Keynote: Energy Storage with Energy Efficient Buildings/Districts: Optimization and Automation: An Overview of Annex 31 Achievements

Fariborz. Haghighat, PhD, ASHRAE Fellow, ISIAQ Fellow
Professor, Concordia Research Chair: Energy and Environment
Concordia University, Montreal, Canada

At present, the energy requirements in buildings are majorly met from non-renewable sources and the contribution of renewable sources is still in its initial stage. Meeting the peak energy demand by non-renewable energy sources is highly expensive for the utility companies and it critically influences the environment through GHG emissions. In addition, renewable energy sources are inherently intermittent in nature. Therefore, to make both renewable and non-renewable energy sources more efficient in building/district applications, they should be integrated with energy storage systems.

Nevertheless, determining the optimal operation and integration of energy storage with buildings/districts are not straightforward. The real strength of integrating energy storage technologies with buildings/districts is stalled by the high computational demand (or even lack of) tools and optimization techniques. Annex 31 aims to resolve this gap by critically addressing the challenges in integrating energy storage systems in buildings/districts from the perspective of design, development of simplified modeling tools and optimization techniques.

There are several well-established modeling approaches available at the building level. These include approaches such as heating degree day, energy use intensity and load factor, comprehensive (using simulation software) and simplified modeling, etc. Many of the existing simulation software now have built-in options/libraries to accommodate energy storage in buildings. However, most of the existing models consider buildings as standalone systems, barely representing the complexity of an urban/district setting. This leads to over-simplification of the building model and less accuracy in the results. In Annex 31, advanced concepts for effective modeling of buildings in urban setting are proposed. Moreover, innovative ideologies on simplified modeling of buildings (such as multiple linear regression) and their components (e.g. PCM heat exchangers, electrically heated floor, thermally activated walls, etc.) are presented as examples. Furthermore, the potential of PCM-based free cooling over the conventional district heating and cooling system is emphasized in terms of annual primary energy savings.

On the other hand, modeling a district not only includes several buildings, but also the interactions amongst them, at least one heating/cooling network and at least one energy resource. If energy storage is also utilized, it should be included, too. Therefore, modeling at the district level is much more complicated and computationally intense, which requires sacrificing some accuracy compared to the building level. That is why simplified models have received considerable attention at the district level. Several tools have also been developed to achieve different objectives with diverse features and various levels of complexity. In this regard, Annex 31 recommends that screening of existing tools should be conducted (prior to modeling) to select and use the best one for that specific case. Note that the developed tools are often criticized for their limitations in terms of accuracy and frustrating computational time. To resolve this, a 4-step procedure has been developed in Annex 31 to accurately predict the demand profile of different types of district systems with high resolution (hourly interval) and in a timely manner. In addition, two levels of model validation (for the 4-step procedure) at the district level are illustrated as examples.

Once developed and validated, building/district models can then be used for system optimization based on various criteria. Generally, objective functions can be classified in two major categories of environmental and cost. Multi-objective optimization at the district level is very common which (due to the complexity and size of the system) suffers from long computational time. Therefore, some methods have been introduced in Annex 31 to reduce this period for instance by the parallelism of the models, surrogating modeling and utilization of satisfaction functions. Besides, state-of-the-art optimization examples at the building/district levels are presented.
This presentation will give an overview of research work which was carried out within Annex 31 of the International Energy Agency.

Dr. Fariborz Haghighat is a professor at the Department of Building, Civil and Environmental Engineering – Concordia University, Canada. He has a Concordia Research Chair in Energy and Environment which aims to achieve sustainability in the built environment. His current research focuses on the fundamental of heat and mass transport in the building and HVAC systems, and on its applications in the design and analysis of energy-efficient, healthy/immune, and sustainable buildings.

Professor Haghighat is a Fellow of the ASHRAE and an elected member of the International Academy of Indoor Air Science. He is the Editor of the International Journal of Sustainable Cities and Society, an Associate Editor of the International Journal of Building and Environment, and a member of the Editorial Board of several international scientific journals. He has published more than 300 journal and conference papers and presented numerous talks on selected aspects of Energy and Environment. Presently, he is the operating agent of Annex 31 of the Energy Conservation through Energy Storage of the International Energy Agency implementing agreement.