Continuous Process Versus Batch Process Power Demand Management

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Introduction

Utility billing for separate Hot Mill and Cold Mill facilities is based on energy usage during 'On-Peak' periods. In this paper we present separate solutions for the two facilities that combines the properties of the using processes to optimize production to save money on the utility bills. The desired result was to curtail MW usage appropriately during the On-Peak periods and minimize the impact on production. The nature of the differing loads at the two facilities led to different solutions. These systems had a short payback period.

Hot Mill

Overview

In 2006 a Steel Mill asked if we could put in a 'Power Demand Management' system into the existing Hot Mill Substation Control System. Their electrical bill had an 'On-Peak Average MW' component per Clock-Based 30 Minute Demand Period. They wanted to normalize their On Peak Demand Period Average MW as much as possible to optimize their electrical bill for the same overall productivity.

Architecture

The existing control system architecture was set up for monitoring and displaying energy usage, monitoring various switch statuses, and handling various curtailment requests from the utility provider. Given the existing infrastructure, no new hardware was needed to implement the Power Demand Management.

The Control System Architecture started as a PLC5 with Powermonitor 1400's on RIO and migrated over the years through Control Upgrades and Substation Upgrades to a ControlLogix with SEL 735's on Modbus TCP.

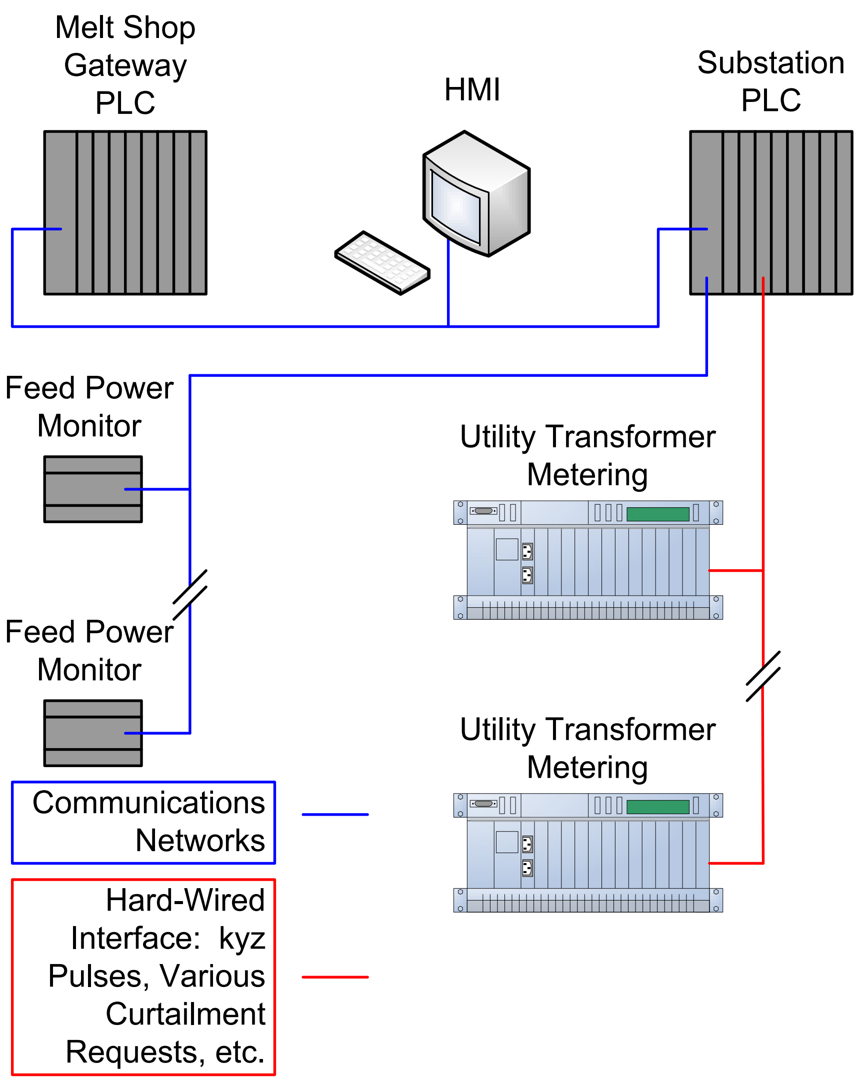

Figure 1 Hot Mill Facility Control Architecture

Strategy

We first calculated what the Projected Average MW would be at the end of the Demand Period.

Units:

MWh/sec:

$$(1\ MW)(1\ Hour) = \ 1\ MWh$$

$$(1\ MW) * \left(\frac{1\ Hour}{60\ Minutes}\right) * \left(\frac{1\ Minute}{60\ Seconds}\right) = \frac{0.00028\ MWh}{1\ Second}$$

MWh in Remaining Demand Period (Seconds):

$$MWh\ Remaining = \left(\frac{MWh}{Second}\right) * Seconds\ Remaining\ in\ Demand\ Period$$

Projected MWh:

$$\text{Projected MWh} \ = \ \text{Accumulated MWh} \ + \ \text{Remaining Seconds MWh}$$

Projected Average MW:

$$Projected\ Average\ MW\ = \frac{Projected\ MWh}{Demand\ Period\ Length\ in\ Hours}$$

Next we needed to calculate what the No EAF Projected Average MW would be at the end of the Demand Period with just the rest of the facility's current load and if the Arc Furnaces were stopped. Once the No EAF Projected Average MW reaches the Target Average MW, the Arc Furnaces are disabled until either the next Demand Period starts, or the Target Average MW is changed.

No EAF MW:

$$MW\ No\ EAF = Total\ MW - EAF\ MW$$

No EAF MWh/sec:

$$(1\ MW)(1\ Hour) = \ 1\ MWh$$

$$(1\ MW\ No\ EAF) * \left(\frac{1\ Hour}{60\ Minutes}\right) * \left(\frac{1\ Minute}{60\ Seconds}\right) = \frac{0.00028\ MWh}{1\ Second}\ No\ EAF$$

No EAF MWh in Remaining Demand Period (Seconds):

$$No\ EAF\ MWh\ Remaining = \left(\frac{MWh}{Second}\right) No\ EAF * Seconds\ Remaining\ in\ Demand\ Period$$

No EAF Projected MWh:

$$\text{No EAF Projected MWh} = \text{Accumulated MWh} + \text{No EAF Remaining Seconds MWh}$$

No EAF Projected Average MW:

$$Projected\ Average\ MW = \frac{No\ EAF\ Projected\ MWh}{Demand\ Period\ Length\ in\ Hours}$$

At the first example time in the Trend Chart below, the clock time was 9:45AM, 5 minutes into a Demand Period and 25 minutes from the end of the Demand Period. At this point, it is know that at the current MW usage they will exceed the Target Average MW of ~200 MW, but it is not yet time to turn off the Arc Furnaces. Next in the Trend Chart below it can be seen that the Arc Furnaces turned off at ~10:05 AM, once the No EAF Projected Average MW predicted that the rest of the facility's MW load would bring them to the Target Average MW at the end of the Demand Period.

Although not significant compared to the Arc Furnace loads, there were several Non-Continuous loads had to be modelled properly to avoid nuissance Arc Furnace shut downs or overshoots on the Average MW for the Demand Period.

We used a Lag Filter for the Non-Continuous MW values used for our calculations, restarting each Demand Period at the previous Demand Period's Non-Continuous Average MW.

Figure 2 Hot Mill Trend Recording

Cold Mill

Overview

In 2013 we were asked to do a similar Power Demand Management System for a Cold Mill facility. This facility wanted to normalize their On Peak Demand Period Average MW per Demand Period as much as possible to optimize their electrical bill for the same overall productivity. In this case the largest MW load was the Tandem Mill.

Architecture

In the case of the Cold Mill facility, only the Substation Metering was in place; the remaining Communications Networks and PLC had to be installed. We chose a Rockwell ControlLogix platform due to the numerous communications protocols supported by third party providers, primarily Prosoft.

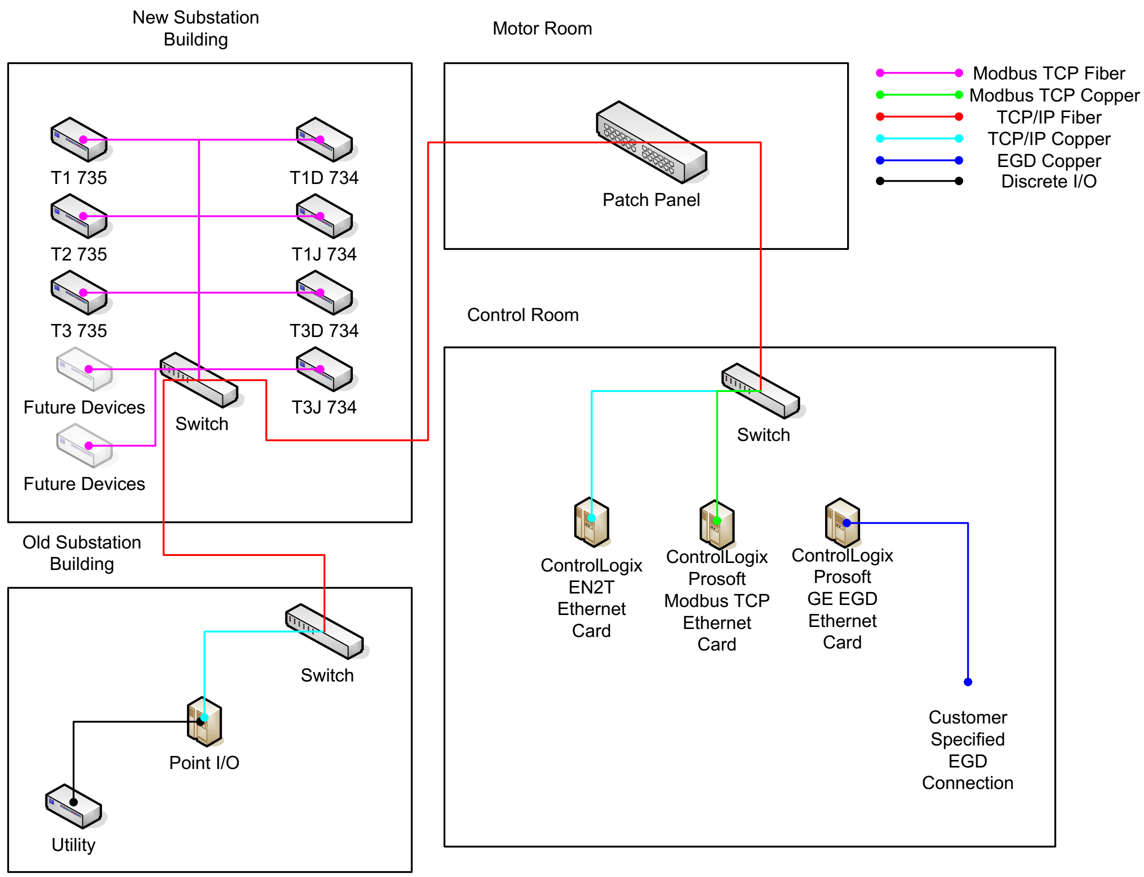

Figure 3 Cold Mill Facility Control Architecture

Strategy

Unlike the Hot Mill's Arc Furnaces, the Cold Mill's Tandem Mill could not be stopped mid-process without undesirable consequences. For the Tandem Mill we listened for the Model Setups on the Ethernet Global Data Network. We then calculated what the Average kW would be for the Demand Period if we run the Next Coil. If the Next Coil Average kW is below the Target Average kW the Tandem Mill can start the Next Coil. If the Next Coil Average kW is above the Target Average kW the Tandem Mill cannot start the Next Coil.

Next Coil kW:

$$Next\ Coil\ kW = Stand\ 1\ kW + \cdots + Last\ Stand\ kW$$

Next Coil kWh/Second:

$$Next\ Coil\frac{kWh}{Second} = Next\ Coil\ kW * \frac{1\ Hour}{60\ Minutes} * \frac{1\ Minute}{60\ Seconds}$$

Next Coil Run Time Seconds:

$$Next\ Coil\ Run\ Time\ Seconds = \frac{(Coil\ Length\ in\ Feet)}{Coil\ Run\ Speed\ in\ Feet\ per\ Second}$$

Next Coil kWh:

Use the lesser of Next Coil Run Time Seconds and Seconds Remaining in Demand Period. We do this to only use the portion of the Next Coil's kWh that will run during the current Demand Period.

$$Next\ Coil\ kWh = Next\ Coil\frac{kWh}{Second} * Seconds\ Used$$

No Tandem Mill kWh/sec:

$$(1\ kW)(1\ Hour) = \ 1\ kWh$$

$$(1\ kW) * \left(\frac{1\ Hour}{60\ Minutes}\right) * \left(\frac{1\ Minute}{60\ Seconds}\right) = \frac{0.00028\ kWh}{1\ Second}$$

No Tandem Mill Remaining Seconds kWh:

$$\begin{aligned}&\mathit{No\ Tandem\ Mill\ Remaining\ Seconds\ kWh}\\&\quad = \mathit{Seconds\ Remaining\ in\ Demand\ Period} * \mathit{No\ Tandem\ Mill} \frac{kWh}{Second}\end{aligned}$$

No Tandem Mill Projected kWh:

$$\begin{aligned}&\mathit{No\ Tandem\ Mill\ Projected\ kWh}\\&\quad = \mathit{Accumulated\ kWh} + \mathit{No\ Tandem\ Mill\ Remaining\ Seconds\ kWh}\end{aligned}$$

Projected kWh with Next Coil:

$$\mathit{Projected\ kWh\ Next\ Coil} = \mathit{Next\ Coil\ kWh} + \mathit{No\ Tandem\ Mill\ Projected\ kWh}$$

Projected Average kW with Next Coil:

$$\mathit{Projected\ Average\ kW\ Next\ Coil} = \frac{\mathit{Projected\ kWh\ Next\ Coil}}{\mathit{Demand\ Period\ Length\ in\ Hours}}$$

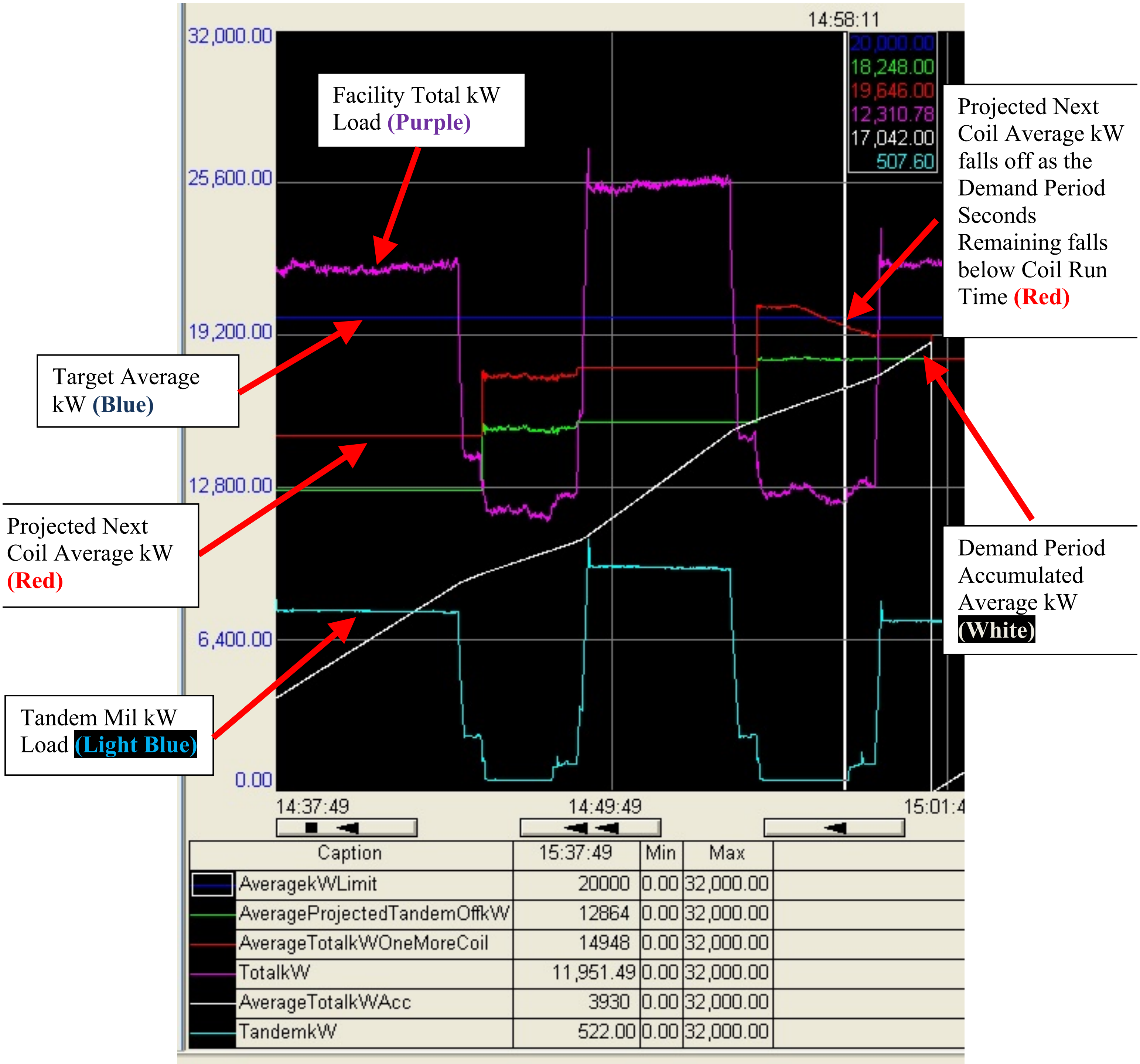

Figure 4 Cold Mill Trend Recording

Conclusion

We chose two different strategies for two different facilities, based on the nature of each facility's largest electrical load. At the Hot Mill we could stop and restart the Arc Furnaces in the middle of a heat with little consequences, we were able to control our Demand Period Average MW by inhibiting the Arc Furnaces at the appropriate time. At the Tandem Mill we had to consider each coil's kWh as a discrete unit of energy to be allowed or denied.