THE PERSONAL WATER CALCULATOR

DECISION SUPPORT ON RESIDENTIAL WATER USE OPTIONS BY AN INTEGRATED MODEL ON THE INTERNET

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ABSTRACT

In this paper, we present the Personal Water Calculator (PWC), an internet communication tool, intended to raise awareness and provide decision support relating to residential water use. Given inputs by the user, it calculates the personal use of drinking water and related parameters (production of waste water, use of hot water and energy, costs). The user can explore a variety of personal and technical options. The target group for the PWC are laypersons, the medium it uses is the internet.

Communication tools for laypersons need more than just good science and a good underlying structure. Other factors such as design, colour, beauty or humour are critical if we want to maintain the user's interest. With this tool, we want to demonstrate how the internet can be used by ecological engineers to communicate their ideas and solutions to a broad audience.

MOTIVATION

Do you know how much water you use every day?
Do you know how much you pay for drinking water and wastewater?
Do you think the price for water is going to rise within the next 5 years?

Are you able to answer these questions correctly? The average citizen of Switzerland is not. There is a widespread information deficit on questions related to water use. Water prices are low. Drinking water costs about 1.50 Swiss Francs per m^3 (Preisüberwachung 1998), wastewater costs are in the same range. Water meters are scarce and Swiss water consumption ranks among the highest in Europe (see e.g. Feurich 1997).

Today, potential "water savers" are discouraged by barriers in the Swiss domestic water technology market. Water conservation appliances are difficult to get. The plumbers are reluctant to install them because they are not familiar with them and fear to risk technical problems, such as sewer clogging. The merchants don't want to put them on stock for fear of not finding customers. The local water works obtain their revenues by selling water and are not particularly interested in conservation efforts by their clients. Thus, the whole domestic water technology market slows down the adoption of new water conservation technology.

This situation contrasts sharply with the fact that water prices are expected to rise significantly within the next few years. The renewal of sewers and treatment plants, many of the which are now 15-20 years old, will become necessary soon. However, federal subsidies will no longer be available. Experts expect a 2-6 fold rise of wastewater fees in the near future (Lehmann 1994).

A significant rise of water prices would intensify the public debate on water policy.As citizens become involved in these discussions, there is a need for aids that allow for a personal assessment of the matter. The experience gathered at EAWAG with the "Personal CO_2-Calculator" (Schlumpf et al. 1999) has shown, that personal assessment tools can be very interesting for discussion support. They are able to provide the users with direct feedback on their personal behaviour and integrate information from different sources, even from outside the actual model. They can illustrate mechanisms and causal relationships that are not immediately obvious, answer questions related to

the topic, and raise awareness to new technologies not yet widely known. They also allow the users to play around with different options, compare them with others and have fun together. The "Personal Water Calculator" (PWC) is an attempt to adapt this approach to the topic of water consumption.

THE SWISS MARKET FOR DOMESTIC WATER TECHNOLOGY

The Swiss domestic water technology market is now about 100 – 120 years old. Until recently the market was "a system of considerable closedness" towards newcomers from abroad as well as from Switzerland (Kartellkomission 1991). There were various agreements between the different actors: e.g. the manufacturers would only sell to the members of the merchants' association, which in turn would only sell to certain plumbers they had on a list. Consumer prices and craftsmen fees were more or less fixed, at a rather high level. Competition was kept to a minimum. "Almost paradise on earth", in the words of a Swiss marketing executive.

The market was liberalized in the 90s. The cartel no longer exists, but the process of liberalization is not yet completed. Some segments of the market are still highly regulated. For example, a plumber generally needs a special permit by the local water works, if he wants to work in a certain area.

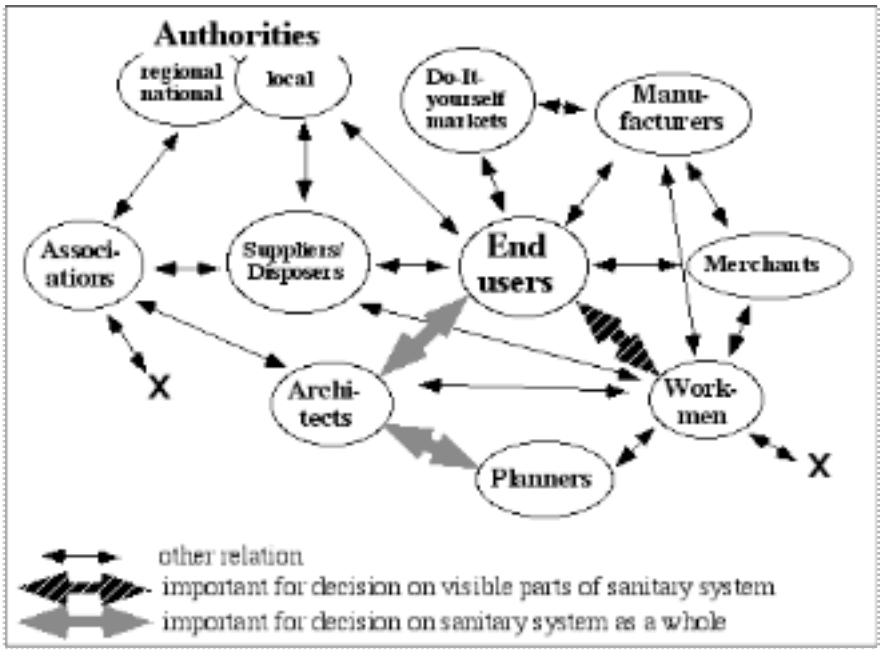

Figure 1: The Swiss domestic water technology market (simplified sketch): actors and relations

Who decides on the choice of a sanitary system[1] and why? An understanding of these questions is very important for the design of our communication tool. Therefore, before starting with the PWC, we conducted a study to identify the various actors in the domestic water technology market, their roles and relationships (Schönborn & Pahl-Wostl, unpublished).

Figure 1 shows the market network from the viewpoint of an end-user who is interested in water conservation technology[2] and tries to obtain it on the market. The end-user stands in the centre. A large portion of the money spent on the market comes from him or her. However, end-users are

[1] Sanitary system: the totality of water technology in the household (including piping, appliances etc.)
[2] Water conservation technology: water and energy saving water technology, such as: flow limiters; water saving faucets, shower heads, flushing toilets, dish washers and washing machines; water meters; systems for grey and rainwater reuse; waterless urinals; composting toilets; vacuum toilets

usually laypersons when it comes to domestic water technology. They delegate decisions to experts, in this case the architects, who represent the end-users to the rest of the market.

Although they play a key role, the architects do not decide alone. Very often, particularly in bigger buildings, the expertise of architects is not sufficient for the design of a sanitary system. At this point, planners come into the picture. They will propose a concept according to their experience and professional standards, which will usually be state-of-the-art but rather conservative.

The workmen (e.g. plumbers), who do the actual work in the building, have no influence on the choice of the sanitary system. However, they often help the end-users in making decisions, for example by accompanying them to an exhibition at a local merchant, where the visible parts of the sanitary system are purchased. They also influence the architects by their pricing policy: for installing standard technology they charge less than for installing technology with a certain risk - and water conservation technology is still considered risky.

Another important actor are the local suppliers and wastewater treatment operators. In Switzerland, they mostly belong to the municipalities and have a monopoly in their area. Both suppliers and wastewater treatment operators put up regulations in their area of operation. They are controlled by democratic mechanisms. However, in reality, democratic control on complex technical questions is difficult to ensure. For example, the water suppliers decide on petitions for rainwater reuse systems. If opposed to rainwater reuse, they can obstruct the reuse of rainwater in a whole area for a long time.

The other actors on the market mostly have no direct influence on the end-users regarding the choice of domestic water technology. Do-It-Yourself markets are of rather marginal importance in Switzerland.

The PWC can potentially address several actors at several points of the market network. It can potentially be used for education and training of architects, planners and plumbers. It can also be used during consultation meetings as a "common denominator" between architect and client. Furthermore, traders and even waterworks can potentially use the PWC as a marketing tool. However, in our opinion the most important function of the PWC is the education of the end-users. Those who spend the money should know what they spend it on.

THE PERSONAL WATER CALCULATOR

Goals and target group

The goal of the PWC is to raise the awareness of end users for questions related to the parameters water use, wastewater production, energy consumption (for hot water) and costs. It was primarily designed for the use in a focus group setting (see Schlumpf et al. 1999) as part of the interdisciplinary EAWAG project "Resource Efficiency in Urban Water Management". A second target group are citizens who use the internet. Since the PWC was made for residents from the German part of Switzerland, the present version is in German.

Vision, structure and design

The vision of the PWC was, to create an interactive tool which is easily understandable, fun to use and self-explanatory. The visible screen is divided into three frames (Fig.2):

(a) the input frame: core of the PWC where navigation takes place and inputs are made
(b) the output frame: display of results in an interactive diagram
(c) the menu frame: navigation and links that always appear ("always-links")

The graphic user interface of the PWC is designed like a virtual house (Fig.2). The central turntable of the PWC is a picture of a house with different rooms. The user can "walk" (= browse) through the "rooms" and play with various technical and behavioral options. Any change of an option leads to a complete recalculation of all output parameters. The results of his actions are displayed immediately in an interactive diagram in the output frame. For example, if the user changes the frequency of taking a shower from twice a week (default value) to once a day in the input frame, the

corresponding bar in the interactive diagram will immediately more than triple its size - thus indicating the increase in water consumption.

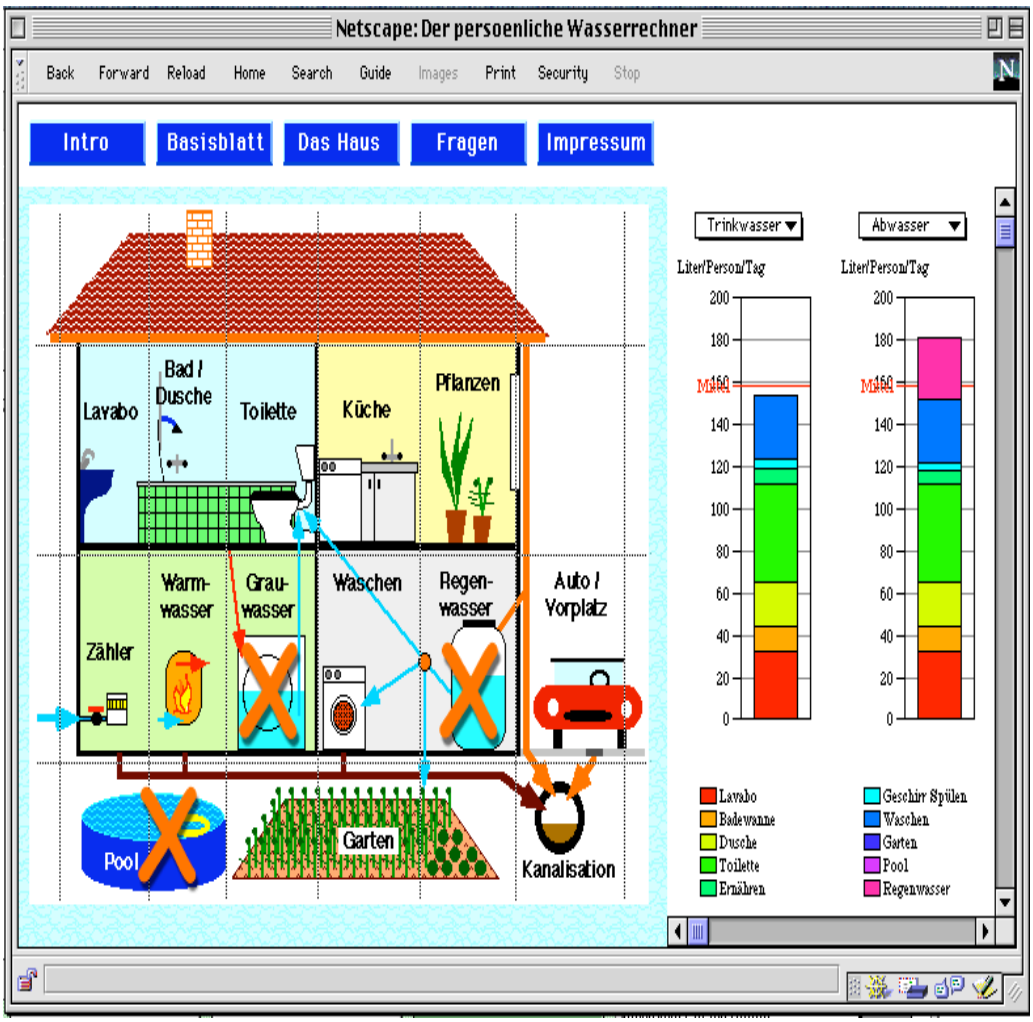

Figure 2: Central turntable of the PWC

The input frame also contains various hypertext links, which either lead to websites outside the PWC or to a built-in expert character, "Urs, der Monteur" ("Urs, the plumber"), who answers all sorts of questions and offers information along the way. A mouseclick on either of these links opens up a new window.

We attempted to attract the user's attention by rapid direct feedback to his or her choice of options (via the interactive diagram), easy accessibility (access on a mouseclick) and short information units written in colloquial German. These features are supported by an attractive design of the graphic user interface (the "rooms" of the "house" resemble actual rooms, to evoke the "feeling" in that room. E.g., bathroom and kitchen are tiled, the cellar has a white brick wall etc.) and the use of "calm" graphic elements (no flickering banners, GIF-animations, rapidly moving applets or movies).

Medium

The PWC uses client side internet technology. It relies heavily on the Netscape Navigator™ 4.0 or higher and does not run on Microsoft's Internet Explorer™ (tested until version 4.5). Javascript- and Java-options in the browser must be enabled. A colour screen sized 600 x 800 pixels is recommended.

Humour
The expert character "Urs der Monteur" mentioned above is a collection of answers to questions which turned up during the course of preliminary tests of the PWC. The instrument "Urs" also allows to introduce humour, funny aphorisms or even jokes to the PWC. Urs is a typical Swiss name. He stands for a smart, astute, down to earth plumber as every Swiss knows one.

Calculator
The core of the PWC is a set of equations which allow to calculate a personal budget based on water related activities. The following table shows activities or activity related appliances, plus the technical (e.g. choice of low-flow shower head) and behavioural (e.g. how often and how long the shower is used) options associated with them.

Activity or appliance	Technical options	Behavioral options
Wash-bowl	yes	yes
Bathing tub	yes†	yes
Shower	yes†	yes
Toilet	yes*†	yes
Food	no	yes
Dish washing	yes	yes
Laundry washing	yes*	yes
Garden	no*	yes
Pool	no	yes
Rainwater	no*	no

A budget can be calculated for use of drinking water, wastewater production, hot water consumption and costs. In addition, a number of activities / appliances can be influenced by the choice of rainwater reuse (indicated by * in the table) or greywater reuse (indicated by † in the table).

Equation 1 gives an example for a typical equation used in the PWC:

$$\mathbf{D_{TW} = V_D \times N_D \times T_D \times p \ (= D_{AW})} \qquad \mathbf{(1)}$$

D_{TW} = drinking water consumption in shower [liter / person / day]
D_{AW} = wastewater production in shower [liter / person / day]
V_D = water flow of showerhead [liter per minute] (technical option)
N_D = Frequency of showering [showers per day] (behavioral option)
T_D = Average duration of use [minutes] (behavioral option)
p = 0.8 if water switched off during soaping, else 1.0 (behavioral option)

In total, the PWC contains more than 100 equations and more than 130 different variables.

Database and calibration
The data used in the PWC were either taken from the literature, provided by experts, or derived from own calculations and measurements. The published database in the field of domestic water technology is rather thin. For planning purposes, a water consumption of 180 L/person/day is generally assumed in Switzerland, although this number is now 20 years old now and water consumption has been decreasing for years. Recent measurements were conducted by Gaille (1998) and by Schmon and Tarnowski (1999). However, in both cases, variance was huge and the results are not statistically significant for Switzerland as a whole. In spite of these shortcomings, we used the values given by Gaille (1998) to calibrate the PWC. His total specific water consumption of 158,9 L/person/day is supported by the statement of many experts, that the total water consumption has gone down over the last decade.

System boundaries

The PWC calculates the consumption for one person in his/her private household. The consumption of a whole family can be estimated by every person going through the calculator individually, and subsequent addition of the results.

The following situations are not yet adequately represented in the PWC:
- situation with very small children whose water consumption depends entirely on their parents
- situation with temporary residents in the house (e.g. because there is an office in the building)
- personal water consumption in the office / at work
- share of public water consumption (e.g. water used for watering of parks, for public swimming pools etc.); to our knowledge there are no data available
- users from outside the German part of Switzerland
- of course, the PWC does not account for water used as input in products we consume (foodstuff, cosmetics etc.)

OUTLOOK

Since the first version of the PWC has been completed only very recently (end of May 1999) and has not yet been tested in the environment it was designed for, we cannot yet report on any experience with it. However, the relevance of such a tool seems quite obvious from the very positive feedback we got during preliminary test runs. We are planning to use the PWC in focus groups with citizens during the course of this year (1999). We will also try to establish the PWC as a tool to obtain realistic estimates for water consumption in domestic households and to evaluate the potential demand for domestic water saving measures. Furthermore, the results will be used to further improve the database of the PWC.

Internet communication tools, such as the Personal Water Calculator, have a high potential for use in situations, where complex technical or scientifical problems need to be explained to a broad audience of laypersons. This is in many respects the situation ecological engineers face in western industrialized countries. They are trying to introduce new technologies, such as source separation (no-mix) toilets or constructed wetlands into an existing market, where they are not welcome at first. We are convinced that internet communication tools can play a significant role in this discussion and can significantly contribute to the advancement of more sustainable concepts and technologies in the future.

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