# Test methods and scheme rules for energy labelling of tap water devices

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## Keywords

hot tap water use, energy labelling, energy classification, energy efficiency, tap water devices, basin mixers, sink mixers

## Abstract

One way of helping to reduce harm to the environment is to reduce our use of tap water. This has the effect not only of saving fresh water, but also of reducing the amount of energy that would have been used for heating domestic hot water. A number of investigations in recent years have shown that installation of new energy-efficient taps and shower mixers can substantially reduce the use of water and heat in residential, hotels, schools, hospitals and other buildings.

Existing test methods and standards are not considering energy efficiency and requirement criteria for energy efficiency are not settled. A technology procurement project in 2002 found that there were considerable differences in the amount of energy used for the same end purposes. In order to guide purchasers to choose the most suitable products, a labelling system to indicate energy efficiency would be very useful. It would help purchasers to avoid products with low energy efficiency at the same time as it would provide a boost for the development of more energy-efficient products. In the end it would lead to both a better household economy and benefits for the society.

Such a system is under development in Sweden by researchers, technicians, manufacturers, authorities, standardisation institutes, purchasers and consumers representatives. New standards with test methods for measuring energy efficiency and requirement criteria for classification of energy efficiency has been developed and are now out for consideration. At the same time are scheme rules for the energy labelling system under development. First out are tap water devices for basins and kitchen sinks while shower mixers will be considered within the next step. In the extensions the plans are to introduce the energy labelling system into European level.

## Introduction

An extensive effort, both national and international, has been carried out in recent years to make energy usage more efficient. One field, still not exhaustively investigated and having a potential for significant energy savings while still keeping the end users requirements of comfort, is tap water mixers for energy-efficient use in residential, hotels, schools, hospitals and other buildings.

A number of investigations in recent years have shown that installation of new energy-efficient taps and shower mixers can substantially reduce the use of water and heat. A technology procurement project of energy efficient tap water mixers was carried out in Sweden 2001 – 2003 with the objectives to promote development of energy- and cost-efficient tap water mixers. Calculations from the project shows that replacing two-lever mixers with single-lever mixers may give a energy saving potential of 500 kWh per year and household (Persson, 2000).

In a multifamily house in Göteborg two-lever mixers were replaced with single-lever mixers with different energy saving techniques while site measurements were made of changes in energy use (Wahlström, 2000). The results shows that 26% cold water and 28% hot water could be saved when modern taps were installed (thermostatic mixers in the bath/shower and single-lever mixers in the basin and kitchen) instead of old two-lever mixers. Thereafter the single-lever mixers were provided with different energy savings techniques and the water saving was increased to 51% of cold water and 38% of hot water. Replacing of old tap mixers with energy efficient single-lever mixers can be earned back somewhere between the first and third year via reduced energy and water costs, without any loss in comfort or quality of life. The project is not only showing a great energy saving potential, but also that the size of the energy saving is dependent of which energy saving techniques that the taps are equipped with.

In connection with the technology procurement laboratory test were made for several different kinds of water devices on the market (Fiskum, 2004). The results shows that tap water mixers sold on the Swedish market under recent years have considerable differences in energy use for the same end purposes. A large amount of hot water is used unnecessarily, i.e. for end use where it doesn't matter if the water is cold or hot. Here good technical solutions may be able to influence the user to a more energy efficient behaviour.

In Sweden there are a bit above 4 million flats and 1.2 million tap water devices are sold yearly on the Swedish market, which gives large national savings possibilities. The potential is greatest for replacing two-lever mixers with single-lever mixers. In the coming years many of the two-lever mixers installed before the 1990 will be exchanged due to renovation or/and design reasons.

The market for taps is very competitive, and a labelling system to indicate energy efficiency would help purchasers to choose the most suitable products. It would help them to avoid products with low energy efficiency and provide a boost for the development of more energy-efficient products. Existing test methods and standards are not considering energy efficiency and requirement criteria for energy efficiency are not settled.

#### FEASIBILITY STUDY

In order to investigate whether a suitable laboratory test method for measuring the energy efficiency of taps and mixers can be developed, and whether it would be possible to use the results of the measurements to set requirement criteria at various levels for labelling, a feasibility study was made (Wahlström, 2007). The feasibility study also investigated the possibilities of establishing a joint standardisation and labelling project for energy-efficient taps and shower mixers, and of uniting manufacturers in supporting it.

Laboratory measurements to measure energy efficiency were carried out on kitchen taps, bathroom taps and thermostatic shower mixer taps. The energy efficiency can be measured by measuring temperature, flow and distribution pressure of a number of different use sequences, together with rinse times for defined activities. The total energy efficiency can then be determined by summing the energy use of a defined scheme of activities, intended to represent different user applications. A future labelling system should encourage technical improvements aimed at improving energy efficiency rather than at limiting water flow. The criteria checked in the laboratory methods are therefore intended to show the benefits of various behaviour-related methods and energy-efficient shaping of the water jet.

The results show that it is possible to measure energy use for different activities of use, and to agree on a test scheme of activities for calculation of the total energy efficiency of a tap. The test methods that have been tested in the investigation are repeatable, and can be described in such a way as to allow them to be reproduced and repeated in other test laboratories. The requirement criteria for energy efficiency can be decided by measurement of performance parameters of a carefully chosen scheme of use activities. The energy efficiency can be calculated for the entire scheme, and its value can then be used to label the products as belonging to various energy classes.

The feasibility study suggests one method for energy labelling of kitchen and bathroom taps, and another for shower taps. The kitchen and bathroom taps method has been developed to the stage that it can be used directly as a basis for standardising a test method, and for developing labelling criteria, while the shower tap test method may need additional laboratory measurements before it is quite ready for standardisation and labelling purposes.

#### ESTABLISHING OF TEST METHODS AND SCHEME RULES

As a follow up of the feasibility study a labelling system is now under development in Sweden by researchers, technicians, manufacturers, authorities, standardisation institute, purchasers and consumers representatives. A new standard with test methods for measuring energy efficiency and requirement criteria for classification of energy efficiency of basin and sink mixers are under development (ft-SS-820000, 2009). At the same time are scheme rules for the energy labelling system under development (Wahlström et al., 2009).

In a recent project that aimed to increase the knowledge of how tap water is used in Swedish households, measurements were made of hot and cold water use at each tapping point in ten dwellings: four apartments in apartment buildings, and six single-family buildings (Wahlström et al., 2007). The number of households is too low to represent the water use at national level, but can still contribute with important knowledge of how we use water in our homes. Figure 1 shows the division of cold and hot water between tapping points (note that cold water for flushing the toilet is not included).

The project shows that it is equally important to develop energy efficient tap water devices for kitchen sinks as for showers since the hot water use is relatively equally distributed. First out are, therefore, tap water devices for basins and kitchen sinks while shower mixers will be considered within the next step.

In the extensions the plans are to introduce the energy labeling system into European level. An average European water consumption can be set as 150 l/person and day, which is about 25% lower than the Swedish average water consumption. Assuming that energy use for hot water as well as water use is 25% less in Europe than in Sweden gives an average saving potential of 375 kWh per household and year. In the expanded EU there lives about 500 million people and in average there is 3 persons per flat which gives 166 million flats. That gives an average energy saving potential exceeding 60 TWh per year on European level.

## Method for measuring energy efficiency

Existing test methods in the standard EN-817 of tap water devices are focusing on leak tightness, mechanical and hydraulic performance, mechanical endurance, acoustic characteristics etc and are not including energy performance (EN-817, 2008). There are a few methods for labelling of water savings, for example the Australian labelling system with energy stars (AS/NZS, 2005).

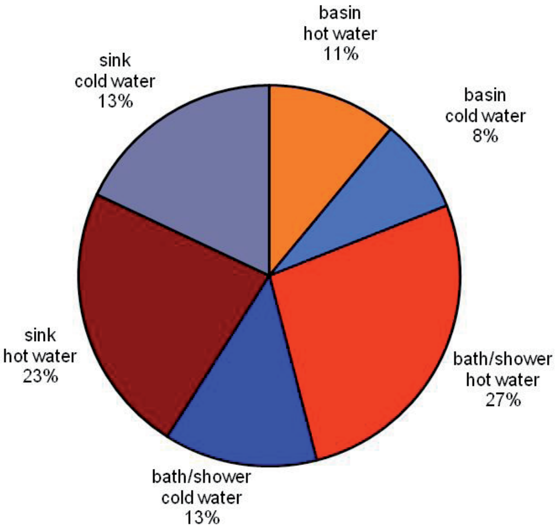


*Figure 1. Division of tap water use between tapping points in 10 Swedish households.*

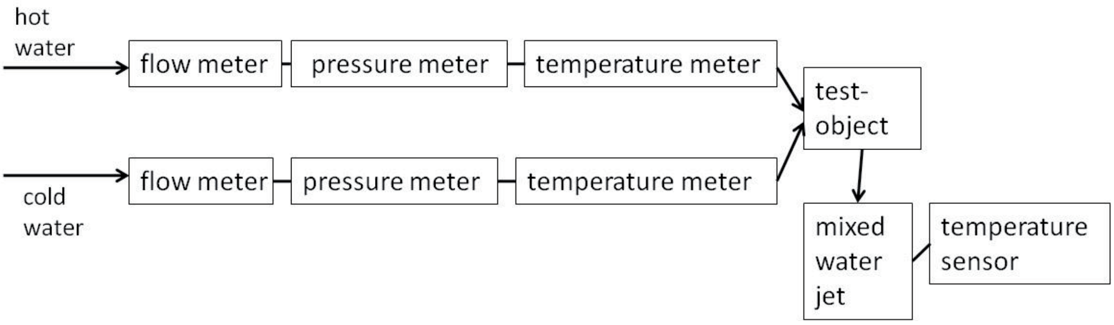


*Figure 2. Principal sketch of testing equipment with hot and cold water circuits.*

There are also building regulation's criteria of minimum flow through the device that with today's technique could be possible to reduce during main use of the device while still giving required comfort (BBR, 2008). The minimum flow must, however, be possible to fulfil when required. Energy efficient tap water devices are equipped with a special technique that will influence the user to reduce hot water use without limiting the user´s end purpose. These criteria have been considered during development of the test method suggested below. The test methods are valid for mechanical basin and sink mixing valves including mounting unit and flow straightener. A more detailed description of test methods can be found in the proposal of standard ft-SS-820000, 2009.

## TESTING EQUIPMENT

The testing object is placed in a testing equipment with connections to hot and cold water in isolated water pipes. Meters of pressure, temperature and flow are installed at each water connection.

Each water circuit includes control devices of:

- temperatures between 6 to 15°C for cold water and between 50 to 65°C for hot water
- distribution pressure between 0.1 to 0.5 MPa
- water flow between 0.5 to 20 liters per minute.

Distribution pressure is measured with an uncertainty of ± 1 % of measured value. Distribution temperatures of cold and hot water are measured with an uncertainty of ± 0.5°C of measured value. Distribution flows is measured with an uncertainty of ± 2% of measured value.

Temperature of the mixed water jet is measured 10 ± 0.5 cm vertical from the outflow of the water device. The mixed water jet temperature is measured with the help of a small vessel that temporarily collects the water flow in such an amount that temperature device´s measuring rod is placed in water (not in air). The collected water shall be flowing.

## RINSE TEST

The efficiency of the tap water device is valued by measuring the time it takes to rinse a test material with a spot of caramel coloring and a spot of caramel coloring mixed with oil.

### Test material

The test material is a yellow dishcloth (15 × 15 cm), a white plate of polycarbonate (25 × 25 cm) and red caramel coloring. Before the test, the dishcloth should be well rinsed. The plate of polycarbonate is mounted with a leaning of 2 cm of 25 cm. The dishcloth is placed on the plate of polycarbonate with the centre of the dishcloth 16 cm vertical below the outflow of the water device.

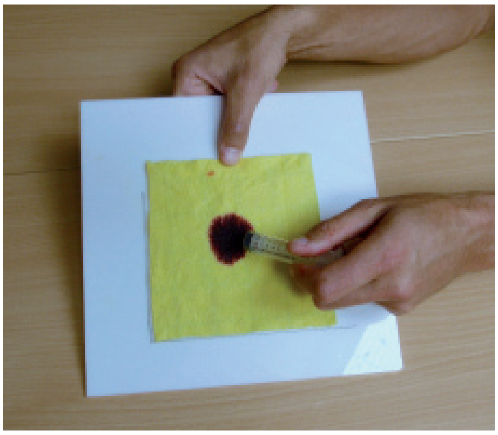

*Figure 3. Application of caramel colouring at dishcloth.*

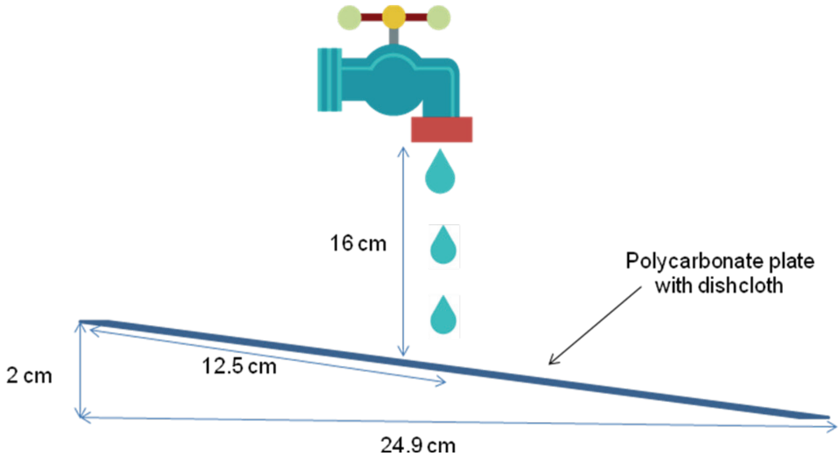


*Figure 4. Principal sketch of test equipment for rinse test.*

**Preparation of test material**

Preparation of caramel colouring and oil is performed by mixing equal shares of caramel colouring and peanut oil (20% saturated fatty acids, 53% simple unsaturated fatty acids, 27% of polyunsaturated fatty acids).

The dishcloth is moistened with water and 0.5 ml red caramel colouring or the mixture of caramel colouring and oil is applied with a syringe at the centre of the dishcloth, see Figure 3.

**Performing the rinse test**

A water jet with defined flow rinse the dishcloth from caramel colouring. The time is measured from placing the test material below the water jet until the water that is flowing out from the edge of the poly carbonate plate is colourless.

The rinse test is repeated 20 times. The 2 slowest values and the 2 fastest values are excluded and a mean value of rinse time is calculated from the 16 remaining tests.

## ACTIVITY TESTS

The tap water device's energy efficiency is evaluated by measuring the energy use for different activities. Each activity is assumed to represent a normal and frequent use of tap water. It is not meant to represent a special purpose of use, for example cleaning lard from a frying pan, but rather a use that is made without particular consideration. Each activity is defined with distribution temperatures and pressures and position of the device's control stick, while mixed water temperature, flow and activity time are measured. Each activity is independent of each other and can be performed in optional order. Between each activity the device is shut down and the control stick is placed in straight forward position.

**Standardised flow**

The flow that maximum can be reached at a defined distribution pressure and a normally use of the tap water device. Standardised flow is achieved through one simple operation that opens the water flow. No extra operation is needed.

**Standardised temperature**

The temperature that maximum can be reached at a defined distribution pressure and a normal use of the tap water device. Standardised temperature is achieved through one simple operation that opens the water flow. No extra operation is needed.

**Maximum flow**

The flow that maximum can be reached at a defined distribution pressure. The maximum flow is achieved through one or several operations (temporarily or during the whole activity).

**Activity scheme**

In the first three activities the distribution temperature of cold water is 8 ± 1°C and distribution temperature of hot water is 55 ± 1°C. Each activity is measured for 60 seconds while flow and mixed water temperature is registered.

1. Standardised temperature, standardised flow and distribution pressure 100 ± 20 kPa.
2. Standardised temperature, standardised flow and distribution pressure 300 ± 20 kPa.
3. Standardised temperature, standardised flow and distribution pressure 500 ± 20 kPa.

In activity 4 to 6 the distribution pressure is 300 ± 20 kPa, the distribution temperature of cold water is 8 ± 1°C and distribution temperature of hot water is 55 ± 1°C. Each activity is measured for 60 seconds while flow and mixed water temperature is registered.

4. Standardised flow and control stick in position 45 ± 1 degrees towards hot water.
5. Standardised flow and control stick in straight forward position.
6. Standardised flow and mixed water temperature of 38 ± 1°C.

In activity 7 to 9 the distribution pressure is 300 ± 20 kPa, the distribution temperature of cold water is 8 ± 1°C and distribu-

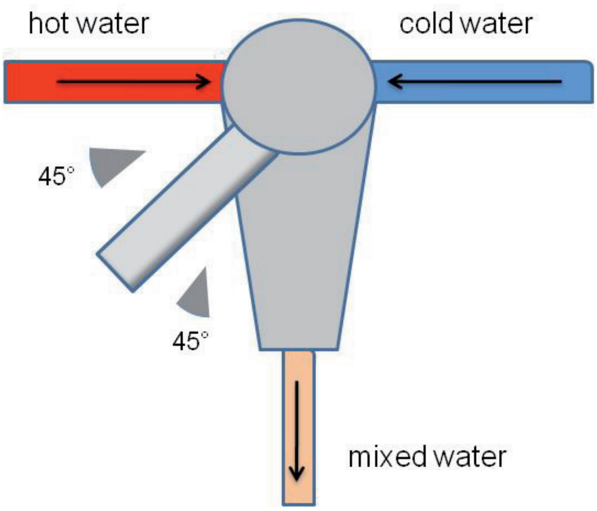


*Figure 5. Principal sketch on control stick in position 45 degrees towards hot water.*

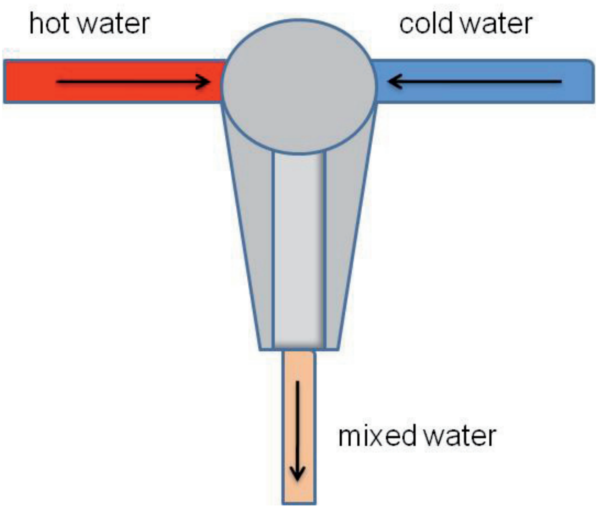


*Figure 6. Standardised flow and control stick in position straight forward.*

tion temperature of hot water is 55 ± 1°C. Mixed water temperature is set to 38 ± 1°C. Rinse time and flow is registered.

7. Rinse time is measured at maximum flow.
8. Rinse time is measured at standardised flow.
9. Rinse time is measured at flow 3 ± 0.1 litres per minute for basin mixers and at flow 5 ± 0.1 litres per minute for sink mixers.

For activity 10, 11 and 12 the distribution pressure is 300 ± 20 kPa, the distribution temperature of cold water is 8 ± 1°C and distribution temperature of hot water is 55 ± 1°C. Mixed water temperature is set to 50 ± 1°C. Rinse time and flow is registered.

10. Rinse time of oil mixture is measured at maximum flow.
11. Rinse time of oil mixture is measured at standardised flow.
12. Rinse time of oil mixture is measured at flow 3 ± 0.1 litres per minute for basin mixers and at flow 5 ± 0.1 litres per minute for sink mixers.

### CALCULATION OF A MIXER'S ENERGY USE

Energy use is calculated for each activity according to: ρ

$$Q_{activity} = \dot{V}_{mixed} \cdot t_{activity} \cdot (T_{mixed} - T_{coldw}) \cdot Cp \cdot \rho / 3600$$

**Equation 1**

and

$$\dot{V}_{mixed} = \dot{V}_{cold} + \dot{V}_{hot}$$

**Equation 2**

where

$Q_{activity}$ = energy use for an activity (kWh)
$\dot{V}_{mixed}$ = flow of mixed water (m³/s)
$t_{activity}$ = rinse time or time for one activity (seconds)
$T_{mixed}$ = temperature of mixed water jet (°C)
$T_{coldw}$ = temperature of cold distribution water (°C)
$Cp$ = heat capacity of water (J/(kg,°C))
$\rho$ = density of water (kg/m³).

Energy use for a series of activities is calculated according to:

$$Q_{series\_of\_activities} = \sum_{i=activity}^{6} Q_i$$ **Equation 3**

where

$Q_{series\_of\_activities}$ = total energy use for a series of activities

Energy use for a series of rinse activities is calculated according to:

$$Q_{series\_of\_rinse\_activities} = 2 \cdot \sum_{7=activity}^{12} Q_i$$

**Equation 4**

where

$Q_{series\_of\_rinse\_activities}$ = total energy use for a series of rinse activities

The mixer's total energy use is adjusted according to the time for one rinse activity. The adjustment is made since it is important for a user that a rinse activity should not take too long time. The mixer's total energy use is calculated according to:

$$Q_{mixer} = Q_{series\_of\_activities} + Q_{series\_of\_rinse\_activities} \cdot \left[1 + \frac{(t_{rinse} - 18)}{(36)}\right]$$

**Equation 5**

**Table 1. Classification of basin and sink mixers.**

| Energy Class | $Q_{mixer}$ (kWh) |
|---|---|
| A | $Q_{mixer} \leq 1.6$ |
| B | $1.6 < Q_{mixer} \leq 2.2$ |
| C | $2.2 < Q_{mixer} \leq 2.8$ |
| D | $2.8 < Q_{mixer} \leq 3.4$ |
| E | $3.4 < Q_{mixer} \leq 4.0$ |
| F | $4.0 < Q_{mixer} \leq 4.6$ |
| G | $4.6 < Q_{mixer}$ |

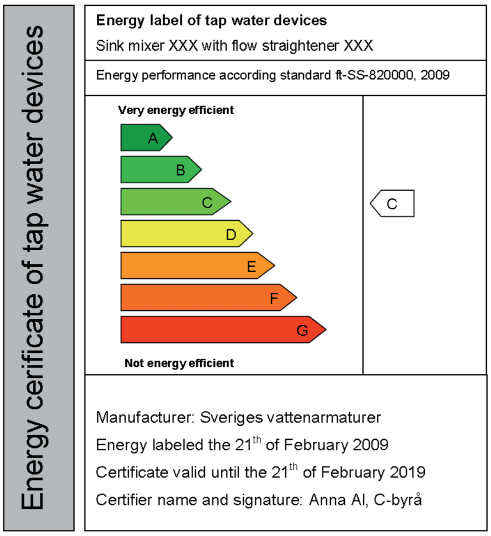


*Figure 7. Example of energy performance certificate.*

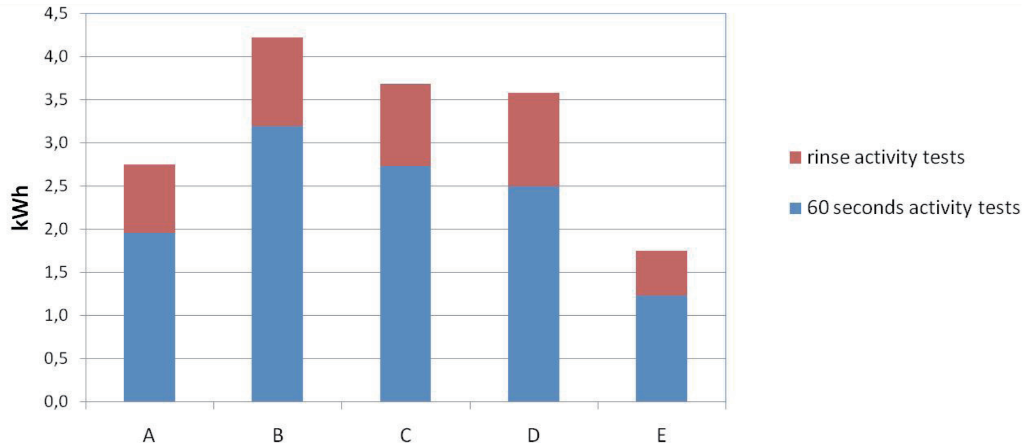


*Figure 8. Energy use of a series of activities for five basin mixers.*

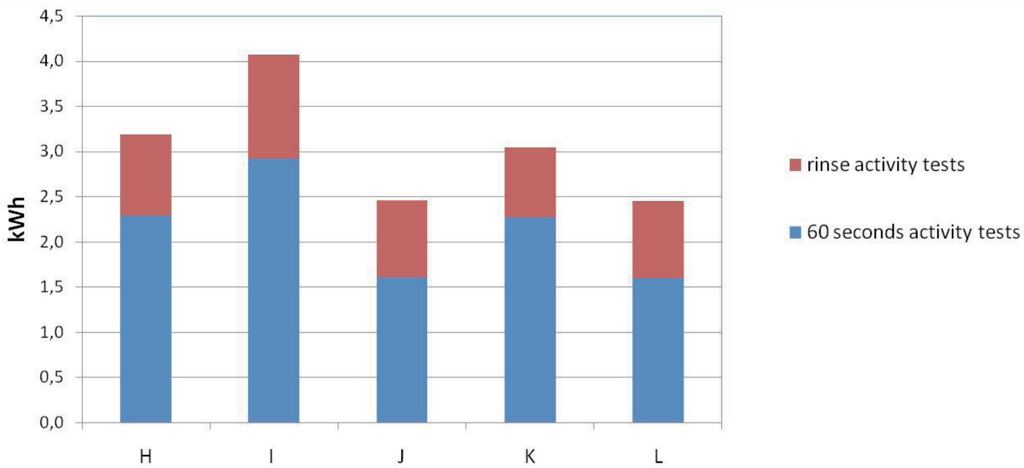


*Figure 9. Energy use of a series of activities for five sink mixers.*


*Figure 10. Picture of test equipment at the laboratory in the Netherlands.*

where

$t_{rinse}$ = rinse time (seconds)

$Q_{mixer}$ = a mixer's energy use (kWh)

#### ENERGY CLASSIFICATION AND LABELLING

The tap water device's total energy use for a series of activities is used for classification according to Table 1.

Based on the test measurements and energy classification the tap water device may get an energy performance certification according to scheme rules for energy labelling (Wahlström et al., 2009). An example of energy performance certificate is given in Figure 7.

### Laboratory tests with the method

In the previous feasibility study the suggested test method with a scheme of activities was tried out in a testing laboratory in Sweden (Wahlström, 2007). During the autumn 2008 the testing method has been further developed and tried out by limited laboratory tests. In order to check if the developed test method is repeatable, and can be described in such a way as to allow it to be reproduced and repeated in other test laboratories, new laboratory test were performed in a testing laboratory in the Netherlands in November 2008. Five basin mixers and five sink mixers from different manufacturers were tested and the results are given in Figure 8 and 9.

### Conclusion and further work

The testing of test method at the laboratory in the Netherlands shows that the test method is repeatable and tap water devices from different manufacturers shows different results. This means that the method can be used in order to classify energy efficiency of tap water devices. Comparison with the testing made on the laboratory in Sweden shows that the tests allows to be reproduced and repeated in other test laboratories.

The new standard (ft-SS-820000, 2009) with test methods for measuring energy efficiency and requirement criteria for classification of energy efficiency is now sent out for consideration to authorities, actors within the field and end consumers in Sweden. At the same time are scheme rules for the energy labelling system under development (Wahlström et al., 2009) and the first labelled tap water device may be on the market at the end of 2009.

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