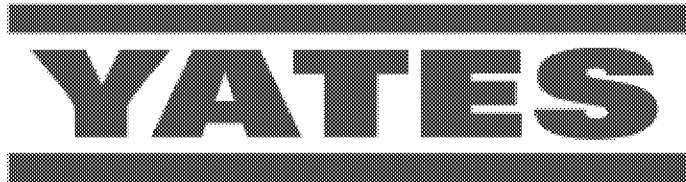


**CITCO Greenhouse Gas Avoidance Calculator
Sub-Application Support
Emission Avoidance Calculations**

Prepared by
YATES Engineers, LLC
Greenville, SC
Project No. 15450-0002



1. Document Scope

The scope of this document is to provide a basis for the greenhouse gas (GHG) avoidance calculations for each of the CITCO sub-application types. The intent of this document is not to supersede the emissions avoidance calculations in the GHG avoidance calculator but to serve as a convenient summary of annual electricity consumption of business as usual (BAU) base case and proposed equipment.

All sub-applications consider an uptime with the facility operating 362 days/year at 24 hours/day.

2. Waste Heat Recovery

Project to include equipment dedicated to recover waste heat available from **Redacted** Recovered heat will be used directly for building heat and process fluid heating. All recovered energy will directly replace the facilities natural gas consumption.

For process equipment where there is available recoverable heat, the recovered enthalpy is quantified by equipment suppliers. The auxiliary equipment that is listed on the Project Budget Workbook is required to capture and reuse this energy. The proposed equipment is calculated to recover 14.5 mmBTU/hr Avg and 30 mmBTU/HR at the peak case. The average heat recovery accounts for season difference for both building heat and process fluid heating.

$$\begin{aligned} \text{Annual Energy [therms/yr]} &= 14.5 \left[\frac{\text{MMBTU}}{\text{hr}} \right] \cdot \frac{10 [\text{therm}]}{1 [\text{MMBTU}]} \cdot 24 \frac{\text{hrs}}{\text{day}} \cdot 362 \frac{\text{days}}{\text{yr}} \\ &= 1,259,760 \text{ therms/yr} \end{aligned}$$

3. Industrial Process Equipment Electrification

3.1 Variable Speed Equipment

High efficiency variable speed process equipment was implemented into the design of **Redacted** project scope. Power consumption is minimized by controlling electric motor speed, which provides the ability to optimize energy utilization during operation. The business as usual case (BAU) describes drives that are of constant speed and rely on additional equipment to throttle outputs when demand is lower than maximum, which fixes torque load.

The BAU overall energy usage is calculated by multiplying the total motor power in kW by annual uptime. The figure for variable speed equipment uses the same calculation but uses a 0.8 factor that represents the average increased efficiency. A total of 2750 HP of variable speed driven equipment has been identified from the project process equipment list.

$$\begin{aligned} \text{Annual Energy}_{BAU} [kWh] &= 2750 \text{ HP} \cdot \frac{0.7457 [kW]}{1 [HP]} \cdot 24 \text{ hrs} \cdot 362 \text{ days} \\ &= 17,816,264 \text{ kWh} \end{aligned}$$

$$\begin{aligned} \text{Annual Energy}_{proposed} [kWh] \\ &= 0.8 \left(2750 \text{ HP} \cdot \frac{0.7457 [kW]}{1 [HP]} \cdot 24 \text{ hrs} \cdot 362 \text{ days} \right) \\ &= 14,253,012 \text{ kWh} \end{aligned}$$

The US DOE publication Motor Systems Tip Sheet #11, Adjustable Speed Drive Part-Load Efficiency: DEO/GO-102012-3730, November 2012 was referenced along with pulp and paper industry applications to determine energy savings when comparing variable to constant speed.

3.2 Variable Speed Vacuum Blower System

When comparing € Redacted with similar grade structures there is ~40% less power used in the direct drives for vacuum blowers in comparison to the traditional liquid ring pump configuration. The business as usual case (BAU) described in the Industrial Process Equipment Electrification Sub-Application for liquid ring pumps is 8062 HP. With the proposed uptime this is equvalued to an annual electricity consumption of 52,230,800 kWh.

$$\begin{aligned} \text{Annual Energy}_{BAU} [kWh] &= 8062 \text{ HP} \cdot \frac{0.7457 [kW]}{1 [HP]} \cdot 24 \text{ hrs} \cdot 362 \text{ days} \\ &= 52,230,809 \text{ kWh} \end{aligned}$$

Based on vendor supplied information for design conditions that are specific to the Redacted scope there is a maximum of 5826 HP consumed for the proposed vacuum blower system.

This maximum power consumed by the vacuum blower system is less than the installed motor power of 5826 HP due to high efficiency variable speed drive motors that will be used to optimize motor speed and reduce power consumption when possible. As described **3.1 Variable Speed Equipment**, the average power consumption for the vacuum blower system is estimated to be 20% less than the maximum 5826HP due to the multiple variable speed drive motors that can minimize power consumption during normal operating conditions.

$$\begin{aligned} \text{Annual Energy}_{proposed} [kWh] \\ &= 0.8 \left(5826 \text{ HP} \cdot \frac{0.7457 [kW]}{1 [HP]} \cdot 24 \text{ hrs} \cdot 362 \text{ days} \right) \\ &= 30,195,653 \text{ kWh} \end{aligned}$$

4. High Efficiency Compressors and Lighting High-Efficiency Electric Pumps, Motors, Compressors, and/or Lighting

4.1 Installing High-Efficiency LED Fixtures & Lamps

High-efficiency LED lighting is to be used throughout the proposed facility. Energy reductions and the related GHG avoidance are calculated by comparing the summated lamp wattages of traditional fixtures in comparison to LED fixtures. An example below is of LED lighting (484 W) that is specific to manufacturing areas to traditional high-bay lighting (900 W)

$$Annual\ Energy[kWh] = W_{avg} [W] \cdot \frac{1 [kW]}{1000 [W]} \cdot Count [-] \cdot 24\ hrs \cdot 362\ days$$

$$\begin{aligned} Annual\ Energy_{BAU} [kWh] &= 900 [W] \cdot \frac{1 [kW]}{1000 [W]} \cdot 700 [-] \cdot 24\ hrs \cdot 362\ days \\ &= 5,473,440\ kWh \end{aligned}$$

$$\begin{aligned} Annual\ Energy_{proposed} [kWh] &= 484 [W] \cdot \frac{1 [kW]}{1000 [W]} \cdot 700 [-] \cdot 24\ hrs \cdot 362\ days \\ &= 2,943,494\ kWh \end{aligned}$$

This calculation is continued for area lighting and office lighting using the respective wattage and counts found in the sub-application document.

4.2 Installing High-Efficiency Electric Compressors

In the [Redacted] supplied by energy efficient compressors will be supplied with variable speed drives and have capability for speed control. Based on vendor supplied information two (2) 400 HP variable speed compressors are to be included in the mill air distribution system and will have capability to control motor speed, which provides the ability to optimize energy utilization during operation.

The BAU and proposed annual energy consumptions are determined based off the rated motor horsepower determined during project design. As described in **3.1 Variable Speed Equipment**, the average power consumption for the variable speed system is estimated to be 20% less than the maximum.

$$\begin{aligned} Annual\ Energy_{BAU} [kWh] &= 400\ HP \cdot \frac{0.7457 [kW]}{1 [HP]} \cdot 24\ hrs \cdot 362\ days \\ &= 2,597,955\ kWh \end{aligned}$$

$$\begin{aligned} Annual\ Energy_{proposed} [kWh] &= 0.8 \left(400\ HP \cdot \frac{0.7457 [kW]}{1 [HP]} \cdot 24\ hrs \cdot 362\ days \right) \\ &= 2,073,165\ kWh \end{aligned}$$