Energy Efficiency and Reliability Solutions For Rail Operations and Facilities

November 2014

A Report By

The Connecticut Academy of Science and Engineering

For

The Connecticut Department of Transportation

Energy Efficiency and Reliability Solutions For Rail Operations and Facilities

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This study was initiated at the request of the Connecticut Department of Transportation on October 25, 2013. The project was conducted by an Academy Study Committee with the support of the UConn Transportation Institute/UConn Center for Clean Energy Engineering, with Ray Necci serving as Study Manager and Technical Lead. The content of this report lies within the province of the Academy's Transportation Systems and Energy Use and Production Technical Boards. The report has been reviewed by Academy Members A. George Foyt, ScD, and Herbert S. Levinson, DrEng, PE. Martha Sherman, the Academy's Managing Editor, edited the report. The report is hereby released with the approval of the Academy Council.

Richard H. Strauss
Executive Director

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16. Abstract: The objectives of the study included examining energy consumption of the facilities comprising the three major rail yards on the New Haven Rail Line as well as platform stations and identifying energy efficiency and cost savings opportunities for rail operations/facilities. This study will focus on identifying opportunities and options to improve energy efficiency and reliability. Solutions for reducing energy costs and reliance on fossil fuels that take into account the needs of Connecticut’s rail operations/facilities will be recommended. The primary conclusions include the following: CTDOT should assign a staff person to serve as an energy manager tasked with leading energy efficiency and conservation efforts for all rail facilities/stations and incorporating the importance of these efforts into the culture of the department. Under the energy manager’s leadership, CTDOT should implement a comprehensive process to exploit energy efficiency and reliability opportunities for rail facilities/stations. This process should include conducting periodic energy audits of facilities, developing an energy management plan, and incorporating the findings into an asset management plan. Project planning, engineering and design, and construction, as well as rail operations that are conducted at the facilities/stations should be integrated into this process. Importantly, initiatives and projects should be evaluated with results integrated into future planning.

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EXECUTIVE SUMMARY

This study was conducted for the Connecticut Department of Transportation (CTDOT) by the Connecticut Academy of Science and Engineering (CASE). The objectives of the study included examining energy consumption of the facilities comprising the three major rail yards on the New Haven Rail Line as well as platform stations and identifying energy efficiency and cost savings opportunities for rail operations and facilities. This study focused on identifying opportunities and options to improve energy efficiency and reliability. Additionally, solutions for reducing energy costs and reliance on fossil fuels that take into account the needs of Connecticut's rail operations and facilities will be recommended. The report includes the following:

- Literature Review
- Connecticut Practices
- Best Practices
- Recommendations and Conclusions

BRIEF STATEMENT OF PRIMARY CONCLUSION

CTDOT should assign a staff person to serve as an energy manager tasked with leading energy efficiency and conservation efforts for all rail facilities/stations and incorporating the importance of these efforts into the culture of the department. Under the energy manager's leadership, CTDOT should implement a comprehensive process to exploit energy efficiency and reliability opportunities for rail facilities/stations. This process should include conducting periodic energy audits of facilities, developing an energy management plan, and incorporating the findings into an asset management plan. Project planning, engineering and design, and construction, as well as rail operations that are conducted at the facilities/stations should be integrated into this process. Importantly, initiatives and projects should be evaluated with results integrated into future planning.

LITERATURE REVIEW

An extensive literature search was conducted to identify previous studies in this field, including research on new energy saving, clean energy, and energy reliability technologies. Common findings from the literature reviewed include:

- The largest energy loads consistently identified for typical commercial buildings were heating ventilating, and air conditioning (HVAC), and lighting. Since the facilities that comprise the rail yards in Connecticut are not typical commercial buildings further analysis of the load profiles for these buildings is required before this finding can be confirmed.
- Renewable energy sources have been successfully utilized to help reduce utility purchased energy. Since the various suggested systems are not ideal for every

geographical location, Connecticut-specific factors such as weather, wind and sun availability must be evaluated. Additionally, a cost-benefit analysis should be conducted as part of the decision making process for renewable energy project

- Funding options are available for reducing the cost of energy upgrades.
- Internal policies, procedures, and practices, including use of an energy management system, are inexpensive solutions to reduce energy consumption, thereby reducing cost.
- Division of loads into categories expands the understanding of a system total energy consumption identifying which components or subsystems require the most energy.

CONNECTICUT PRACTICES

Current practices regarding rail facility energy use, including existing loads and Connecticut practices were identified through research team site visits to the New Haven, Stamford and Bridgeport rail facilities to gather information. Metro North Railroad (MNR), Connecticut Light and Power (CL&P) and United Illuminating (UI) provided documentation related to electricity bills and meters for analysis. Southern Connecticut Gas and Yankee Gas provided natural gas information and billing information.

Based on industry best practices, the operations and energy loads that comprise the rail facilities have been divided into initial subcategories based on research team visits to the New Haven, Stamford and Bridgeport Rail Yards and the West Haven and Milford platform stations. Electricity and gas bills were analyzed to determine the energy cost paid for the three major rail yards and the Milford platform station. Further information is required before accurate estimates can be made regarding how much energy is being used by specific load categories and by individual facilities. For load categories, the duty cycle of equipment and the measurement of electricity consumption need to be determined and monitored over time.

BEST PRACTICES

Commonalities identified in the studies and reports that were reviewed indicate several best practices that are critical to understanding, managing and improving existing facilities and systems with respect to energy efficiency. Before improvements can be made the entire system, both at the overall level and subsystems level, must be understood in terms of current energy consumption. In several previous studies, this information was obtained by conducting an energy audit to identify loads and areas of cost savings opportunities. Various loads that exist in a facility in terms of numbers present, frequency of use (or duty cycle), and the energy consumption profile must be identified.

A common strategy among most of the large-scale studies reviewed was to divide unique load profiles into categories; benefits include simplification of complex systems and the ability to identify the size of the load relative to others at a particular facility. This allows the focus to be directed toward the largest loads first, which will more significantly reduce energy consumption; smaller loads can then be addressed for a holistic approach.

Simulations were a recurring practice implemented in order to understand loads, air flow, scheduling and other impacts on energy efficiency. Once the system is divided into categories and methodically analyzed and understood, conservation opportunities will become more apparent.

Internal policies which promote sustainable energy and smart energy use, where applicable under feasibility and safety standards, must be developed setting various goals, such as saving energy, protecting ecosystems, and enhancing resiliency, followed by long-term targets that are monitored over time. These policies and procedures can become part of a workplace culture that ingrains energy-saving behaviors into daily tasks. Among the common best practices is to establish an energy management system that is a framework of authority inside an organization for determining who will manage the implementation and changes to energy-saving policies. It is important to understand the cost and benefit and the total cost of ownership, which includes costs associated with: purchase, installation, maintenance and disposal, encompassing the entire life cycle of the investment. HVAC and lighting were the two areas that were most commonly the largest loads of a commercial facility. More specifically average energy use distribution in commercial buildings is estimated to be 20% lighting, 16% space heating, 15% space cooling, 9% ventilation, 7% refrigeration, 4% water heating, 4% electronics, 4% computers, 1% cooking, 15% other, and 5% unattributed.

RECOMMENDATIONS

The following recommendations are intended to provide CTDOT with guidance to further enhance the efficiency and reliability of rail facilities and rail stations.

The recommendations are based on industry best practices and available information gathered through site visits, interviews, a focus group session, data on electricity and natural gas usage, and expert guidance from the CASE study committee. These recommendations are based solely on the issue of energy savings; the question of whether or not an initiative or project will save money must be determined by a total cost of ownership analysis.

Further detailed information is needed to gain a complete understanding of rail yard facility and rail station energy usage and to develop an energy profile for each facility. This will provide a foundation for conducting energy audits of the facilities and stations that can then be used to develop and prioritize energy efficiency initiatives and projects.

Conduct an Energy Audit: Before any upgrades can be considered a thorough energy audit should be conducted based on data for a minimum of 12 – 18 months, and possibly longer to determine changes and trends in operations, usage and cost. The audit should include the monitoring of individual facilities and their respective energy usage over time, rail operations, billing, energy procurement, and submetering. Analysis of the duty cycle of machinery/tools should be included in order to identify both usage and opportunities to reduce energy consumption while maintaining ability to conduct maintenance operations effectively.

This process will identify energy savings opportunities, and will provide a method to aid in prioritization for use of available funds for initiatives and projects. It will provide a baseline for energy consumption for the overall rail network, facilities, equipment and various operations. This baseline will enable an accurate total cost of ownership analysis to be conducted to quantify energy and cost savings, and will be useful for monitoring the impacts of future initiatives and upgrades will have on these savings. Computer modeling can be used in the analysis of energy consumption to establish this baseline.

Lighting: A preliminary estimate of the number of light fixtures at rail facilities was made through site visits conducted during this study. However, the type of lighting technology installed in the fixtures was not determined. Once this information is obtained it will be possible to calculate the percentage of energy use and cost attributable to lighting, and the cost savings and payback period that could be achieved through installation of energy efficient lighting. Although the exact energy profile for each rail facility is not known the following recommendations have been proven to reduce energy use:

- LED technology was cited in multiple reports. Recent advances that improve the spectrum of lighting have made it a viable option.
- Control systems have the capability of dimming lights or turning some or all fixture off when a room is not occupied. Since lights operate 24/7 at all facilities opportunities for improvement exist.
- For better temperature control, paint the pit walls of the Stamford Maintenance of Equipment Facility a light color that reflects illumination, as compared to the current dark color that absorbs illumination.
- The West Haven Rail Station has an excessive number of lights energized even though it has adequate natural daylighting. Consideration should be given to reducing lighting during daylight hours.

HVAC: Further analysis of how the HVAC systems in the rail facilities are controlled should be investigated before accurate estimates can be made regarding their energy consumption. For example, factors that affect energy use, including controllers that operate HVAC systems (i.e., temperature settings and programmability features) should be identified and assessed. This information along with average local temperatures, can be used to estimate the current duty cycle of the HVAC systems. Also, air and water leaks at all facilities should be repaired to help reduce the demand on HVAC systems. Additionally, radiant floor heating for work areas should be analyzed as an option for reducing heating cost and improving the work environment in rail yard shops.

Solar PV Systems: The New Haven Rail Yard has adequate roof space and Connecticut is located at a latitude that is appropriate for installation of a PV system to supplement purchased electricity. Net metering and battery storage options should be assessed to determine the best option for this application. Additional PV system opportunities should be assessed for rail stations, platforms stations and other rail facilities.

New Haven Rail Yard Electricity System: An analysis of the power distribution system for the New Haven Rail Yard should be conducted to gain a more complete understanding of how each building receives power and to identify if there are additional electrical paths served by the UI feeder. Also, further analysis is needed to identify if there are additional submeters in use for rail yard facilities, which would be helpful in determining the kWh usage for the buildings serviced by each meter. Once the submetering is understood more detailed monitoring will be useful to manage and analyze energy usage and the impacts that future initiatives will have on electricity consumption. More intelligent meters that are properly calibrated will help provide further insight into specific facility energy profiles. Additionally, the naming convention for yard buildings is inconsistent and makes analysis of the yard's complex electrical system challenging. A single name for each facility, such as the common name referred to by staff, should be adopted for official documents and signage.

Natural Gas: Based on 2013 billing information, natural gas is currently less expensive than electricity in terms of price per kWh (to enable a direct comparison between natural gas and electricity, energy units for natural gas were converted from BTUs to KWh), although this may not necessarily be the case universally. Also, natural gas is available at all three rail yards. A detailed technical and cost-benefit analysis of the value of using combined heat and power (CHP) for onsite production of electricity and use of waste heat for heating and cooling using microturbines or fuel cells should be conducted. A hybrid system that primarily relies on electricity provided by the utilities, supplemented by a PV system, and possibly a natural gas-fueled CHP system, will increase reliability by producing electricity onsite. It has the additional benefit of using waste heat for heating and cooling.

Other: The past practice of turning off the power for rail car operation at the Stamford Car Wash Facility on weekends should be reinstated.

Energy Management: It is recommended that CTDOT develop and implement an energy management plan and assign a staff person to serve as an energy manager with overall responsibility for leading conservation efforts for all rail facilities and rail stations. The energy manager should interface with the Department of Energy and Environmental Protection (DEEP) in support of energy procurement contracts for the state's rail system and participation in the state's Lead by Example efficiency program. This will ensure that CTDOT is fully aware of and participates in the state's electric and gas procurement process, and is able to use and benefit from existing programs for saving energy. The energy manager should also be a part of CTDOT's asset management review team to provide input regarding those projects that will provide a positive energy savings for rail facilities and rail stations. This will allow projects to be ranked with appropriate priority and be considered with other safety, operational and maintenance projects. Also, this will provide for consistency across all of the state's rail facilities regardless of the individual property manager for each facility. Additionally, the energy manager should issue annual reports to the department's management to demonstrate the progress made in reducing energy use and to encourage energy efficient construction for both new facilities and renovation of existing facilities.

As previously stated, additional information is needed to fully assess electricity usage at the rail yards and stations before developing a plan to reduce energy consumption at rail facilities. A detailed energy audit should be conducted for each rail facility for which CTDOT is responsible. A review of existing energy meters and the need for additional submeters should be included as part of all energy audits. A fully developed metering scheme will allow for a proper analysis of energy use, permitting a comprehensive analysis of energy distribution and use and helping focus energy conservation efforts on those projects that have the greatest return on investment.

CONCLUSIONS

The best practices gathered from the literature review detailed in Section 2 offer solutions that have been proven successful at increasing energy efficiency for facilities. Based on industry best practices, energy usage should be analyzed in detail as an initial step in the decision making process. Dividing the entire system into load categories aids analysis by helping to simplify complex systems and allowing for more accurate estimates to be calculated for each category's energy consumption profile.

Total cost of ownership including purchase, installation, fuel cost and escalation rate, maintenance and disposal/salvage value, encompassing the entire life cycle of any initiative, should be determined. This analysis is used to prioritize and select the energy efficiency and reliability initiatives included in a facility capital plan, and determine if an initiative actually saves money over the long term.

Connecticut's current practices were observed during several onsite visits to rail yards and rail stations conducted by the research team. The various loads have been reviewed and sorted into broad categories. However, these facilities are large and active, resulting in the possibility that some specific tools or equipment that comprise the load profiles may not have been included in the analysis.

Studies identified in the literature review have shown that lighting and HVAC systems are typically the largest loads; therefore, it is important to conduct energy audits to understand these existing systems thoroughly and provide a more accurate picture of how each facility consumes energy.

The utility bills, supporting consumption documentation, and the research team's site visits have been a good start, but there is still conflicting information regarding submeters. Diagrams of the distribution building at New Haven Rail Yard have shown that additional documentation required to answer these final questions concerning power flow and metering exists. The spreadsheets that the MNR electrician maintains need to be examined in order to determine how much power is consumed by individual buildings. This information, along with the utility bills, will provide an understanding of which buildings consume the most energy, as well as guidance for focusing energy saving initiatives.