

TC 6.9 RTAR

Design and Utilization of Thermal Energy Storage to Increase the Effectiveness of Renewable Energy Resources

TC 6.9 Thermal Energy Storage

Energy Conservation/Design Tools

- The Research Classification
 - Basic/Applied
 - Advanced Concepts
 - Projects related to Technology Transfer

TC Priority 2

Estimated Cost \$100,000

State of the Art (Background)

Renewable energy sources will be a key element in the achievement of net-zero energy buildings. Many renewable energy resources, notably wind and solar, suffer from intermittent, variable or unpredictable availability. These energy sources may be influenced by obvious and expected seasonal or diurnal cycles, the vagaries of climate and weather or other economic or practical influences. Utility peak demand may, or may not, coincide with the peak power production of the renewable resource. Additionally, the substantial infrastructure that must provide power during lapses in those energy sources represent an enormous investment that diminishes the value and acceptability of renewable energy sources. TES, as well as other energy storage technologies, have the potential to enhance the value of renewable energy by maximizing the consumption of renewable power as well as reducing the level of expensive and infrequently used reserve generating capacity. However, there is currently no readily accessible source of data that provides the correlation between renewable resource and overall generation profiles for distinct utility territories and no methodology for constructing a targeted TES design.

Advancement to the State of the Art

TES design and application for conventional cooling applications is well developed. However, the use of TES in support of renewable energy technologies has not been studied to any significant degree. Different renewable energy sources possess different reliabilities and variations in capacity. By providing accurate descriptions of the resource generation profile, a design process can be formulated for specific building categories and utility entities. The optimal selection, control and design of TES systems can increase the economic viability of technologies that often must still rely on artificial incentives for acceptance.

Justification and Value to ASHRAE

TES is a core technology within ASHRAE's sphere of technical expertise. Also, TES is one of the few practical technologies capable of reconciling the temporal conflicts between the supply of renewable energy resources and their demand. By advancing the viability of renewable energy sources, ASHRAE continues to establish itself as a global force in achieving a sustainable world, as well as provides valuable guidance in the application of an HVAC technology vital to the attainment of NZEB.

Objective

The principle goals of the research are to define the relationships between the availability of specified renewable energy sources, the demand profile of the associated utilities and the cooling load contribution to those demands and formulate a TES design procedure that optimizes the benefits of the renewable energy resource.

It is expected that wind energy will be the focus for this project. Wind energy is enjoying substantial growth but can also exhibit relatively poor correlation to energy demand as well as relatively low Equivalent Load Carrying Capacity (ELCC). Therefore, wind energy may benefit substantially from TES application.

These goals will be achieved by:

1] Characterize the summer peak-day demand profile for three utilities in the United States that serve three distinct geographical areas.

2] For the three utilities selected above:

Characterize the hourly wind resource energy generation for an average summer 24 hour weekday period.

The minimum potential availability will be predicted for the utility peak load 24 hour period. It is expected that these factors will be related to the statistically acceptable level of reliability for conventional generation technologies.

3] Construct cooling load profiles for three different types of buildings (office, educational & retail) for each of the utilities identified in Task 1. Peak day and average day profiles should be compiled.

4] Design a TES system, for each building type and utility, that minimizes the impact on the utility peak power requirements when the renewable energy sources are at their minimally expected availability for the peak day. The design shall be limited to chiller (refrigeration) and storage capacity selections and a control sequence.

5] Design a TES system, for each building type and utility, that minimizes the energy cost of the building. The design shall be limited to chiller (refrigeration) and storage capacity selections and a control sequence.

6] Identify and summarize conflicts in the Task 4 and Task 5 designs.

5] Provide the information in an electronic format that will allow designers and planners to superimpose or compare any combination of relevant parameters. For example, the minimal availability of wind power could be compared to the peak demand profile for the PJM summer period.

References

Michael Milligan, Measuring Wind Plant Capacity Value, National Renewable Energy Laboratory
Michael R. Milligan, Variance Estimates of Wind Plant Capacity Credit, AWEA Windpower '96, Denver, Colorado, June 23- 27, 1996

Paul Gipe, Grid Integration of Wind Energy, December 20, 2007
<http://www.wind-works.org/articles/GridIntegrationofWindEnergy.html>

www.ucei.berkeley.edu/CSEM/conf2005/10th-POWER-Slides/5Kahn-Slides.ppt

Fripp, M.; Wiser, R.H., Effects of Temporal Wind Patterns on the Value of Wind-Generated Electricity in California and the Northwest, Power Systems, IEEE Transactions, Volume 23, Issue 2, May 2008
Page(s):477 – 485

Dvorak, M.J., Jacobson, M.Z., Archer, C.L. (2007): California offshore wind energy potential. Proceedings from Windpower 2007: *American Wind Energy Association Windpower 2007 Conference & Exhibition*, June 36,

D.L. Elliott, L.L. Wendell, and G.L. Gower, *An Assessment of the Available Windy Land Area and Wind Energy Potential in the Contiguous United States* (Golden, Colo.: National Renewable Energy Laboratory, 1991).

Shiu, H., California Wind Energy Collaborative, California Renewables Portfolio Standard, Renewable Generation Integration Cost Analysis Multi-year Analysis Results and Recommendations Final Report, California Energy Commission,