Automatic Building Energy Modeling (AutoBEM)

Abstract

Buildings in China, India, the United States (US), and United Kingdom (UK) consume 39-45% of each nation's primary energy with fast-growing countries like India projected to use 76% of their primary energy by 2040. In 2017, approximately 130 million residential and commercial buildings in the United States consumed 45% of primary energy, 73% of all electricity, and $435 billion in energy bills. Demand charges (i.e. peak usage) can account for 20-70% of a utility bill and continue to grow even as energy prices are decreasing, due largely in part to adoption of intermittent renewables and less efficient, more costly generation assets which must be brought online during peak demand. In an effort to reduce this mortgage on national economies, create a more sustainable built environment, and develop a more resilient electrical grid, grid-interactive efficient buildings can be realized by better understanding and quantifying weather impacts, microclimate effects, and building load impacts on electrical distribution networks for each building at the scale of a city.

Scalable methods have been created to allow urban-scale energy modeling – to identify and synthesize a fully-articulated building energy model for every building in an area of interest. This was applied to several U.S. cities involving the automatic creation of over 140,000 building energy models for real and in-design buildings at Oak Ridge, TN, Chattanooga, TN, and Chicago, IL. Each building was simulated on the nation’s fastest supercomputer, Titan, using EnergyPlus to analyze relationships among climatic conditions, urban morphology, land cover, and energy use. The Weather Research Forecast (WRF) model was scaled on several High Performance Computing (HPC) resources to simulate and empirically validate microclimate variation under different urban morphologies.

In order to quantitatively assess business value and either enhance existing or propose new programs for utilities, the ability to detect, generate, and simulate a building energy model has been applied to a 1,385 km^2 utility district involving over 160,000 buildings in a smart grid backed by a fiber optic network. The Electric Power Board of Chattanooga, TN is operating the electrical distribution and communications networks has prioritized and guided the creation of a virtual utility in order to assess a prioritized list of potential revenue streams and determine the most cost-effective programs for their organization and their rate-payers. We provide an overview of the technical capabilities developed for generally-applicable urban-scale building energy modeling to any geographical area and the utility-defined use cases being assessed.