

RESEARCH TOPIC ACCEPTANCE REQUEST (RTAR) FORM
TC/TG: TC 6.9 Thermal Energy Storage

Title:

TES System Performance Metrics Related to Carbon Emission Reductions at the Power Generation Source

Applicability to ASHRAE Research Strategic Plan:

This research project is aligned with the following goal within the ASHRAE Research Strategic Plan 2005-2010; A6 - *Develop integrated, best practice design methods that will allow ... environment impact to be minimized...*

Research Classification:

Advanced Concepts

TC/TG Priority:

2

TC Vote:

8-0-0

Reasons for Negative Votes and Abstentions:

Estimated Cost:

\$80,000

Estimated Duration:

8 months

Other Interested TC/TGs:

TC 1.10 – Cogeneration

TC 2.8 – Building Environmental Impacts & Sustainability

Possible Co-funding Organizations:

U.S. Department of Energy

U.S. Environmental Protection Agency

Chicago Climate Exchange

Application of Results:

Thermal Energy Storage – Systems & Equipment Handbook Chapter 50

Other “sustainable” and “environmental” chapters within the ASHRAE handbooks.

State-of-the-Art (Background):

The application of TES systems to shift the electric load from peak periods to off-peak periods has been well documented over the past 30 years. Utility companies often offer Time-of-Use (TOU) electric rates that incentivize customers to shift electric load from “on-peak” periods to “off-peak” periods of the day, and rate structures in general discourage high on-peak electric demand. Typically, the peak periods occur during the daytime and afternoon hours. In general, during the warmer (summertime) daytime hours, electric power generation plants are running near their maximum power output to the electric grid in their territory. To provide this maximum electric power, many electric power generators will energize their lowest efficiency, highest operating cost “peaker” plants during the high demand daytime period.

These peaker plants are usually the least efficient type of power generator within the utility company’s portfolio of plants. However, these peaker plants are required to meet the power demands of the electric grid during the daytime period. But at nighttime the peaker plants are de-energized, and the resulting average efficiency of the electric power generation will improve, partly because these peaker plants are no longer operating. Additionally, nighttime power generation, in general, has been found to be more energy efficient¹ than daytime power production. In other words, the utility company will require more fossil fuel, and potentially produce more harmful emissions, during the daytime to generate the same number of MWh’s than during nighttime for a variety of reasons including cooler ambient temperatures, higher plant loading, increased dispatch flexibility and reduced transmission losses.

The amount of carbon air emissions is directly proportional to the amount of fossil fuel burned at a power plant. Therefore, there is more carbon emissions per MW produced during the peak periods (daytime), as

compared to off-peak periods (nighttime). Some of the air emissions data is available on the EPA website. However, there is no calculated average efficiency of the electric grid or average air emissions per MW, based on daytime or nighttime hours. Therefore, there is no accepted formulaic method of determining the amount of carbon emissions that a Thermal Energy Storage System, or other load shifting technology, can save by shifting the electric usage from peak periods (daytime) to off-peak periods (nighttime).

Advancement to the State-of-the-Art:

Because TES systems are designed to shift large amounts of electric power from peak periods to off-peak periods, TES systems provide a benefit in the form of carbon emissions reductions relative to the average power plant efficiency of the electric grid when comparing daytime to nighttime operation. By understanding the relationship between the time of day, and the average carbon emissions per MW of the electric grid (served by power plants within a certain territory of the electric grid), we can estimate the positive environment impact that Thermal Energy Storage systems can provide.

Justification and Value to ASHRAE:

By understanding the average day/night carbon emissions of the power plants serving specific territories within the electric grid, engineers can estimate, more accurately an end user's carbon footprint. Understanding this relationship will provide engineers with an estimating tool that can be used when calculating the environmental impact of electric load shifting technologies like Thermal Energy Storage, Turbine Inlet Cooling, and others. The results of this study can be incorporated into the ASHRAE Handbook for use by engineers when calculating the carbon footprint of facilities. As a leader in Sustainable design techniques, ASHRAE has a distinct interest in giving engineers the tools necessary to calculate the effects of mechanical systems on the environment. Also, ASHRAE can utilize this data when advocating carbon emission reduction policy at a Federal Government level.

Note: This study will have direct relative benefit to peak shaving, peak shifting systems, and energy reduction systems; transcending HVAC, lighting, plug load, and building envelope systems.

Objective:

1. Determine specific geographical or ISO related regions, where it would be reasonable to assume that the electric power would be supplied by the nearby regional power generation plants.
2. Compile average carbon emissions per MW based on daytime and nighttime operation of electric power generation plants within the geographical region or ISO territory of the electric grid.
3. Relate the average and marginal carbon emissions data, daytime vs. nighttime, and outdoor ambient conditions, and annual seasonal periods.
4. Based on the relationships listed above, provide an average value of the carbon emissions per MW of electric power provided to a certain geographic region based on daytime and nighttime periods.

1] California Energy Commission. 1996. Source Energy and Environmental Impacts of Thermal Energy Storage, report #500-95-005 www.energy.ca.gov/reports_500.html

Key References:

EPA Website: <http://epa.gov/cleanenergy/energy-resources/egrid/index.html>

EPA Website: <http://camddataandmaps.epa.gov/gdm/>