

Is a Machine More Efficient Than the Hand?

What are the washing-up techniques that can transform a consumer from a carefree dishwasher to a supereconomic one?

by Rainer Stamminger

In seeking to understand and prevent global warming and other man-made environmental problems, the energy consumption of household appliances has come under close scrutiny. One household task—dishwashing—can be accomplished by an appliance, by hand, or by some combination of the two. To investigate the environmental effects of these competing methods, I and a team of researchers from the University of Bonn conducted a test comparing the energy consumption and performance of manual dishwashing with that of dishwashing machines.

To rule out possible regional differences in dishwashing techniques, we persuaded 113 people from seven countries in Europe to participate in the dishwashing experiment. We compared their use of water and energy and the cleanliness they achieved to the consumption generated by two energy-efficient dishwashers. To reduce variability in test conditions, we had most of the test subjects wash dishes in one laboratory at the University of Bonn. For test subjects, we chose visitors who had not lived for too long in Bonn or Germany to ensure that they had not adopted German behavior. To make sure that we were getting a correct picture of the consumer behavior for a specific country, the tests were redone using the same equipment in laboratories in France, Italy, Spain, and the United Kingdom.

A Dirty Challenge

We based our test design on a widely accepted European test of the performance and consumption of



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dishwashers—EN 50242. This standard specifies that 12 place settings of dishes—140 individual pieces including china, glasses, and cutlery—be soiled with seven

different kinds of food: spinach, minced meat, oak flakes, milk, margarine, tea, and egg yolk. The soiled dishes are then placed in an oven and dried at 176°F

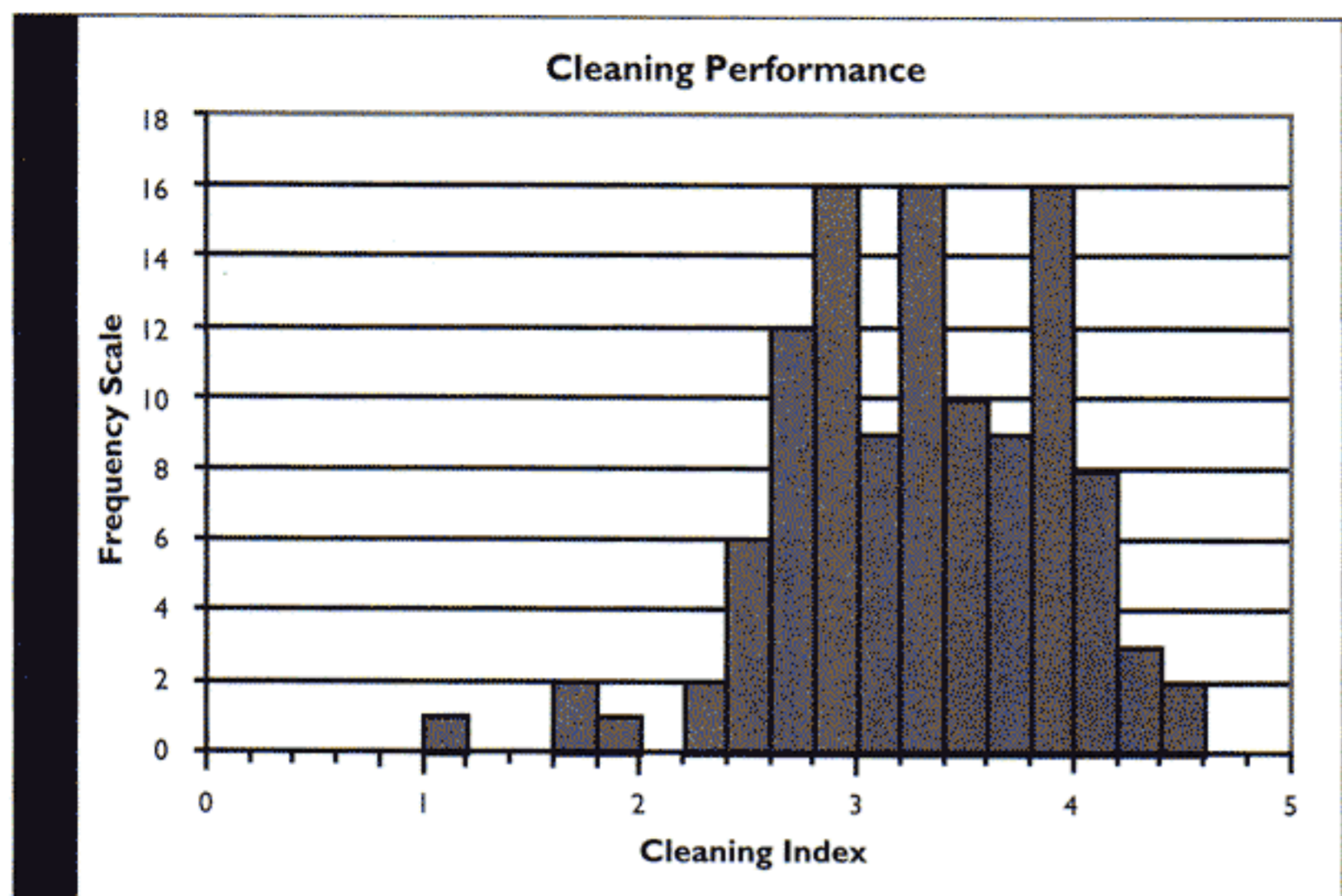


Figure 1. A score of 0 means that food residue larger than a dime is left on the item after cleaning. A score of 5 means a clean plate.

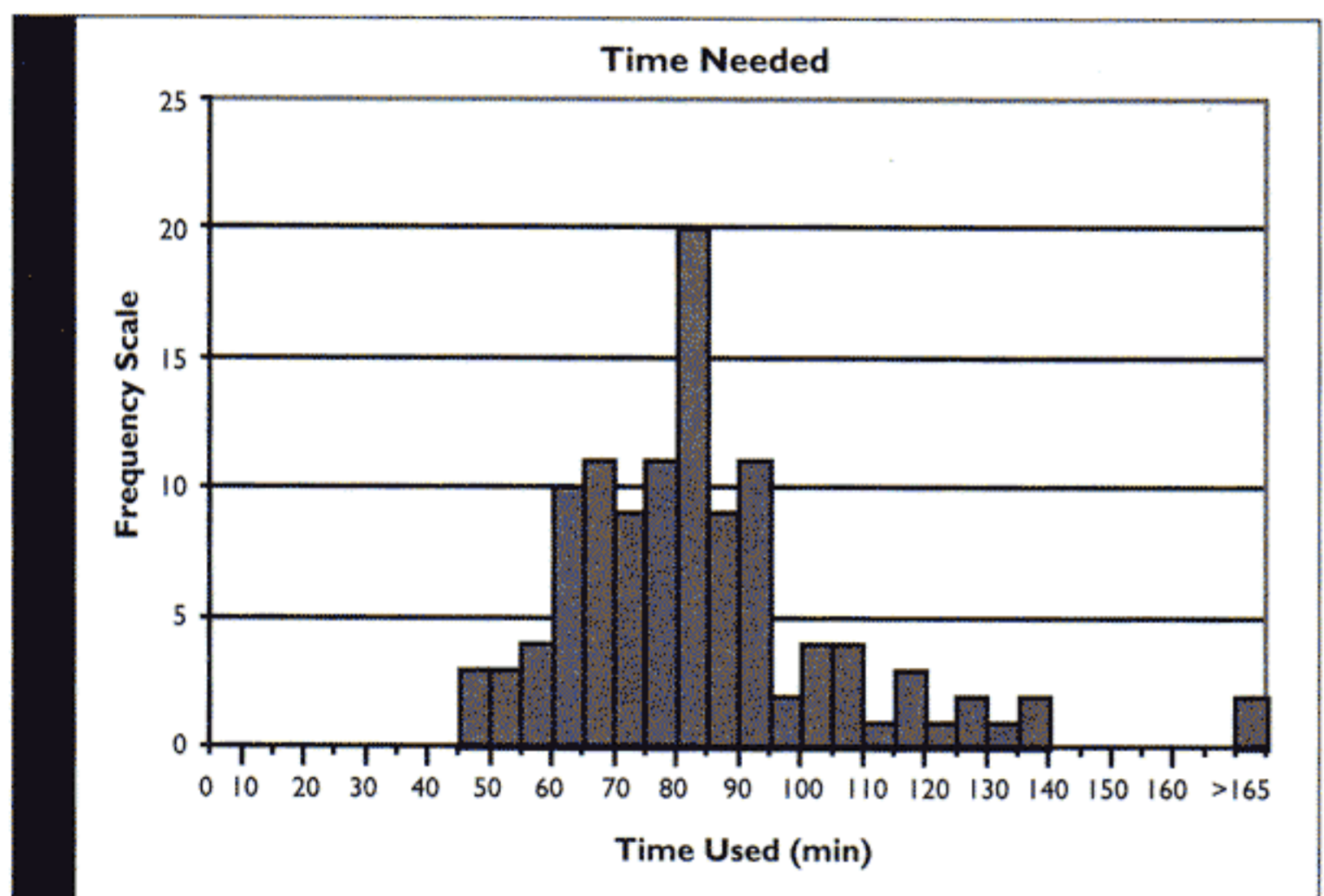


Figure 2. Text subjects took between 45 and 165 minutes to hand wash 12 place settings of dishes.

(80°C) for two hours; the milk residues are dried on in a microwave oven. For the most part, we replicated this test procedure, but we tweaked it by only leaving these dirty dishes out at an ambient temperature for two hours. We did this because we didn't want to introduce a systematic disadvantage for hand dishwashing into the test setup. In normal household use, food residues are not burned on. For the same reason, the milk soiling was not burned in a

microwave oven as hard as is specified by the standard.

After the two-hour drying period, all of the dishes were given to a test subject in a kitchenlike laboratory. Two sinks with hot and cold tap water, a variety of cleaning tools, and 22 hand dishwashing detergents from different countries were made available. The subject was asked to clean and dry the dishes as he or she would do it at home. Then the subject was left

alone—almost. With the aid of a video camera and water and temperature sensors, the subject's behavior was recorded. After the test was finished, the cleaning performance was visually assessed, as is specified in EN 50242, using a scale of 0 to 5. A score of 0 means that residues larger than 200 square millimeters—about the size of a dime—were left on an item; a score of 5 means that no residues were left on an item. The average of the scores for all items cleaned by one person was taken as a measure of that subject's cleaning performance.

The manual dishwashing performances were compared to the effectiveness and resource efficiency of two automatic dishwashers that had received an A/A/A label. This is the European Energy Labeling Schema's label for the best performance in cleaning and drying with a minimum consumption of energy. The two dishwashing machines were tested using the same protocol that we used for our human subjects. Each machine was tested five times on two different settings—the standard cycle and the intensive cycle for heavily soiled articles.

Carefree to Superclean

In reviewing the results, we were struck by the great variety of different practices that our subjects used for cleaning dishes. They ranged from using continuously running hot water and pouring dish detergent on the sponge only to cleaning each item with four rinses: soaking, precleaning in about 1 inch of pure water, cleaning in water with detergent, and rinsing in pure water. Clearly, there is no one universal way to clean dishes in Europe; neither is there a clear preference for any one practice in any one country. Nor did we find a clear correlation between any dishwashing practice and the gender or age of the test subjects.

Nevertheless, in observing the behavior and practices shown during dishwashing, we found that our subjects fell into three general categories. We call these the super dishwashers, the dishwashing economizers, and the care-free dishwashers. The super dishwashers seemed to focus their efforts on getting

the dishes as clean as possible. Although visual assessment of the results didn't always confirm the value of their efforts, these test subjects were clearly dedicated to the cleaning process itself.

Consequently, they did not try to be economical with water, energy, or detergent. This does not necessarily mean that they were deliberately wasting these resources, however.

The second type, the dishwashing economizers, seemed to focus on consuming as little water, energy, or detergent as possible. This does not necessarily mean that they actually did consume as little as possible; in many cases, the savings in one parameter were balanced by a relatively generous consumption in another parameter—for example, by washing with cold water but using a large amount of detergent.

We were surprised to find a third category of test subjects: the carefree dishwasher. They neither tried to do a good job nor seemed to be aware that wasting water, energy, or detergent was undesirable. These subjects typically kept the water running most of the time—sometimes even while they were drying the dishes! Often they washed the dishes in a disorganized and haphazard way.

With only a few exceptions, the subjects scored between 2.5 and 4.5 points on cleaning performance (see Figure 1). The two automatic dishwashers, running under identical conditions, achieved scores of 3.3 and 4.0, in the standard cycle. In the intensive cycle, which is recommended for heavy soiled loads, they scored 4.3 and 4.4, respectively. For manual dishwashing, results below 3.5 were regarded as “really dirty” or “not acceptable to be placed on a dinner table.” Clearly, about half of our test subjects did not achieve an acceptable level of cleanliness. It may be that these test subjects washed the dishes somewhat carelessly because they knew that they would not be eating off these plates, glasses, and china themselves. If these test subjects had tried to get the dishes really clean, they probably would have used even more water, energy, and detergent and would have taken much more time—increasing the comparative efficiency of an automatic dishwasher in these subjects' houses.

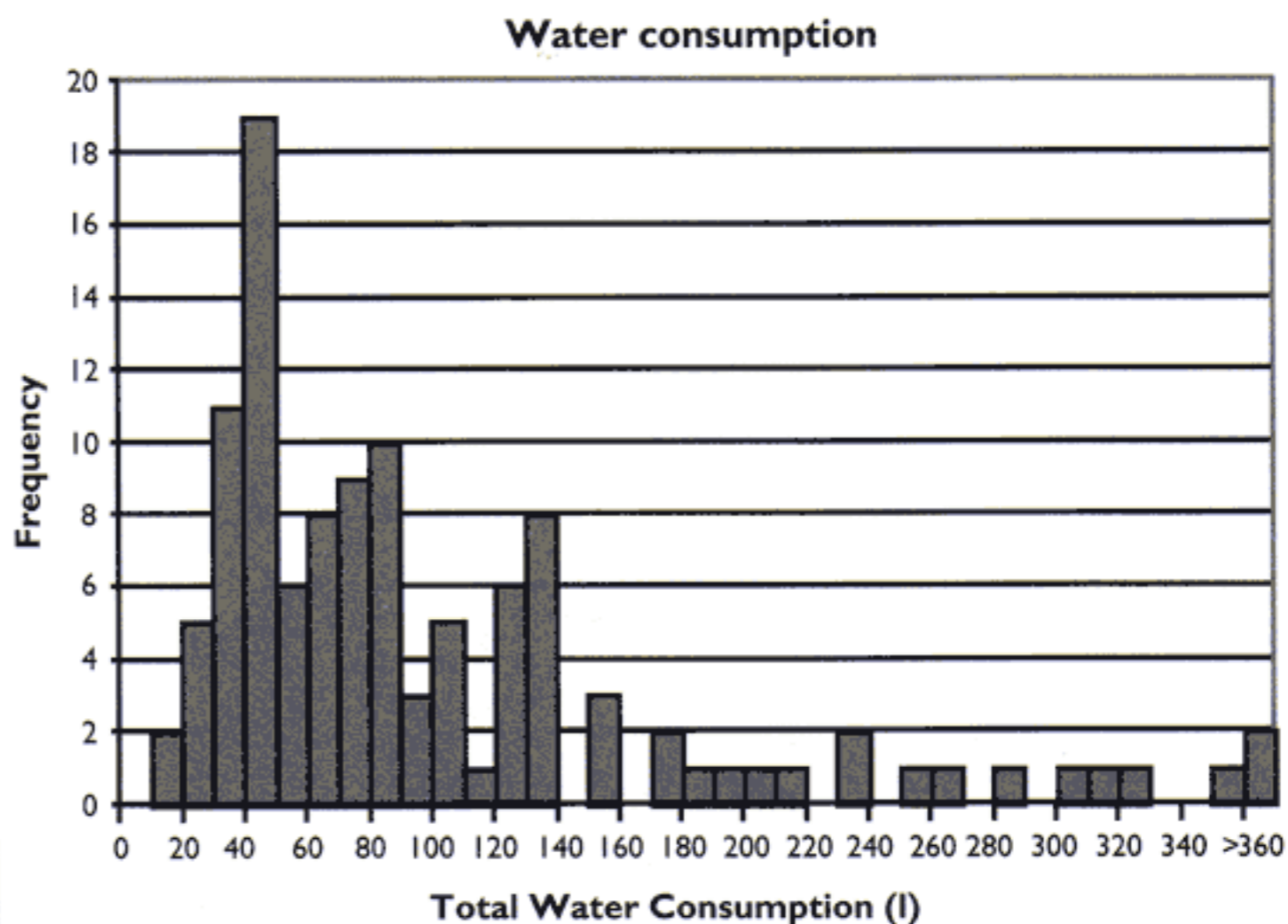


Figure 3. Many test subjects used more than 53 gallons of water to wash 12 sets of dishes.

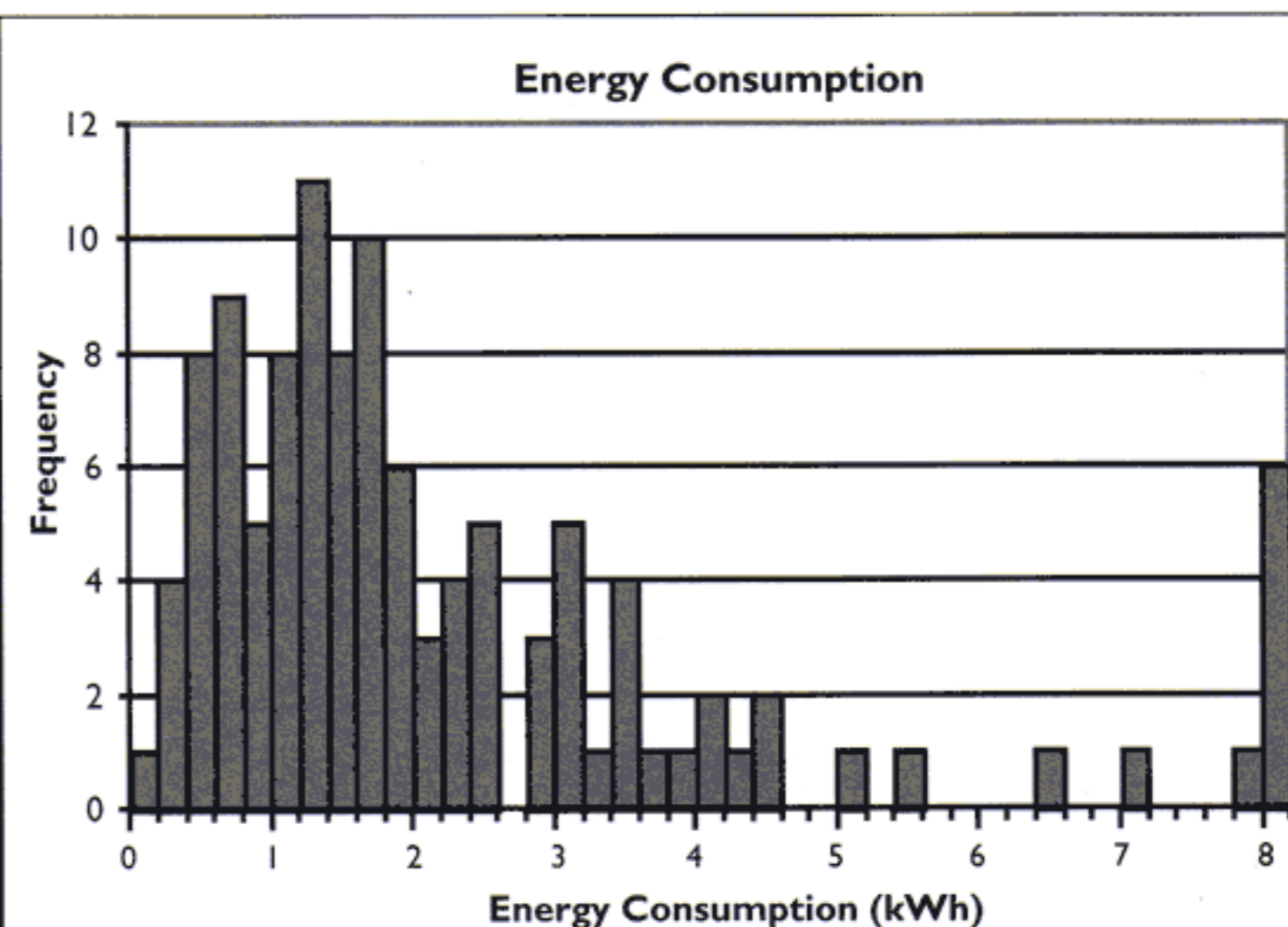


Figure 4. The highest energy consumption for hand washing was 16.6 kWh.

Time and Energy

To clean the 12 place settings of dishes, the 113 test subjects used on average 27 gallons (103 liters) of water and 2.5 kWh of water-heating energy. The total time needed for cleaning and drying the 140 pieces ranged from 45 minutes to more than 165 minutes, with a clear peak in the distribution of cleaning times at around 80 minutes (see Figure 2). Compare this time to the roughly 15 minutes it takes to both load

and unload a dishwasher with the same number of dishes, and the 80 and 160 minutes it takes to run a dishwasher. Using a dishwashing machine clearly saves at least 30 minutes—and more typically 65 minutes—of working time. However, the total elapsed time before the dishes are cleaned, dried, and ready for reuse may be twice as long using a dishwasher as it is when the dishes are cleaned and dried by hand.

Assuming that the number of dishes used in our test represents the number of



One of our dishwashing study subjects is at work in the laboratory.

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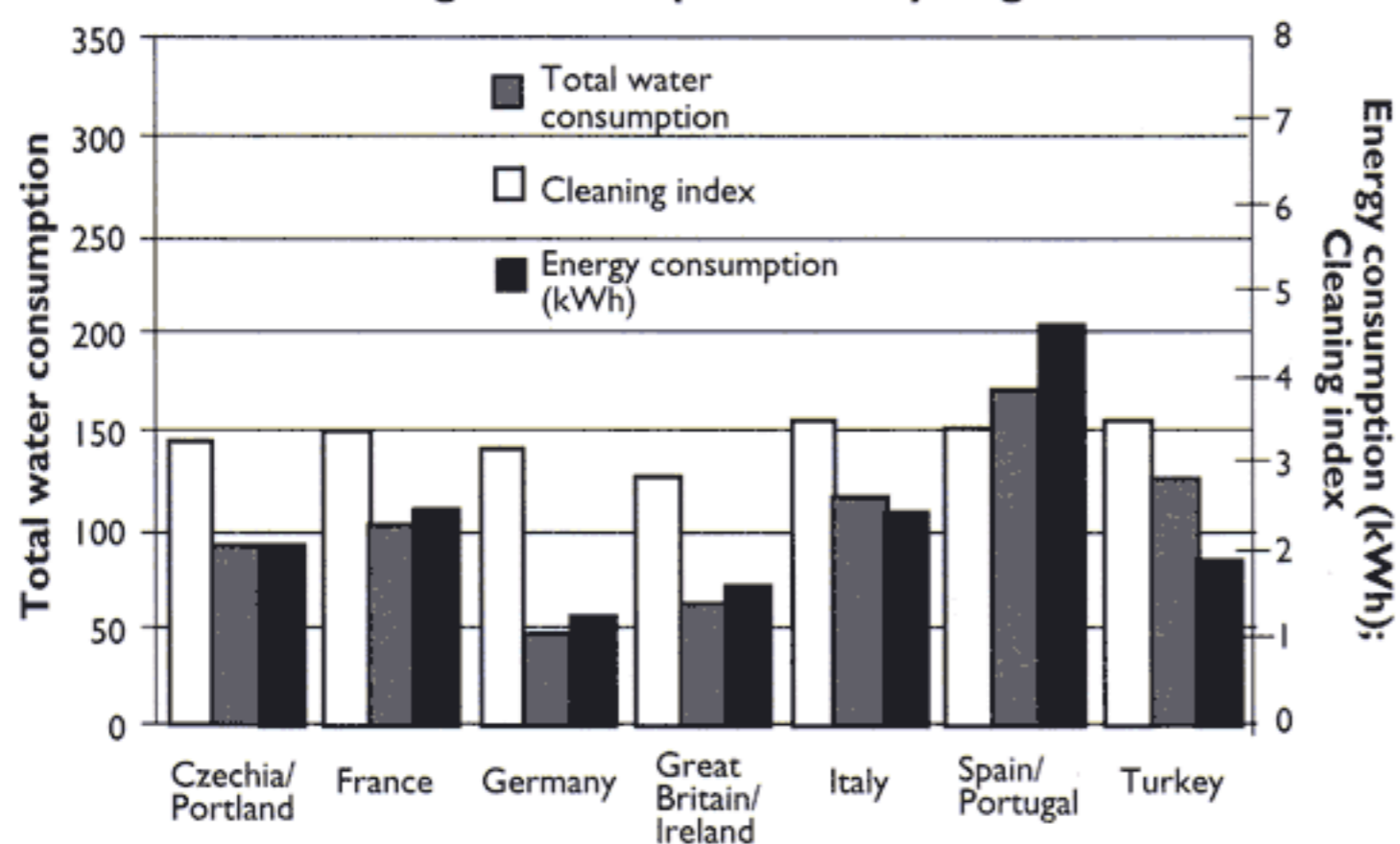
between 1 and 2 kWh, a second around 3.5 kWh, and another significant grouping shows up above 5 kWh. The highest energy consumption was 16.6 kWh. (The energy reported here is the energy needed to heat cold water from 59°F (15°C) to the temperature used for washing the dishes, which varied depending on who was doing the washing. Energy losses associated with the heating process are not included in these figures.)

A dishwashing machine, in comparison, uses about 4 gallons (15 liters) to clean a full load and consumes between 1 kWh (standard cycle) to 2 kWh (intensive cycle) of electrical energy. While using the automatic dishwasher clearly saves water, comparing the energy consumed by the automatic dishwasher to the energy consumed in hand dishwashing is more complex, as distribution and generation losses for the machine's electricity use have to be taken into account.

Obviously the average consumption of water and energy differs from country to country (see Figure 5). When we looked at the extreme values per country, we were surprised to find that good and bad cleaners—savers and wasters—can be found in almost all countries. Therefore, further analysis must be undertaken before country-specific differences can be clearly identified. The same holds true for trying to find correlations between the gender or age of the test subjects and their cleaning performance or consumption pattern in washing dishes by hand.

Rather than searching for faint correlations, it may be more useful to try to find a best-practice behavior for cleaning dishes. This behavior would combine an acceptable level of performance with the lowest possible consumption of water, energy, detergent, and time. To identify a best-practice behavior, it is useful to analyze the correlation between the performance achieved and the energy and water consumption values (see Figures 6 and 7). When we examine these data, we find almost no correlation between the energy used and the performance achieved. There is a small correlation between performance and the time spent, and a slightly stronger

Averaged Values per Country/Region



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Figure 5. The average consumption of water and energy varies by country or area, but the extreme values show that there are good and bad cleaners—savers and wasters—in every country. (The number of people tested was different between countries/regions.)

dishes that get washed on a daily basis in a typical home, and that it takes 80 minutes to wash these dishes, then it takes a total of about 500 working hours a year to clean dishes by hand. This is equivalent to 12.5 weeks of work, based on a normal 40-hour work week.

The amounts of water and energy consumed by the test subjects to clean the dishes do not fall into any clear

pattern; both values vary considerably (see Figures 3 and 4). For water consumption, a first cluster in the distribution occurs around 8 to 26 gallons (30 to 100 liters), while a second occurs around 34 gallons (130 liters). But many test subjects consumed more than 53 gallons (200 liters), and 1 subject consumed 118 gallons (447 liters). Similarly, for energy consumption, a first cluster occurs

correlation between performance and water consumption.

Clearly, new dishwashers are able to achieve at least the same level of performance using significantly less water than the amount used by any test subject. However, the data show that it should be possible to achieve a good performance in washing dishes by hand without spending too much time, water, and energy! Identifying this combination of super dishwasher and dishwashing economizer will give us the best practice in manual dish washing—the supereconomic dishwasher. Identifying this behavior will have to be part of our future studies. Once we identify this best-practice behavior, considerable amounts of time, water, energy, and detergent could be saved if consumers were to get trained in the best way of manually washing dishes.

Getting to Supereconomic

For the time being, we offer the following recommendations to anyone who aims to become a supereconomic dishwasher:


- Remove large food scraps from the dishes with a spoon or a fork.

- Manual dishwashing is much easier if the food is not dried on the dishes. Therefore, it is best to start washing dishes soon after the meal. (Perhaps the guests can help.) In contrast, automatic dishwashers can clean dishes that have been stored in a dishwasher for several days.

- Do not prerinse the dishes under running tap water—whether you are washing them by hand or in a dishwashing machine.

- Manual dishwashing is best done in two sinks—one with hot water and detergent, the other with cold water for a quick rinse.

- The amount of detergent used should be appropriate to the job to be done. Don't use too much and don't use too little; stick to the amount recommended by the manufacturer.

- If you can afford an automatic dishwasher, use one—preferably a new one. A full, energy-efficient dishwasher cleans best and has the lowest environmental impact of any method. 

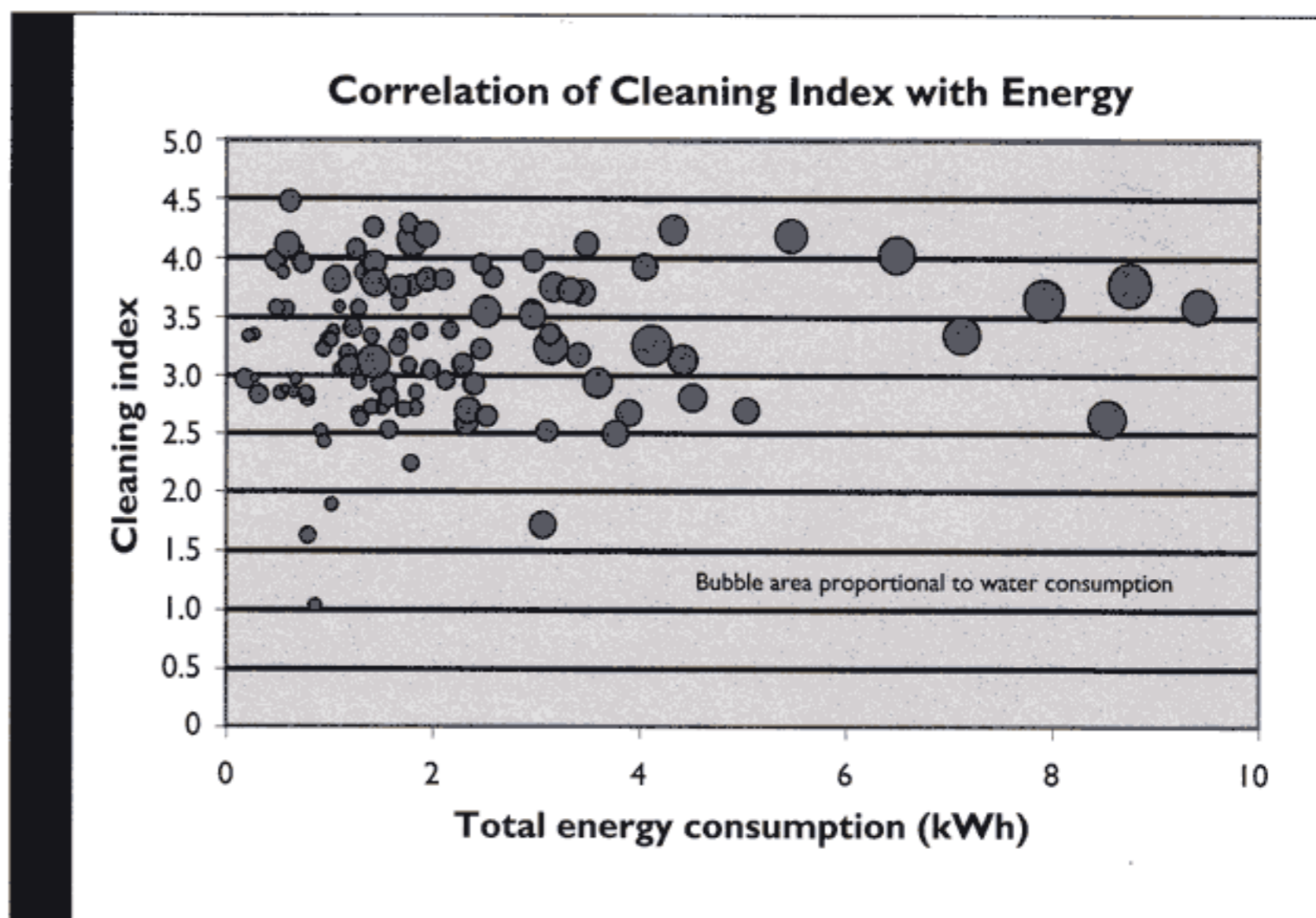


Figure 6. The data show that there is almost no correlation between the energy used to clean dishes by hand and the effectiveness of the cleaning.

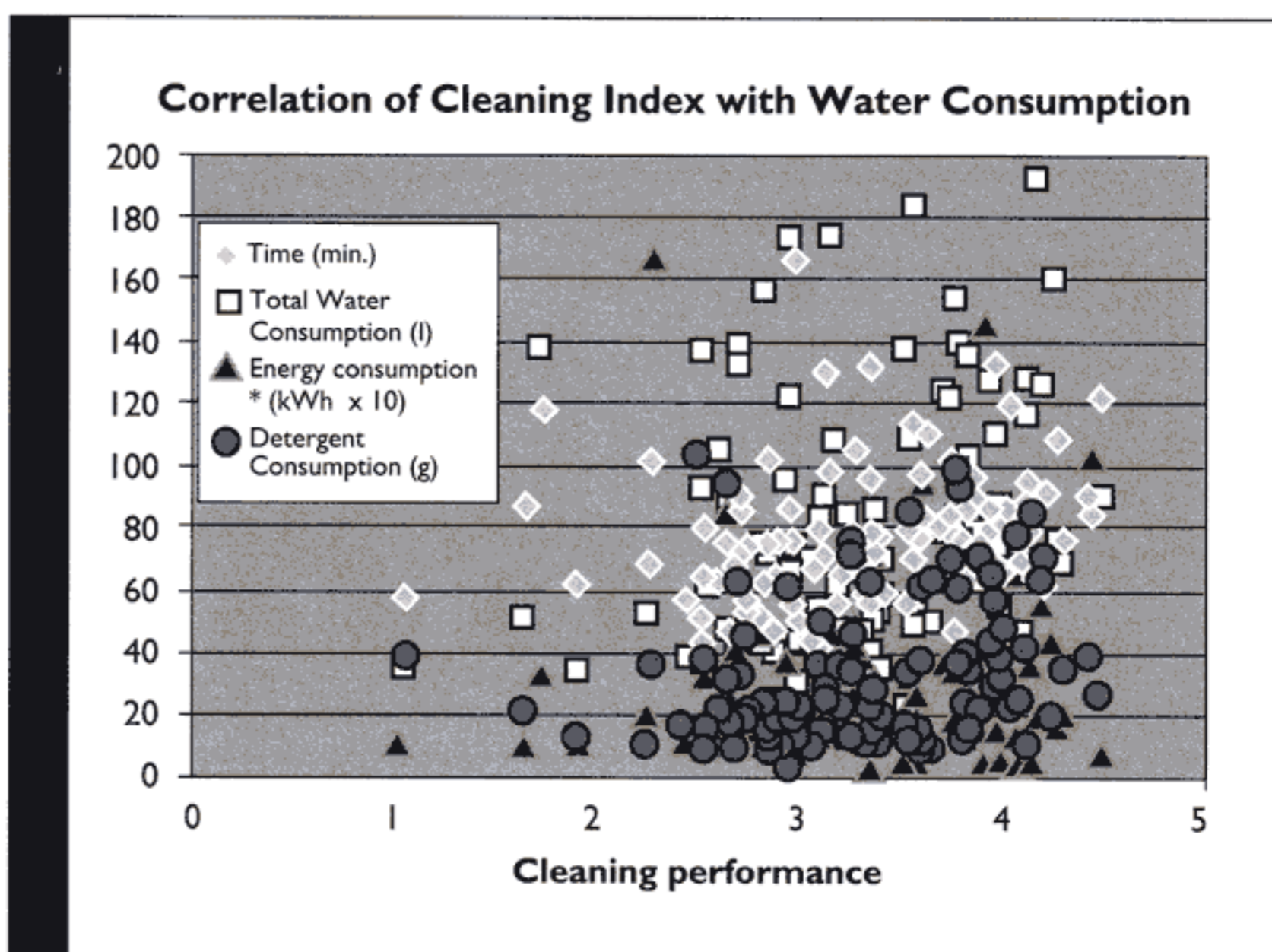


Figure 7. There is a small correlation between dish cleaning performance and time spent washing, and a slightly stronger correlation between cleaning performance and water consumption.

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