



Shaping Tomorrow's  
Built Environment Today

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### ENERGY MANAGEMENT SUBCOMMITTEE

A Subcommittee of TC 7.6 Building Energy Performance

2017 Annual Conference in Long Beach

Monday, June 26, 2017

4:15 PM to 5:15 PM (Pacific Time)

Room Bixby 4, Floor SS1, Long Beach Convention Center

#### Attendance

Name	Affiliation	E-mail Address	Status
John Constantinide	Alpha MRC Architects Engineers	john.constantinide@alphamrc.com	CM
Annie Smith	Ross & Baruzzini	asmith@rossbar.com	CM
Adam McMillen	IMEG	Adam.m.mcmillen@imegcorp.com	G
Jim Butler	SES	Jbutler406@hotmail.com	G, YEA
Dennis Landsberg	L&S Energy Services	DLandsberg@ls-energy.com	M
Bruce Hunn	Hunn Building Energy	hunnbuildingenergy@gmail.com	M
Ian Nelson	Command Cx	inelson@command-cx.com	CM
Eric Yang	ZSG	ericyangCEM@gmail.com	M
Nate Boyd	Hanson Professional Services	Nateboyd.bsme@gmail.com	CM
Steven Carlson	XRG Analysis	carlson@xrganalysis.com	CM
Sreenidhi Krishnamoorthy	UC Davis	sreenidhik@gmail.com	G
Nicholas Shockley	Honeywell	nick.shockley@novar.com	G

#### MINUTES

- I. John called meeting to order and group made introductions
- II. John gave reminder of ASHRAE Code of Ethics
- III. Las Vegas Minutes were ratified
- IV. Old Business
  - a. Education and Training Material
    - i. Engagement with IFMA – Dick Pearson: still plans to do this
    - ii. Engagement with APPA
      1. Joe Hofstetter to interact with APPA Western Pennsylvania Region – John to follow up
      2. Nate Boyd will work with APPA President on Building EQ Committee and interaction with FLAPPA (Florida Region of APPA)
    - iii. Dick Pearson suggested ASHE (American Society of Healthcare Engineers) as another organization that ASHRAE could partner with to help them with their energy management resources. Him and Nate Boyd to work on this.
  - b. Conference Programs: Future Programs – Annie Smith gave update on status of technical sessions for Chicago and Houston. Dick Pearson volunteered to speak at technical session (targeting Houston conference) on smart water meters.
  - c. HVAC Applications Handbook, Chapter 36: Update and Finishing Revisions – John Constantinide gave update on editing progress and deadlines for submitting changes. Editing of energy portions is essentially complete and now the focus is the water parts.

*The Technical Committee does not act for Society.*



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Deadline is to finish editing before Chicago so the main TC can approve the changes at the Houston meeting before they are made in the authoring portal in time for publication summer 2019.

- d. Water-Energy Nexus: Collaboration with TC 2.8 Water-Energy Nexus and Green Guide Subcommittees
  - i. John gave a review of Austin Christianson & Victor Rodriguez's literature search summary concerning energy and water nexus. (See Attachment A)
- e. Apply Research to ASHRAE Standards and Documents:
  - i. John provided Ricson Chude's analysis of active and completed research projects and application to Standards that TC 7.6 is the cognizant committee of. (See Attachment B.)
  - ii. John to follow up with Florida Energy Center. Nate and John swapped contacts there.

V. New Business

- a. Basecamp – Subcommittee to use Basecamp going forward where applicable. John will set it up and organize it around the long range plan objectives.
- b. Standard 105 – Bruce gave update. Std 105 to continue being focused on energy and will not take on water. TC 2.8 and TC 6.6 to be cognizant committees over potential new standard to be made concerning water usage (to be a parallel standard to Std 105).

VI. Open Forum

VII. Adjournment

# **Report on links between water and energy use, efficiency, and/or management**



**By: Austin Christianson & Victor  
Rodriguez**

**June 23rd, 2017**

The following articles were found to demonstrate quantitative and qualitative linkages between energy and water usage and/or efficiency in a variety of ways. These linkages stem from new equipment technologies, design practices, and resource management techniques that consider both water and energy use, and the relation between these resources. Benefits are not only seen at the building level, but also at the community level through reduced impact on energy and water infrastructure and surrounding environments. This report can provide as a basis for the formulation of research projects that demonstrate stronger links between energy, water, and resource efficiency and conservation.

### **State-of-the-art review revealing a roadmap for public building water and energy efficiency retrofit projects:**

Bertone, Edoardo, et al. "Review Article: State-Of-The-Art Review Revealing a Roadmap for Public Building Water and Energy Efficiency Retrofit Projects." *International Journal of Sustainable Built Environment*, vol. 5, 01 Dec. 2016, pp. 526-548.

Governments occupy a significant proportion of building stock and their associated annual water and energy costs can be substantive. Research has shown that significant reductions in energy and water consumption as well as carbon emissions can be achieved through retrofitting public buildings. However, in most countries the current retrofitting rate is very low due to a number of barriers, including a lack of supportive legislation, regulations, guidelines, industry capacity and financial mechanisms. This paper provides a comprehensive review of the barriers as well as the best international practices covering numerous aspects of public building retrofits. Among others, the most important barriers identified were a lack of consideration of the water-energy nexus, and the limited availability of effective financing mechanisms. However, existing buildings continue to be retrofitted at a very low rate of about 3% per year in both the EU and US. One of the negative consequences of delaying the refurbishment of water/energy inefficient public buildings is also the loss of productivity due to a poorer indoor environment, which in the US was estimated to cost as much as US\$22.8 billion per year. A number of revolving loan programmes for which EPSC qualify have been also rolled out in a number of US states. All of these proved to be successful in engaging borrowers, creating more work opportunities for ESCOs, reducing energy costs and environmental pollution. To date, more than 30 states have established loan programmes for energy efficiency and renewable energy improvements.

#### **Recommended strategies:**

1. Create defined energy and water regulatory policies: create strong, enforceable legal standards to underpin change
2. Enhanced water and energy monitoring, data collection and auditing protocols
3. Implement financing schemes combined with energy/water savings insurance mechanisms
4. Government implementation of retrofit programme awareness-raising and capacity-building initiatives
5. Development of enhanced retrofit guidelines
6. Modelling retrofit project options systematically

In conclusion, the implementation of the herein recommended framework would lead to an increased rate of water/energy retrofitting in public buildings, which also provides a number of economic, social, employment and environmental benefits, especially in regards to the energy-water nexus.

### **Emerging Technologies: Energy-Efficient Dehumidification:**

Dieckmann, J. McKenney, K. Brodrick, J. 2009. "Emerging Technologies: Energy-Efficient Dehumidification". ASHRAE Journal 51(8).

The use of a recuperative precooling and reheating configuration or equipment that uses the Cromer Cycle as an alternative to hot gas reheat can significantly increase the energy efficiency of dehumidification. The use of these two methods can approximately double the latent cooling efficiency of conventional equipment. The combination of energy efficient dehumidification practices and condensation collection leads to a system that saves energy and provides an alternative source of water for non-potable needs.

### **Emerging Technologies: Smart Irrigation Systems:**

Hastbacka, M. Dieckmann, J. Brodrick, J. 2012. "Emerging Technologies: Smart Irrigation Systems". ASHRAE Journal 54(8).

Approaches to water efficient irrigation systems include systems that collect AC condensate along with rainwater for storage and then route this water to landscaping to offset potable water use. When combined with intrinsically drought tolerant landscaping and "smart irrigation systems" that measure site and climate conditions, outdoor potable water use can be greatly reduced. This is in comparison to old practices of watering based on time of day, day of week, or water application rates. Reducing potable water use along with the generation of wastewater can produce significant savings in energy. Significant electrical energy is consumed for the pumping of water, treating of waste water, and pressurizing of water distribution networks. Any recovery and reuse of water can contribute to a net reduction in energy use at the building and community level.

### **Emerging Technologies: Power Plant Water Use Water Electricity Trade-Offs, Part 2:**

Cooperman, A. Dieckmann, J. Brodrick, J. 2012. "Emerging Technologies: Power Plant Water Use Water Electricity Trade-Offs, Part 2". ASHRAE Journal 54(1).

While there has been an increase in power generation from renewables and other resources the majority of power generation is done through water cooled thermoelectric power plants. Water consumed by these power plants is primarily used for evaporative cooling. The

current consensus is that water consumed for cooling purposes is not significantly offset by water saving strategies employed at these power plants. In addition, it is favorable to use evaporative cooling vs air cooling when considering both water use and efficiency of energy generation jointly.

### **Emerging Technologies: Drain Water Heat Recovery:**

Cooperman, A. Dieckmann, J. Brodrick, J. 2011. "Emerging Technologies: Drain Water Heat Recovery". ASHRAE Journal 53(11).

It is estimated that at the time hot water is sent down the drain it still contains between 80% to 90% of the thermal energy it contained when it left the water heater relative to cold supply water. The use of drain water heat recovery also known as a greywater heat exchanger can reduce energy consumed for water heating by preheating incoming water before it enters the water heater.

### **Emerging Technologies: Heat Pump Water Heaters:**

Zogg, R. Dieckmann, J. Roth, K. Brodrick, J. 2005. "Emerging Technologies: Heat Pump Water Heaters". ASHRAE Journal 47(3).

The majority of residential hot water heaters in areas that do not have gas service are electric resistance water heaters. However, dramatic savings in energy can be realized through the use of heat pump water heaters(HPWHs). Reliability concerns, higher installation cost, and added complexity have prevented HPWHs from gaining market share in past decades. As more reliable models are produced and market conditions call for greater efficiency this trend may reverse and lead to more energy efficient use of hot water.

### **Emerging Technologies: Water/Electricity Trade-Offs:**

Cooperman, A. Dieckmann, J. Brodrick, J. 2011. "Emerging Technologies: Water/Electricity Trade-Offs". ASHRAE Journal 52(12).

Evaporative cooling in residential applications is discussed along with the trade-offs between energy consumption and water consumption from a home owners perspective. Costs of water used for evaporative cooling is compared to avoided energy costs. Water use and energy savings vary with outdoor conditions, and It is found that evaporative cooling in the southwest region of the united states when compared to DX cooling results in 9% to 16% less energy used. From the homeowners perspective the cost of water and energy is favorable when compared to conventional DX cooling. The cost of both water and energy use was found to be 20% of the cost of energy used for DX cooling.

### **Saving Energy With Cooling Towers:**

Morrison, F. 2014. "Saving Energy with Cooling Towers". ASHRAE Journal 56(2).

Methods for optimizing energy use in cooling towers include selecting cooling towers that use variable speed drives, increasing heat transfer surface area within the tower, optimizing condenser water flow, and using a closer approach than might be typical for a particular area. Tower approach is defined as the difference between temperature of water leaving the tower and the entering wet-bulb temperature. Overall water cooled systems save energy compared to air-cooled systems. When evaluating these systems for optimal energy usage it is important to consider all subsystems and their relations to each other.

### **Saving Water with Cooling Towers:**

Morrison, F. 2015. "Saving Water with Cooling Towers". ASHRAE Journal 57(8).

Make up water used to compensate for evaporation is the largest use of water in a cooling tower and is dependent on the load and psychometric properties of the ambient air entering the tower. Considering this the best way to not only reduce energy use but also water consumption in a cooling tower is to reduce building loads as much as possible. As water evaporates minerals and dissolved solids are left in the remaining water that circulates through the tower. As this recirculated water becomes increasingly saturated with minerals scaling can occur on the heat transfer surfaces. To prevent this water must be bled from the system in proportion to the evaporation rate and then replaced with fresh makeup water in order to keep the recirculating water from becoming saturated with minerals. The bled rate in a cooling tower is known as blowdown and is the next largest use of makeup water after evaporation. Any reduction in building loads will have a direct impact on water evaporation and thus result in reductions in the amount of blowdown required. In addition, the use of corrosion resistant materials, filters, and sump sweepers can result in cooling towers that can tolerate higher concentrations of minerals and dissolved solids. To offset potable water use alternative sources of water can be used for makeup. Common alternative sources include reclaimed water from a treatment plant, AC condensate, and harvested rainwater.

### **Using Water Wisely for California Dairies Waterside Economizer at The Energy–Water Nexus:**

Somayajula, K. Al-Shaikh, A. 2016. "Using Water Wisely for California Dairies Waterside Economizer at The Energy–Water Nexus". ASHRAE Journal 58(12).

Waterside economizers have become increasingly popular in recent years due to more emphasis on decreasing utility cost and increasing energy efficiency. Data centers take most of the credit for implementing them because of their ever increasing loads and new ASHRAE thermal guidelines for data centers. However other industries can benefit from the application of water side economizers. The referenced article discusses the application of water side economizers at dairies to precool milk before being further cooled by mechanical refrigeration and then stored. The mechanical refrigeration systems observed were cooled by groundwater. By diverting load away from mechanical refrigeration reliance on groundwater was greatly reduced while overall energy efficiency was boosted.

### **Water & Energy Use in Steam-Heated Buildings:**

Shapiro, I. 2010. "Water & Energy Use in Steam-Heated Buildings". ASHRAE Journal 52(5).

A series of building surveys have shown that steam-heated buildings use more water than non-steam heated building. Results from four retrofit projects where steam boilers are replaced with hydronic boilers show that converting from steam heat to hydronic heat saves more energy than cases where old steam boilers are replaced with new steam boilers.

### **Modeling the determinants of large-scale building water use: Implications for data-driven urban sustainability policy:**

Kontokosta, Constantine E. and Rishee K. Jain. "Modeling the Determinants of Large-Scale Building Water Use: Implications for Data-Driven Urban Sustainability Policy." Sustainable Cities and Society, vol. 18, 01 Nov. 2015, pp. 44-55.

The results of this paper indicates that the energy use intensity (EUI) of a building have statistically significant effects on the water use intensity (WUI) of multi-family housing; therefore linking energy and water at the community level. This analysis found that reducing urban water consumption by 1 Mt in the residential sector would yield a reduction of .4 Mt coal equivalent in energy savings, and every 10% increase in energy consumption is associated with a 2.8% increase in water consumption. Finally, the correlation between water and energy use suggests that energy consumption data could be used to guide opportunities to reduce water use, and vice versa. The positive relationship between these two resources flows can be used to design programs, incentives, and enforcement mechanisms that simultaneously address energy and water use. Examples include financial incentives for buildings that install systems to improve both energy and water efficiency, or targeted enforcement that audits energy consumption in buildings that have high water consumption profiles.

### **Relationship between building hot water usage and energy and carbon reduction:**

Cheng, C. L., et al. "Relationship between Building Hot Water Usage and Energy and Carbon Reduction." Building Services Engineering Research & Technology, vol. 37, no. 6, Nov. 2016, p. 682.

This article proposes a calculation model for estimating the energy consumption and



CO2 emissions resulting from hot water usage and for evaluating the potential for carbon reduction by using a water efficiency strategy. Efforts to save hot water could achieve synergy with carbon reduction policies and benefits to building service engineering. This study involved conducting a case study in Taiwan, and a calculation model was established to estimate energy consumption and CO2 emissions from hot water usage and to evaluate the potential for reducing energy consumption and carbon emissions by using a water-saving strategy. This revealed that 77% of energy consumption and CO2 emissions from water usage were caused by hot water usage. Hot water usage accounted for approximately 20%–30% of daily water consumption and contributed 1.83% from 2.38% of water factor to carbon emission per capita from 1990 to 2010 in Taiwan. The quantitative potential reveals the motivation for saving hot water and the feasibility of a low-carbon society. According to simulations applying the model, promoting water heating systems that involve using sustainable energy resources is one option for reducing CO2 emissions and saving energy.

### **China energy-water nexus: Assessing the water-saving synergy effects of energy-saving policies during the eleventh Five-year Plan:**

Gu, Alun, et al. "China Energy-Water Nexus: Assessing the Water-Saving Synergy Effects of Energy-Saving Policies during the Eleventh Five-Year Plan." *Energy Conversion and Management*, vol. 85, 01 Sept. 2014, pp. 630-637.

Energy and water have become major factors limiting sustainable development in China. This paper's findings indicate that energy-saving efforts in these industries will result in savings in water consumption. This study suggests that a cooperative relationship between water and energy conservation efforts should be an important factor in creating policies that encourage simultaneous savings of both resources. Furthermore, their calculations suggest that promoting energy-saving techniques in industries also results in substantial water conservation. Therefore, creating effective energy-saving policies and extending their application to major industrial sectors should create cooperative water and energy savings, thereby maximizing the benefits of these policies. Strict environmental policies covering industrial energy and water use must be enforced. Additionally, the government should set spontaneous resource-saving mechanisms to reward enterprises (or industries) that satisfactorily accomplished their voluntary commitments.

### **The economics of green transition strategies for cities: Can low carbon, energy efficient development approaches be adapted to demand side urban water efficiency?:**

Topi, Corrado, et al. "The Economics of Green Transition Strategies for Cities: Can Low Carbon, Energy Efficient Development Approaches Be Adapted to Demand Side Urban Water Efficiency?." *Environmental Science & Policy*, vol. 58, Apr. 2016, p. 74.

The purpose of this paper was to investigate whether existing approaches to energy efficiency strategies progressively include other priority resources, in particular water. To test this hypothesis they used a robust and well accepted methodology, the ELCC (Economics of Low Carbon development strategies for Cities) developed by SEI and CCCEP, and extended it to the case of demand side water efficiency strategies for cities. The results show that, with an upfront investment of s 17 million, a feasible subset of Bologna's households could be equipped

with five selected cost-effective measures, generating annual savings of s 10.2 million and reducing the total domestic water consumption of 34% by 2020 compared to the 2012 initial value. With an additional 28.5 million, households could be equipped with more costly appliances reaching an overall water reduction of 37% by 2020. Their findings confirm that it is possible to successfully extend current approaches to urban energy efficiency strategies to include demand side water efficiency, adding an important building block to the construction of an integrated Nexus-based approach to green development strategies at the city-level.

### **Opportunities for knowledge co-production across the energy-food-water nexus: Making interdisciplinary approaches work for better climate decision making:**

Howarth, Candice and Irene Monasterolo. "Opportunities for Knowledge Co-Production across the Energy-Food-Water Nexus: Making Interdisciplinary Approaches Work for Better Climate Decision Making." *Environmental Science and Policy*, vol. 75, 01 Sept. 2017, pp. 103-110.

This paper seeks to explore how knowledge co-production can help identify opportunities for building more effective, sustainable, inclusive and legitimate decision making processes on climate change. This would enable more resilient responses to climate risks impacting the nexus while increasing transparency, communication and trust among key actors. In so doing, it helps inform a new generation of complex systems models to analyze climate change impact on the food-water-energy nexus.

Exploration of workshop discussions identified five themes, which provided insights into opportunities that may emerge from nexus shocks and opportunities to increase resilience to nexus shocks.

1. Contextual factors that help mitigate nexus shocks
2. Strategic thinking that builds on the understanding of the big picture of nexus shocks' complexity
3. Collaboration and communication characterized by the importance of establishing knowledge-transfer partnerships to design and implement a robust and efficient response to shocks
4. Anticipating social responses, by blending insights from the multiple sectors involved in the response to nexus shocks thus complementing knowledge and providing a framework which considers the big picture, to better deal with the complexity of nexus shocks
5. Processes to shape the right governance structure to respond to nexus shocks with the following desirable characteristics (i) resilience and efficiency to enable flexible planning and procedures, (ii) complementary and flexible mechanisms and institutions able to operate swiftly when needed, and (iii) innovation to decentralize decision making to better manage tailored, case-by-case solutions to cope with nexus shocks. The relevance of proper timescales in decision making emerged as a transversal opportunity in all the five themes.

### **Sustainable development and the water–energy–food nexus: A perspective on livelihoods:**

Biggs, EM, et al. "Sustainable Development and the Water-Energy-Food Nexus: A Perspective

on Livelihoods." *Environmental Science & Policy*, vol. 54, n.d., pp. 389-397.

Previous research has failed to explicitly or adequately incorporate sustainable livelihoods perspectives. This is counterintuitive given that livelihoods are key to achieving sustainable development. In this paper they present a critical review of nexus approaches and identify potential linkages with sustainable livelihoods theory and practice, to deepen our understanding of the interrelated dynamics between human populations and the natural environment. The outcome is an integrated framework with the capacity to measure and monitor environmental livelihood security of whole systems by accounting for the water, energy and food requisites for livelihoods at multiple spatial scales and institutional levels.

## ATTACHMENT B

### TC 7.6 - Energy Mgmt Subcommittee LTP Objective 5\_DRAFT

TC 7.6 is concerned with the estimation, measurement, analysis benchmarking, and management of whole building and building systems energy and water performance. This includes performance and resource management of new and existing buildings.

TC 7.6 is cognizant for the following guidelines and standards:

- Guideline 14: Measurement of Energy and Demand Savings
- Standard 90.1: Energy Efficient Design of New Buildings Except Low-Rise Residential Buildings
- Standard 90.2: Energy Efficient Design of Low-Rise Residential Buildings
- Standard 100: Energy Conservation in Existing Buildings
- Standard 105: Standard Methods of Measuring, Expressing, and Comparing Building Energy Performance

#### **COMPLETED Research Reports Identified**

Report #	Project Title
RP-1627	Actual Energy Performance of Small Office and K-12 School Buildings Designed to Meet the 30% ASHRAE
RP-1681	Low Energy LED Lighting Heat Distribution in Buildings
RP-1449	Energy Efficiency and Cost Assessment of Humidity Control Options for Residential Buildings
RP-1363	Generation of Hourly Design-Day Weather Data
RP-1651	Development of Maximum Technically Achievable Energy Targets for Commercial Buildings Ultra-Low Energy Use Building Set
RP-1633	Data and Interfaces for Advanced Building Operations and Maintenance

#### **ACTIVE Research Reports Identified**

Report #	Project Title
RP-1607	Design and utilization of thermal energy storage to increase the ability of power systems to support renewable energy resources
RP-1629	Testing and modeling energy performance of active chilled beam systems

**Discussion of Project Relevance to TC 7.6**

Report #	Overview	Comments
RP-1627	The purpose of Research Project RP1627 is to determine the effectiveness of 30% Advanced Energy Design Guidelines (AEDGs) for K-12 schools and small office buildings, determine the factors common to well and poorly performing buildings, and to provide recommendations for how future AEDGs could be made more effective.	<p>The report provides field verified performance of sampled commercial buildings designed in accordance with ASHARE 30% AEDGs. The findings are useful to building operators and designers.</p> <p>The report does not provide any unique finding that warrant the update of existing standards or guidelines where TC 7.6 is the cognizant committee.</p>
RP-1681	In this project, fourteen LED lighting luminaires' heat gain distributions were determined through systematically designed experiments. LED lighting selection criteria were defined first based on currently established product standards and programs for the LED lighting industry. Fourteen different LED lighting luminaires were then chosen and tested. Prior to the formal test, a pilot test on three selected LED luminaires were conducted. Following the pilot test, all fourteen luminaires were formally tested under base-case test conditions.	<p>The report provides some guidance on the different levels of heat gain into the space from different LED technologies. The findings are useful to industry (i.e. lighting designers, building staff, etc ).</p> <p>The report does not provide any unique finding that warrant the update of existing standards or guidelines where TC 7.6 is the cognizant committee.</p>
RP-1449	As homes are getting more energy efficient there is evidence that relative humidity levels are increasing (Rudd and Henderson 2007). This implies that sensible heat gains to the building have been reduced more than moisture loads, leaving a mix of latent and sensible loads that are poorly matched to the sensible heat ratio of conventional air conditioning systems. This study used a detailed TRNSYS model to simulate the performance of a wide variety of air conditioners, dehumidifiers, and ventilation control options in a typical 2,000 square foot, single story residence.	<p>The report provides some guidance on the different configurations of ventilation, control systems and their relative impact to humidity levels.</p> <p>Recommendation is to consider adopting findings to relevant finding to update on section 6 of Standard 90.2.</p>

RP-1363	The study focused on the development of updated, coherent procedures for generation of design-day temperature and solar profiles. Output was to be in a format suitable as input for load calculations, equipment performance analysis, and fenestration heat gain calculations.	The report does not provide any unique finding that warrant the update of existing standards or guidelines where TC 7.6 is the cognizant committee.
RP-1651	The objectives of the assessment were to: 1) Identify a comprehensive suite of advanced technologies to be included in modeling of ultra-low energy targets; 2) Simulate the maximum commercial building energy efficiency levels that are technically achievable now or in the near future (~2030) by modeling the DOE prototypes buildings with various combinations of technologies to maximize efficiency; 3) Simulate alternative scenarios to examine the relative impact of individual technologies and practices on EUI.	The report provides relevant findings on the energy savings potential of over 30 energy efficiency measures over a multitude of building types.  Recommendation is to consider adopting findings to update relevant sections in Standard 100 and 105 that discuss EUI targets and proposed EEMs.
RP-1633	The research described in this report seeks to expand such investigations to consider visualization of operational metrics focused on an audience including facility managers, control technicians, heating ventilation and air conditioning (HVAC) technicians, facilities service providers, and commissioning engineers.	The report provides relevant findings on practices in development of data-driven metrics and visualizations to support advanced building operation and maintenance.  Recommendation is to consider adopting findings to update relevant sections in Standard 105
RP-1607	The principal goals of the research are to: Identify the additional value propositions TES provides for buildings, campuses (or micro-grids), and power systems that have large penetrations of as-available renewable energy. Develop a methodology to evaluate those value propositions. Quantify the magnitude of these value propositions for selected case studies constructed using actual utility data, weather data (wind and irradiance), and building load profile data. Relate the value propositions to the design (capacity and response rate) and operating parameters and dispatch strategy of TES systems, in order to begin to formulate a TES design procedure that optimizes the operational capabilities of the TES to compensate for the as-available nature of the renewable energy resources.	The report does not provide any unique finding that warrant the update of existing standards or guidelines where TC 7.6 is the cognizant committee.

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RP-1629	The results of the project will provide a detailed assessment of the simulation capabilities of building energy simulation programs to predict the performance of active chilled beams and the resulting system performance of net-zero energy design strategies. Recommended modeling improvements will be available for program developers to implement in their respective energy simulation programs.	Report not ready – TBD
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