

Respos to Comments referees (186632)

Non-residential water demand model validated with extensive measurements

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Thank you for the valuable comments on our manuscript. We will consider all remarks to improve our paper. Our response to your comments is given below.

Furthermore we want to state that it is almost two years since we first submitted this paper to the CCWI 2011. This was ongoing research then, and parts of the research were published and presented in several conferences, but the research is finished now. We propose to expand this peer reviewed paper to cover the entire validation, including testing the peak demands (cold and hot water) and its consequences for the design and the testing of the assumptions both based on diurnal patterns and assumptions on building standardisation.

1) validate the **assumptions of how to standardise** buildings:

* compare simulated **diurnal patterns** of the standardised buildings and measured cold and hot water demand patterns (2 buildings of each category of variable size)

* **surveys** will show whether the assumptions of the **dominant variable** corresponds with practice (min. 4 buildings for each typology in each category).

Proof of concept: when the surveys show that the standardisation of the buildings correspond with practice **and** the diurnal demand patterns correspond with practice, it shows that the basis is solid.

2) compare predicted (design rules) and measured **peak demand** values of cold and hot water. When the basis is solid, this step shows that the derivation of the design rules, based on 100 simulations per value of x is reliable.

3) compare the resulting designs for pipe diameter, water meter and heaters from developed design rules, old design rules and measured practical values.

D. Loureiro (Referee)

Two principal improvements are recommended:

i) to support better the background with available studies about non-residential water demands.

Although, the research about non-residential water demands is limited, the background about the characterization of this type of users should be improved with available studies (e.g., Cobacho et al., 2005, Vickers, 2001), in order to illustrate some important facts, namely the variability of demand, the fact that some users have similar behaviour with residential households whereas others have a completely different behaviour and the types of non-residential categories adopted by the water utilities, etc

Thank you for your suggestions. We will include more literature references in the introduction.

ii) to improve the justification about the transference of the proposed procedure to various types of buildings in the Netherlands and in other countries.

The paper shows that the solid basis of SIMDEUM and the standardisation of buildings for offices, hotels and nursing homes result in a reliable prediction of peak demand values by the design rules derived with the procedure based on SIMDEUM.

With this paper we show that the procedure leads to good results for three types of non-residential buildings. The way we show this, is by not only showing that the procedure leads to good end results (maximum flows and hot water uses), but also by showing that the underlying principle (the assumptions of the appliances and people in the buildings and the resulting diurnal patterns of cold and hot water) are sound. These results suggest that the procedure for the design rules will result in reliable prediction for other buildings, when the standardisation of the buildings is solid.

We did use SIMDEUM, based on the physical basis, to develop diurnal profiles for several different buildings, like schools, shops, restaurants, sporting facilities etc. However, these are not published. One example is described in Blokker et al. (2011), where a theatre hotel is shown. Also in other countries, we successfully used SIMDEUM for simulating the water demand for residential water use.

We will add this more clearly to the paper.

Specific comments

Page 458, lines 3-4: is important to justify the choice of offices, hotels and nursing homes for this study and in what type of category they can be classified: small-scale or large-scale users.

The buildings are chosen based on the cooperation with the Dutch installing branche, where they were mostly interested in these buildings – the justification for those is in (Blokker et al. 2011). They are most often applied in practice. Moreover, they are characterised by a generalised construction. This in contrast with for example a hospital or a prison, which are more specific.

The buildings can be characterised as small-scale. The choice for the measurement locations is mostly practical, it is difficult to find good measurement locations.

Page 458, lines 24-26: a more detailed explanation is recommended about the fact that simulated demand for cold water appears to underestimate the instantaneous peak demand in Figure 1.

Figure 1 shows the average diurnal patterns. It has to be emphasized that the simulated diurnal pattern is based on the standardised building (where only the number of beds is the input). Of course it is possible that the building in practice can deviate (little or more) from the standardisation. This figure illustrates that the bases is solid, since the total daily pattern corresponds. We will add a figure that shows the peak demands for all measurements and simulations; this figure shows that the frequency distribution follows a normal distribution and also shows that the peak demands are very comparable between measurements and simulations.

Page 459, lines 13-14: the choice of the dominant variable in each case should be discussed or supported with background information and the source of information used ought to be presented.

We presented this in another paper. We will describe the background here.

Page 461, lines 1-4: the use of the presented rule is based on the assumption that MMF follows a theoretical distribution (i.e., Normal distribution). It is recommended to support better this assumption and the contribution of this approach for this study.

We will add a figure, see reply to remark on page 458, lines 24-26.

Page 461, line 9: refer the time step usually adopted to obtain MMF for design purposes.

Time step is 1 s, we will add this.

The old Dutch design rules (see table) were based on measurements that were also done on a per second time base. It is a matter of choice. We believe that in the home a person would definitely notice a 1 second pressure loss when they are in the shower.

Moreover, the time step strongly influences the measured maximum. An increase in the time step gives a considerable decrease in the measured maximum. With a time step of 1 second we are sure that we measured the true maximum.

Page 465, lines 3-5: the conclusions refer that the procedure is easily transferable. It is recommended to refer the mains steps, if the procedure is applicable to only to smallscale users or also to large-scale users and some ways to overcome the variability of non-residential users.

We will put more details in this section. The boundary conditions etc wil be given.

K. Van Zyl (Referee)

1. The main concern I have with the paper is the weight given to the measured peak demands in the development of new design guidelines. The peak demand of a building is a probabilistic value. This means that it is not possible to propose a design value that will never be exceeded - the best that can be done is to propose a design value that has an acceptably low risk of being exceed, for instance 1 in 10 years.

The authors' approach is to model and measure the peak demand of a small number of buildings over a short period of time and then to use this data to show that their model is better than the existing design guidelines. This is claim, as well as the claim that the existing guidelines are too conservative, cannot be verified without quantifying the probabilistic nature of the peak demand and then comparing it to an acceptable risk of being exceeded.

This paper describes the results of only one part of a validation procedure existing of a number of steps. However, we propose to extend the paper, see introduction.

specific comments

a. Page 459, line 24: "The resulting design parameters are defined as the 99-percentile of the 100 values of the different peak demand values." This statement is made without any rationale to why the 99 percentile is chosen. In addition, the impression is given that this value is the 99 percentile for the peak consumption of the users measured, but this cannot be claimed without a proper statistical analysis of the data.

The 99-percentile in fact means that once per 100 days this value is exceeded for one second. This value is arbitrary, and was chosen in concert with the installation sector. We will add information (including a figure) to show the frequency distribution of measured and simulated maximum demands.

b. Page 462: the data was measured for only a short period of time and for only a very small number of buildings (one or two), making it risky to assign too much importance

to the values, especially the values close to the limits of the measurements (i.e. the 99 percentile). In addition, it is important to discuss the potential consequences of an under-designed system and use this information in deciding the desired level of confidence for a new design guideline. The same points are valid for the claim of a 99.7 percentile on page 461, line 3.

See also introduction. We agree that it is not fair to draw the conclusion that the new design rules are good based on only a few measurements of maximum demands. That is why we also look at the underlying principles (assumptions on users and appliances in the buildings and diurnal patterns).

c. Page 462, line 9: “The design rules show an improved prediction compared to the existing Dutch guidelines, which overestimate MMF_{cold} with 30–80%.” This might be true for a typical peak demand, but there is no statistical proof that the values obtained are representative.

This is true. The existing Dutch guidelines were based on a lot of measurements, they do not have a physical basis (such as the design rules based on SIMDEUM do have). It is difficult to prove one way or the other that the old design rules are valid or not valid. However, the measured buildings in the late 1970s (and were built maybe even decades before that) had different appliances and uses. For example, offices nowadays have coffee machines instead of a coffee lady, have employees with more flexible hours (even working from home sometimes), have water saving toilets, etc. It is to be expected that the old maximum flows are no longer valid. The measurements that we have all show smaller maximum demands. In this paper we only present the measurements that we purposely did for this study, i.e. per second measurements and at least for 30 days.

d. Page 462, line 19: the same error is made by taking the average of the peak demand for certain days. Is it acceptable for a design guideline to specify the average peak demand, i.e. about half the peak demands are likely to exceed the design value?

We will explain this better, also by showing the frequency distribution of the measured maximum demands. The issue with the hotels is that days with full occupancy and days with low occupancy do not show a continuous normal distribution for the max demands.

2. Bottom of page 458 and top of page 459. It is not clear at this point what is part of this paper, and what is part of other studies. Two steps of validation are mentioned, and the second is clearly included in the paper. Aspects of the first step are clearly excluded, but it is not clear which parts of the first step are included in this paper. What other papers form part of the verification, and what still needs to be done?

In the meantime, the other steps have been finished as well and will be described/presented in other papers. We will add these aspects in this paper.
Pieterse-Quirijns et al. (2012). Modelling sustainability in water supply and drainage with SIMDEUM. CIB 2012 in Edinburgh
Pieterse-Quirijns et al. (2013). Validation of non-residential cold and hot water demand model assumptions. CCWI 2013

3. The paper doesn't give an overview of the current standards in the Netherlands – only their design values for specific buildings. More information on the scope, methods and rules included in these guidelines are required to understand how the design values for the buildings are obtained.

We will add some information. An issue is that the old standards were not very scientifically founded.

4. The same is true for the SIMDEUM model. It is acceptable to refer the reader to another paper for details, but this should not be required for the reader to understand the basic assumptions, data requirements and methods used in the model. For instance, was SIMDEUM calibrated in any way on the buildings referred to on the top of page 462?

We will describe SIMDEUM more extensively. Calibration of specific buildings is described in Blokker et al. (2011). In that paper, SIMDEUM for non-residential buildings is developed and used to simulate the water demand of the buildings with the number of appliances and users as in reality. In current paper, the standardised buildings of the design rules are validated.

5. Page 460, line 5+. Clamp-on ultrasonic flow meters can be highly accurate under controlled conditions, but are much less reliable when used in the field. What measures were taken to verify or estimate the accuracy of the clamp-on meters?

The accuracy is lost when the meter is put to close to bends or diameter changes and so on. We paid particular attention to these requirements. We will add this to the paper.

6. Page 460, line 9: Categories are referred to, but how and where are these categories defined? How many categories were tested and how many were omitted in this study?

We will add a summary of all categories and their characteristics.

7. Page 463, line 13: The authors claim that the new design guidelines will result in better water quality. However, unlike in a distribution system, it is not clear to me that water stagnation is really the case inside a building. The pipe diameters inside a building may be small enough that the water will be completely replaced even for small withdrawals. This statement should be better motivated.

We will add some thoughts on this. Inside a home you are correct. However, in a larger building (e.g. a hotel) this may not be the case. We will do some calculations.

8. Page 464, line 21. It is not clear how the reduced hot water peak estimate will necessarily lead to ‘enormous energy savings’. Please explain.

The design of heater systems is based on the characteristic number of heat demand. When the design rules result in a smaller (we found two to four times) design of the heating system, you need less energy to heat the system, you will have less energy losses etc. We will quantify instead of using words as enormous.

Minor comments

1. The name SIMDEUM is marked with the Registered Trade Mark (R) sign. While this is necessary in commercial documents, the (R) symbol is not necessary in a scientific document that makes it clear that this is the name of a product. The use of this symbol might even be interpreted as advertisement or commercial intent.

We will correct this.

2. The term ‘hygienic consequences’ doesn’t sound right in English. Replace with a more generally used term such as ‘health risk’.

we will change the words

3. I have never seen the term ‘maximum momentary flow’ in water supply literature. Perhaps replace this with a more common term such as ‘instantaneous peak demand’?

we will change the words

4. Page 457, line 28: the term ‘(inter)national’ is ambiguous and can be read as ‘national and international’ or ‘national or international’. Clarify.

we will clarify.

5. Page 458, line 27: It is not clear what the ‘dominant variable’ refers to. Please expand.

We will include more information on the definition and determination of the dominant variable in different buildings.

6. Page 460, line 13: rephrase the phrase “were the most encountered problems.”

we will change it.

S. Buchberger (Referee)

Pg 461 line 4 – The authors state that a value located 3 standard deviations above the sample average would “represent the 99.7 percentile”. The normal distribution would give the 99.87 percentile. What probability distribution did the authors assume? What is the basis for selecting this distribution?

The normal distribution gives 99.7 percentile. We will add a figure to show the normal distribution can be assumed.

Pg 461 Eq (1) – Show the units associated with MMF

Okay.

Pg 463 line 27 – Replace “gain” with “savings”

Okay

Pg 467 Table 1 – Define “loading units”

Okay

Pg 469-470, Table 3 – Include the sample size for the “measured” and the “SIMDEUM” results. Round the HWU results to the nearest litre.

Sample size is the number of days that we measured, we will add the information. We will give better thought on significant numbers.

The computer model SIMDEUM seems essential for finding maximum HWU volumes for various time periods. However, is SIMDEUM necessary to estimate the instantaneous peak flows? The authors know the number and the demand of each type of fixture in the building. From user habits, the authors can estimate the probability that an individual fixture will be in use during the peak period. With this basic information it is possible to use the direct analytical method proposed by Wistort (1995) to estimate

the instantaneous peak water demand in the building. Wistort's method is an extension of the original 1940 method proposed by Hunter. It can be shown that the Poisson Rectangular Pulse (PRP) method and Wistort's method are conceptually identical and will yield equivalent results. It would be worthwhile to compare Wistort's analytical estimates for the peak demand against the SIMDEUM predictions given in Table 3.

Hunter, R.B. (1940) Methods of Estimating Loads on Plumbing Systems, Building Materials and Structures Report BMS65, US Dept of Commerce, Natl Bureau Standards, Wash DC, 23 pp.

Wistort, R.A. (1995) A new look at determining water demands in building: ASPE direct analytic method, Technical Proceedings, ASPE 1994 Convention

We will take a look at this. This method was never used in the Netherlands. We can include this in the discussion part.
