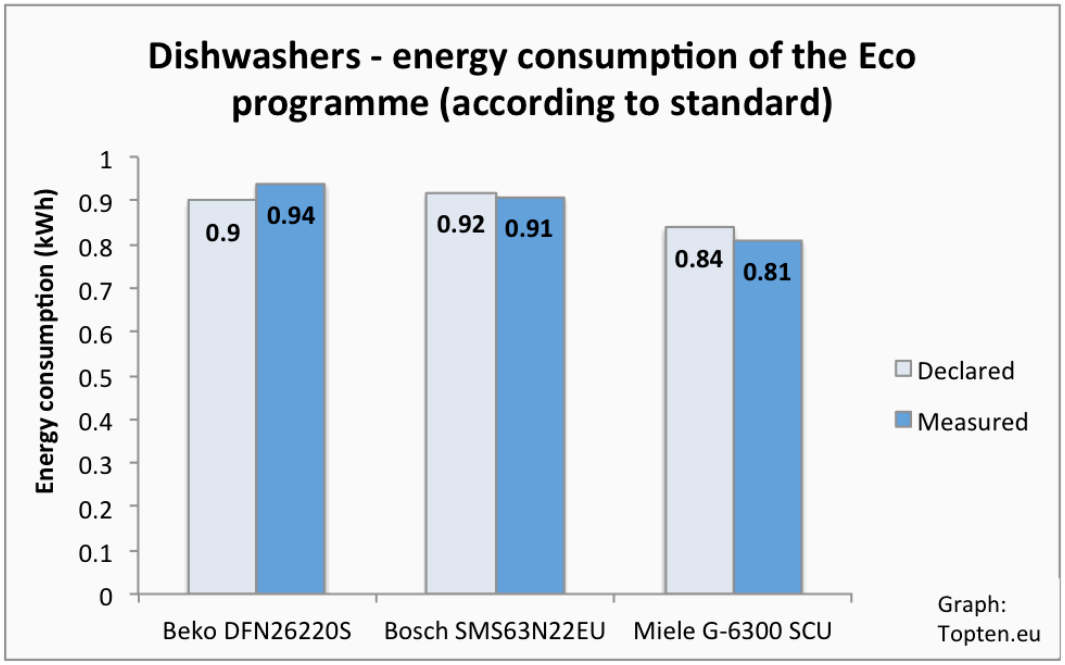


Figure 10: Declared and measured energy consumption of the three dishwasher models in the Eco programme. These tests were performed according to the EN 50242 standard (Eco programme without extra functions, standard dish load and soiling).

For the BEKO DFN26220S the measured energy consumption was 4% higher than declared. The verification tolerance is 10%, so there is no indication of compliance problems in this

result. The measured energy consumption of the two other models, the Bosch SMS63N22EU and Miele G-6300 SCU, was lower than declared.

Soiling: very small impact on Eco programme

Figure 11 shows the difference in energy consumption of the Eco programme when the soiling level was varied, for the three dishwasher models. All test runs shown in Figure 11 were performed with full load according to EN 50242; only the soiling was varied.

It is a bit surprising that the energy consumption is higher with simple soiling than heavy standard soiling for all three models. For two models the Eco programme also consumed 0.01 kWh more when run with clean dishes instead of dishes that were soiled according to EN 50242. For the third, the Beko model, the energy consumption was the same with clean dishes and heavily soiled dishes.

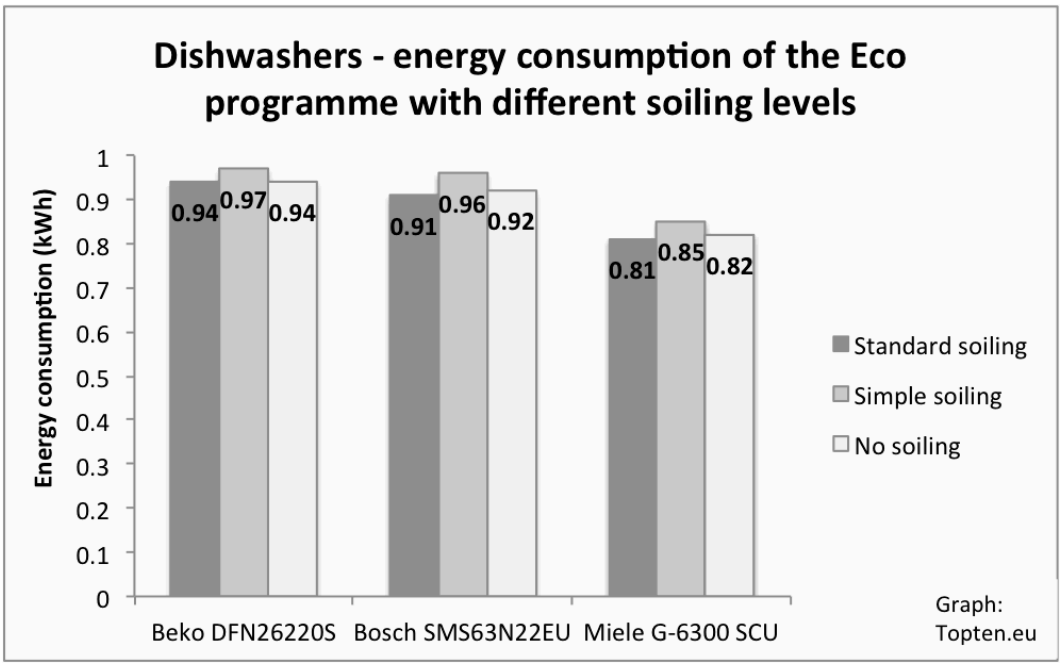


Figure 11: Measured energy consumption of the three dishwasher models in the Eco programmes with different soiling levels: (heavy) standard soiling, simple soiling and no soiling.

Expectations would have been that the energy consumed increases with soiling level. Could these results hint at dishwashers recognising a test situation (standard soiling) and adapt by using less energy than for other soiling levels? Topten deems it very unlikely, for the following reasons:

- Observed differences are very small; maximally 5%, which is only half of the verification tolerance. Such a small difference hardly justifies a potentially complex detection and adaptation system.
- According to information by the VDE testing engineer, cycle results can vary even when performed according to standard conditions. Variation seems to be normal for dishwasher cycles, therefore the declaration and compliance checks are based on statistical averages from five test runs.
- The extra energy needed to heat up and melt the frozen milk (around 0.015 kWh) could explain part of the higher energy consumption with simple soiling.
- The Eco programme is not expected to use turbidity sensors (it is however not excluded that in some models it does). Without sensors, the programme would be running independently of the soiling levels.

Concluding on this; Topten deems it likely that the Eco programmes of the three tested dishwasher models have no turbidity sensors active, and the small energy consumption differences between the different cycles are in the range of normal variation in dishwasher test runs. The fact that energy consumption was (a little) higher with simple soiling than standard soiling for all three tested models could be attributed to coincidence.

Standard water: no recognising based on hardness

When measured with full load according to EN 50242, simple soiling and water that is softer than according to EN 50242, the energy consumption of the Eco programme was lower than when measured with standard water according to EN 50242, for all three dishwasher models (Figure 12). If the dishwashers did recognise a test situation based on the standardised water and adapt their performance accordingly, energy consumption with standard water would be lower than with different water, not higher. The results in Figure 12 show that there is no recognising of the standard water - at least not based on water hardness.

The differences in energy consumption of 5% to 6% seem to be in the range of normal variation for single test runs.

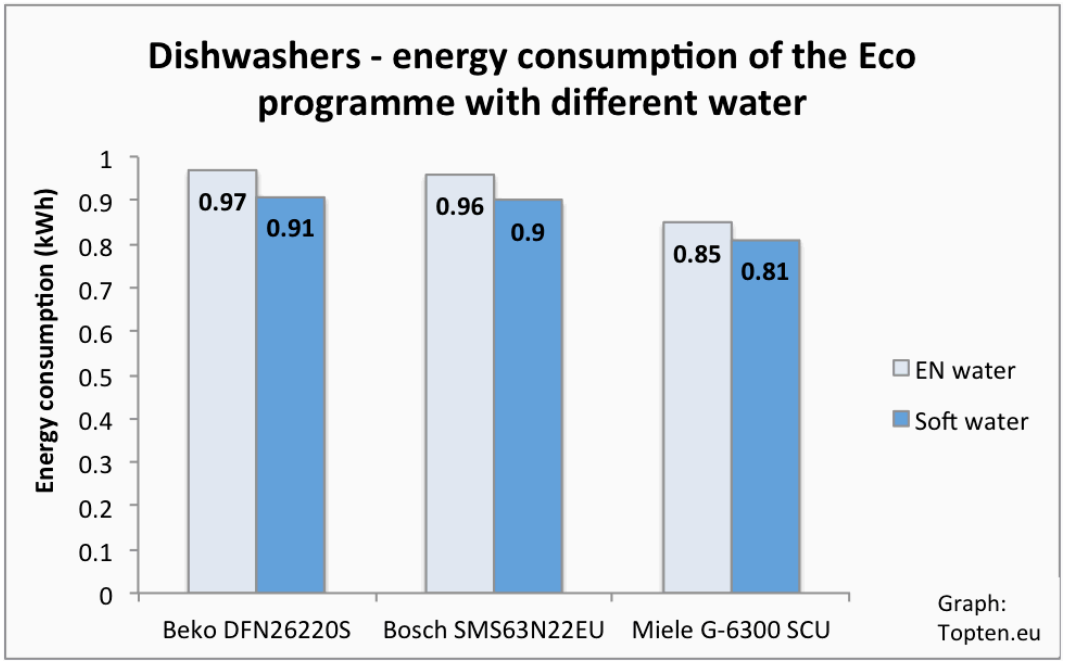


Figure 12: Measured energy consumption of the three dishwasher models' Eco programmes, with simple soiling: once with water with standard characteristics according to EN 50242, once with water that was softer (having a lower calcium content).

Dish load: no unexpected impact

As expected, the test runs in the Eco programme with the new load according to IEC 60436 used a little less energy than those with the current standard load according to EN 50242 (both tests with full load, simple soiling, standard water). This was expected, because the total mass of the IEC load is lower than that of the EN load, and hence there is less mass that needs to be heated up.

The energy consumption difference was 2% and 3% for the Beko and Miele models, respectively, and 7% for the Bosch model.

At the same time the results contain no hint that the tested dishwashers could be detecting a test situation by measuring the weight of the dish load. Would they do so, the energy consumption would be lower when measured with current standard conditions (EN load).

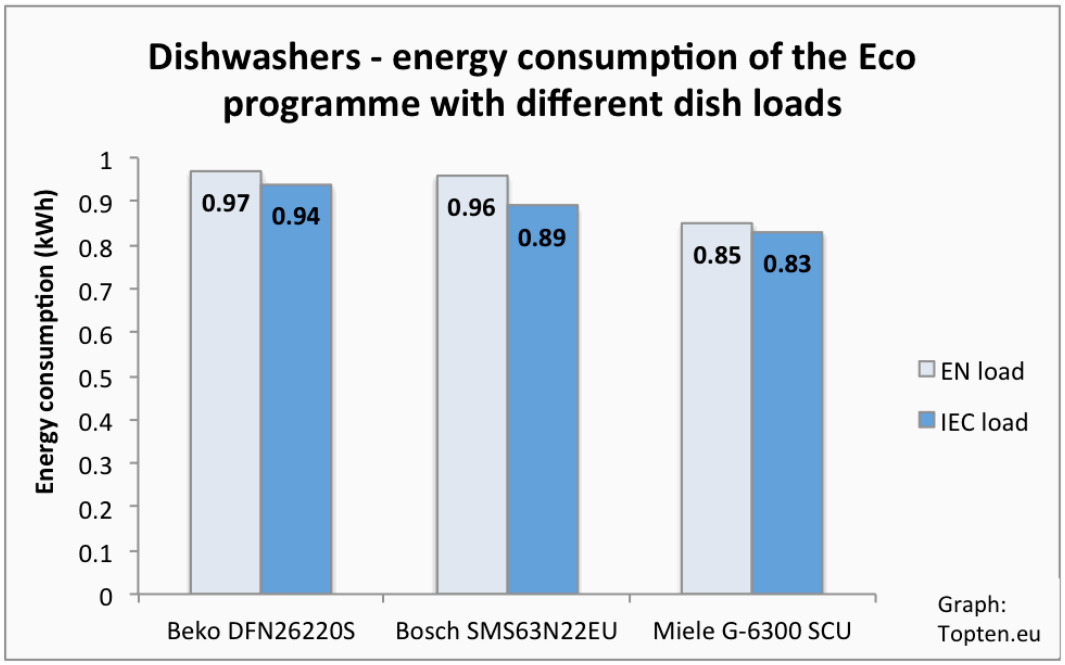


Figure 13: Measured energy consumption of the three dishwasher models' Eco programmes, with simple soiling: once with a dish load according to the current EN 50242, once with the future standard load according to IEC 60436.

Eco programme: small energy differences with different dishes and soiling

Figure 14 summarises the different results shown in Figure 10 to Figure 13 for the three dishwasher models, comparing them to the declared energy consumption. These results have all been obtained with the Eco programme, without any extra functions, and full load. What has been varied is the type of dish load (according to EN 50242 or IEC 60436), the level of soiling (according to EN 50242 / simple soiling / no soiling) and the water hardness.

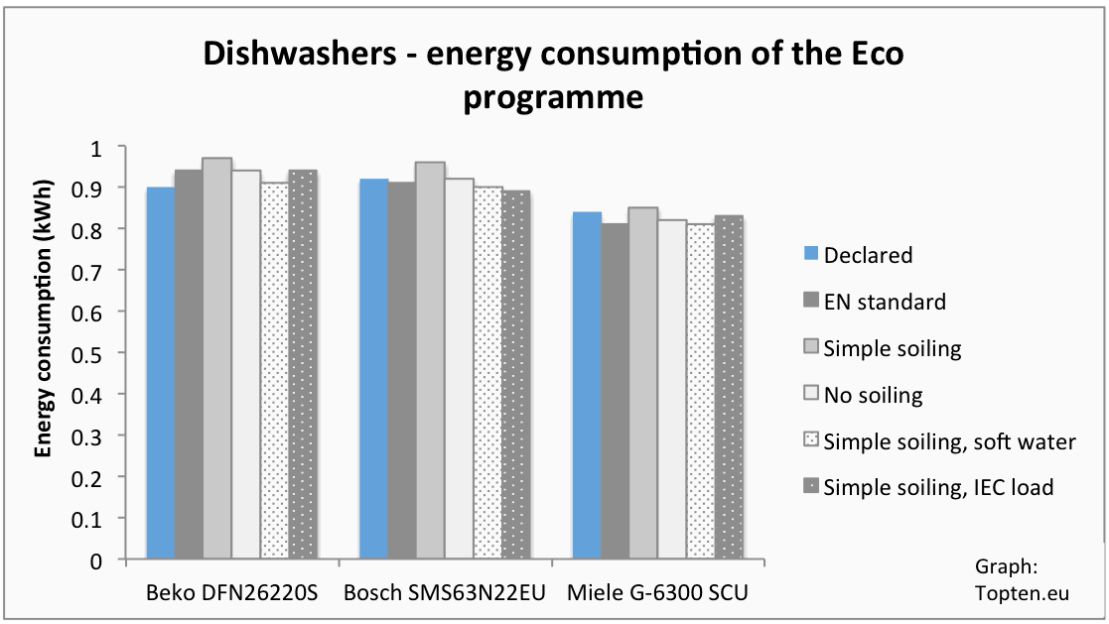


Figure 14: Measured energy consumption of the three dishwasher models' Eco programmes, with different dish loads, soiling levels and water.

Table 10 quantifies the differences in energy consumption of the Eco programme when measured with different dish loads, soiling or water. The energy consumption differences

between the most and least consuming test run (out of five test runs) were quite small: 7%, 8% and 5% for the three dishwasher models. Even though the tests were not performed according to standard conditions, the differences are smaller than the verification tolerance of 10%.

Table 10: Energy consumption differences of the Eco programme in different test runs

	Beko DFN26220S	Bosch SMS63N22EU	Miele G-6300 SCU
Declared (kWh)	0.9 kWh	0.92 kWh	0.84 kWh
Average from tests (kWh)	0.94 kWh	0.92 kWh	0.82 kWh
Maximum (kWh)	0.97 kWh	0.96 kWh	0.85 kWh
Minimum (kWh)	0.91 kWh	0.89 kWh	0.81 kWh
Difference Max – Min (%)	7%	8%	5%

Extra functions can increase energy consumption of Eco programme by 30% to 50%

The tests investigating the impact of extra functions on the energy consumption of the Eco programme were performed with the full load according to IEC 60436 and simple soiling. The results for the three models are shown in Figure 15, Figure 16 and Figure 17.

The two extra functions available for the Beko DFN26220S model are named ‘Short’ (shorter programme duration) and ‘SteamGloss’ (better drying). Combining either of these with the Eco programme increases the energy consumption by 0.22 kWh (23%) (Figure 15). Both can also be combined: this leads to an increase of 0.26 kWh (28%) compared to the Eco programme without extra functions.

When comparing to the declared energy consumption, not to a measured, (0.9 kWh), the differences are bigger for this model: 29% (‘Short’ or ‘SteamGloss’) and 33% (both).

Beko’s manual informs users that extra functions can change programme duration, and that selecting ‘half load’ can save water and electricity. For the other extra functions, Beko does not mention an influence on energy consumption. Excerpts from the manual can be found in Annex 1 (in German).

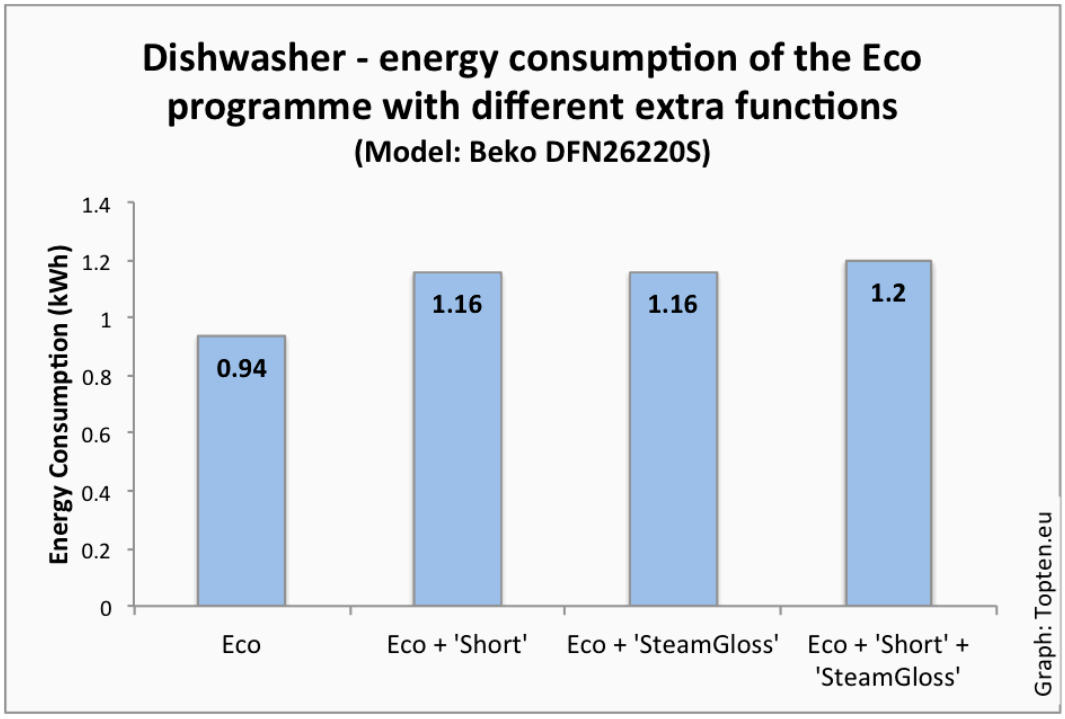


Figure 15: Beko DFN26220S - Measured energy consumption of Eco programme with extra functions activated (IEC load, simple soiling).

For the Bosch SMS63N22EU, available extra functions are 'VarioSpeed' (shorter programme duration) and 'IntensivZone' (for mixed dishes with pots and pans). 'VarioSpeed' resulted in an energy consumption that was 0.42 kWh higher than without this extra function - an increase of 47% (Figure 16). 'IntensivZone' lead to an increase of far less - 0.15 kWh (17%). Combination of both extra functions had a similar effect as the 'VarioSpeed' function alone: energy consumption was 0.44 kWh (49%) higher than without extra functions.

Comparing the above-mentioned energy consumption values to the declared consumption, the increase caused by the extra function would be 42% ('Short'), 13% ('SteamGloss') and 45% (both).

In the manual, Bosch informs users that the VarioSpeed function can increase water and energy consumption. For the IntensivZone function, there is no such note. Excerpts from the manual can be found in Annex 1 (in German).

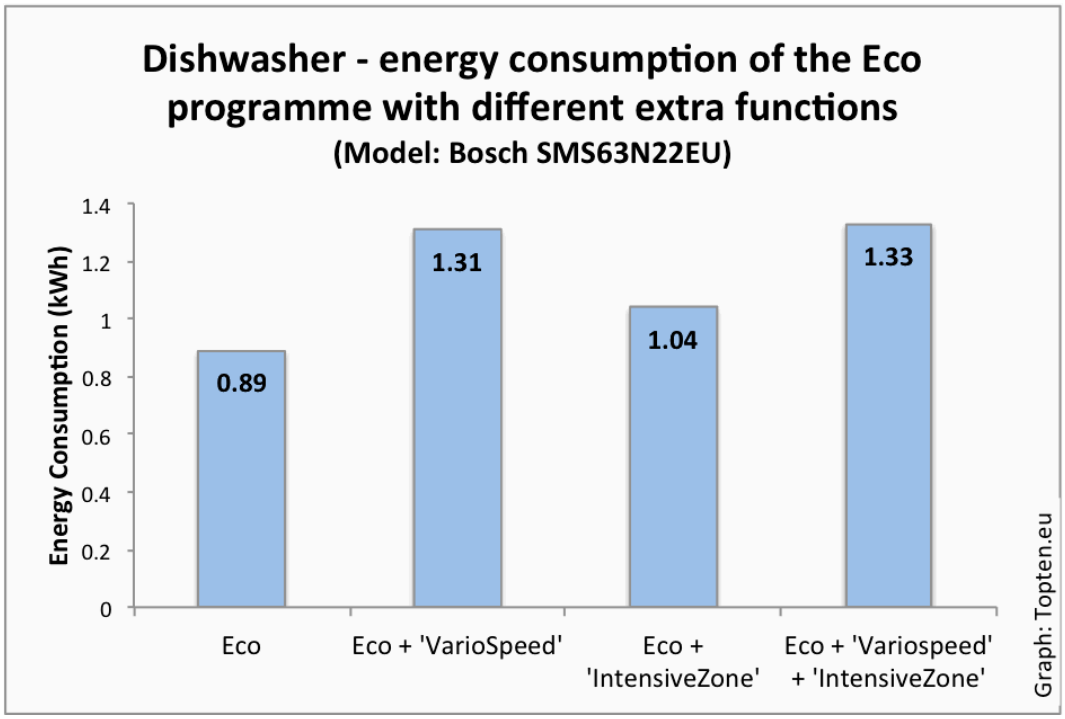


Figure 16: Bosch SMS63N22EU - Measured energy consumption of Eco programme with extra functions activated (IEC load, simple soiling).

For the Miele G-6300 SCU, extra functions available to go with the Eco programme were 'AutoOpen Off' (deactivating the automatic door opening during the drying phase), 'Short' and 'ExtraSaving' (lower energy consumption). Without the door being opened during the drying phase, 0.24 kWh more energy was consumed (29%) (Figure 17). The 'Short' function brought along a lower increase of 0.1 kWh (12%) only. The 'ExtraSaving' function did reduce the energy consumed by 0.04 kWh (-5%).
For the Miele model, the measured value used as a reference was very close to the declared consumption (0.84 kWh).

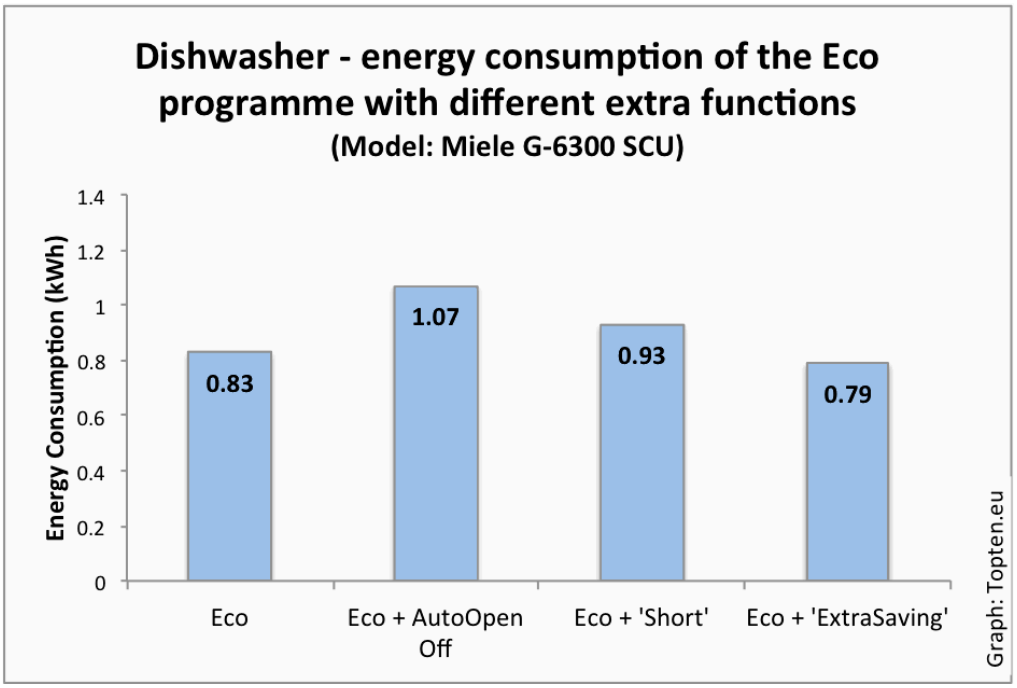


Figure 17: Miele G-6300 SCU - Measured energy consumption of Eco programme with extra functions activated (IEC load, simple soiling).

Extra functions can increase the energy consumption of the Eco programme by around 30% to 50%. The resulting energy consumption is far from the declared value, even though this is based on the same programme.

Miele informs users that the 'Short' function can slightly increase the energy consumption. For the ExtraSaving, an energy reduction of up to 20% is mentioned. For switching off the AutoOpen, there is not information about the impact on energy consumption. Excerpts from the manual can be found in Annex 1 (in German).

Other programmes consume more energy than Eco – Short uses less

The measured energy consumption of different programmes, shown below for the three dishwasher models, was established with full load according to IEC 60436 and simple soiling.

For the Beko DFN26220S, three programmes were tested this way apart from the Eco programme: Auto, Schnell&Sauber (Quick&Clean) and Intensive (Figure 18). The Auto programme used 1kWh in this setting – 6% more than the Eco programme (11% more than declared for the Eco programme). 'Quick&Clean', equivalent to a 'Normal' programme in other models, used 26% more than the Eco programme (31% more than declared), while the Intensive programme used 49% more energy than the Eco programme (56% more than declared).

The measured values are more or less in line with the energy consumption ranges indicated by the manufacturer for these programmes (Table 7). 'Quick&Clean consumed 0.12 kWh less than indicated, 'Intensive' used 0.03 kWh more.

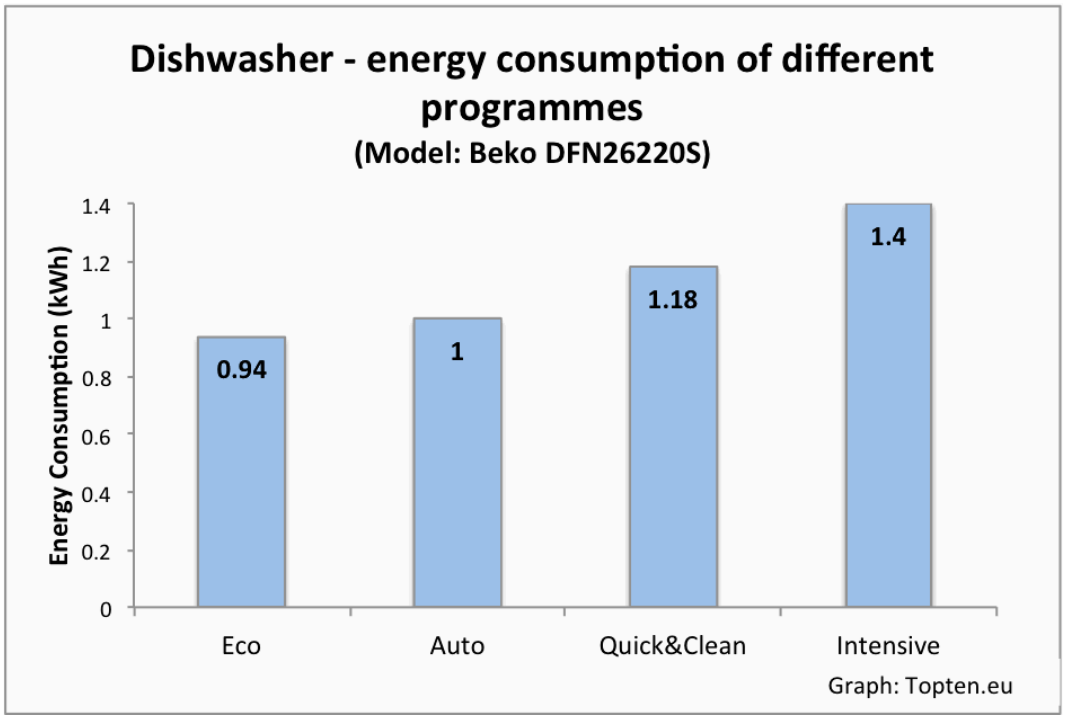


Figure 18: Beko DFN26220S - Measured energy consumption of different programmes (IEC load, simple soiling).

For the Bosch SMS63N22EU, the Auto, Intensive and Short programmes were measured with IEC load and simple soiling next to the Eco programme (Figure 19). The Auto programme used 25% more energy than the Eco programme (21% more than declared for the Eco programme), and the Intensive programme used 52% more (47% more than declared for the Eco programme). The Short programme used 19% less energy than the Eco programme (22% less than declared).

For the Auto programme, the measured energy consumption is in the range indicated by the manufacturer (Table 8). For the Intensive and the Short programmes, the measured values were lower than those indicated (Intensive: 0.1 kWh; Short: 0.08 kWh lower).

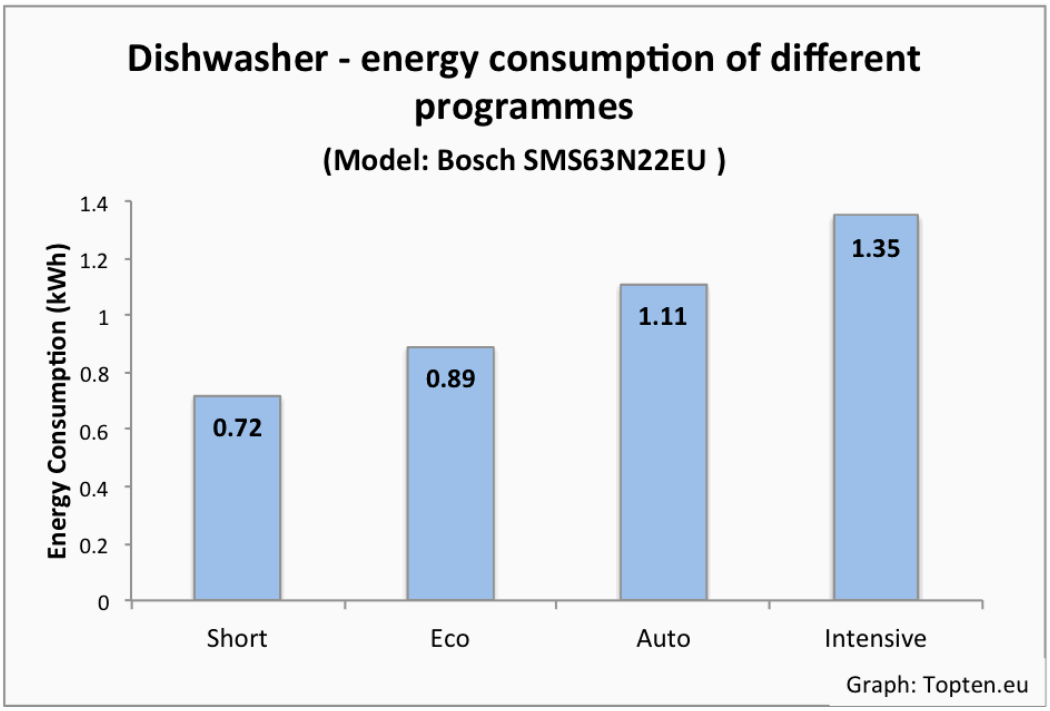


Figure 19: Bosch SMS63N22EU - Measured energy consumption of different programmes (IEC load, simple soiling).

More programmes were tested with full load according to IEC 60436 and simple soiling with the Miele G-6300 SCU model (Figure 20). With these settings, the Auto programme used 12% more energy than the Eco programme, ExtraQuiet 27% more, Normal 35% more and the Intensive programme used 73% more energy than the Eco programme. The differences to the energy consumption that is declared for the Eco programme are very similar, since the value measured for the Eco programme was close to that declared. All measured values are in line with those indicated in the manual (Table 9).

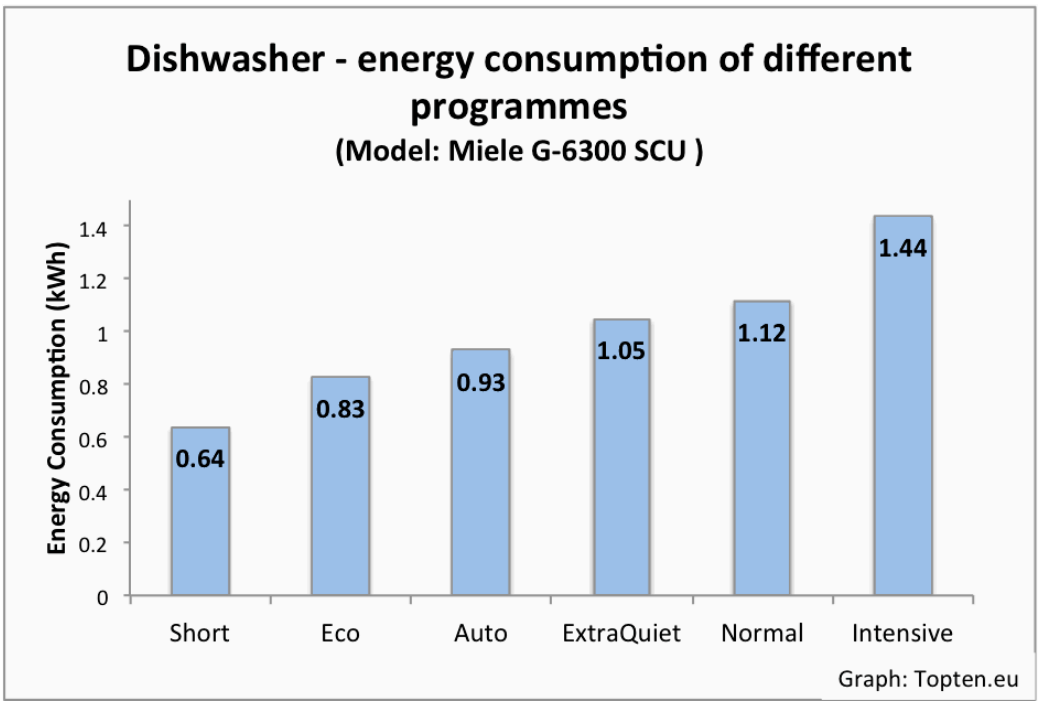


Figure 20: Miele G-6300 SCU - Measured energy consumption of different programmes (IEC load, simple soiling).

For both the Bosch and the Miele model, the **Short programme** used around 20% less energy than the Eco programme. (The Beko's short programme was only tested with half load. Compared to the half load consumption of the Eco programme, it consumed 26% less energy). Having the Sinner cycle in mind, this result may be surprising: reducing time would require a higher temperature and hence energy input to obtain the same cleaning result. However, the Short programmes do not achieve the same cleaning levels as the Eco programme: they're recommended for use for lightly soiled dishes.

The three dishwasher models' **Auto programmes** used 0.93, 1 and 1.11 kWh - 6% - 25% more energy than the Eco programme. Since the Auto programmes adjust their performance to the degree of soiling detected by the turbidity sensor, energy consumption is expected to vary strongly depending on the soiling.

The **Normal** or 'Quick&Clean' programmes used 1.12 and 1.18 kWh – 35% or 26% more than the Eco programme.

Most energy was consumed by the **Intensive** programmes, recommended for heavily soiled dishes by all three manufacturers. These programmes used 1.35 to 1.44 kWh, 49% to 73% more than consumed by the Eco programmes.

Programmes other than the Eco programme can use around 25% - 35% more energy than the Eco programme; the Intensive programme can use 50% to 75% more. These programmes may have higher functionality, cleaning heavily soiled dishes, or other advantages to users such as shorter programme duration or a lower noise level. Eco is not necessarily the most eco programme: Short programmes use less energy than the Eco programmes. Short programmes are recommended for lightly soiled dishes. For light soiling, Short programmes are the most economical choice.

The energy consumption values indicated for the different programmes in the manual are correct.

Is energy consumption in programmes different from the Label programme related to the energy efficiency class? This question cannot be sufficiently answered based on the tests that were performed within this testing project. First, no other performance aspects next to energy consumption have been analysed, and potential differences between the models are unknown. Second, as some variation in energy consumption – even at standard conditions – seems to be normal. Comparable energy consumption values for the different models shown in Figure 21 have been established based on a single test run and should thus be considered as indicative. The Beko DFN26220S and Bosch SMS63N22EU are in energy efficiency class A++, the Miele G-6300 SCU is in A+++. The Miele model should thus be around 11% more energy-efficient. Indeed Figure 21 show that for most programmes, the Miele model consumes a little less energy than the two A++ models. Only for the Intensive programme the Miele model's consumption is higher.

Energy efficiency for dishwashers means that models with capacity for more place settings can use more energy. Since the A+++ Miele model is the one with the highest place setting capacity of the three tested models, its relative consumption would be lower than that of the Beko and Bosch model with place for less place settings.

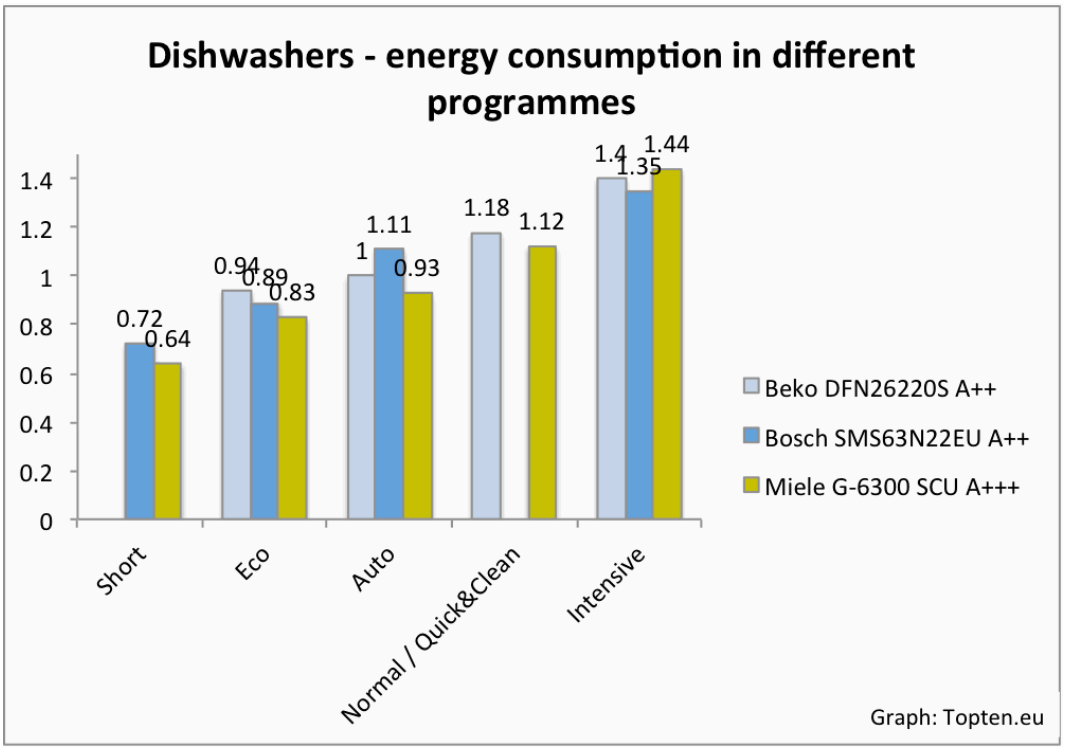


Figure 21: Energy consumption of different programmes of the three dishwasher models.

Even if programmes different from the Eco programme can use up to 70% more or 20% less energy than declared for the Eco programme, it seems that other programmes of energy-efficient models, are also more efficient. The ranking provided by the Energy Label could be valid for many programmes, and not only the Eco programme. However, the ranking does not seem to be valid for all programmes.

Different dishwasher uses can increase energy by 70% - or decrease it by 30%

Figure 22 to Figure 24 show the results of a selection of measurements that were done with different soiling, loads, programmes and extra functions, for the three dishwasher models. These results were obtained under very different conditions, with programmes designed to fulfil different functions, to achieve different levels of cleaning performance. Differences in energy consumption are expected and justified. The three figures below just provide information on how large the differences in energy consumption can be when using dishwashers in different ways. In these tests, the most-consuming dishwashing cycle would use 100% to 148% more energy than the least-consuming cycle.

In the Beko model, the most energy-consuming cycle tested was the ‘Intensive’ programme combined with both extra functions (‘Short’ and ‘SteamGloss’). This combination consumed 1.56 kWh – 144% more than the least consuming cycle, which was the ‘Mini 30°C’ – a short programme recommended for lightly soiled dishes - with half load. Compared to the declared consumption of the Eco programme, the high-consuming combination used 73% more energy. The least-consuming combination (Mini 30°C, half load) used 29% less energy than declared for the Eco programme.

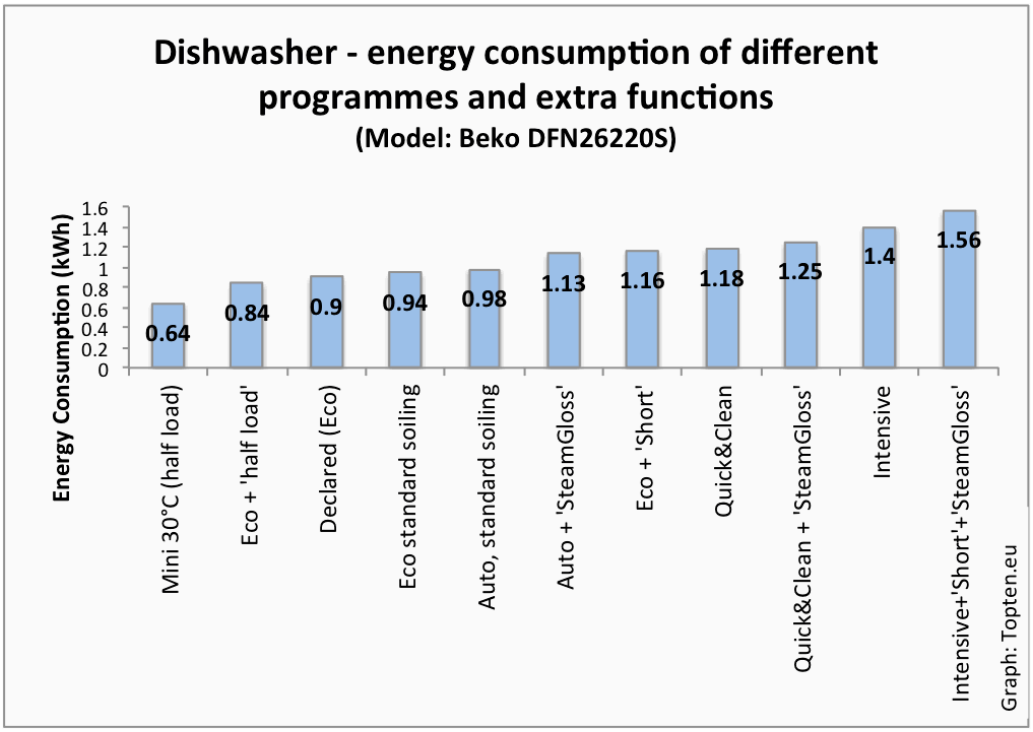


Figure 22: Beko DFN26220S - Measured energy consumption of different programmes and extra functions

For the Bosch model, the most consuming combination that was tested (the Auto programme combined with the 'VarioSpeed' and 'IntensiveZone' extra functions), used twice as much energy as the least consuming programme, which was the Short programme. The high-consuming combination used 57% more energy than was declared for the Eco programme, while the Short programme used 22% less than that.

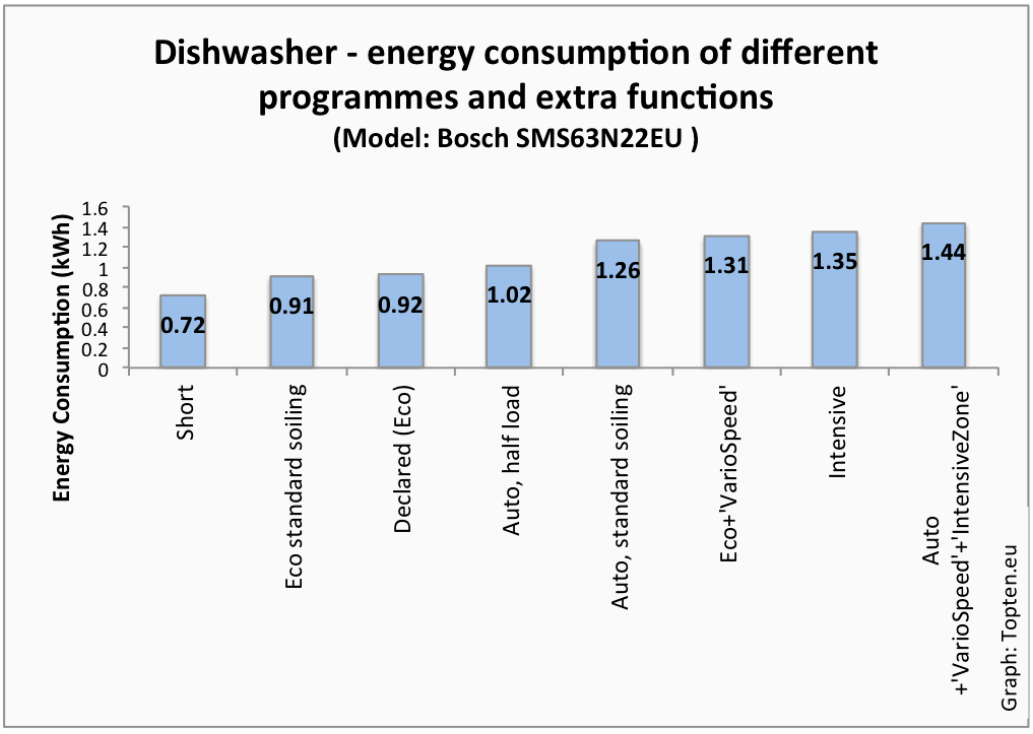


Figure 23: Bosch SMS63N22EU - Measured energy consumption of different programmes and extra functions

For the Miele model, the difference between least ('Short' programme with 'short' extra function) and most consuming combination ('Intensive' programme) was 148%. Surprisingly the 'short' extra functions seems to lead to a reduction in energy use with the 'Short' programme, but to an increase with the 'Normal' programme. The Intensive programme used 71% more energy than declared for the Eco programme, the Short programme with the extra function 'short' used 31% less than that.

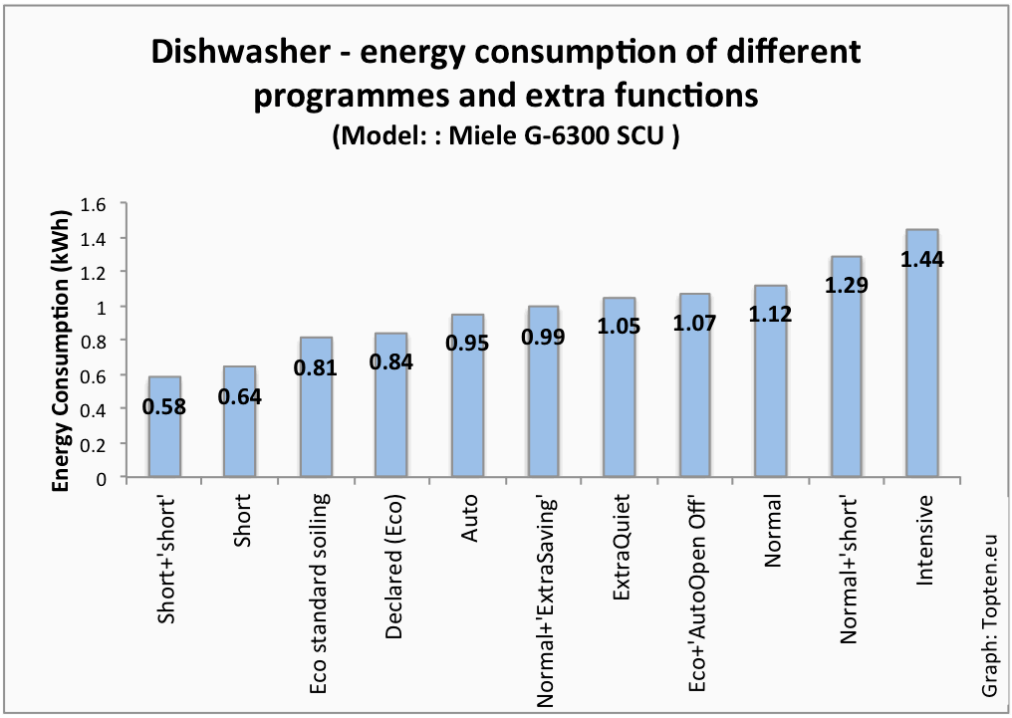


Figure 24: Miele G-6300 SCU - Measured energy consumption of different programmes and extra functions

Using a dishwasher different from the way it is tested in the lab - with different programmes, extra functions, dishes and soiling levels - changes its energy consumption to levels that are different from that declared on the Energy Label. Combinations tested in the measurements for the present study resulted in energy consumption values that are 60% to 70% higher than declared, but also 20% to 30% lower.

Half load: energy reduces only around 10%

The measurements with half load were performed with the Eco programmes, the future IEC load and simple soiling. For the half load test runs, only 50% of the place settings were filled into the dishwashers. The Beko model features an extra function for 'half load'. For one test, this was selected, for the other half load test it was not selected.

The results shown in Figure 25 reveal that the energy reduces only around 10%.

In the Eco programme, the reduction reached 11% for the Miele model, and 7% for the Bosch model. The Beko model reduced the energy consumption by 7% when the 'half load' extra function was not selected, and by 11% with this function activated.

With the Auto programme, half load lead to an energy reduction of 15% for the Beko model, 8% for Bosch, and 10% for the Miele model.

For the Miele G 6300-SCU, half load energy reduction was also measured for the Normal programme: it was 9%.

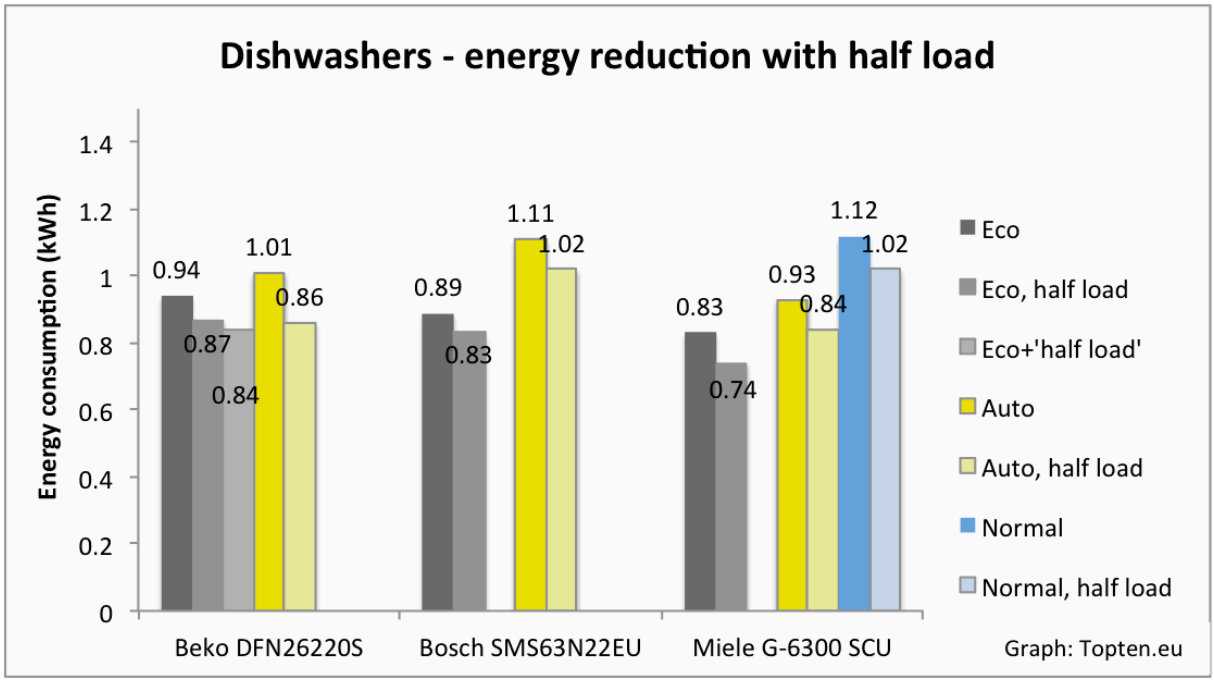


Figure 25: Measured energy consumption with full and half load in Eco and Auto programmes. + 'half load' means that this extra function has been selected.

With a 50% lower mass of dishes that needs to be heated up, a certain energy reduction is expected to be realised automatically. There is a rule of thumb that one third of the heating energy is needed to heat up the dishes, one third to heat up the water and another third to heat up the machine. Assuming that 10% of the energy is consumed by the pump, this leads us to expecting a physical energy reduction of 15% for half load (0.9 (total heating energy) * 0.33 (dishes heating energy) * 0.5 (half load)).

The measured energy reduction is only around this expected physical energy reduction, so it does not seem that there is any energy reduction beyond this.

This is in line with what was said in the draft preparatory study by the JRC (2015): the amount of water needed remains almost the same, no matter to what extent a dishwasher is filled. It depends on the interior volume and design, and on the amount of water needed by the pump, but not the quantity of dishes.

Not filling dishwashers fully hence wastes more than 40% of energy. User information about this was not found in all the manuals: while Beko and Miele advice users to completely load the dishwasher in order to clean efficiently, such a hint could not be found in the Bosch manual.

Hot Fill: around 20% energy savings for most tests

The last measurements aimed at quantifying the energy saving potential by Hot Fill. The Bosch and Miele models are compatible for Hot Fill (connection to tank with water that has been heated with renewables). For both of these models the energy consumption of the Eco programme when filling in hot water (45°C; EN load, simple soiling) was measured and can be compared to the same tests without Hot Fill.

For the Bosch model, Hot Fill with the Eco programme saved only 8% of energy (only 4% even when compared to the declared consumption of the Eco programme). Additionally, the impact of Hot Fill in the Auto programme was assessed (IEC load, simple soiling). Here, Hot Fill saved 18% of energy.

As the other results with Hot Fill show (see below), savings of around 20% are common. The low savings by Hot Fill in the Bosch's Eco programme could possibly be explained by a

feature this model has: The Bosch SMS63N22EU has a water tank of around 1.5 litres capacity attached to its side. Without Hot Fill, such a tank can help save energy and, possibly, also water. If hot instead of cold water is stored in the tank, energy can be lost, because the water in the tank will cool down instead of heating up. Water tanks as energy-saving features are further addressed below in chapter 6.2.
The Bosch manual contains information that Hot Fill can save energy and time when the hot water is heated 'in an energetically favourable way' and installations are suitable.

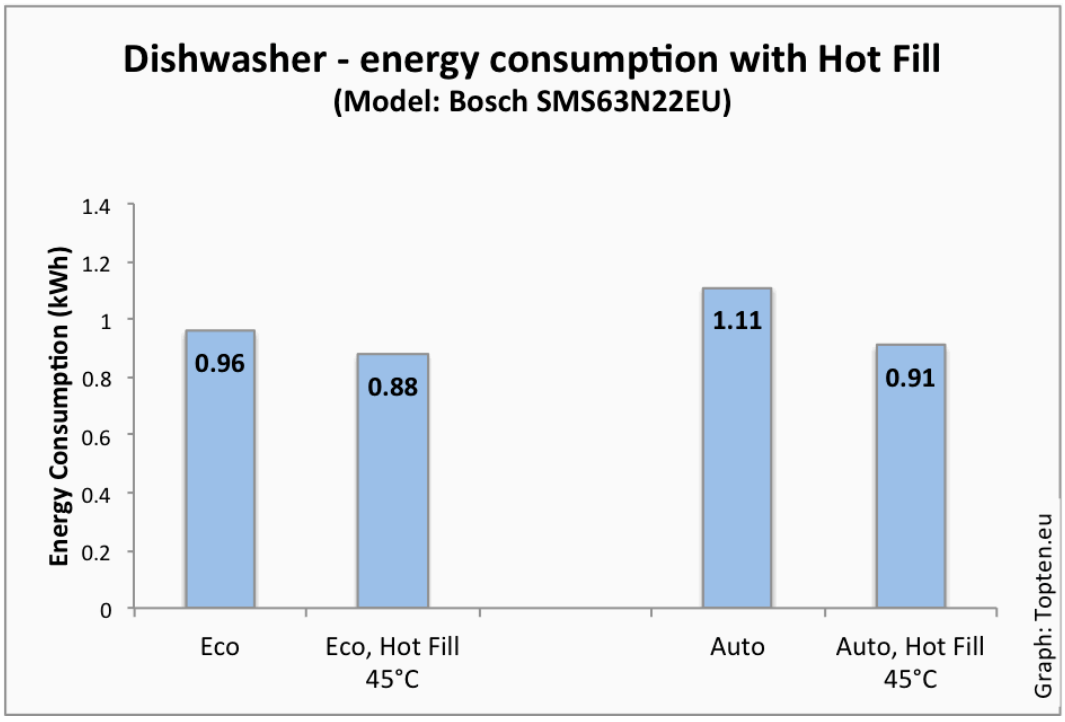


Figure 26: Bosch SMS63N22EU - Measured energy consumption without and with Hot Fill (hot water at 45°C) for the Eco and Auto programmes.

For the Miele model, measured energy savings in the Eco programme by Hot Fill (EN load, simple soiling) were 21% (20% compared to the declared consumption of the Eco programme). With the Normal programme (IEC load, simple soiling), Hot Fill lowered the dishwasher's energy consumption by 23%. The SolarSave programme renounces on additional heating. Compared to the declared energy consumption of the Miele model, this programme saves 92%. Since this programme may wash at low temperatures, its performance cannot be compared to that of the other programmes. A drawback is the high-water consumption of this programme: it uses 27 litres (see results table in Annex 2) – around two to three times more than other programmes. If water is heated with solar power, it should normally by used economically. If the water is heated with a heat pump water heater, this saves roughly two thirds of energy compared to electrical heating without heat pump. These savings will however be outweighed, if three times more water is used.
The Miele manual informs users that Hot Fill is recommended if the hot water is heated 'in an energetically favourable way', and that in this case it saves time and electricity.

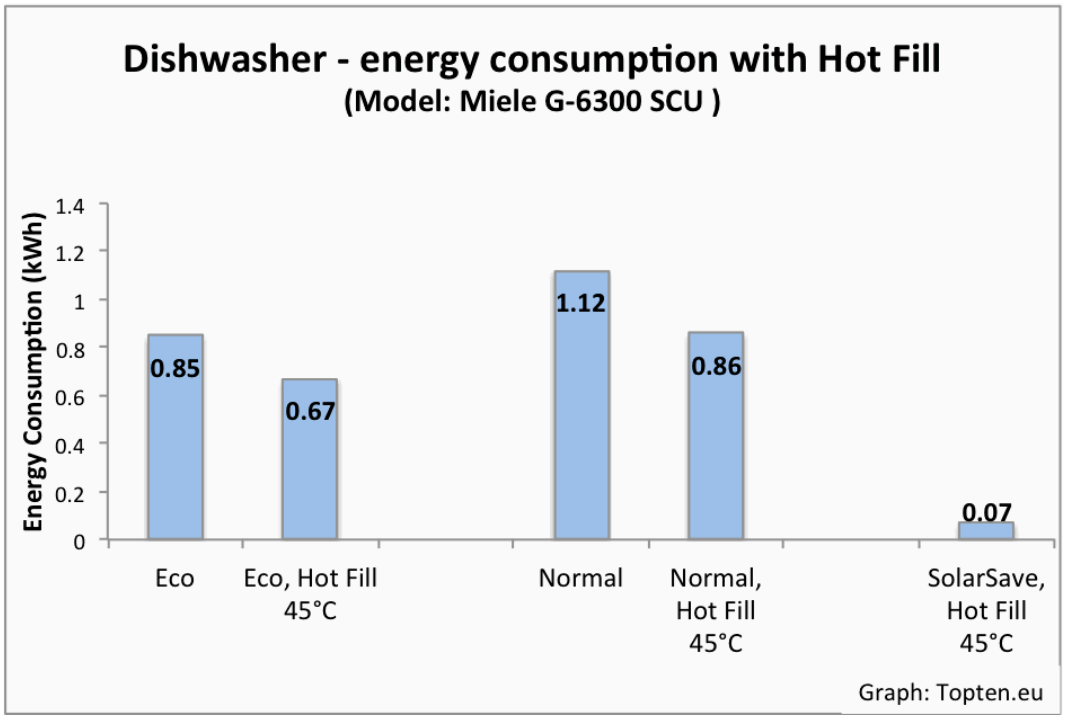


Figure 27: Miele G-6300 SCU - Measured energy consumption without and with Hot Fill (hot water at 45°C) for the Eco and Normal programmes, and for the SolarSave programme with Hot Fill.

For most tested cycles, Hot Fill saved around 20% of energy.

For the effectiveness of Hot Fill, the length of the pipe between hot water tank and dishwasher is decisive, because the water in there will cool down between cycles or even phases within one cycle. In the VDE lab, this pipe is very short – shorter than it will be in most households (total water in external plus internal dishwasher pipe is around 400ml at the lab). On the other hand, the temperature of 45°C that was used in the tests is rather low: in many households it can be hotter, around 55°C. While one effect (short pipe) may lead to overestimating the potential savings, the other one (low temperature) may lead to underestimating it. As a result, real saving by Hot Fill, may be close to the resulting 20% found in the tests.

Assuming that one third of the heating energy is needed to heat up the water (the other two thirds for heating up the dishes and the machine), the 20% savings that have been found in the tests are about what can be expected for normal dishwashing programmes. In its preparatory study, the JRC estimates that only two other design options have the potential to save as much or more energy (longer programme duration: 20%; heat pump: 40%).

Even more energy – around 90% - can be saved with a programme that renounces on additional heating, at least if no high cleaning performance is needed.

5.2 Other results

This chapter presents findings that were not obtained directly through the measurements, but in research or discussions related to organising the dishwasher tests.

User guidance

Additionally, to energy and water consumption, the VDE institute assessed how the three dishwasher models are guiding users: how easily can the Eco programme be found? Which programme is pre-selected when the dishwasher is switched on?

Tests by VDE found that for all three models the Eco programme is pre-selected when the appliances are switched on. This is in line with the regulation requiring the Label programme to be the 'default' programme, and it makes it easiest for users to select this programme. The different programme selection panels are displayed below in Figure 28 to Figure 31.

Figure 28: Programme selection panel of the Beko DFN26220S. Image source: VDE

Figure 29: Beko DFN26220S: Legend explaining the programmes' number on top of the door

Figure 30: Programme selection panel of the Bosch SMS63N22EU. Image source: VDE

Figure 31: Programme selection panel of the Miele G-6300 SCU. Image source: VDE

The Miele model's manual however mentions a 'memory' function. If this is activated, the default programme will no longer be the Eco programme, but the last used programme. Users must actively change the setting.

Energy-saving feature: Water tank

The tested Bosch model SMS63N22EU features a water tank. It is a very flat water tank covering one side of the appliance, acting as a heat exchanger. Such water tanks are not uncommon with dishwashers. At the end of a cycle, tap water is filled into the tank to have it preheated to room temperature for the next cycle. Also during a dishwashing cycle, the tank can be used to preheat water a bit. Such a water tank saves the dishwasher heating energy.

Other models may even fill the tank with warm rinsing water at the end of a cycle, if the water is clean enough. In case another cycle is run shortly after the first one, the tank water can save energy, because it will still be warm. If the next cycle is run only after the water has cooled down, it will at least be pre-heated to room temperature and still save energy. Such a water tank also saves water, of course.

Figure 32: Water tank attached to the side of the Bosch dishwasher model.

Water tanks make it difficult to predict a dishwasher's behaviour. Like other energy-saving features, they may be activated in a cycle or not – depending on the algorithm. Activation can depend on the programme, on the programme that was run before, on the time gap between two programmes, or other aspects. So, it's difficult to determine whether the water from the tank was used in the Hot Fill cycle with the Bosch model's Eco programme (see above). However, if a water tank is used in combination with Hot Fill, energy will be lost instead of saved: instead of hot water, water at room temperature from the tank will be used initially. Hot water may be filled into the tank, where it cools down. Models with a water tank should deactivate this at first installation if connected to a hot water pipe: installers could be asked on the display if the unit is connected to hot water, and the water tank be deactivated if the answer is 'yes'. The same is true for other features that may not make sense in certain situations.

Another aspect is that a water tank is not always active. Its activation may depend on the programme or other aspects, and usually also on the time elapsed since the last cycle. For hygienic reasons, models with water tank are programmed to only use the tank water if it has

not been stored in the tank for too long. Depending on the algorithm, this may mean that the tank water will be disposed of if the dishwasher has not been used for e.g. three days. Some models may stop tracking the time when they're disconnected from the mains, and empty the water tank whenever they're re-connected. Yet other models may rinse the tank with hot water after e.g. 20 cycles. This means that for users with specific habits (e.g. using the dishwasher only twice a week, disconnecting it from the mains after each cycle, but also with preferences for programmes that may not use the water tank), energy-saving features may only seldom be active, and the resulting energy consumption may be higher than declared.
Users should be well informed about how a dishwashing model reacts to their behaviour, and activation/deactivation of energy-saving features should be made transparent in the manual. Even better would be to inform consumers before they make their purchase decision. Users with specific habits could use this information to better understand, how a model would perform under their own dishwashing habits.
Also, energy-saving features should be deactivated in cases where they may not save energy (e.g. a water tank with Hot Fill). Of course, this should also be transparent to users.

Water consumption

Water consumption was measured, but not systematically assessed for this study. All results on water consumption can be found in the overview table in Annex 2. Water consumption varied between 10.4 and 20.9 litres for the Beko DFN26220S (average: 12.3l), between 9.4 and 17.5 litres for the Bosch SMS63N22EU model (average: 12.2l), and 9.7 and 27.7 litres for the Miele G-6300 SCU (maximum apart from the SolarSave programme is 16.4 litres; average is 12.3l with/ 12.9 without SolarSave consumption). The water consumption values for the different models cannot be directly compared, because not for all models the same set of conditions and programmes was tested.
The tables in the Annex show that water consumption is lowest for the Eco programmes for all three models (around 10 litres per cycle).
Water consumption is usually higher in regeneration cycles (see below). On average, every fourth or fifth cycle can be a regeneration cycle, so for around four to five test cycles per model water consumption will have been increased due to regeneration.

Regeneration cycles: inclusion to result with new standard

Regeneration cycles: dishwashers do regenerate from time to time, meaning they may rinse their internal space with hot water, exchange all the remaining water, de-carbonise everything etc. In such a regeneration cycle, the water consumption can be higher than normal. Energy consumption is usually not increased.
Most models regenerate after four or five cycles, the exact frequency depends on how a model has been programmed. Users are advised to choose the local water hardness. Usually a dishwasher model regenerates more often if used with harder water (higher calcium content).
During the five test cycles that are used for calculating the average energy and water consumption for the Energy Label, regeneration can occur. With the current standard, a 'suspect' regeneration cycle is not used for calculating the average consumption. With the new test standard, the results of all five test runs will be used – potential regeneration cycles will thus be included in the result.

Combination of tests to avoid circumvention

Circumvention is not unknown to dishwashers: according to the testing engineer, one reason for the combined testing of cleaning and drying (CCD) is to avoid circumvention. It seems that some dishwashers showed different behaviour in the separate test runs for cleaning

performance and energy consumption, and drying performance, respectively. While cleaning performance and energy consumption is measured in the same test runs today, drying performance is assessed separately and with clean dishes. This procedure is technically easier, because wet soil can clog and inhibit drying.

With the tests being combined in the same test runs in the future, dishwasher models will have to clean and dry well, while being energy-efficient at the same time – just as is expected they should do in people's homes.

With the current test standard, also sound power is tested with clean dishes. With the new standard, the acoustic test will be performed with one of the glasses containing frozen milk. According to the testing engineer, also the reason for this change is to avoid circumvention: some models had clearly lower sound power levels when tested with clean instead of soiled dishes. The milk is expected to melt and to activate potential sensors over the course of the cleaning cycle. The sound power test has to be performed in the acoustic test lab, therefore it cannot be combined with the other test runs.

6 Conclusions and recommendations

6.1 Key results and conclusions

- **No compliance issues:** the results of all measurements that were performed with standard conditions were in line with the declared values.
- **No hints on circumvention in tests:** no hints were found in the tests that the tested dishwasher models might recognise a test situation based on the dish load, level of soiling or water hardness, and adapt their performance accordingly. However, circumvention has been an issue also with dishwashers. Standardisation bodies have already taken steps to avoid circumvention: the new standard combines the cleaning and drying performance measurements (combined cleaning and drying, CCD) to avoid different, optimised behaviour for the two tests, and the acoustic test will include some soiling, which shall make circumvention more complex.
- **If used differently from the way a dishwasher is measured for the Label declaration, it can consume up to 70% more energy than declared: Most important aspect contributing to energy differences is the programme diversity (different programmes and extra functions).** Users choosing programmes other than the Eco programme, such as Normal, Quick&Clean, Auto or Intensive, may end up with energy consumption that is up to 70% higher than declared. For two of the tested models, the most energy-consuming programme would only get a class C efficiency, one combination would be in D. This idea does not consider the higher functionality of more energy-intense programmes. Considering that some programmes wash at higher temperature, this difference is not unexpected. But for consumers it may not be obvious that the energy label is referring only to one of the programmes.
  Manufacturers provide information on the consumption of all programmes (based on Ecodesign regulation), which is in line with the results of the project tests. Today's declaration on the Label however does not consider this big variation in energy consumption that comes with the big range of use possibilities in dishwashers.
  It is not clear if the Label's rating is valid for all programmes or if it's possible that for some programmes other than the Eco programme, a dishwasher rated as A++ could be more efficient than an A+++ model. Results from this study imply that the rating could be valid for many, but not all programmes. To find out more about this, more research would be needed.
- **When using the Label programme, energy consumption can be 30% to 50% higher than declared: Extra functions can increase energy consumption of the Eco programme.** If the Eco programme is combined with extra functions such as 'Short' or 'Extra Drying', this can result in a 30% to 50% higher energy consumption. Manuals do inform users about the impact on energy consumption of some, but not of all of these extra functions.
- **Energy consumption can also be lower than declared: Short programmes use around 20% less energy than the Eco programme.** Short programmes use less energy than the Eco programme. In one test, a Short programme in combination with an extra function 'short' used even 30% less than declared for the Eco programme. (This is no general rule: In combination with other programmes, extra functions such as 'Short' or 'Timesaver' however lead to a higher consumption.)

Short programmes operate at lower temperatures, and are recommended for lightly soiled dishes. Hence, for such dishes, the Eco programme is not the most eco choice.
As for the other programmes, manufacturers indicate the energy consumption of the Short programmes in the manual. Still, this result came a bit surprising: with the sinner cycle in mind, shorter programmes are expected to use more energy, because they need to operate at higher temperatures. This is not true for the Short programmes that have been tested though: they don't achieve the same cleaning performance as the Eco programme.
The low energy consumption of the short programmes is not clearly communicated to users, even though it is indicated in the manufacturer's programme information. The information is contradicted:

1) The name 'Eco' of the Standard programme implies that this is the most economical and ecological programme.
2) Based on the information requirements of the Ecodesign regulation, manufacturers inform users that 'the Eco programme is the most energy-efficient programme to clean normally soiled tableware'. This may be correct, since it is referring to 'normally soiled tableware', but the formulation does not make transparent that for lightly soiled dishes the Short programme is more 'eco' than the Eco programme. Additionally, most manufacturers combine (or replace) this technically correct formulation with own sentences, saying that the Eco programme 'is an especially environmentally friendly programme' or should be selected for energy-saving dishwashing'. These formulations are not technically correct, since there is no condition regarding the soiling level. But even without these not fully correct additions, it is very questionable that users would understand the importance of 'normally soiled tableware' in the official formulation.

This makes it impossible for most consumers to understand that for lightly soiled dishes the Short programme is the more energy-efficient option than the Eco programme.

- **Half load: energy reduces only around 10%,** even when choosing a 'half load' extra function. This is not surprising and has physical reasons. It is key that users are well informed that not filling their dishwasher fully will lead to a waste of water and energy. Today, this advice is not in all the manuals and not easy to find.
- **Hot Fill can save 20% energy under certain conditions:** If a household's hot water is heated in an energy-efficient way and the pipe between water tank and dishwasher is short, then Hot Fill can save 20% of energy with most programmes. With special Hot Fill programmes that renounce on additional heating, energy savings can reach 90%. Since a hot water tank is often placed in or near the kitchen (meaning short pipes are common), and more and more houses are installing solar panels on their roofs, this saving option should be promoted. In its preparatory study, the JRC estimates that only two other design options have the potential to save as much or more energy (longer programme duration: 20%; heat pump: 40%).
- **Water tank may hinder energy savings through Hot Fill:** If the water from the hot water tank is filled into a dishwasher's water tank instead of the dishwasher's interior directly, energy savings will be lost. In order to realise these potential savings, it is key that dishwashers suitable for hot fill are designed in an appropriate way: models with a water tank should deactivate this at first installation if connected to a hot water pipe, and Hot Fill programmes should also use water in an efficient way.

Without adding a requirement to test and declare the savings through Hot Fill, this is difficult to address with regulations. This however seems exaggerated. It seems more adequate to trust in manufacturers' ability to design smart products.

- **Energy-saving features may not always be active.** The Bosch model that was tested in the project features a water tank, which acts as a heat exchanger. A water tank can save energy and water, but it may not always be activated. Depending on programme choice, dishwashing cycle frequency or disconnection from the mains it may be deactivated, e.g. for hygienic reasons. If a water tank – or any other energy-saving features – is not activated, the energy consumption will be higher than declared. The activation and deactivation of energy-saving features is not transparent. This means that for some users, depending on their habits and preferences, they might not be active normally and energy consumption can be increased for most cycles.

6.2 Can the situation be compared with diesel cars?

No hints on circumvention have been found in the tests for this project. However, the fact that standardisation bodies are changing the measurement standard by combining testing of different functions into one test run might be an indication that some dishwasher models might have been recognising a test situation with their sensors and adapting their performance to yield better results for the aspect that was being measured. The future measurement standard will make circumvention more unlikely.

The tests done for this project itself could not find any hints on dishwasher models that could be detecting a test situation and adapting the performance accordingly.

For diesel cars, VW had admittedly installed a software that was doing exactly this: artificially lowering the NOx emissions for the test.

Also, when not looking at circumvention, but at the difference between the declared value yielded according to regulations and standards, and the consumption / emission that can occur when used differently, the two cases cannot be compared. While diesel cars were found to be emitting on average 7 times, in extreme cases 25 times more NOx (ICCT, 2014), the highest energy consumption measured with dishwashers exceeded the one declared by 70%. This difference is 35 times smaller than with diesel cars.

While for diesel cars it is about emissions exceeding a maximum permissible value, for dishwashers it is about exceeding a declared value. And of course, while NOx emissions by cars directly harm human health, electricity consumption by dishwashers does not directly impact people's health.

Clearly, the situation with dishwashers – and assumedly other home appliances – is not comparable with that for diesel cars. It is far less dramatic.

Still, the results from this study allow formulating some recommendations that could further improve the situation for dishwashers and other home appliances.

6.3 Recommendations

1. Combination of testing of different aspects

Assessment of different functions and aspects, which are combined in real-life operation, should also be combined for the tests as far as possible, in order to make circumvention more challenging. This can be considered as a general rule for testing.

Separate testing of different aspects can allow products to adapt and behave differently, depending on which aspect is being assessed (presuming that the model under test can detect the test situation). For dishwashers, standardisation bodies have noticed that separate testing of cleaning and drying performance and sound power can facilitate circumvention, and have already taken steps to improve the test standard accordingly. With the new test standard (IEC 60436:2015 and EN 50242:2016), testing of cleaning and drying performance will be combined, together with measuring the energy and water consumption, and drying performance will no longer be assessed with clean dishes. It is technically more challenging, but makes circumvention more complex, while also reducing the number of test runs. For the sound power test, test conditions will also be closer to those of the other test runs and closer to real-life, since it will no longer be performed with clean dishes, but with a glass of frozen milk added. The sound power test seems to be difficult to combine with the other test runs, because it has to be done in the acoustic test lab.

Combining the testing of different aspects is closer to reality: products are expected to perform well in all different aspects and functionalities at the same time, and/or make trade-offs.

2. 'Normal' programme should be Label programme

The name 'Eco' for the Label programme is misleading. The Label programme must be suitable to clean normally soiled dishes. The Short programmes, recommended for lightly soiled dishes, use less energy. So, for lightly soiled dishes, the Eco programme is not the most economical and ecological programme. Pushing users to using the Eco programme may miss energy savings, when a short programme could be more adequate.

On the other hand, 'Normal' programmes are the most used programmes and their name expresses that they're suitable to clean normally soiled tableware (which the name Eco does not communicate).

Therefore, the Energy Label should refer to the 'Normal' programme, and the measurement standard should be changed to refer to the 'Normal' programme as well, to delete today's contradiction between regulations (referring to a 'standard programme') and the measurement standard (saying that the Eco programme should be tested).

3. Need for consumer information

Users need to be well informed about how their dishwasher works and how they can contribute to its energy-efficient operation. The following information should be systematically included in the manuals:

- Not filling the dishwasher to its full capacity wastes energy & water. Two cycles run at half load consume around 80% more energy than one full load cycle.
- Transparency on activation deactivation of energy-saving features, such as a water tank. Users should be informed that specific use habits can lead to a higher energy consumption.
- Clear information on when a connection to hot water makes sense from an energy point of view: when the hot water is heated efficiently (e.g. with a heat pump) and/or with

renewables (e.g. solar panels), and when the pipe between water tank and appliance is short (max. 1-2 litres (Bush, Nipkow, 2007)).

4. Hot Fill can be an important saving option: need for communication

Hot fill can save 20% to 90% energy. Since the availability of this option strongly depends on the building (water heating with renewables or heat pump, short pipe) it cannot be a requirement. But the high potential savings justify better communication to make sure that those consumers having the right conditions in their home are aware of it. An icon on the Label could show if a dishwasher model can be connected to hot water. At the same time, it would raise the awareness among consumers.

More detailed information about when a hot water connection makes sense would have to be in the manual and/or the Label Fiche.

5. A new approach to testing and declaring may be needed to address the big range of ways to use products

For dishwashers, the new measurement standards IEC 60436:2015 and EN 50242:2016 have already been changed to become more consumer-relevant:

- A new dish load has been elaborated, which is more consumer-relevant. It includes larger items (pans) and also plastic parts.
- Regeneration cycles from the test are included to the calculation of energy and water consumption. With the current standard, suspect regeneration cycles are not used to calculate the average consumption. However, with regeneration occurring around every fourth to fifth cycle, they are definitely part of consumer-relevant consumption. This change makes the standard more consumer-relevant.

These changes cannot address the fact that the declaration on the Energy Label, referring to just one of many ways how product can be used, has a limited relevance. If used differently from how dishwashers are tested, their energy consumption can be up to around 70% higher – or 20% to 30% lower than declared. Especially the programme diversity leads to this big variation. It seems that the Energy Label's ranking is valid for most programmes. Still, for some programmes, it may be that an A++ model is more energy-efficient than an A+++ model.

Is the situation satisfactory; are changes needed to address these discrepancies?

On the one hand, the discrepancies are considerable, and most users are probably not aware of them. On the other hand, the differences are in the expected range, and most of them are made public in the manuals. Interested users have the information to know how much energy any of the programmes is using. For extra functions, far less information is provided. But it is nearly impossible to provide detail info for each programme – extra function(s) combination – information that would hardly be considered by users.

In order to address the differences in energy consumption due to different programmes, extra functions and ways of use, a new approach to testing and declaring would be needed. An idea that has been discussed among energy efficiency and product experts is inspired by the development in testing of cars after Dieselgate:

1. Test and declaration according to clearly defined, standardised test conditions, like today.
2. The most consuming use (programme, settings – probably excluding extreme uses) must consume maximally an XY% amount more than what's declared.
3. Additionally, manufacturers could declare their most efficient programme / mode: e.g. Eco mode: 20% less than declared.

Ways would have to be found to introduce such a new approach without increasing too much the testing burden, and to make sure that consumers understand the additional information provided. This should be further discussed. More thoughts about this idea can be found in the next chapter 7.4.

6. Smart product design needed - and smaller dishwashers?

In order to realise the potential savings by Hot Fill it is key that dishwashers are designed in an appropriate way: models with a water tank should deactivate this at first installation if connected to a hot water pipe, and Hot Fill programmes should also use water in an efficient way.

It is up to manufacturers to consider the different ways their products may be used and design them in a smart way, so that energy savings are not hindered.

Additional research could look into the question if small and average-sized households find enough small dishwashers on the market, and if smaller dishwashers could reduce energy and water waste due to under-loading. Possibly incentives for more small models could be included in the frame of the regulations' revision, or promotion programmes could be considered.

6.4 Discussion: idea for new approach to testing and declaring

A new approach in testing and declaring could move to the same direction as testing is going for cars: cars will no longer only be tested in a lab at very specific conditions. Instead cars will additionally be tested on the road, with a wide range of driving patterns allowed during the test. The new real-driving emissions test standard for cars[7] contains only the boundary conditions of what the tester can do. This will make cheating a lot more difficult, and emission limits must be met in a wide range of possible driving conditions and situations.

Dishwashers need not be taken out of the lab. And, unlike for cars, dishwasher tests do not only check if models are respecting minimum performance limits. Instead, the results are used to compare the models among each other with the Energy Label. So, comparable test conditions are needed for testing products for the Energy Label. The declared energy consumption, cleaning and drying performance etc. need to be assessed at clearly specified conditions – exactly the same for all models, and the results must be repeatable and reproducible.

However, the big difference in energy consumption that is possible with different programmes and uses could be addressed by introducing a limit on this: programmes different from the Label programme, would have to consume maximally an XY% amount more energy than that declared for the Label programme. For this 'max consumption', the measurement standard would define parameters that can be varied and how (the 'boundaries'), only excluding extreme uses of little real-life relevance for those parameters than can be varied. For dishwashers, this may mean that any combination of programmes and extra functions would have to meet this 'max consumption' limit. Possibly 'Intensive' programmes could be excluded from this, which would allow setting a more ambitious max consumption limit. It could be discussed if also other parameters such as the load and soiling could be varied. Programme diversity is the most important aspect leading to a big variation in energy consumption, so the 'boundary condition' concept could be limited to this for dishwashers to keep it simple.

[7] http://europa.eu/rapid/press-release_IP-15-5945_en.htm

More concrete, this approach could for example mean for dishwashers:

- Dishwashers must consume maximally 50% more energy than declared on the Label, if any of the available programmes and extra functions are used.
  OR
- Dishwashers must consume maximally 20% more energy than declared on the Label, if any of the available programmes except the intensive programme, and any of the extra functions are used.

This 'max consumption' limit would make sure that dishwashers cannot consume too much excess energy when used differently than in the lab. If this limit is (too) ambitious, it might impact the manufacturers' possibilities to declare low consumption for the Label programme. In order to have an incentive for low-consuming options, it might be good if manufacturers could declare how much their most energy-saving option saves (compared to the declared value). For instance, there could be a number on the Label, indicating that the least energy-consuming programme e.g. consumes '-20%' energy than declared.

In summary, the new approach to testing and declaring could look like this:

1. Declaration and test according to standard with clearly defined test situation, like today
2. The most consuming use (programme, settings – probably excluding extreme uses) must consume maximally an XY% amount more than what's declared.
3. Additionally, manufacturers could declare their most efficient programme / mode: e.g. Eco mode: 20% less than declared.

This approach could also be discussed for other product categories with programme diversity similar to dishwashers: washing machines, washer-driers, tumble driers, e.g. also TVs (where it's more about 'settings diversity' than programme diversity). There are many open questions that would need to be investigated:

- Which of these approaches and elements might be suitable for the different product categories?
- Which variables could be changed in the 'max consumption' test, and to which extent (programmes, settings, conditions)?
- Would performance (cleaning and drying) also have to be established for testing the 'max. consumption' and energy-saving option? Especially for the low-energy option there might be a risk that this is designed solely for the Label declaration, if there is no requirement to perform sufficiently well.
- Would manufacturers declare which is their 'most consuming' use?
- How can the additional testing burden be limited? For a complete compliance test, MSAs would have to test the standard declaration, but also the max consumption and the energy saving mode. Especially if also performance needs to be assessed for these modes, the additional testing burden may be too much. E.g. for washing machines, the declared energy consumption could possibly be changed to refer to only one programme (40°C cotton) instead of two as today, since the second (60°C cotton) could be covered by the 'max consumption test. Can similar ways be found for other products, to not increase the test burden?

7 References and links

Eric Bush, Barbara Josephy, Jürg Nipkow: Schlussbericht Warmwasseranschluss. Dezember 2007.
http://www.topten.ch/sites/default/files/flyer%20pdfs/Schlussbericht%202007%20Warmwasseranschluss.pdf

CENELEC:

EN 50242:2008: Electric dishwashers for household use – Methods for measuring the performance (current measurement standard)

EN 50242:2016: Electric dishwashers for household use – Methods for measuring the performance (new, future measurement standard)

Ecopliant: http://www.ecopliant.eu/

European Commission: Commission regulation No 1016/2010 of November 2010 implementing Directive 2009/125/EC of the European Parliament and of the Council with regard to Ecodesign requirements for household dishwashers

European Commission: Commission delegated regulation No 1059/2010 of 28 September 2010 supplementing Directive 2010/30/EU of the European Parliament and of the Council with regard to energy labelling of household dishwashers

European Commission, DG Energy: Mandate to CEN, CENELEC and ETSI for standardisation in the field of household dishwashers. M/481 EN, January 2011.

ICCT: Vicente Franco, Francisco Posada Sanchez, John German, Peter Mock: Real-World exhaust emissions from modern diesel cars. Part 1: aggregated results. White Paper. October 2014.

IEC 60436:2015: Electric dishwashers for household use – Methods for measuring the performance. https://webstore.iec.ch/publication/23625

Ina Hook, Angelika Schmitz, Rainer Stamminger: Dishwashing behaviour of European consumers 2015. Uni Bonn, October 2015.

Joint Research Centre (JRC): Draft preparatory study on the revision of the Ecodesign and Energy Labelling regulations for dishwashers.
Tasks 1 – 4, June 2015.
Tasks 5 – 7, November 2015
JRC regulation review study project website:
http://susproc.jrc.ec.europa.eu/Dishwashers/index.html

Market Watch: Report on Laboratory Testing Activities. March 2016.

Topten / Coolproducts comments on the draft preparatory study, 2015:
http://www.topten.eu/uploads/File/Environmental%20NGOs%20-%20Comments_DW_Prepstudy%20Tasks%205-7.pdf

VHK: 'Omnibus review study on Cold appliances, washing machines, dishwashers, washer-driers, lighting, settop boxes and pumps. Final report. March 2014.

Annex

Annex 1: Programme specifications and user guidelines (in German)

Excerpts from the manuals of the selected models

BEKO DFN26220S

Programmtabelle

Programmnummer	P0	1 Reference*	2	3	4	5	6
Programmname	Selbstreinigung	eco	Auto	Intensiv	Schnell&Sauber	Mini 30'	Vorspülen
Reinigungstemperaturen	-	50°C	40°C- 65°C	70°C	70°C	35°C	-
Verschmutzungsgrad	Wir empfehlen, dieses Programm alle 1 – 2 Monat durchlaufen zu lassen: Es reinigt das Gerät von innen, sorgt für eine bessere Hygiene. Lassen Sie dieses Programm nur „Leer" durchlaufen, geben Sie dabei kein Geschirr in die Maschine. Damit das Programm besonders wirksam arbeitet, empfehlen wir, dazu ein spezielles Reinigungsmittel für Geschirrspüler einzusetzen.	Ein besonders energiesparendes Programm für Geschirr des täglichen Bedarfs, das schnell wieder benutzt werden soll.	Ermittelt den Verschmutzungsgrad des Geschirrs selbsttätig, passt Temperatur, Wassermenge und Spülzeit automatisch an. Für sämtliches Geschirr geeignet.	Für stark verschmutztes Geschirr, für Töpfe und Pfannen.	Ein Programm zur flotten, täglichen Reinigung schwach bis mittelmäßig verschmutzten Geschirrs, das bald wieder verwendet werden soll.	Für leicht verschmutztes Geschirr des täglichen Bedarfs; ohne grobe Verschmutzungen oder vorgespült.	Zum Entfernen von Rückständen von verschmutztem Geschirr, das mehrere Tage in der Maschine wartet - verhindert das Entstehen übler Gerüche.
		Mittel	Mittel - Viel	Viel	Mittel	Wenig	-
Reinigungsmittel A=25 cm³/15 cm³ B=5 cm³		A+B	A	A+B	A+B	A	-
Programmablauf (ohne Optionen)		Vorspülen - Reinigen - Kaltspülen - Klarspülen - Trocknen - Ende	Der Programmablauf wird dem Verschmutzungs-grad des Geschirrs angepasst.	Vorspülen - Reinigen - Kaltspülen - Klarspülen - Trocknen - Ende	Reinigen - Kaltspülen - Klarspülen - Trocknen - Ende	Reinigen - Kaltspülen - Klarspülen - Ende	Vorspülen - Ende
Programmdauer (min)	75	202	110-200	156	58	30	15
Wasserverbrauch (l)	14,4	10	10,2-14,4	16,2	10,2	10,4	4
Stromverbrauch (kWh)	0,7	0,9	0,90-1,45	1,43	1,3	0,8	-

Die auf der Tabelle angegebenen Verbrauchswerte sind unter Normbedingungen ermittelt. Abweichungen sind daher unter Praxisbedingungen möglich.
* Referenzprogramm für Prüfinstitute Die Prüfungen entsprechend EN 50242 müssen mit vollem Salzbehälter des Wasserenthärters, mit vollem Vorratsbehälter für Klarspüler und dem Testprogramm durchgeführt werden.

Tasten

Ein-/Austaste
Zum Ein- und Ausschalten des Gerätes.
Das Gerät schaltet sich ein, das Energiesparprogramm ist bereits voreingestellt. Die Programmnummer des Energiesparprogramms erscheint in der Programmanzeige. Beim Abschalten erlischt das Display.
Start/Pause/Abbrechen-Taste
Mit dieser Taste können Sie ein ausgewähltes Programm oder eine Funktion starten, anhalten oder abbrechen.
Programmauswahltasten
Mit diesen Tasten wählen Sie Spülprogramme aus der Tabelle „Programmdaten und durchschnittliche Verbrauchswerte".
Zeitverzögerungstaste
Diese Taste nutzen Sie, wenn das Gerät erst später mit der Arbeit beginnen soll.

Programmauswahl

1. Schalten Sie das Gerät mit der Ein-/Austaste ein.
2. Wählen Sie ein für Ihr Geschirr geeignetes Programm aus; orientieren Sie sich dabei an der Tabelle „Programmdaten und durchschnittliche Verbrauchswerte".
3. Drücken Sie die Programmauswahltasten, bis die Nummer des gewünschten Programms in der Programmanzeige erscheint. Mit der Taste P+ wechseln Sie zum nächsten, mit P- zum vorherigen Programm.

Zusatzfunktionen

Die Spülprogramme Ihres Geschirrspülers wurden auf beste Reinigungsleistung optimiert; dabei werden die Art der Verschmutzung, der Verschmutzungsgrad sowie die Eigenschaften des Geschirrs berücksichtigt.
Dank der Zusatzfunktionen können Sie Zeit, Wasser und Energie sparen, dabei rundum sauberes Geschirr genießen.

- Zusatzfunktionen können die Programmdauer beeinflussen.
- Die Verfügbarkeit der Zusatzfunktionen hängt vom jeweiligen Spülprogramm ab. Sie werden bemerken, dass die Anzeigen der Zusatzfunktionen, die Sie bei bestimmten Programmen nicht auswählen können, abgeschaltet sind.

So ergänzen Sie ein Programm mit Zusatzfunktionen:

1. Wählen Sie das gewünschte Spülprogramm mit den Programmauswahltasten.
2. Beim aktiven Spülprogramm werden ausgewählte Zusatzfunktionen im Display angezeigt. Wenn Sie die entsprechende Funktionstaste noch einmal drücken, erlischt das Symbol, die Auswahl ist wieder aufgehoben.
3. Die Auswahl wird aufgehoben, wenn Sie die Funktionstaste noch einmal drücken.

Halbe-Beladung-Funktion

Mit dieser Taste betreiben Sie das Gerät, wenn es nicht komplett gefüllt ist.

1. Geben Sie das Geschirr wie gewünscht in die Maschine.
2. Schalten Sie die Maschine mit der Ein-/Austaste ein.
3. Wählen Sie das gewünschte Programm, drücken Sie die Halbe-Beladung-Taste. Die Halbe-Beladung-Anzeige erscheint in der Funktionsauswahlanzeige im Display.
4. Starten Sie das Programm durch Drücken der Start-/Pause-/Abbrechen-Taste.

- Mit der Halbe-Beladung-Taste können Sie bei Verwendung des unteren und oberen Korbs Ihres Gerätes sowohl Wasser als auch Strom sparen.

Schnell+ Funktion

Diese Funktion verkürzt die Dauer des Spülprogramms und senkt den Wasserverbrauch durch Spülen mit höherem Druck.

SteamGloss-Funktion

Diese Funktion sorgt für eine besonders gute Trocknung.

Tray Wash-Funktion

Wählen Sie das Programm Intensiv 70 °C und drücken Sie zum Ausführen dieser Funktion die Funktionstaste.

4 Inbetriebnahme

Tipps zum Energiesparen

Wenn Sie die folgenden Hinweise beachten, können Sie Ihr Gerät besonders ökologisch und Energie sparend einsetzen.

- Wischen Sie grobe Speisereste vom Geschirr ab, ehe Sie es in den Geschirrspüler geben.
- Starten Sie das Gerät erst, wenn es komplett gefüllt ist.
- Orientieren Sie sich bei der Programmauswahl an der Programmtabelle.
- Füllen Sie nur so viel Spülmittel wie auf der Spülmittelverpackung empfohlen ein.

Source: beko, Geschirrspüler Bedienungsanleitung.
http://www.beko-hausgeraete.de/geschirrspueler-standgeraete.html?item=802

Bosch SMS63N22EU

Programmübersicht

In dieser Übersicht ist die max. mögliche Programmanzahl dargestellt. Die entsprechenden Programme und ihre Anordnung entnehmen Sie bitte Ihrer Bedienblende.

Geschirrart	Verschmutzungsart	Programm	Mögliche Zusatzfunktionen	Programmablauf
Töpfe, Pfannen, unempfindliches Geschirr und Besteck	stark haftende, eingebrannte oder angetrocknete, stärke- oder eiweißhaltige Speisereste	Intensiv 70°	alle	Vorspülen Reinigen 70° Zwischenspülen Klarspülen 65° Trocknen
		auto Auto 45° - 65°	alle	Wird entsprechend der Verschmutzung mit Hilfe der Sensorik optimiert.
gemischtes Geschirr und Besteck	leicht angetrocknete, haushaltsübliche Speiserückstände	auto Auto 45° - 65°	alle	Wird entsprechend der Verschmutzung mit Hilfe der Sensorik optimiert.
		eco Eco 50°	alle	Vorspülen Reinigen 50° Zwischenspülen Klarspülen 65° Trocknen
empfindliches Geschirr, Besteck, temperatur-empfindliche Kunststoffe und Gläser	gering haftende, frische Speisereste	Sanft 40°	IntensivZone Zeit sparen Halbe Beladung Extra Trocknen	Vorspülen Reinigen 40° Zwischenspülen Klarspülen 55° Trocknen
		Schnell 45°	Extra Trocknen	Reinigen 45° Zwischenspülen Klarspülen 55°
alle Geschirrarten	kaltes Abspülen, Zwischenreinigung	Vorspülen	keine	Vorspülen

Gerät bedienen

Programmdaten

Die Programmdaten (Verbrauchswerte) finden Sie in der Kurzanleitung. Sie beziehen sich auf Normalbedingungen und den Wasserhärte-Einstellwert H:04. Unterschiedliche Einflussfaktoren wie z. B. Wassertemperatur oder Leitungsdruck können zu Abweichungen führen.

Aquasensor *

* je nach Modell

Der Aquasensor ist eine optische Messeinrichtung (Lichtschranke), mit der die Trübung des Spülwassers gemessen wird.

Der Einsatz des Aquasensors erfolgt programmspezifisch. Ist der Aquasensor aktiv, kann „sauberes“ Spülwasser in das nächste Spülbad übernommen und der Wasserverbrauch um 3–6 Liter gesenkt werden. Ist die Verschmutzung stärker, wird es abgepumpt und durch Frischwasser ersetzt. In den Automatikprogrammen werden zusätzlich Temperatur und Laufzeit dem Verschmutzungsgrad angepasst.

Gerät einschalten

1. Wasserhahn vollständig öffnen.
2. EIN-/AUS-Schalter [1] einschalten.
   Die Anzeige des Programmes Eco 50° blinkt. Dieses Programm bleibt gewählt, wenn nicht eine andere Programmtaste [2] gedrückt wird. In der Ziffernanzeige [10] blinkt die voraussichtliche Programmdauer.
3. Drücken Sie die START-Taste [6].
   Der Programmablauf startet.

Hinweis

- zum umweltschonenden Betrieb des Geschirrspülers:
Aus ökologischen Gründen wird das Programm Eco 50° bei jedem Gerätestart voreingestellt. Dies schont Umweltressourcen und nicht zuletzt ihren Geldbeutel.
Das Eco 50° Programm ist ein besonderes umweltschonendes Programm. Es ist das „Standardprogramm“ nach EU Verordnung 1016/2010, das den Standardreinigungszyklus zur Reinigung von normal verschmutztem Geschirr und den kombinierten Energie- und Wasserverbrauch zur Reinigung dieser Art von Geschirr am effizientesten darstellt.

Restlaufanzeige

Bei der Programmwahl erscheint die restliche Programmlaufzeit in der Ziffernanzeige [10].

Die Laufzeit wird während des Programmes von der Wassertemperatur, der Geschirrmenge sowie vom Grad der Anschmutzung bestimmt und kann (abhängig vom gewählten Programm) variieren.

Programmauswahl

Sie können je nach Geschirr- und Verschmutzungsart ein passendes Programm aussuchen.

Hinweise für Testinstitute

Testinstitute erhalten die Hinweise für Vergleichsprüfungen (z.B. nach EN60436).

Hierbei handelt es sich um die Bedingungen zur Durchführung der Tests, jedoch nicht um die Ergebnisse oder Verbrauchswerte.

Anfrage per E-Mail an:

dishwasher@test-appliances.com

Benötigt werden die Erzeugnis-Nummer (E-Nr.) und die Fertigungsnummer (FD), die Sie auf dem Typenschild [32] an der Gerätetür finden.

Zusatzfunktionen

* je nach Modell

Über die Tasten Zusatzfunktionen [5] einstellbar.

Zeit sparen (VarioSpeed) *

Mit der Funktion „Zeit sparen“ kann die Laufzeit je nach gewähltem Spülprogramm um ca. 20% bis 50% verkürzt werden. Die jeweilige Laufzeitveränderung wird in der Ziffernanzeige [10] dargestellt. Um bei verkürzter Laufzeit optimale Reinigungsergebnisse zu erzielen, werden Wasser- und Energieverbrauch erhöht.

Halbe Beladung *

Wenn Sie nur wenig Geschirr zu spülen haben (z. B. Gläser, Tassen, Teller), können Sie die „Halbe Beladung“ zuschalten. Dabei werden Wasser, Energie und Zeit eingespart. Zum Spülen geben Sie etwas weniger Reiniger als für eine komplette Maschinenbeladung empfohlen in die Reinigerkammer.

Hygiene *

Während des Reinigungsvorganges wird die Temperatur erhöht. Dadurch wird ein erhöhter Hygienestatus erreicht. Ideal ist diese Zusatzfunktion z. B. zum Reinigen von Schneidebrettern oder Babyflaschen.

IntensivZone *

Perfekt für gemischte Beladung. Sie können stärker verschmutzte Töpfe und Pfannen im Unterkorb zusammen mit normal verschmutztem Geschirr im Oberkorb spülen. Der Sprühdruck im Unterkorb wird verstärkt, die Spültemperatur etwas erhöht.

Extra Trocknen *

Eine erhöhte Temperatur während des Klarspülens und eine verlängerte Trocknungsphase ermöglichen es, dass auch Kunststoffteile besser trocknen. Der Energieverbrauch ist leicht erhöht.

Warmwasseranschluss *

* je nach Modell

Der Geschirrspüler kann an Kalt- oder Warmwasser bis max. 60 °C angeschlossen werden.

Der Anschluss an Warmwasser wird empfohlen, wenn dieses aus einer energetisch günstigen Warmwasserbereitung und geeigneter Installation zur Verfügung steht, z.B. einer Solaranlage mit Zirkulationsleitung.

Dadurch werden Energie und Zeit gespart.

Mit der Einstellung Warmwasser *A:0 1* können Sie Ihr Gerät optimal auf den Betrieb mit Warmwasser abstimmen.

Empfehlenswert ist dabei eine Wassertemperatur (Temperatur des einlaufenden Wassers) von mindestens 40 °C und höchstens 60 °C.

Der Anschluss an Warmwasser wird nicht empfohlen, wenn das Wasser aus einem Elektroboiler bereitgestellt wird.

Source: Bosch, Geschirrspüler SM…, SB…, de Gebrauchsanleitung. http://www.bosch-home.at/SMS63N22EU.html#tab4

4. 00. Programme

Anzahl Programme	6
Anzahl verschiedener Spültemperaturen	5
Vergleichsprogramm	Eco
Programmdauer Vergleichsprogramm (min)	210 min
Name Programm 1	Intensiv
Temperatur Programm 1 (°C)	70
Programmdauer Programm 1 (min.)	125-135
Name Programm 2	Auto
Temperatur Programm 2 (°C)	45-65
Programmdauer Programm 2 (min.)	90-160
Name Programm 3	Eco
Temperatur Programm 3 (°C)	50
Programmdauer Programm 3 (min.)	210
Name Programm 4	Glas
Temperatur Programm 4 (°C)	40
Programmdauer Programm 4 (min.)	85-90
Name Programm 5	Schnell
Temperatur Programm 5 (°C)	45
Programmdauer Programm 5 (min.)	29
Name Programm 6	Vorspülen
Temperatur Programm 6 (°C)	0
Programmdauer Programm 6 (min.)	15

5.00. Verbrauchswerte

Energieeffizienzklasse - neu (2010/30/EC)	A++
Jährliche Energieverbrauch (kWh/annum) - neu (2010/30/EC)	262 kWh/annum
Jährliche Wasserverbrauch (l/annum) - neu (2010/30/EC)	2660 l/annum
Trocknungsklasse	A
max. Wasserzulauftemperatur (°C)	60 °C
Energieverbrauch (kWh)	0,92 kWh
Wasserverbrauch (l)	9,50 l
Stromverbrauch Programm 1 (kWh)	1.45-1.5
Wasserverbrauch Programm 1 (l)	12-15
Stromverbrauch Programm 2 (kWh)	0.95-1.6
Wasserverbrauch Programm 2 (l)	7-18
Stromverbrauch Programm 3 (kWh)	0.92
Wasserverbrauch Programm 3 (l)	9.5
Stromverbrauch Programm 4 (kWh)	0.85-.9
Wasserverbrauch Programm 4 (l)	11-14
Stromverbrauch Programm 5 (kWh)	0.8
Wasserverbrauch Programm 5 (l)	10
Stromverbrauch Programm 6 (kWh)	0.05
Wasserverbrauch Programm 6 (l)	4

http://www.bosch-home.at/SMS63N22EU.html#tab2

Miele G-6300 SCU

Programmübersicht

Programm	Programmablauf				
	Vorspülen	Reinigen	Zwischen-spülen	Klarspülen	Trocknen
		°C		°C	
ECO [1]		52	X	47	X
Automatic	variabler Programmablauf, sensorgesteuerte Anpassung an Geschirrmenge und Speiserückstände				
	nach Bedarf	47-65	nach Bedarf	57	X
Normal 55 °C	X	55	X	60	X
Intensiv 75 °C	2X	75	X	60	X
Fein	X	44	X	57	X
Schnell 40 °C		40	X	45	X
ExtraLeise		46	X	64	X
SolarSpar	2X	X	X	X	X
Maschinen-reinigung		75	2X	70	X

[1] Dieses Programm ist in Bezug auf den kombinierten Energie- und Wasserverbrauch zur Reinigung von normal verschmutztem Geschirr am effizientesten.

Programmübersicht

Verbrauch [2]			Dauer [2]	
elektrische Energie		Wasser		
Wasser kalt 15 °C kWh	Wasser warm 55 °C kWh	Liter	Wasser kalt 15 °C h:min	Wasser warm 55 °C h:min
0,84 [3] / 0,83 [4]	0,49 [3] / 0,48 [4]	9,7	3:18	3:08
0,70 [5] -1,30 [6]	0,50 [5] -0,85 [6]	6,5 [5] -16,0 [6]	1:25-2:45	1:20-2:35
1,10	0,70	14,0	1:59	1:47
1,45	0,95	15,0	2:54	2:40
0,90	0,45	13,5	1:53	1:42
0,65	0,25	11,0	0:46	0:35
1,10	0,80	10,5	4:48	4:38
	0,05	27,5		1:29
2,10	1,35	21,5	1:56	1:34

[2] Die genannten Werte wurden nach EN 50242 ermittelt. In der Praxis können aufgrund abweichender Bedingungen oder durch Einfluss von Sensoren deutliche Unterschiede auftreten. Die angezeigte Dauer stellt sich auf Ihre Haushaltsbedingungen ein.

Durch die Anwahl von Programmoptionen werden Verbrauch und Dauer der Programme verändert (siehe Kapitel "Programmoptionen").

[3] Geschirrspüler mit Besteckschublade

[4] Geschirrspüler mit Besteckkorb

[5] Teilbeladung mit geringer Verschmutzung

[6] volle Beladung mit starker Verschmutzung

Programmübersicht

weitere Programme

Schnell

Programm mit kurzer Programmdauer zur Entfernung von frischen, wenig haftenden Speiserückständen. Das Programm ist auch für temperaturempfindliche Gläser und Kunststoffe geeignet.

ExtraLeise

Sehr leises Programm mit verlängerter Laufzeit. Das Programm ist geeignet für gemischtes, unempfindliches Geschirr, Töpfe und Pfannen mit normalen, leicht angetrockneten Speiserückständen.

SolarSpar

Programm ohne Heizung, wenn der Geschirrspüler an Warmwasser mit mindestens 45 °C angeschlossen ist (siehe Kapitel "Wasseranschluss, Wasserzulauf"). Das Programm ist geeignet zur Reinigung von gemischtem Geschirr und Gläsern mit normalen, leicht angetrockneten Speiserückständen.

Maschinenreinigung

Der Spülraum des Geschirrspülers ist weitestgehend selbstreinigend. Sollten sich trotzdem Rückstände oder Beläge abgelagert haben, verwenden Sie zur Reinigung das Programm "Maschinenreinigung" ohne Beladung. Das Programm ist auf die Reinigung des Spülraums mit Pflegeprodukten (Maschinenreiniger, Maschinenpfleger) abgestimmt (siehe Kapitel "Nachkaufbares Zubehör, Gerätepflege"). Beachten Sie dabei auch die Hinweise auf der Reinigerpackung.

Wenn Sie möchten, dass statt des Programms *ECO* das zuletzt gewählte Programm angewählt bleibt, dann schalten Sie die Funktion Memory ein (siehe Kapitel "Menü Einstellungen, Memory").

Programmoptionen

kurz

Die Option *kurz* bewirkt eine Verkürzung der Programmlaufzeit bis zu 30 % in den Programmen, in denen die Option wirksam ist.

Um ein optimales Spülergebnis zu erzielen, kann sich der Energieverbrauch geringfügig erhöhen.

In Verbindung mit dem Programm "Schnell" bewirkt die Option *kurz* einen Spülgang ohne Trocknung und damit auch ohne automatisches Türöffnen (falls vorhanden).

extra sparsam

Die Option *extra sparsam* bewirkt eine Verringerung des Energieverbrauchs um bis zu 20 % in den Programmen, in denen die Option wirksam ist.

Um ein optimales Spülergebnis zu erzielen, verlängert sich die Programmlaufzeit.

AutoOpen

Die Tür wird am Programmende der Programme mit einer Trocknungsphase (ausgenommen ExtraLeise) automatisch einen Spalt geöffnet, um die Trocknung zu verbessern (siehe Kapitel "Programmübersicht").
Im Programm *ECO* (falls vorhanden) wird die Tür bereits während der Trocknungsphase geöffnet.

Sie können diese Funktion auch ausschalten.

- Wählen Sie die gewünschte Einstellung und bestätigen Sie mit *OK*.

⚠ Wenn Sie das automatische Türöffnen ausgeschaltet haben und trotzdem nach Programmende die Tür öffnen möchten, dann öffnen Sie die Tür ganz. Anderenfalls kann es zu Beschädigungen empfindlicher Arbeitsplattenkanten durch Wasserdampf kommen, weil das Gebläse nicht mehr weiterläuft.

Ihr Beitrag zum Umweltschutz

Sparsam Spülen

Dieser Geschirrspüler spült äußerst wasser- und energiesparend.
Sie können die Sparsamkeit unterstützen, wenn Sie folgende Tipps beachten:

- Nutzen Sie das Fassungsvermögen der Geschirrkörbe voll aus, ohne den Geschirrspüler zu überladen. Dann spülen Sie am wirtschaftlichsten.
- Wählen Sie ein Programm, das der Geschirrart und dem Verschmutzungsgrad entspricht.
- Wählen Sie das Programm ECO (falls vorhanden) für energiesparendes Spülen. Dieses Programm ist in Bezug auf den kombinierten Energie- und Wasserverbrauch zur Reinigung von normal verschmutztem Geschirr am effizientesten.

Wasserzulauf

⚠ Das Wasser im Geschirrspüler ist kein Trinkwasser!

- Der Geschirrspüler darf an Kalt- oder Warmwasser bis max. 60 °C angeschlossen werden.
  Bei energetisch günstiger Warmwasserbereitung, z. B. Solarenergie mit Zirkulationsleitung, empfehlen wir den Warmwasseranschluss. Dadurch werden Zeit und Kosten für elektrische Energie gespart. Dabei wird in allen Programmen mit warmem Wasser gespült
- Für die Verwendung des Programms SolarSpar (falls vorhanden) ist ein Warmwasseranschluss mit mindestens 45 °C und höchstens 60 °C (Temperatur des einlaufenden Wassers) erforderlich.
  Je höher die Temperatur des einlaufenden Wassers ist, desto besser sind Reinigungs- und Trocknungsergebnis.

Source: Miele, Gebrauchsanweisung Geschirrspüler. DE, HG05, M.-Nr. 09 612 130.
https://www.miele.de/haushalt/geschirrspueler-2510.htm?mat=09585550&name=G_6300_SCU#dtptd

Annex 2: Test results overview

The tables below provide all results, comparing the measured energy consumption with the declared value. Duration should only be read as indicative: this indicates when the test was terminated (switched off by tester). Sometimes this did not happen the very minute the cycle was finished. The description of the exact test conditions for each test run is as follows:

PROGRAMME	Programme selected
+ 'Extra function'	Extra function selected
EN / IEC	Load according to current EN50242 standard / to new IEC60436 standard
100% / 50%	Full load / half load
StSo / SiSo / NoSo	Soiling according to standard / simple / no soiling
SoW	Soft water instead of standard water

BEKO DFN 26220S				
Usage	**kWh**	**deviation %**	**water l**	**duration min**
Declared	0.9		10	202
PREWASH, no load	0.01	-99%	4.2	23
MINI 30°C, half load (IEC, 50%, SiSo)	0.64	-29%	10.8	33
ECO + 'Half load' (IEC, 50%, SiSo)	0.84	-7%	10.4	157
AUTO half load (IEC, 50%, SiSo)	0.86	-4%	13.6	128
ECO half load (IEC, 50%, SiSo)	0.87	-3%	10.8	200
ECO soft water (EN, 100%, SiSo, SoW)	0.91	1%	10.7	197
'Standard' (ECO, EN, 100%, StSo)	0.94	4%	13.7	200
ECO without soiling (EN, 100%, NoSo)	0.94	4%	10.8	197
ECO new load (IEC, 100%, SiSo))	0.94	4%	10.8	205
ECO simple soiling (EN, 100%, SiSo)	0.97	8%	10.8	197
AUTO, standard soiling (IEC, 100%, StSo)	0.98	9%	11	195
AUTO, simple soiling (IEC, 100%, SiSo)	1	11%	11	187
AUTO + 'SteamGloss' (IEC, 100%, SiSo)	1.13	26%	14.3	146
ECO + 'Short' (IEC, 100%, SiSo)	1.16	29%	10.8	75
ECO + 'SteamGloss' (IEC, 100%, SiSo)	1.16	29%	11.4	238
QUICK&CLEAN (IEC, 100%, SiSo)	1.18	31%	10.6	55
ECO + 'Short' + 'SteamGloss' (IEC, 100%, SiSo)	1.2	33%	17.7	118
QUICK&CLEAN + 'SteamGloss' (IEC, 100%, SiSo)	1.25	39%	14.3	146
INTENSIVE (IEC, 100%, SiSo)	1.4	56%	16.8	159
INTENSIVE + 'Short' + 'SteamGloss' (IEC, 100%, SiSo)	1.56	73%	20.9	149

Bosch SMS63N22EU				
Usage	**kWh**	**deviation %**	**water l**	**duration min***
Declared	0.92		9.5	210
SHORT (IEC,100%, SiSo)	0.72	-22%	9.9	36
ECO half load (IEC, 50%, SiSo)	0.83	-10%	14.3	208
ECO Hot Fill 45°C (EN, 100%, SiSo)	0.88	-4%	9.6	206

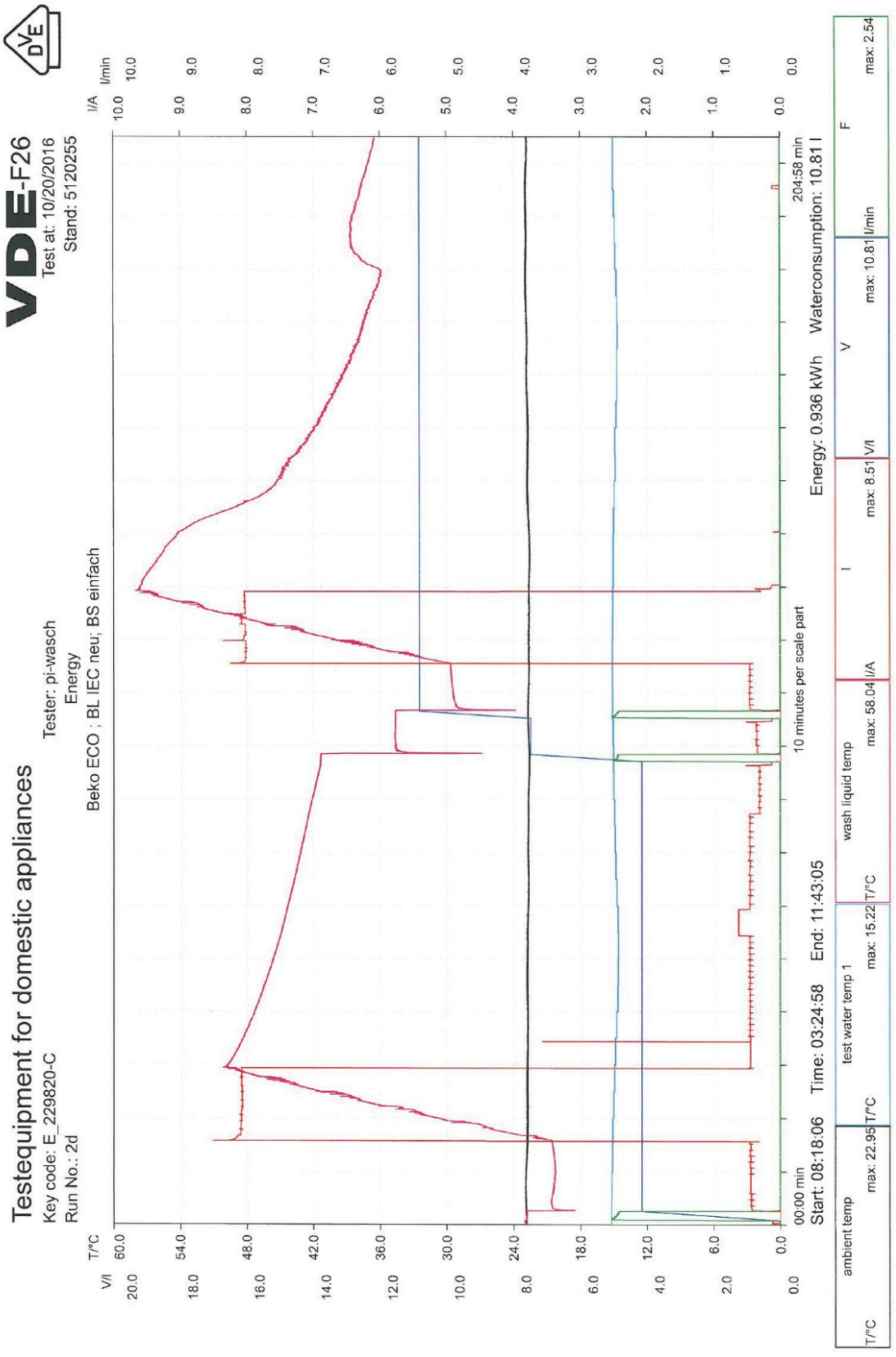
ECO IEC load (IEC, 100%, SiSo)	0.89	-3%	9.4	206
ECO simple soiling, soft water (EN, 100%, SiSo, SoW)	0.9	-2%	9.4	206
'Standard' (ECO, EN, 100%, StSo)	0.91	-1%	9.4	206
AUTO Hot fill 45°C (IEC, 100%, SiSo)	0.91	-1%	17.5	139
ECO without soiling (EN, 100%, NoSo)	0.92	0%	9.4	206
ECO simple soiling (EN, 100%, SiSo)	0.96	4%	9.4	208
AUTO half load (IEC, 50%, SiSo)	1.02	11%	16	143
ECO + 'Intensivezone' (EN, 100%, SiSo)	1.04	13%	14.6	219
AUTO simple soiling (IEC, 100%, SiSo)	1.11	21%	12.9	147
AUTO (IEC, 100%, StSo)	1.26	37%	15.3	158
ECO + 'Timesaver' (EN, 100%, SiSo)	1.31	42%	11.3	70
ECO + 'Timesaver' + 'Intensivezone' (EN, 100%, SiSo)	1.33	45%	11.4	75
INTENSIVE (IEC, 100%, SiSo)	1.35	47%	13.3	131
AUTO + 'Timesaver' + 'Intensivzone' (IEC, 100%, SiSo)	1.44	57%	14.9	96

Miele G6300-SCU

Usage	kWh	deviation %	water l	duration min
Declared	0.84		9.7	190
SolarSAVE Hot Fill (IEC, 100%, SiSo)	0.07	-92%	27.7	99
SHORT + 'Short' (IEC, 100%, SiSo)	0.58	-31%	18	35
SHORT (IEC, 100%, SiSo)	0.64	-24%	11	52
ECO Hot fill 45°C (EN, 100%, SiSo)	0.67	-20%	16.4	190
ECO half load (IEC, 50%, SiSo)	0.74	-12%	9.9	151
ECO + 'ExtraSaving' (EN, 100%, SiSo)	0.79	-6%	9.9	219
'Standard' (ECO, EN, 100%, StSo)	0.81	-4%	9.9	192
ECO soft water (EN, 100%, SiSo, SoW)	0.81	-4%	9.9	198
ECO without soiling (EN, 100%, NoSo)	0.82	-2%	9.9	192
ECO IEC load (IEC, 100%, SiSo)	0.83	-1%	9.9	193
AUTO, half load (IEC, 50%, SiSo)	0.84	0%	10.1	102
ECO simple soiling (EN, 100%, SiSo)	0.85	1%	9.9	158
NORMAL Hot fill 45°C (IEC, 100%, SiSo)	0.86	2%	14.2	137
ECO + 'Short' (EN, 100%, SiSo)	0.93	11%	9.9	108
AUTO, simple soiling (IEC, 100%, SiSo)	0.93	11%	13.6	115
AUTO, Standard soiling (EN, 100%, StSo)	0.95	13%	13.5	125
NORMAL + 'ExtraSaving' (EN, 100%, SiSo)	0.99	18%	15	164
NORMAL half load (IEC, 50%, SiSo)	1.02	21%	13.9	135
EXTRAQUIET (IEC, 100%, SiSo)	1.05	25%	10.7	347
ECO + 'AutoOpen Off' (EN, 100%, SiSo)	1.07	27%	9.9	210
NORMAL (IEC, 100%, SiSo)	1.12	33%	15	131
NORMAL + 'Short' (IEC, 100%, SiSo)	1.29	54%	10.9	115
INTENSIVE (IEC, 100%, StSo)	1.44	71%	15.9	183
Intensive (IEC, 100%, SiSo)	1.44	71%	15.9	183

Annex 3: Measurement diagrams

Diagrams provided by VDE showing the course of a tested cycle for each of the three models:



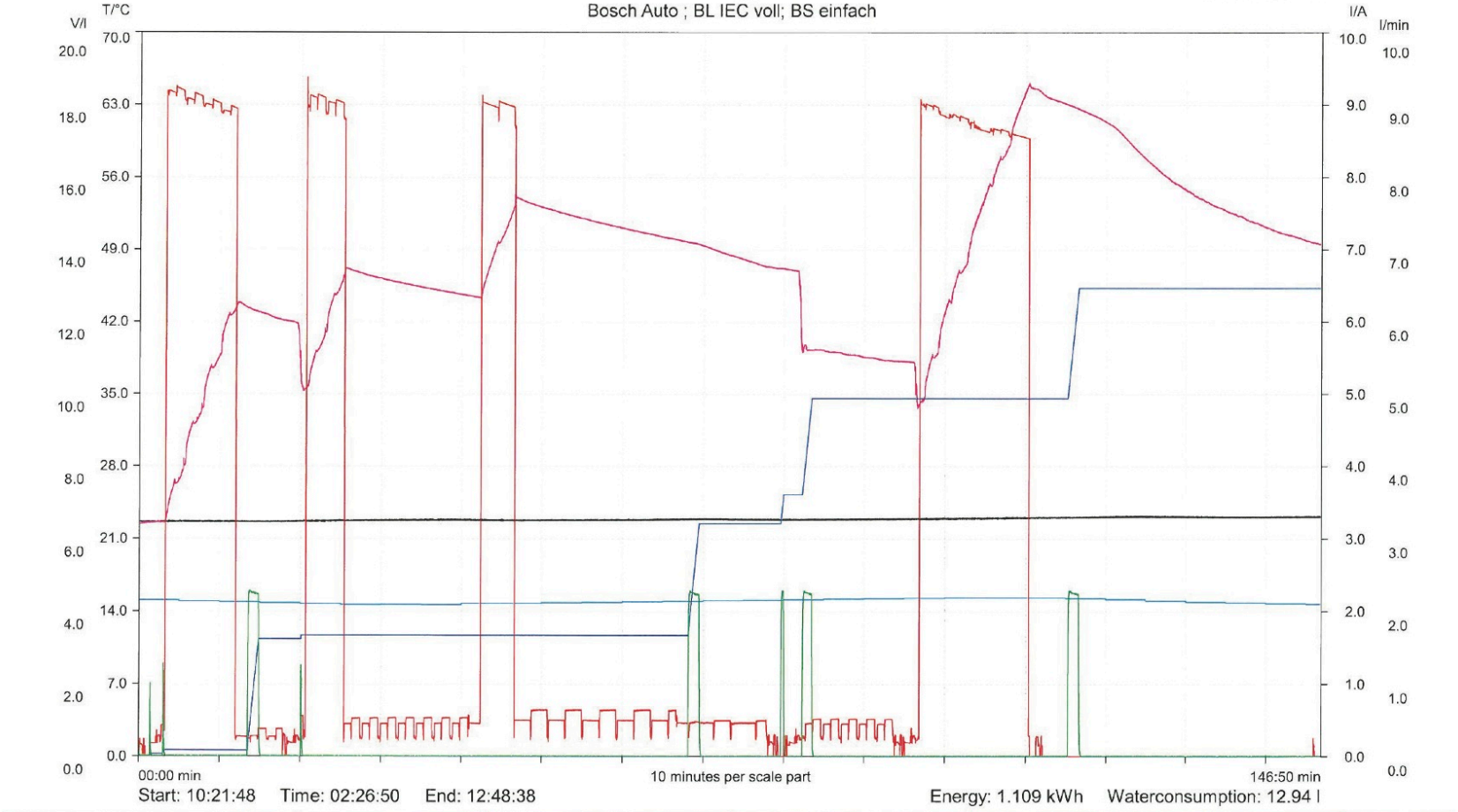
Testequipment for domestic appliances

VDE-F26

Key code: E_229820-A
Run No.: 2h

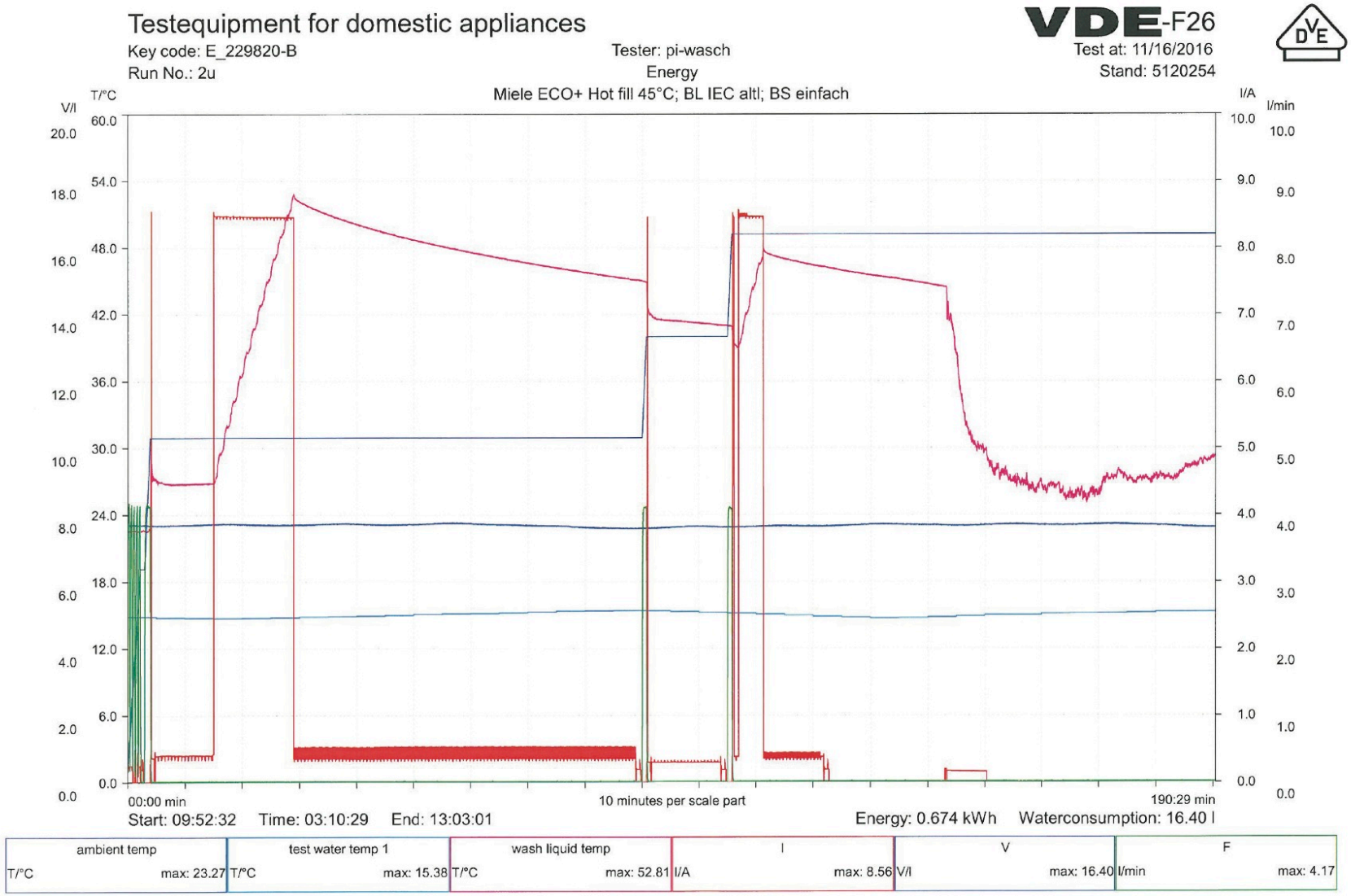
Tester: pi-wasch
Energy
Bosch Auto ; BL IEC voll; BS einfach

Test at: 10/26/2016
Stand: 5120253



Start: 10:21:48 Time: 02:26:50 End: 12:48:38 Energy: 1.109 kWh Waterconsumption: 12.94 l

ambient temp	test water temp 1	wash liquid temp	I	V	F
T/°C max: 23.19	T/°C max: 15.32	T/°C max: 65.06	I/A max: 9.37	V/l max: 12.94	l/min max: 2.28


Testequipment for domestic appliances
VDE-F26
Key code: E_229820-B
Tester: pi-wasch
Test at: 11/16/2016
Run No.: 2u
Energy
Stand: 5120254
Miele ECO+ Hot fill 45°C; BL IEC altl; BS einfach
T/°C
V/l
I/A
l/min
00:00 min
10 minutes per scale part
190:29 min
Start: 09:52:32
Time: 03:10:29
End: 13:03:01
Energy: 0.674 kWh
Waterconsumption: 16.40 l
ambient temp
max: 23.27
test water temp 1
max: 15.38
wash liquid temp
max: 52.81
I
max: 8.56
V
max: 16.40
F
max: 4.17