GLOBAL CONSORTIUM FOR SUSTAINABILITY OUTCOMES

Urban-Rural On-Campus Solutions: Sustainability Accelerator Program "Hot Water Project"

Final Report

UROC PROJECT TEAM

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1| INTRODUCTION

Washing hands in warm or hot water is a common practice in cities worldwide. Despite scientific evidence that shows hot water does not significantly reduce bacteria, many countries' building regulations require the provision of it on a basis of comfort leading to unnecessary carbon emissions. The misconception that hot water is an essential component in handwashing hygiene and perception that it is a 'social norm' perpetuate this practice. Since cold water usage requires less energy than warm or hot water, policy and behavioural change is essential to realize the potential for carbon emissions reductions and energy savings.

The aim of the Global Consortium for Sustainability Outcomes (GCSO) — Urban-Rural On-Campus Solutions (UROC) "Hot Water Project" was to provide a scalable solution driving measurable carbon reductions using reliable research and evidence. The results provide tried and tested cases on three separate campuses over the course of one year, with research and evidence spanning from Asia to Europe to North America. The approach was to challenge the requirements of provisioning hot water in public facilities. Specifically, the approach adopts the premise that a proportion of hot water in buildings is provided for comfort rather than hygiene requirements and is therefore an unnecessary contributor to wasted energy and greenhouse gas emissions. This report provides necessary information on this topic, as well as guidance on how to navigate the pathway towards reducing or eliminating hot water in public facilities as a carbon saving initiative. It sets out the framework for using the university campus as a living laboratory (living lab) for sustainability interventions.

Participating GCSO member universities evaluated the use of hot water for handwashing across several geographic locations: King's College London, UK; Dublin City University, Ireland; and Arizona State University, USA. The project's **experimental living lab design** included the following key characteristics:

- Non-essential hot water removal at three university campuses;
- Approximately three campus buildings selected (e.g., offices, lecture halls, libraries) to be the sites of removal;
- Both technical and social interventions utilized;
    - Technical intervention – the installation of flow meters and temporary turn-off of hot water supply depending on the local supply system (e.g., steam, boilers); essential hot water provided by installation of point-source heaters.
    - Social intervention – various social engagement measures (e.g., surveys, focus group discussions) applied to different buildings for comparative purposes (see Section 2.1 Engagement Strategy below).

2| ENGAGEMENT AND EVALUATION STRATEGIES

The **engagement strategy** refers to the aim and approach to engage with stakeholders at the three pilot universities, and in turn, how these actors were approached to become engaged in the interventions. The **evaluation strategy** refers to the aim and approach of evaluating the different approaches to the hot water turnoff and related project activities as well as an overall comparison between the different interventions. Both the evaluation strategy and engagement strategy needed to be closely linked in this project due to the character of the evaluation. To ascertain changes in the attitudes and behaviour of building users, it was necessary to carry out broad surveys to develop baseline data for pre- and post-intervention comparisons. As these surveys were among the first interactions between the research team and the building users, they were also perceived as a form of engagement. Accordingly, both engagement and evaluation are presented below.

2.1 Engagement Strategy

To identify viable and effective engagement methods, the first step was to decide on the intensity of engagement. A scale of engagement intensities from the field of real-world lab research (based on well-established concepts for political participation, e.g., Arnstein, 1969 and Menny et al., 2018) was adapted and specified to the living lab approach of this project (see Table 1).

Table 1. Overview of participation levels and operationalization in the UROC project

Ladder of Participation		**Applied to UROC**		
Level of Participation	**Description**	**Aim**	**Engagement methods**	**Comment**
5. Empowerment	Power of decision-making is transferred to stakeholders	Transformation process towards sustainable use of the building and related changes in behaviour within and outside of the university	Identify key stakeholders, support them with information to derive a project idea, facilitate exchange and mutual learning, mediate in conflict situations, formative evaluation and/or supervision	Not feasible/ appropriate due to limited project time, budget constraints and pre-decided technical intervention (hot water turn-off)
4. Collaboration	Equal partnership with stakeholders	Include stakeholders into the design process, share responsibility for future sustainability measures (including upscaling)	Co-design: e.g., regular meetings with stakeholders, joint project work from design of the work plan to the final evaluation, joint planning of the use of the intervention in teaching	Limited feasibility, due to short overall project duration and pre-decided intervention. Inclusion in social intervention partly appropriate and feasible: e.g., inclusion in teaching & activity of student groups

3. Cooperation	Mutual exchange, decisions remain with scientists	Include perspectives from stakeholders early enough to improve the design of the intervention, both technically (e.g., excluding first aid rooms) or socially (e.g., taking up the topic of energy consumption in lectures); understand and reduce side effects and raise awareness for sustainability issues	Group discussions (focus groups, also as part of ongoing meetings like department meetings) visibility: giving contact info, semi-regular presence in the buildings	Probably the most appropriate level to make maximum use of a technical intervention that is already decided; feasible due to limited time and budget to realize engagement
2. Consultation	Questioning stakeholders (primarily one-way communication)	Gain insight into water use (e.g., gender differences), identify unwanted side-effects (reduced hygiene due to unwashed hands), do "baseline-assessment"	Online-questionnaires, comment boards, structured interviews, including baseline-assessment (allows for cooperation as well)	High feasibility - Any form of interviews for the baseline-assessment will be seen as consultation by the stakeholders
1. Information	Information for stakeholders (one-way communication)	Reduce evasion (e.g. residents use bathroom facilities in other buildings) and reduce opposition	Signs, emails, short presentations on the day, info-leaflets (depending on the existing communication channels)	Providing additional information, e.g., regarding hygiene, possible
0. No engagement		Reduction of hot water use	Turning off hot water	Already scheduled

Since the project began with a specific technological intervention (the turn-off of non-essential hot water) planned for a set timeframe, this pre-determined technology-centred approach considerably reduced the possibilities for more meaningful engagement of stakeholders in co-designing the method(s) of intervention to be taken in the project. Nevertheless, a specific engagement plan was drafted in each location, building on the aims of the overall project in general and aims of each implementing university in particular. The project team chose to apply low- to medium- level strategies for engagement relating to Information, Consultation and Cooperation (see Table 1). These three strategies were designed to be carried out in the different buildings of each implementing university to learn more about the adequate depth of engagement. Each strategy required certain core 'issue area' identifications:

- For engagement on the level of *information*, it was crucial to identify relevant issues from the building users.
- For engagement on the level of *consultation*, it was necessary to identify relevant questions that address the perceptions of hot water use and the implications of a hot water shut-off.
- For engagement on the level of *cooperation*, it was important to open a discussion with various user groups, if possible, before the shut-off.

To address all three requirements efficiently yet comprehensively, a methodological combination of focus groups, internet-based and in-person surveys were held in each university with stakeholders inhabiting the different buildings for which the hot water turnoff was planned. While surveys focused on users from different university groups (students, administrative and scientific personal), focus groups involved not only users, but other important stakeholder groups such as maintenance personal. The engagement began with informal focus group interviews to deepen local understanding and prepare engagement as soon as possible, as well as contributing data for the evaluation. Original plans on timing of engagement and intervention (non-essential hot water turnoff) were modified and postponed during the project. This was due to learnings arising from assessments of stakeholder views as well as difficulties to secure basic requirements for starting the hot-water turn-off, e.g., late permissions by higher level management/municipal administration for reasons of health or legal concerns (see Section 4, Summaries from the Implementation Teams).

Dublin City University

DCU held the first focus group discussions. The notes from these focus groups were reconstructed into the form of a "constellation analysis", a mental map visualization of the hot water shut-off drawn from the building users' perspectives (Schön et al. 2007). It was discovered that users of different buildings can attach entirely different concepts to the hot water shut-off despite being at the same university with a comparable socio-cultural background, climatic conditions, legal requirements, etc. Also, building users did not often refer to themselves, but abstractly to potential hot water users who might or might not be opposed to the intervention. This distance from the project and its outcomes flagged a barrier for more intense forms of project collaboration. The issues and important user groups revealed in the conceptual maps helped address the opposition against the hot water shut-off systematically.

King's College London

At KCL, initial interviews and focus group discussions took place in the three buildings selected for shut-off in order to engage with and learn about key stakeholder groups' perceptions. These groups differed widely between the buildings, with some being rather staff-dominated, some mixed with staff and students, and another mostly student dominated (a library). Insights from initial interviews and group discussions revealed considerable differences in the support of and scepticism towards the hot water-turnoff, sustainability awareness and hygiene concerns. The student union was identified as being strongly in favour of the initiative and consecutively became an explicit supporter. This made an engagement strategy with different intensities more suitable. For example, at a baseline level, generic communication about the project was made available university wide (e.g., in form of an intranet page with Q&A, taking up concerns raised in the surveys and interviews). In buildings with high levels of support for the initiative, high sustainability awareness and satisfaction with sanitary facilities, an engagement strategy of medium-level intensity was implemented, such as information giving (e.g., posters) about the initiative, carbon reduction and hand-washing best practices/hygiene, all of which was complemented by surveys and group interviews. At buildings with either a rather low initial support level and high hygiene concerns or a high visibility of action within the overall university, highest levels of engagement were most appropriate. These included, for example, monitoring of hygiene aspects and engaging the student union in communication events. Finally, a temporary pre-scheduled hot-water turnoff due to standard maintenance provided a low-level entry point for the shut-off in one building. Overall, the intervention was framed as a research project - and not primarily a resource (e.g., money) savings attempt – for the purpose of garnering more support in times of frequent budget cuts.

Arizona State University

Online surveys were conducted with users of six different buildings and revealed medium-level support for the hot water turn-off idea presented (in fact, approx. 45% of the respondents were found to either disagree or strongly disagree with the idea). In-person surveys were also conducted with building users in front of one of the pilot buildings to engage in conversation about how water and people's perceptions regarding the shut off. Hot water is considered, for example, important for hand hygiene and respondents were interested in concrete numbers to show the carbon and resource savings potential of the initiative. Taking into consideration the experiences from KCL, these first results made a targeted and intensive engagement strategy advisable. It was found that overall approval of the initiative increased over the four-month hot water shut off.

For the baseline assessment, 281 participants were surveyed in addition to leading two focus groups. In the post-survey, 298 participants completed online and in-person surveys discussing their water use habits, views concerning "necessary" hot water, and their reaction to different types of advertisements concerning the hot water shut off. In the pre-survey, 52.4% of staff and faculty and 75.3% of students said they strongly agreed or agreed with the initiative. In the post-survey, 56.3% of staff and faculty and 84.3% of students said they strongly agreed or agreed with the effort.

Focus groups included very few participants but gave positive insights into effective strategies for the shut off. Focus group participants agreed with the initiative and opened the conversation to other initiatives the campus could participate in to further the university's sustainability goals.

Key Findings and Insights

- **Engagement intensity level needs to be planned well in advance** to adapt the project to local conditions; this is particularly true for more intensive engagement formats, which require time.
- **Engagement results need to be fed back into the project design**. The combination of engagement measures and elements of formative, ongoing evaluation appears promising/suitable for effective and iterative project management.
- **Engagement should start as early as possible**, not only to secure the basic requirements for putting in place the technical intervention (e.g., acquiring needed

permissions), but also to allow for iterations and project adaptations to fit stakeholder requirements and, finally, to provide space for meaningful engagement of stakeholders in case of such demand.

- **Key stakeholders can vary widely between buildings,** e.g., depending on the inhabitants (e.g., different university groups), technical and infrastructural requirements for turn-off as well as administration and ownership of the buildings. While this also holds true at different universities, there appears to be a number of common key stakeholder groups in all locations (e.g., owners, general management, users, and health and safety officers).
- **Seemingly small interventions may raise considerable resistance**. These (e.g., the hot water turn-off) can evoke larger feelings of dissatisfaction when associated with, for example, budget cuts, or other fears (e.g. about hygiene), and a lack of information about the underlying motivation or compelling argument for the purpose or need of the intervention. This reinforces the need for engagement early-on, that is targeted and meaningful.

2.2 Evaluation Strategy

Both a combined formative and summative evaluation was applied to the project. The **formative evaluation** refers to the process of ongoing reflection in order to make improvements to the experimental design while still moving the project forward. **Summative evaluation** refers to comparing aims and results, in order to understand effectiveness and efficiency of the performed experiments and associated processes. Both evaluation strategies were combined at various points during the course of the project, with each following its own timeline and applying particular tools and methods for data generation and assessment (see Figure 1).

The project's evaluation strategy aimed to support learnings from the experiments, in this case, the social and technical interventions contributing to the turn-off of non-essential hot water at the three implementing universities. The strategy was adjusted to the experimental design and coordinated with the engagement strategy described above. Overall, it aimed to contribute to the project's objectives of development, implementation and assessment of resource-saving interventions in the management of universities in general, regarding hot water provision in particular; and, insights into the scalability of these interventions. The evaluation thereby contributed to a coordinated learning from the actions (interventions), reflections on the experiments performed and supported the overall aim of developing scalable solutions for saving resources and carbon emissions.

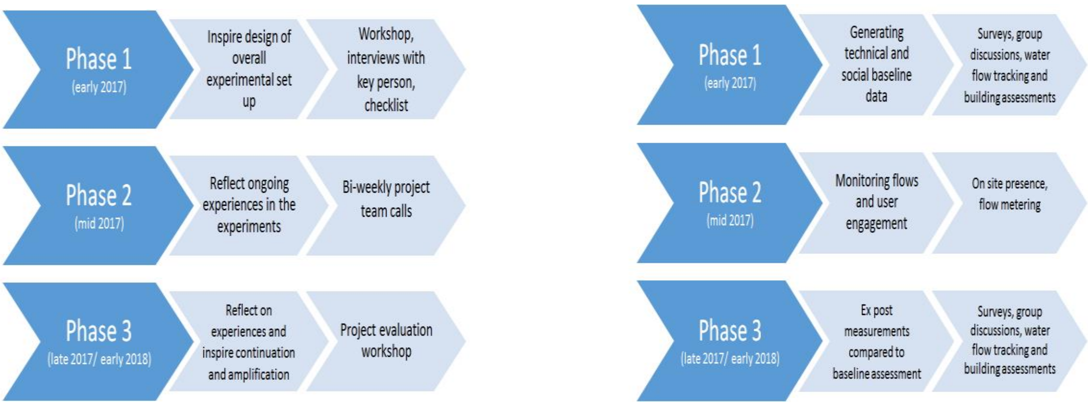

Figure 1. Formative evaluation phases, aims and methods (left) and Summative evaluation phases, aims and methods (right) within the UROC project

To organize data collection and assessment, a generic evaluation scheme was adapted and utilized for this project (Luederitz et al. 2017). This scheme builds upon a logical model of evaluation, differentiating inputs, processes, outputs and outcomes of a sustainability transition experiment (see Figure 2). Because this scheme was developed for experiments with high levels of co-creation between academics and practice partners, it was modified to accommodate lower levels of overall participation in this project (see Engagement Strategy, Section 2.1). Thus, key features of the scheme have different "target groups" as units of analysis (e.g., expertise of project team, and sustainability awareness of the team and key stakeholders) The scheme allows for a structured assessment of the following questions (taken from Luederitz et al. 2017: 64, emphasis in original):

I. *What was generated?* Identify the produced *outputs* and related features including direct results of the interventions; namely built capacities (results of learning processes), actionable knowledge, accountability, structural changes, up-take of experiments, as well as generalizable insights with regards to specific issues or methods.
II. *What was accomplished?* Identify achieved *outcomes* in terms of sustainability. This explores the extent to which generated changes support progress towards sustainability, namely socioecological integrity, livelihood sufficiency and opportunities, intra- and intergenerational equity, resource maintenance and efficiency, socio-ecological stewardship and democratic governance, as well as precaution and adaptation (Gibson, 2006).
III. *How was it completed?* Identify what *processes* led to outputs and outcomes such as sequence of actions, sound methodology, collaboration, reflexivity and learning, and transparency.
IV. *What was invested?* Identify *inputs* that enabled actions and processes and related features, i.e., initial awareness, commitment, expertise, trust, and support (e.g., financial and human resources).

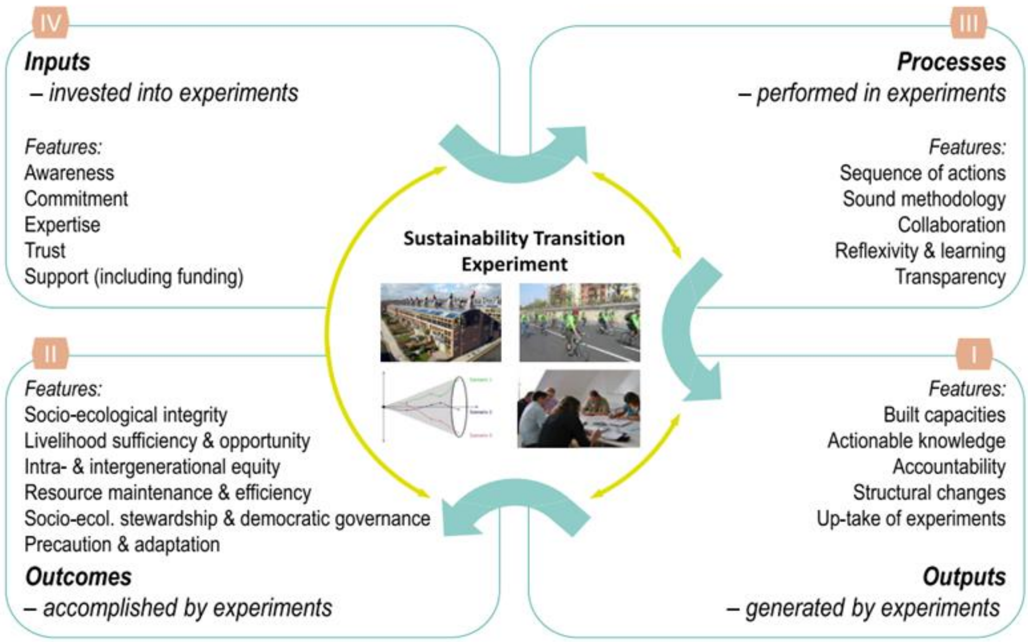

Figure 2. Overview of key features organized into four dimensions (Outputs, Outcomes, Processes and Inputs), that have proven to be important for the success of sustainability transition experiments (Luederitz et al. 2017)

Key Findings and Insights

Several insights can be drawn from an assessment of the key features of Outputs, Outcomes, Processes, and Inputs related to this project:

Inputs: In the university contexts, different features were important for success. Across the three universities these included: trust of stakeholders in university management, existing expertise amongst the project team (e.g., on engagement measures), and existing support of the intervention (e.g., legal support/compliance with regulations, human resources for implementation, permissions by university management).

Processes: The methodology of the technical experiments was not as straight forward as may be assumed. There were different supply systems in use, even at one university. Savings from turning off hot water revealed tipping points, for example, when evaluated against supply levels needed to maintain minimum water temperature and flow levels for hygiene issues (e.g., killing legionella). There are multiple ways in which water is dispensed across the buildings, influencing user experience. **Securing overall support was crucial for starting the intervention and moving it forward.** This includes legal and managerial but also user support and should be worked towards early on.

Outputs: Structural changes had different speeds that needed to be balanced. Technical changes can be put in place rather fast, social change (e.g., perceptions or support) is generally rather slow - although resistance may be rapidly sparked. **Building the implementation**

team's knowledge on how to perform the (social) intervention was crucial for future upscaling/transfer of the experiments.

Outcomes: Risk management was a key issue. Even at the start of the experiments there were immediate real-world impacts, e.g., health issues were of large concern.

In combination, the scheme allows for a (pre-) assessment of sustainability impact of the overall project, however, determining the collective sustainability impacts (long-term outcomes) was outside the scope of the project. It is common practice in participatory sustainability research to assess these impacts some years after the end of the interventions or project. However, there are still multiple information gains that were achieved across the four dimensions:

- Inputs - Initial sustainability awareness and the resource savings activities of users
- Processes - Actions taken, such as turning off the hot water and related methods (e.g., to increase sustainability awareness and support)
- Outputs - Concrete resources saved, changes in levels of sustainability awareness and willingness and capacity to take action amongst stakeholders; increased capacity and actionable knowledge amongst the project team to implement similar initiatives successfully; and, scaling of the experiment, e.g., to new universities (out) or via national legislation (up)

3| Regulatory Assessment

The provision of hot water for hand washing is largely tied to building codes or health and safety legislation (see Table 2). For example, in the UK, there are two areas of regulation that apply to the provision of hot water in sanitary conveniences and washing facilities. The Her Majesty's (HM) Government regulations 2010 (revised in 2016) indicates that the provision for heated water is a requirement in specific areas, e.g., washbasins, showers and food preparation areas. However, references to adequate hand washing facilities related to sanitary convenience or to food preparation areas do not specify hot water as a requirement. The Health and Safety Regulation 21 stipulates that hot or warm water as well as cold water, is a requirement of washing facilities to be considered suitable and sufficient.

This is similarly reflected in Ireland with both the 2008 building regulations and 2007 Health and Safety Authority Guide to safety, health and welfare at work, both stipulating hot and cold water in sanitary conveniences. In European regulations, hot water is only required when necessary, also reflected in the German regulations which detail when hot water is deemed necessary. Of the regulations examined in Asia, Japan does not have regulations with regard to water temperature, noting that hot water is used due to comfort, not hygiene, and that culturally the connection between hot water and hygiene has not been formed. Hong Kong followed British standards previously during colonial times, but now the regulations only state requirements for materials/equipment when hot water systems are installed. An examination of the U.S. regulations reveals that the U.S. Food and Drug Administration Food Code recommends temperature requirements for handwashing sinks of 100°F (38°C).

Table 2. Regulations for hot water provision across the UROC partners

Regulations across the UROC partners		
Country	**Hot water Y/N**	**Regulation w/ key points**
UK	Yes	HM Government - The Building Regulations 2010 (2016 edition): Approved Document G - Sanitation, hot water safety and water efficiency G3: There must be a suitable installation for the provision of heated wholesome water or heated softened wholesome water to: (a) any washbasin or bidet provided in or adjacent to a room containing a sanitary convenience; (b) any washbasin, bidet, fixed bath and shower in a bathroom; and (c) any sink provided in any area where food is prepared. G4: Adequate hand washing facilities must be provided in: (a) rooms containing sanitary conveniences; or (b) rooms or spaces adjacent to rooms containing sanitary conveniences. G6: A suitable sink must be provided in any area where food is prepared. Health and Safety Executive (HSE) Approved Code of Practice, Workplace (Health, Safety & Welfare) Regulations 1992 (2013): Regulation 21 Washing facilities: (1) Suitable and sufficient washing facilities, including showers if required by the nature of the work or for health reasons, shall be provided at readily accessible places. (2) Without prejudice to the generality of paragraph (1), washing facilities shall not be suitable unless – (a) they are provided in the immediate vicinity of every sanitary convenience, whether or not provided elsewhere as well; (b) they are provided in the vicinity of any changing rooms required by these Regulations, whether or not provided elsewhere as well; (c) they include a supply of clean hot and cold, or warm, water (which shall be running water so far as is practicable); (d) they include soap or other suitable means of cleaning; (e) they include towels or other suitable means of drying; (f) the rooms containing them are sufficiently ventilated and lit
USA	Yes	Regulatory requirements - 29 CFR 1910.141 - Occupational Safety and Health Standards, General Environmental Controls, Sanitation* - 1910.141(d)(2)(ii) - Each lavatory shall be provided with hot and cold running water, or tepid running water 21 CFR 211 - FDA Pharmaceutical Facilities - 21 CFR 211.52 - Adequate washing facilities shall be provided, including hot and cold water, soap or detergent, air driers or single-service towels, and clean toilet facilities easily accessible to working areas. - The Food Code of the U.S. Food and Drug Administration (FDA) recommends that hand-washing sinks be equipped to provide water at a temperature of at least 100°F (38°C). Code requirements - 2012 International Plumbing Code (IPC) - Chapter 6 Water Supply and Distribution, Section 607 Hot Water Supply System

Regulations across the UROC partners		
Country	**Hot water Y/N**	**Regulation w/ key points**
		- 607.1 Where required… In non-residential occupancies, hot water shall be supplied for culinary purposes, cleansing, laundry or building maintenance purposes. In non-residential occupancies, hot water or tempered water shall be supplied for bathing and washing purposes. Medical concerns - Cold water may deter individuals with Raynaud's Disease from washing - It affects 3-5% of the population, but there's a chance people have specifically moved to Arizona to get away from the cold because they have Raynaud's disease.
China (Hong Kong)	No	Hong Kong building officials confirmed that codes relating to hot water are in Buildings Ordinance (CAP 123), and only specify requirements if hot water is used. In these cases, the codes reflect emphasis on pipes and materials. Note1: While a British colony, Hong Kong had the option of adopting British building codes and policies, and often did. Note2: On the issue of warm water for hand washing, Hong Kong decided not to adopt the British standard.
Germany	No	"Arbeitsstättenverordnung TA A4.1 Sanitärräume" for sanitary facilities. More in detail ASR A 4.1 - 5.4: (2) Sanitary facilities (toilets) need to offer hand washing possibilities (washbasin providing water and closed drain) as well as rubbish bins. In addition, toilets need to provide measure for cleaning (e.g. soap in dispensers) and drying hands (e.g. one-way towels, hot air drying system, towels). If needed, additionally hot water, as well as hooks for clothes, need to be provided. Note1: Meeting the regulation is not a must but a can/should depending on weighting. Note2: In case of Leuphana, hot water was considered needed in places were e.g. organic impurities need to be cleaned (like the canteen). Cleaning personal of "normal" buildings were decided to not need hot water, as many cleaning substances work without hot water.
Ireland	Yes	Statutory Instruments, S.I. No. 355 of 2008, Building Regulations (Part G Amendment) Regulations 2008. G1(c) Bathrooms and kitchens. A suitable installation for the provision of hot and cold water to the bath or shower bath, washbasin and sink. G2 (3) Sanitary conveniences and washing facilities. There shall be a suitable installation for the provision of hot and cold water to washbasins provided in accordance with subparagraph (2). Health and Safety Authority: Guide to the Safety, Health and Welfare at Work (General Application) Regulations 2007: Regulation 20: Sanitary and washing facilities 20. An employer shall provide and maintain and keep in a clean state— (a) adequate and suitable sanitary and washing facilities for the use of employees, (b) an adequate number of lavatories and washbasins, with hot and cold running water, in the vicinity of workstations, rest rooms, changing rooms and rooms housing showers.

Regulations across the UROC partners		
Country	**Hot water Y/N**	**Regulation w/ key points**
Japan	No	There are no regulations on the temperature of the water supply in washing basins. Note1: Hot water is used due for comfort not hygiene reasons. Note 2: Culturally, hot water use has not been connected to hygiene.
European Regulations	N/A	Council directive concerning the minimum safety and health requirements for the work place 89/654/EEC Section 18 Sanitary equipment – 18.2.3 'suitable washbasins with running water (hot water if necessary)'

Key Findings and Insights

- Policymakers (those having the ability to change the laws) and regulators (those implementing the regulatory requirements) both tend to be reluctant to make changes unless faced with overwhelming evidence that public health and safety precautions have been fully satisfied.
- Current health codes in the state of Arizona do not specify that hot water is needed for proper sanitation during hand washing. However, there was still resistance to shutting off hot water due to the belief that hot/warm water is needed for sanitation.
- At KCL, the Health and Safety Executives (HSE) policy group expressed that the initiative had potential, provided that welfare is not reduced in the workplace. The proof of showing no reduction in welfare falls to the organisation (KCL) and not the HSE. Hence, the policy change process will likely take much time, particularly since government also has a tendency to move slowly.
- Policy makers should be engaged early on including obtaining appropriate permission/derogation to proceed before suggesting a change in policy.
- As part of the initial engagement it is important to ensure no breach of regulations and that all permissions have been obtained prior to the experiment.

4| Summaries from the Implementation Teams

The follow sections give brief summaries from the three pilot locations. Each team has produced their own respective documents supporting the implementation such as risk assessments, options papers, and energy savings predictions.

Arizona State University, Tempe, AZ, USA

Arizona State University implemented the project in four Tempe campus buildings, selected because of specific hot water infrastructure attributes and to provide a variety of building use types: Student Services Building (primarily offices and customer service lobbies), Computing Commons (open format computer lab, classrooms and meeting spaces), McCord Hall (business school classrooms, offices and lounges), and Centerpoint (offices). The first three buildings remain in the study while the fourth was withdrawn due to negative building occupant response within one department's staff to their management.

The four buildings initially selected have individual water heaters that met State Health Codes. Those hot water heaters were metered for one week to develop an estimate of the energy and associated costs to heat the water. Many buildings on the ASU campus were unable to be included because they receive their hot water from the central heating system (boilers). The collection of energy savings data would have been near impossible due to the volume of hot water being used on the entirety of the ASU campus; savings would have been negligible or unseen. Buildings with large secondary needs for hot water (clinical, food preparation, or laboratories) were also not considered to be good candidates for selection.

Thus, the buildings selected utilized hot water primarily for handwashing and did not have labs, showers, or true kitchens, only break areas with sinks. The ASU team also took into consideration the users of each building - to better understand user interactions with hot water and responses to the lack of hot water, a mix of students, faculty, and staff was studied. Building users were engaged through focus groups, in-person surveying, and online surveying once in November as part of the pre-survey and then again in April as a post-survey.

Challenges and Recommendations

Overall, elimination of non-essential hot water was received well by the four pilot buildings at Arizona State University. Only one building presented more problems than the others. The building users were concerned about the elimination of hot water in kitchens and required hot water to be turned back on until instant (point source) hot water systems were able to be installed in all kitchen sinks. The building users who expressed concern were wary of the validity of the science behind the claim that hot water is not necessary in hand washing. This concern may have stemmed from the above average number of flu cases in the most recent flu season. The primary users who expressed concern were staff members, not faculty or students; zero complaints were received from students, which may be because students are more mobile than staff or faculty and do not often have claim over one building in particular.

In the pre-survey, 52.4% of staff and faculty and 75.3% of students said they strongly agreed or agreed with the initiative. In the post-survey, 56.3% of staff and faculty and 84.3% of students said they strongly agreed or agreed with the effort. So, we saw that overall agreement with the initiative improved over the 4-month hot water shutoff.

By shutting off hot water in the three pilot buildings, the savings in energy, cost and GHGs per building are as follows:

	kWh/year	USD/year	mtCO2e
Student Services	12,352.82	$1,300.97	4.94
McCord Hall	13,473.14	$1,307.19	5.39
CenterPoint	-	-	-
Computer Commons	1,535.90	$327.45	0.61
TOTAL	27,361.86	$2,935.61	10.94

There was also some concern in the wording of mirror cling advertisements of the hot water shut-off. The concern was due to the word choice calling the project 'a study'. The word choice made users believe they were being forced to be part of a study and had no way to opt out. With a change in wording, installation of instant hot water heaters, and collaboration between the sustainability team, facilities, and building users, problems were able to be overcome. A strong partnership with the facilities management team was the key to success in the hot water project.

Next Steps

The ASU team will continue to monitor the progress of the pilot buildings and does not have plans to turn the hot water back on in the near future. They are currently working with the university communications team and the department of public affairs to do a much larger handwashing awareness revamp. As many of the hand washing instruction stickers in bathrooms are outdated, these departments want to use the momentum of the project to redo signage to include instructions telling users how to properly wash hands and indicating that no specific water temperature is required. The ASU team is also working with the individual who has proposed changes to International Code Council to change hot water requirements in restroom facilities.

Dublin City University, Dublin, Ireland

Upon reflection, it may have been more impactful to have spent more time understanding individual motivations from smaller focus groups that would have enabled a more strategic approach to engagement. The initial DCU survey was rolled out to all campus users and while just over 45% of respondents agreed with the removal of hot water, those who were 'unsure' or expressed an opposing view were significantly more vocal and their positions seemed to become entrenched. Therefore, in hindsight, spending more time with smaller focus groups may have helped to identify and address the key concerns and enable the roll out of a holistic sustainability information programme within which the hot water removal initiative could have been embedded.

Regarding building and health and safety regulation, this too needed more focus from the outset. That is, it took several months to identify who within Dublin City Council needed to approve a derogation for the implementation of the project, and even more time to identify (still ongoing) what resultant data they would require to propose an amendment to regulations. Internally within DCU there were also some logistical challenges regarding the access to information and responsible staff within the DCU Estates office to support the project. Over the initial period of the project, DCU moved from internal facility maintenance staff to outsourcing this to a facility management company, which added further complication.

Next Steps

Following discussion with Dublin City Council there is agreement to focus on one building, DCU Nursing and Health Sciences, for hot water removal. There are four accessible bathrooms (HG03, HG15, HG25G, HG31) and five universal access bathrooms (H111, H127A, H248, H275, H307), which will be fitted with undersink water heaters. Door counter devices will be fitted to bathroom doors and access numbers recorded. An information campaign on sustainability and the requirement to reduce impact along with hand washing instructions will be implemented in all bathrooms. It is proposed that water will be turned off in May 2018 and energy, water and usage rates will be undertaken. In addition, the following actions will also take place:

- assessment of individual perceptions of 'comfortable water temperature' (undertaken by students)
- continued discussion with the School of Nursing on proper hand washing techniques
- ongoing communication with participants regarding energy savings
- identification of policy change requirements and pathways to policy change

Kings College London, London, UK[1]

Three buildings were selected representing a diverse cross section of building users including academics, administration and students. The buildings display different uses of water including teaching laboratories, library space and catering facilities. Initial assessments of the total quantities of hot water were undertaken by visiting each facility and recording the hot water outlets. These were largely wash basins in sanitary facilities, showers, kitchens (sinks and dishwashers), laboratories, and catering.

Options for the implementation of the removal of hot water were presented to the Estate's engineering team who evaluated these based on the costs and health and safety compliance. The final choice to remove hot water from non-essential areas was to turn off all the hot water across the building at source. This required the installation of several point-of-use (POU) heaters in the essential places such as kitchens. These were powered by electricity and significantly added to the implementation costs. An engineering programme was put in place and implemented before switch-off to install the POU heaters into areas deemed essential.

Following up on complaints raised from building users, it was necessary to re-evaluate areas that had previously been determined non-essential and to install further POU water heaters. It was recognised that the point of use installations needed to be carefully monitored so that installation only occurred based on requirements and not due to comfort. To mitigate this in the future, a robust protocol was established, which included requests requiring supporting documentation (scientific protocol/risk assessment), a period of discussion and inclusion of expert assistance and scientific research to confirm the requirement, identification and agreement of the solution based on the findings.

Challenges and Recommendations

One of the most significant challenges that KCL faced was the perceptions people have when it comes to hot water supply in the workplace. Whist some, such as provision in kitchens, were more easily solved once the definition of a kitchen was established, others were harder to address, as they are of a more historical nature and, similar to the regulations, have not been challenged in many (25) years. By making sure that initial communications addressed myths, such as hot water being required for hygiene (see Appendix), and framing the project in the

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[1] A full report of the KCL case study is available:
O'Donnell, N., Tomson, S., Rinkel, B., Whitehead, M. (2018). *Understanding user attitudes and behaviours to reducing energy consumption through the removal non-essential hot water use in public buildings.* Kings College London.

global climate context, more users began to support the project. It quickly became clear that only providing limited engagement prior to shut-off of hot water was not going to work, as users felt excluded from the process. Moving forward it is strongly recommended that significant engagement is undertaken with building users prior to shut-off. On-going materials and updates to building users should also form part of any communications plan. Key lessons from the behavioural engagement were:

- The initial minimal engagement at the first building resulted in high levels of complaints and building users showing little support for the initiative. Increased communication to this community has reduced the level of complaints, but some resistance still remains, and continued communication will seek to address this.
- The minimal engagement also meant that full understanding of the requirements for the building were not understood. Once brought to light, research and expert opinion were sought and then mitigation put into place. This helped shape the protocol for POU requests.
- Raised levels of engagement prior to switch-off has resulted in previously unidentified issues to come to light. This has allowed the protocol for POU installation to be tested and has also highlighted gaps in departmental paperwork.

Regulations for KCL have also provided a significant challenge, in particular, the Health and Safety (Welfare) Regulations. Early contact with governing bodies should be undertaken and then continued conversation is required until policy change can be made. Evidence that welfare is not being adversely impacted is important in bringing about policy change.

Understanding exactly the way buildings use hot water is essential to the success for the project. Prior to setting any shut-off dates building surveys should be

UNAM Environmental Performance Assessment Tool

An environmental performance assessment tool for buildings was created by UNAM and was to be used across the project partner teams. The tool is based on the development and application of mathematical models as indicators of environmental performance. In total, the tool has 54 indicators: 15 to assess the use of energy, 18 for the consumption of office materials, 15 that address the use of water and 6 for the generation of waste.

The main objective of the tool is to develop a baseline analysis of the environmental performance of a building by studying its facilities, the number of users and the equipment it has (from different types of lights and fixtures, to refrigerators and toilets). The application went through the alpha and beta testing phases and was translated in English in November 2017. The Spanish version was tested at the ITESM facilities (Monterrey, Mexico) with satisfactory results.

The UNAM tool was intended to measure the impact of the use of hot water in the different project locations. Since hot water is not used by the facilities of UNAM, the necessary indicators were not provided in the original tool, but they were created, and the tool was modified for application by the project team. Work is currently being done to make the app more user friendly, adding photographic catalogues, search boxes, and correcting errors present in the interface. The aim is to be able to apply the tool once the corrections have been developed in the app, allowing for its remote application across geographical regions.

undertaken to identify any areas that may need to be deemed essential. Following a protocol of looking at risk assessments and current practices assists in making any determination and is key to making sure that the issue is not related to comfort. Installation of all engineering works should be made prior to the shut-off.

Once shut-off has commenced, it is recommended that there is a clear method for users to raise complaints or provide feedback on the project. An intranet site and clear communications on where to send emails have proved invaluable at KCL. It is also important to make sure that the Estates team are fully briefed on the project.

Next Steps

The project team is moving forward with turning off the hot water in non-essential areas in two further buildings. This will occur following further assessment of POU requirements in large, spread out buildings. Other actions include:

- Implementation of a hygiene monitoring plan to assess whether the unintended consequence of people washing hands less due to no hot water available, is rising bacteria levels;
- Increased communications in the form of posters and screen displays centered on promoting the project, informing users which are cold water bathrooms, and promoting increased hand hygiene;
- Secure potential wider engagement across the university by building support for the initiative and developing a road map for delivery;
- For the remaining two pilot buildings, continue the focus group discussions and circulate additional surveys to assess behavioural changes and reaction to the initiative.

Key Findings and Insights

One of the goals of the project was to assess whether there were unique geographic conditions that might allow for hot water in some locations and not in others. The overwhelming consensus of the project team was that there is no geographic rationale for using hot water. With that said, there were some findings worth considering:

- While geographic location does not contribute to a health, safety, or hygienic reason for hot water, it is clear that there is a preference for hot water in locations that have cold winters. Warm water for handwashing is for comfort and convenience only.
- Similarly, observations across locations confirmed that where hot water is not provided, there are no adverse effects.
- The types of buildings and activities within buildings are important considerations when assessing whether they are good candidates for shutting off hot water. The best opportunities for savings are found with a central stand-alone hot water system that can be turned off entirely. Buildings that have secondary needs for hot water – such as those with clinics, laboratories, or food preparation facilities – are not good candidates.
- Point of use heaters in specific locations may provide opportunities to turn off central boilers in buildings without losing hot water in critical need areas.

- Buildings that receive hot water through district heating systems may still be good candidates as long as it is possible to calculate the overall savings by attributing the energy reduction at the central plant location.

5| Conclusions

The GCSO UROC "Hot Water" project identified the potential to use the university campus as a living lab to test sustainability interventions. In this first year, the project successfully developed and tested tools and methodologies to better understand carbon savings and behaviour change needs associated with removing nonessential hot water. The experiences and insights from the pilot locations provided some qualitative and quantitative evidence and feasibility assessment of the removal within the campus setting – this evidence is crucial to achieve scalability, i.e., changing policy in the public sector. The approach requires a change in attitude to a removal or change to a level of service or provision. The level of information provision certainly increased the understanding and acceptability of the pilot and the pilot tested the levels of engagement. The initial testing of minimal engagement created significant issues with the users and full communications was adopted as soon as issues were starting to be raised.

The project requires continued testing and engagement with the policy/regulators to deliver hard evidence supporting policy change delivering an estimated 3-5% carbon reduction in buildings. This includes greater monitoring and verification efforts to: verify that levels of hygiene have been maintained or even improved; provide a tested and reviewed definition of 'essential hot water'; and, monitor changes in perception to the sustainability intervention before, during and at the end of project through follow-up questionnaires and interviews. The following are reflections and insights on the project process and project outcomes from year one:

- Turning off the hot water required significant retrofitting of point of use water heaters in essential locations requiring substantial investment from the Estates teams.
- Although the behavioral engagement strategy included three levels of engagement from low- mid-range levels of engagement, it became clear that more meaningful, higher-level engagement was required across all buildings.
- Research on the impact of hot and cold water published by World Health Organization and other leading publications was constantly challenged requiring, as a next step, hygiene swab testing to demonstrate no decrease in hygiene.
- A clear definition of 'essential' hot water and a replicable method of assessing this are required.
- The challenge of testing and providing evidence to support a change in legislation whilst still complying with the regulations remains.
- Work still needs to be done to identify the information required to drive a policy change:
    - Carbon and cost monitoring and measurement – for both retrofitting and new construction including savings on legionella testing and other health risks
    - Demonstrate no decrease to hygiene levels from people washing hands less, due to colder water

- Impact on building user comfort – demonstrate there is no significant decrease in comfort, despite the fact that guidelines for this do not exist
- Evidence to define hot, cold and warm water more accurately
- Define the minimum provision for 'essential use'

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APPENDIX: HOT WATER, HAND-WASHING & HYGIENE[2]

Examination of scientific evidence reveals that water temperature has no bearing on the effectiveness of handwashing with regards to hygiene. Current practice has been led by outdated beliefs and comfort rather than scientific findings.

Scientific Research

There have been numerous studies conducted on hand hygiene including research into the use of alcohol gels and best practise for hand washing. In June 2017, in the Journal of Food Protection, Jensen et al. published their recent findings of a study which included the effects of water temperature on handwashing in relation to hygiene. Widely publicised by the media, particularly in the British and American press, the results of this small study concluded that no significant difference was found in bacterial load in water temperatures ranging from 15°C to 38°C (Jensen et al. 2017).

Two other significant papers in this field include Michaels et al. (2002) and Carrico et al. (2013). The former investigated water temperature as a factor in handwashing efficiency to find that all currently employed hand-washing practices are based on untested traditions with the results indicating that water temperature exhibits no effect on transient or resident bacterial reduction during normal handwashing with bland soap. They recommend that food service handwashing guidelines should not specify water temperature descriptors other than perhaps the word 'comfortable' when it comes to defining effective handwashing standards. 'Warm' or 'tempered' would probably also be acceptable (Michaels et al. 2002).

Carrico et al. (2013), examined the environmental cost to using elevated temperatures in handwashing. The conclusions were two-fold: In addition to contributing to skin irritation, using an elevated temperature during handwashing contributes to climate change (Carrico et al. 2013). Like Michaels et al. (2002), they recommend that health and consumer protection

[2] Adapted from: GCSO. (2018). *Urban-Rural On-Campus Solutions: Sustainability Accelerator Program "Hot Water Project" Legislation and Research Report.* King's College London. Retrieved from: https://static.sustainability.asu.edu/sosMS-uploads/sites/64/2018/04/24163934/GCSO-Legislation-and-research-report.pdf

organisations consider advocating for the use of a 'comfortable' temperature, rather than warm or hot water (Carrico et al. 2013).

Best Practice

There are several organisations that provide best practice guidelines for hand hygiene. Two of these are the World Health Organisation (WHO) and the UK National Health Service (NHS).

The 2009 WHO Guidelines on Hand Hygiene in Health Care: A Summary documents best practice on technique, water temperature, skin care and education. The WHO advocates for the use of clean, running water when washing hands, but against using hot water repeatedly, as this increases the risk of developing dermatitis (WHO, 2009). This risk was substantiated by the research of Carrico et al. (2013) who found that the use of hot water increases the risk of skin irritation.

In the NHS document How to Wash Your Hands (NHS Choices, 2016), the recommendation is to use warm or cold water. However, the CG1 Standard Infection Prevention and Control Guidelines for NHS professionals (NHS Professionals, 2013) indicates the use of warm water, but no reason is indicated. The use of tepid water is supported by guidance outlined by Loveday et al. (2014).

Behaviour and Hand Washing

Aunger et al. (2016) reveal that occurrences of handwashing with soap is directly correlated to a person's tiredness or being busy. In addition, they link occurrence with good manners.

In 2015, Berry et al. examined gender in relation to hand washing and found that the defining factor was urinal use by men, which lowered handwashing occurrence. Otherwise, men and women show similar results when using the toilet. Research by Dawson et al. (2017) found that design features are important in encouraging hand hygiene including jet strength, water temperature and device affordance that may improve hand hygiene technology. This was supported by the findings of Berry et al. (2015) and earlier work by Naikoba & Hayward (2001).

Although most studies approach hand hygiene from the healthcare setting perspective, promotion of proper handwashing needs to be sustained long term rather than a single instance educational piece (Naikoba & Hayward 2001). In fact, the creation of a culture promoting hand hygiene at all levels of society goes beyond confining hand hygiene to healthcare alone (Jumaa 2005). From the domestic perspective, the hand hygiene message should focus on interrupting the transfer of microorganisms and the spread of infection rather than just killing microorganisms per se. This is different from the healthcare setting, where it is important to reduce the overall microbial load (Jumaa 2005). There are also significant issues in making global recommendations for hand hygiene due to cultural differences; recommendations must take both geography and cultural factors into account.

Issues of Hot Water Relating to Health

Health risks associated with the storage and delivery of hot water to building occupants fall into two main areas of concern; scalding and legionella (HSE 2012; TMVA 2000). Both risks can be mitigated by the removal of hot water supplies to non-essential areas.

Scalding

The risk of scalding increases exponentially with temperatures above 44°C (HSE 2012). To mitigate the risk of scalding, the HSE (2012) recommends safe temperatures for delivery of hot water and the use of signage where users are at risk.

Legionella

Legionella bacteria proliferate between 20°C and 45°C and only die in temperatures above 60°C (HSE 2012; TMVA 2000). Measures to ensure Legionella is controlled include: maintaining a hygienic system; storing hot water at temperatures > 60°C; and distributing hot water supplies at 50°C, or above 55°C in healthcare settings (HSE 2012; TMVA 2000), which is well above the at-risk temperature for scalding.

CONCLUSIONS

The reasons for removal of non-essential hot water are strongly supported by the literature pointing to a needed change in regulations when examining the UK legal requirements against those of other EU member states. From a scientific standpoint, evidence from research studies and the WHO clearly show that the use of hot water for hand washing and in the promotion of hand hygiene is unnecessary and can, in fact, be detrimental to skin health. Whilst much of the scientific literature advocates for the use of warm water, it is not clear whether this is for scientific reasons or for user comfort. In an examination of the drivers of hand washing behaviours, key factors appear to be outdated beliefs or bathroom design, rather than health and hygiene. Any behavioural change would need to be promoted through a sustained programme of education for it to be effective long-term. From a savings perspective, both carbon emissions and cost would benefit from the removal across the UK Plc.

Initial estimates across the King's College London estate identifies a potential carbon emissions savings of 3-4% annually with an estimated significant corresponding cost savings. Initial results show that in the first pilot building where hot water was temporarily removed as part of planned maintenance, there is a potential 20% carbon saving. In the other pilot buildings, carbon savings could range from 5% to 18% and financial payback between 2.5 and 7 years, depending on replacement point source installations. The on-going research will seek to verify these savings. In addition to direct savings from gas and electric use, operational and maintenance costs will be included in final calculations. An added benefit, identified from the scientific literature is that the exclusion of hot water from washrooms will aid in the prevention of Legionella and remove the risk of scalding.

Preliminary findings from research questionnaires show wide support for the initiative, with many respondents noting the reduction of greenhouse gas emissions and moral grounds as reasons for the support. In addition, the Student Union has challenged the Estates team to become carbon neutral, but Estates can only achieve this with their support. The Student Union has indeed shown interest in being part of the project and in championing it. In review of the evidence, it can be reasonably suggested that regulations should be altered to mitigate the installation of hot water in non-essential areas.

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