



Shaping Tomorrow's
Built Environment Today

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TO: William Stanton Stafford, Chair TC 2.8, sstafford@integralgroup.com
Joy Altwies, Research Subcommittee Chair TC 2.8, altwies@wisc.edu
CC: Pawel Wargocki, Research Liaison Section 2.0, paw@byg.dtu.dk
FROM: Michael Vaughn, MORTS, mvaughn@ashrae.org
DATE: November 6, 2018
SUBJECT: Research Topic Acceptance Request (1859-RTAR), "Residential Water Fixture Use Schedules based on Occupant Behavior"

During their fall meeting, the Research Administration Committee (RAC) reviewed the subject Research Topic Acceptance Request (RTAR) and voted to accept it with comments for further development into a work statement (WS) provided that the key comment(s) and question(s) below are addressed to the satisfaction of your Research Liaison, Pawel Wargocki, paw@byg.dtu.dk, or RL2@ashrae.net, in the work statement draft.

1. It is not clear what open data sets for residential buildings are available and how these data sets can be disaggregated. For this reason it is difficult for RAC to evaluate the appropriateness of the budget.
2. Budget seems high for surveys. Please clarify why \$150k over 18 months if no surveys.
3. Clarify how the 100 houses data will be used.

The work statement draft must be approved by the Research Liaison prior to submitting it to RAC.

An RTAR evaluation sheet is attached as additional information and it provides a breakdown of comments and questions from individual RAC members based on specific review criteria. This should give you an idea of how your RTAR is being interpreted and understood by others. Some of these comments may indicate areas of the RTAR and subsequent WS where readers require additional information or rewording for clarification.

The first draft of the work statement should be submitted to RAC no later than **August 15, 2020** or it will be dropped from display on the Society's Research Implementation Plan. The next likely submission deadline for a new work statement on this topic is **May 15, 2019** for consideration at RAC's 2019 Annual meeting. The submission deadline after that for work statements is **August 15, 2019** for consideration at the RAC's 2019 fall meeting.

Project ID	1859	
Project Title	Residential Water Fixture Use Schedules based on Occupant Behavior	
Sponsoring TC	TC 2.8, Building Environmental Impacts and Sustainability	
Cost / Duration	\$150,000 / 18 Months	
Submission History	1st Submission	
Classification: Research or Technology Transfer	Basic/Applied Research	
RAC 2018 Fall Meeting Review		
Essential Criteria	Voted NO	Comments & Suggestions
Background: The RTAR should describe current state of the art with some level of literature review that documents the importance/magnitude of a problem. References should be provided. If not, then note it in your comments.		4 - More information on whether similar studies have been performed in the past is needed. 9 - Will evaluate water usage in residential buildings, since there are less studies in the US, and there is a wide range of variation. 10 - References should be cited in the background section too.
Research Need: Based on the background provided is the need for additional research clearly identified? If not, then the RTAR should be rejected.		9 - Explains need for developing data collection methods and analysis. Then future studies can roll this out more quickly
Relevance and Benefits to ASHRAE: Evaluate whether relevance and benefits are clearly explained in terms of: a. Leading to innovations in the field of HVAC & Refrigeration b. Valuable addition to the missing information which will lead to new design guidelines and valuable modifications to handbooks and standards. Is this research topic appropriate for ASHRAE funding? If not, Reject.		9 - Will provide useful data for a number of ASHRAE Stds and Handbook chapters
IF ABOVE THREE CRITERION ARE NOT ALL SATISFIED - MARK "REJECT" BELOW & CONTINUE REVIEW BELOW		
Other Criteria	Voted NO	Comments & Suggestions
Project Objectives: Based on the background and need, evaluate whether the project objectives are: 1. Aligned with the need 2. Specific 3. Clear without ambiguity 4. Achievable If not, then appropriate feedback should be provided.		2 - But why single or a few houses observations? The RTAR should state the number of the observation houses. 4 - It is unclear how data obtained in residential buildings can be used to make predictions in commercial buildings. 7 - It is not clear how the results from residences can be extrapolated to commercial buildings. 9 - Clear and focused, 10 - The objectives should be more detailed so that the deliverables of the project can be clearly envisioned. 8 - would like to see further detail information on representation of the buildings
Expected Approach and Budget: Is there an adequate description of the approach in order for RAC to be able to evaluate the appropriateness of the budget? If not, then the RTAR should be returned for revision. Anticipated funding level and duration:		4 - It is unclear how the Authors ensure that data are representative. Is 100 buildings a sufficient number? 7 - It is not clear what open data sets for residential buildings are available and how these data sets can be disaggregated. For this reason it is difficult for RAC to evaluate the appropriateness of the budget. 9 - Proposes analysis using existing available data, followed by stats analysis. I'm not sure why they are mentioning extrapolation to commercial buildings? Also, no actual survey (or validation of the method). 10 - The extrapolation to commercial buildings without any further match with actual data is questionable. Not clear if and when ASPE and AWWA will be approached for co-funding. The budget should be justified. There is no experimental work and the duration is 18 months so it may be too high. 12 - seems like a lot of money for a survey
References: Are the references provided?		10 - 15 references are provided but just 5 are cited along the text.
Decision Options	Initial Decision?	Final Approval Conditions
ACCEPT AS-IS		2 - Important Project. 7 - It is not clear what open data sets for residential buildings are available and how these data sets can be disaggregated. For this reason it is difficult for RAC to evaluate the appropriateness of the budget. Work with your RL to add more clarity of the sources of data and scope in the Work Statement. 9 - Clarify how the 100 houses data will be used. Will these data be split to develop a model and then validate that model (using the two parts of the split dataset)? Also, it is stated that 'a broader dataset is needed', yet no field monitoring is proposed...please clarify. Please clarify why \$150k over 18 months if no surveys. 10 - Cite all the references along the text, especially in the background section. List the deliverables related to the project objectives. Approach ASPE and AWWA before finalizing the Work Statement for this project. Evaluate carefully the budget needed. 8 - need to refine the selection of buildings for water study
ACCEPT W/COMMENTS		
REJECT		

ACCEPT Vote - Topic is ready for development into a work statement (WS).

ACCEPT W/COMMENTS Vote - Minor Revision Required - RL can approve RTAR for development into WS without going back to RAC once TC satisfies RAC's approval condition(s)

REJECT Vote - Topic is not acceptable for the ASHRAE Research Program

Research Topic Acceptance Request Cover Sheet

Date: **06-18-2018**

(Please Check to Insure the Following Information is in the RTAR)

- A. Title
- B. Executive Summary
- C. Background
- D. Research Need
- E. Project Objectives
- F. Expected Approach
- G. Relevance and Benefits to ASHRAE
- H. Anticipated Funding Level and Duration
- I. References

Title: **Residential Water Fixture Use Schedules based on Measured Occupant Behavior**

RTAR # 1859
(To be assigned by MORTS)

Results of this Project will affect the following Handbook Chapters, Special Publications, etc.:

**ASHRAE Applications Handbook: chapters 39, 50, 61
ASHRAE 191P, 90.1, 90.2**

Research Classification:
Basic/Applied Research
Advanced Concepts
Technology Transfer

Responsible Committee: **TC2.8**

Date of Vote: **June 24, 2018**

For		11
Against	*	0
Abstaining	*	0
Absent or not returning Ballot	*	3
Total Voting Members		14

RTAR Authors
Lead: **Bing Dong, Fred Betz**
Others:

Co-sponsoring TC/TG/MTG/SSPCs (give vote and date)
MTG.OBB

Expected Work Statement Authors
Lead: **Bing Dong, Fred Betz**
Others:

Potential Co-funders (organization, contact person information):

Has an electronic copy been furnished to the MORTS?
Has the Research Liaison reviewed the RTAR?

Yes	No
<input checked="" type="checkbox"/>	<input type="checkbox"/>
<input checked="" type="checkbox"/>	<input type="checkbox"/>

* Reasons for negative vote(s) and abstentions

Title:

Residential Water Fixture Use Schedules based on Occupant Behavior

Executive Summary

Describe in summary form the proposed research topic, including what is proposed, why this research is important, how it will be conducted, and why ASHRAE should fund it (50 words maximum)

The proposed research topic is to conduct a statistically significant measurement and analysis of building occupant behavior for water fixture usage in residential buildings. Previous studies have been conducted to develop energy usage schedules documented in the ASHRAE 90.1 User Manual. Similar schedules will be desired by engineers to quantify water consumption.

Background

Provide the state of the art with key references (at the end of this document) substantiating it (300 words maximum)

Most of the studies collected to date take place outside the U.S. where user behavior with water is very different due to the scarcity and/or quality of water. The studies tend to focus on a single building or a single cluster of buildings rather than a broader analysis of numerous facilities spread across a wider area. Per the US Geological Survey, the end-use break down in a residence varies greatly across the U.S. with limited guidance on the cause of this great variation. It is suspected that irrigation is the major difference, however the answer is far from certain as the data does not directly correlate to climatic differences. A broader data set is needed to identify a statistically significant water usage quantity and pattern.

Many other fixture studies have focused on drain line carry in urinals and water closets as this is a primary concern of piping/plumbing engineers. A fine-grained quantification of water usage in fixtures has been a lessor priority to date.

The Water:Energy Nexus is being studied by a T.C. 2.8 sub-committee for the last several years. Hourly fixture usage schedules can be used to align with peak pumping power and water heating for utilities and/or booster pumps to improve the quality of energy models governed by ASHRAE 90.1 and 90.2.

ASHRAE standard 191P, currently under development, requires the quantification of fixture usage. To date it offers user flexibility in determining a usage schedule while working within benchmarks, however for long term viability more reliable data should be referenced.

The domestic hot water profiles found in ASHRAE Applications 2015 haven't been updated since at least 2007.

Research Need

Use the state of the art described above as a basis to specify the need for the proposed effort (250 words maximum)

Occupant behavior-related water use in residential buildings is a critical issue for water conservation, and water use prediction (Suero et al. 2012). Occupant behavior is complex and stochastic, causing a high DWU variability both among residences and within the same residence (Lutz 2012). Corral-Verdugo et al. (2003) found that general beliefs could influence specific water beliefs, and in turn could affect water consumption. Consumer behavior may also be negatively affected by water-saving devices. Inman and Jeffrey (2006) found that residents took longer showers and consumed more water after installation of water-saving devices, due to the belief that their water-saving devices would save water (rebound effect).

In summary, most existing studies on water use behavior models are observed from the perspective of use time of water-consuming devices and lack in-depth behavioral analysis. While energy-related occupant behavior has been studied extensively for residential and commercial buildings (Dong et al., 2015), water use behavior is under-researched. The project starts with residential building types because more data is available, and time needs to be spent developing data collection and analysis methods. Future studies can repeat the process more quickly and spend more effort on data collection.

Project Objectives

Based on the identified research need(s), specify the objectives of the solicited effort that will address all or part of these needs (150 words maximum)

The objectives of this effort include:

- 1) Development of a repeatable method to explore water usage behavior in buildings starting with residential buildings.
- 2) Apply the method developed in (1) to other residential buildings
- 3) Develop residential building water usage profiles.

Expected Approach

Describe in a manner that may be used for assessment of project viability, cost, and duration, the approach that is expected to achieve the proposed objectives (200 words maximum).

Check all that apply: Lab testing , Computations , Surveys , Field tests , Analyses and modeling , Validation efforts Other (specify) ()

1. Select an open data set (at least >100 houses) for disaggregated water usage in residential buildings.
2. Conduct statistical analysis on the data sets including data cleaning, basic data distribution analysis, and usage analysis.
3. Develop an hourly baseline model for residential water usage.
4. Document analysis method and extrapolate to commercial buildings.

Relevance and Benefits to ASHRAE

(350 words maximum)

ASHRAE Technical Committee 2.8 Building Environmental Impacts and Sustainability; Water:Energy Nexus subcommittee has been pursuing a greater understanding of how water is used and the corresponding energy impact. Domestic water is frequently distributed with building level pumps that draw electricity and would require a load profile to estimate peak electrical demand accurately.

ASHARE 191P Standard for the Efficient Use of Water in Building Mechanical Systems contains provisions for quantifying water usage in fixtures within a whole building water balance.

ASHRAE 90.1 regulates domestic hot water in chapter 7. Well defined load profiles are needed to properly estimate domestic water consumption in any project following either the ECB or appendix G compliance paths.

There are numerous stakeholders that could be approached for co-funding such as ASPE and AWWA. These organizations will be approached to augment the scope of this study to more buildings. Where ASHRAE adds the most value is in our skills as modelers (energy, air, light, etc.). Sophisticated modeling has not been a focus of ASPE and AWWA to date with a focus on prescriptive regulation.

The outcomes from this research will contribute to following Chapters in ASRHAE Handbooks:

- Application Handbook: Chapter 39 – Operation and Maintenance Management
- Application Handbook: Chapter 50 – Service Water Heating
- Application Handbook: Chapter 61 – Smart Buildings Systems

It is aligned with ASHRAE Strategic Plans and Initiatives:

- Goal 5: Support the development of ASHRAE energy standards and reduce effort required to demonstrate compliance.
- Goal 2: Progress toward Advanced Energy Design Guide (AEDG) and cost-effective net-zero-energy (NZE) buildings;
- Goal 7: Support development of tools, procedures, and methods suitable for designing low energy buildings.

Anticipated Funding Level and Duration

Funding Amount Range: \$ 150k

Duration in Months: 18months

References – See Next Page

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Inman D and Jeffrey P. A review of residential water conservation tool performance and influences on implementation effectiveness. *Urban Water Journal*. 2006; 3: 127-143.

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Lutz J. Hot water draw patterns in single-family houses: findings from field studies. Lawrence Berkeley National Laboratory, 2012: LBNL Paper LBNL-4830E. Retrieved from: <http://escholarship.org/uc/item/2k24v1kj>

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Suero FJ, Mayer PW and Rosenberg DE. Estimating and verifying United States households' potential to conserve water. *Journal of Water Resources Planning and Management*, 2012, 138(3): 299-306.

Takata, H., Murakawa, S., Nishina, D., & Yamane, Y. (2004). Development of the calculating method for the loads of cold and hot water consumption in office building. In *Proceedings of the CIB/W62 International Symposium on Water Supply and Drainage for Buildings (Paris)*, A-2 (pp. 1-16).

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Feedback to RAC and Suggested Improvements to RTAR Process

Now that you have completed the RTAR process, RAC is interested in getting your feedback and suggestions here on how we can improve the process.