Chilled Water Plants; Basic Principles, Ongoing Commissioning/Operation, and Optimization

kW per Ton and Load Profiles

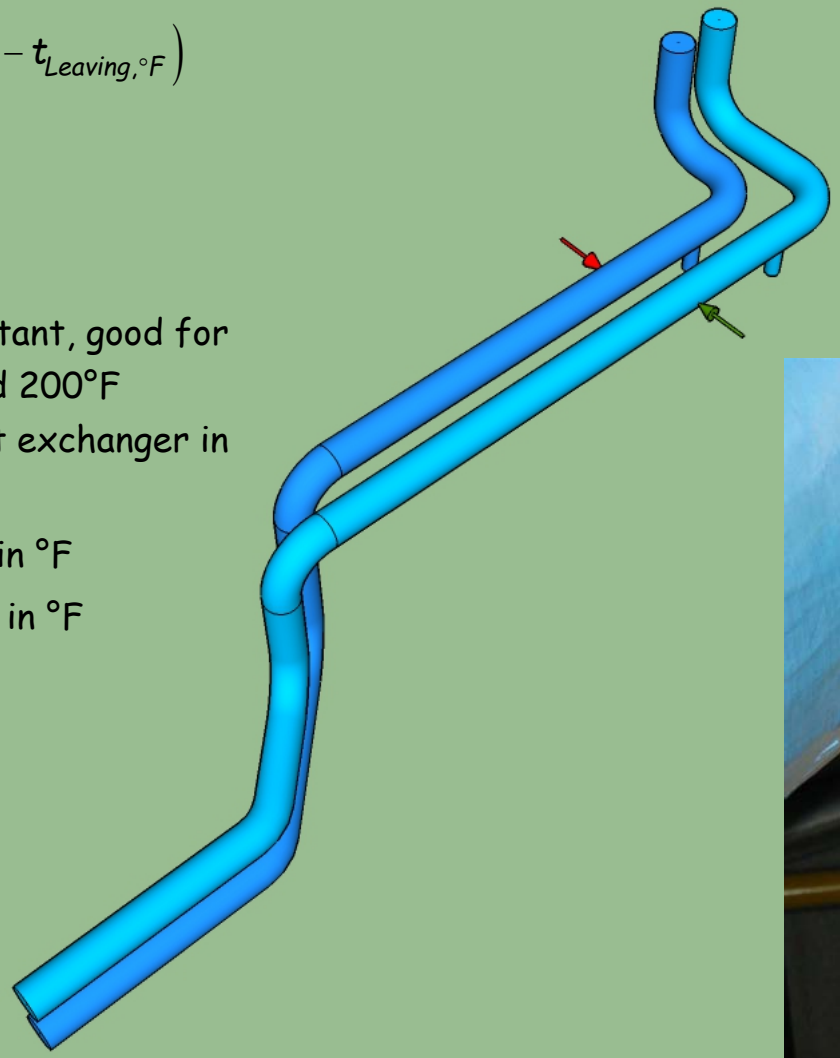
Presented By:
David Sellers
Senior Engineer, Facility Dynamics Engineering

Asking About the Load Profile

$$Q_{Btu/Hr} = 500 \times Flow_{gpm} \times \left(t_{Entering,°F} - t_{Leaving,°F}\right)$$

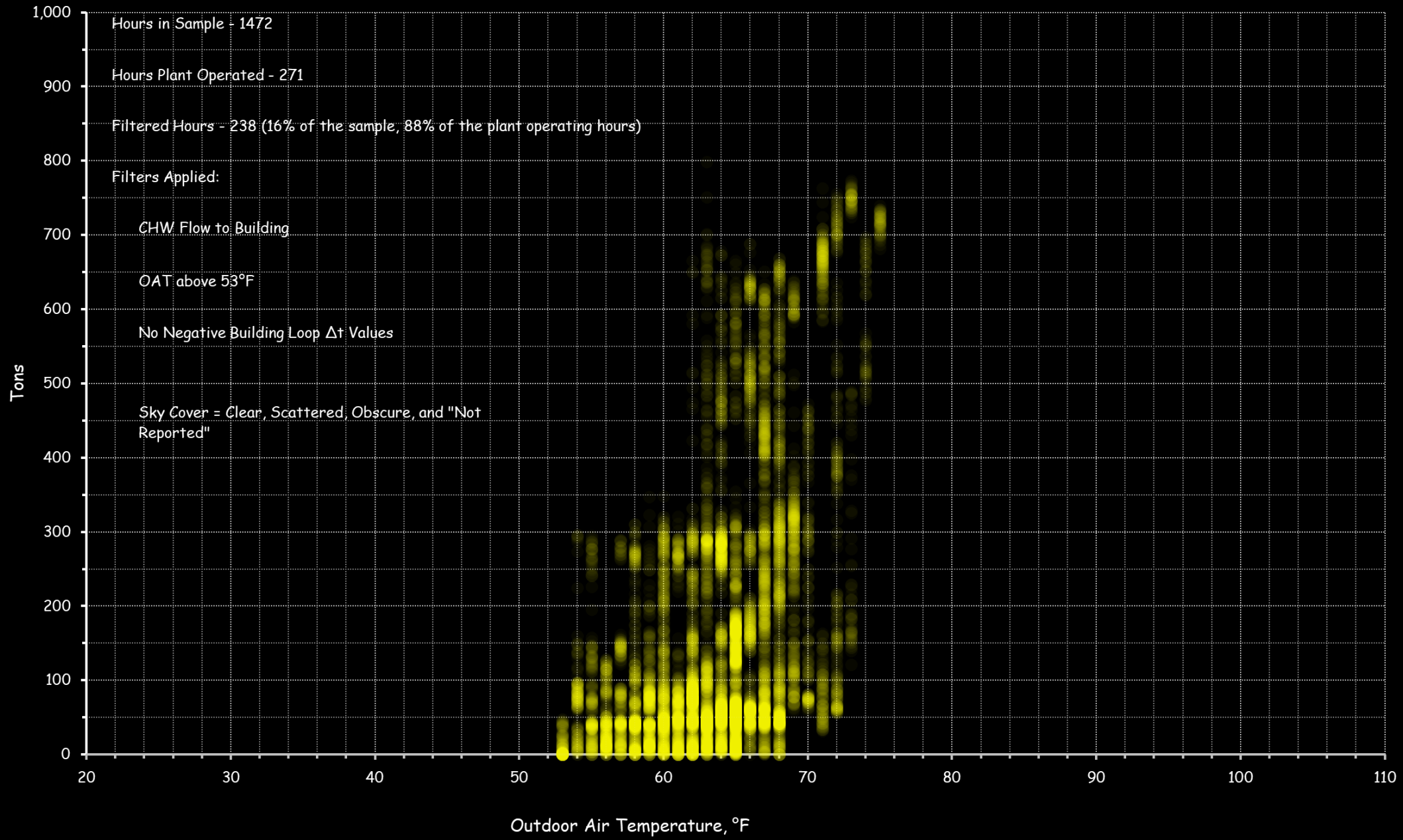
Where:

$Q_{Btu/Hr}$	=	Load in Btu/hr
500	=	Units conversion constant, good for water between 30 and 200°F
$Flow_{gpm}$	=	Flow through the heat exchanger in gallons per minute
$t_{Entering,°F}$	=	Temperature entering in °F
$t_{Leaving,°F}$	=	Temperature leaaving in °F



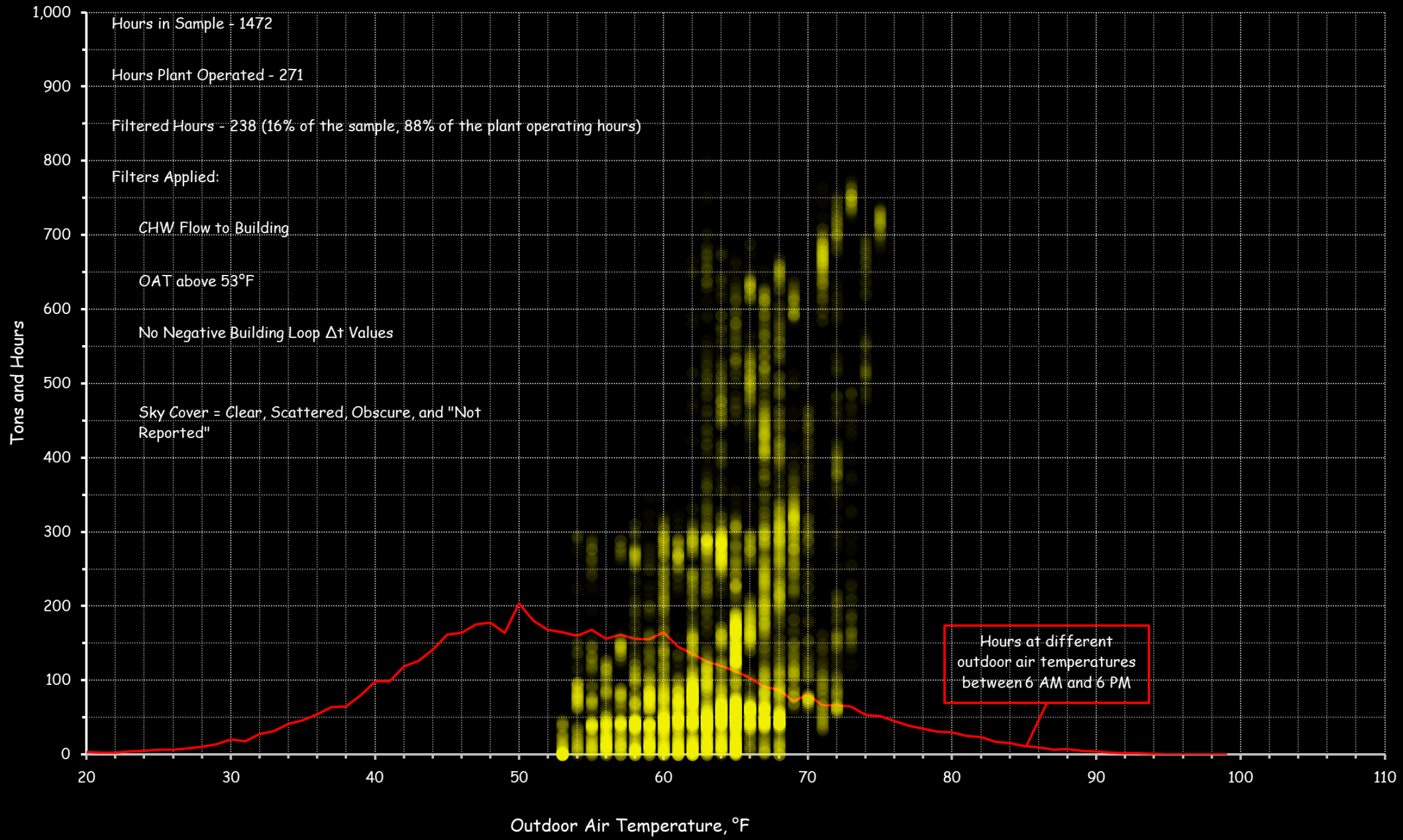
Central Plant Tons vs. Outdoor Temperature

Thursday 09/24/15 12:00 AM through Monday 12/07/15 11:59 PM



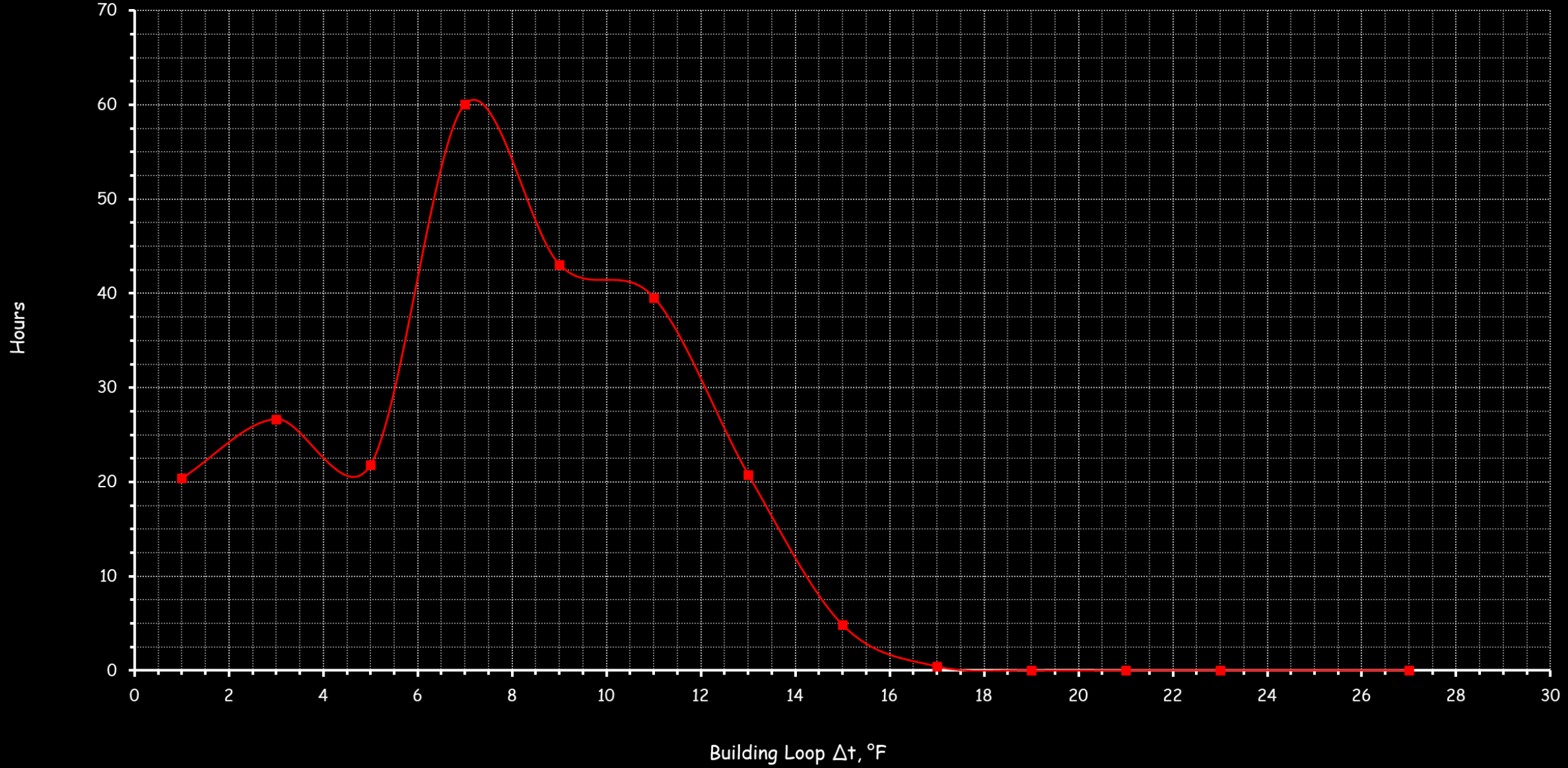
Central Plant Tons vs. Outdoor Temperature

Thursday 09/24/15 12:00 AM through Monday 12/07/15 11:59 PM

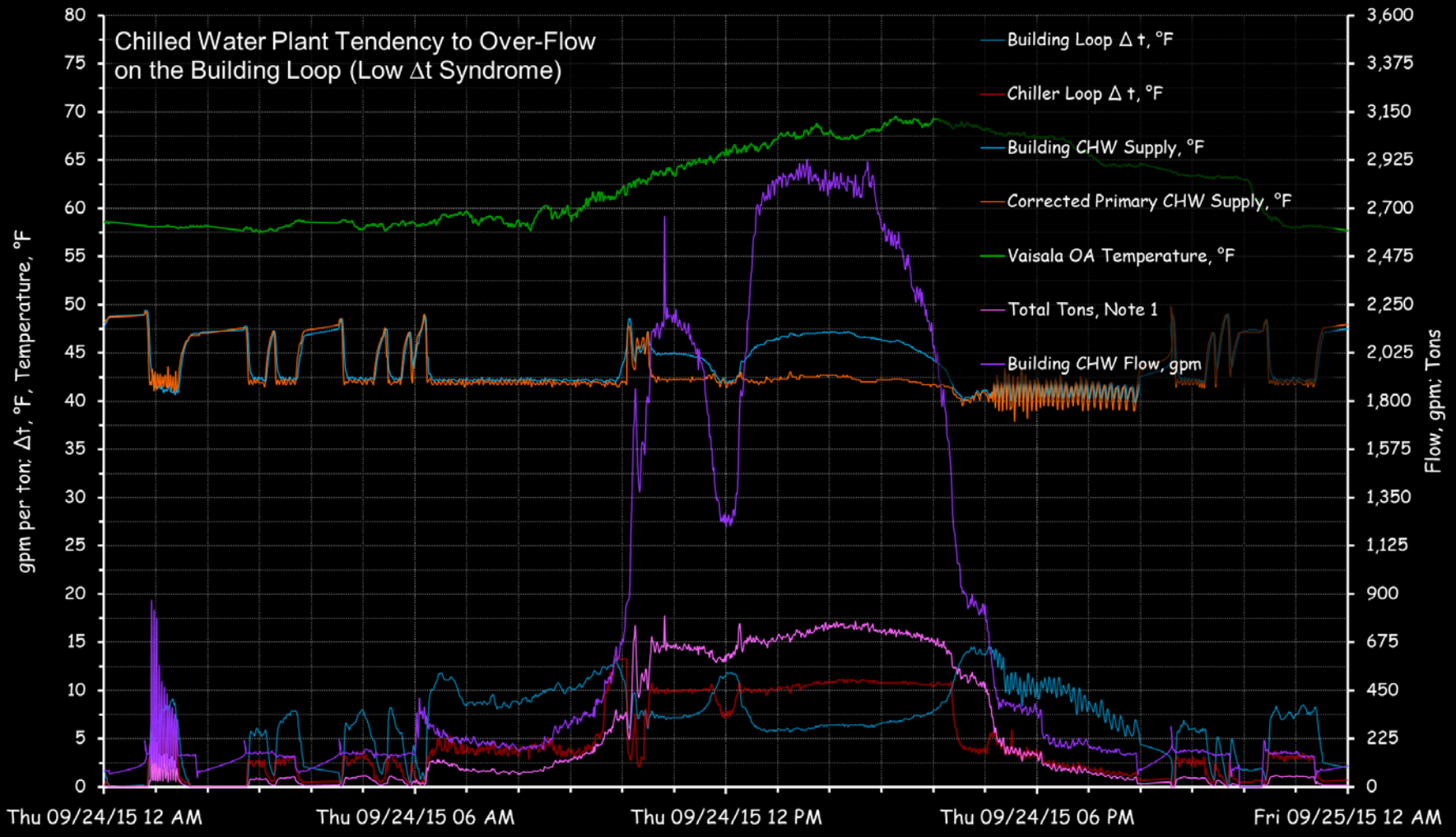


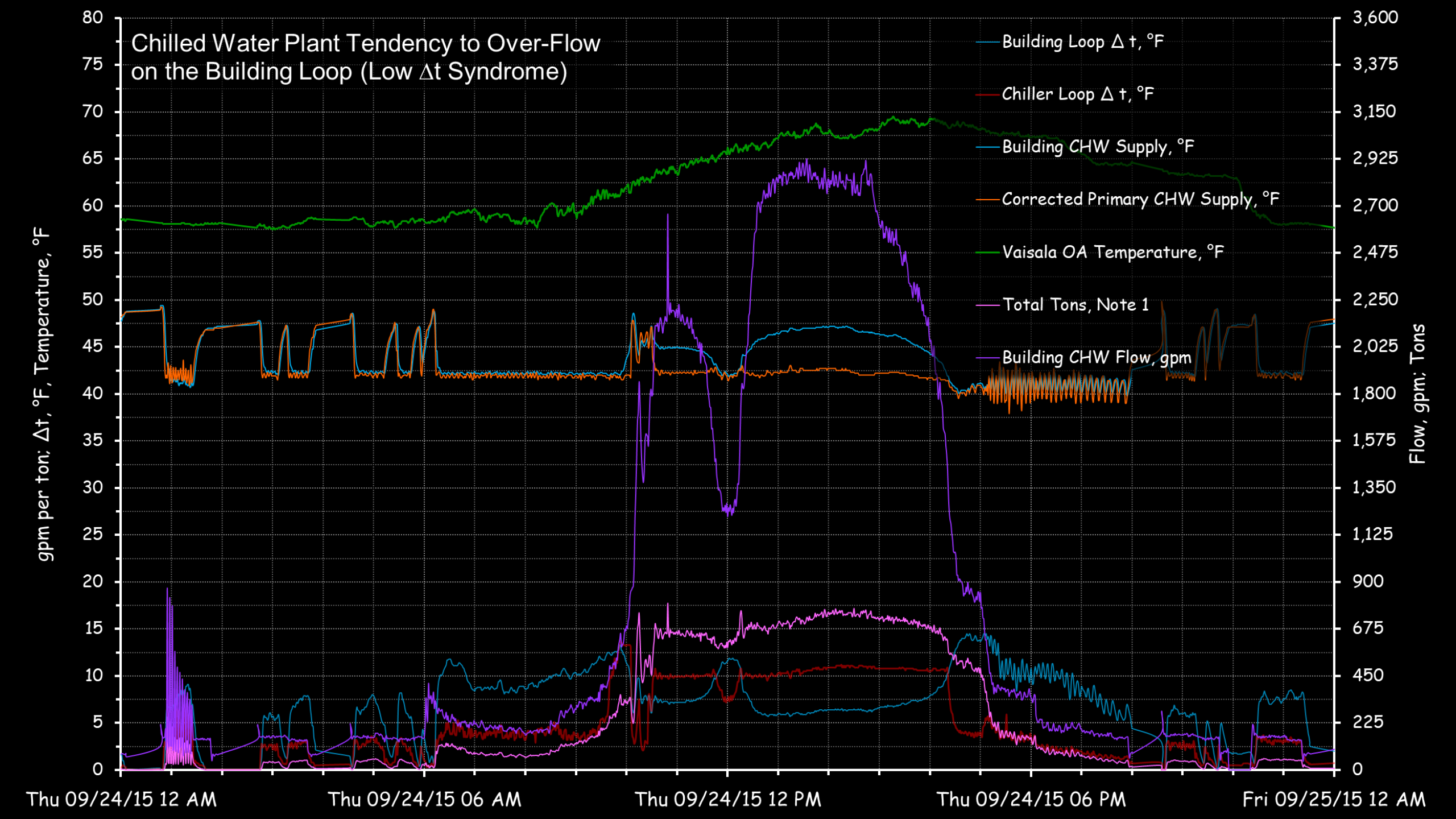
Hours vs. Building Loop Δt

Thursday 09/24/15 12:00 AM through Monday 12/07/15 11:59 PM



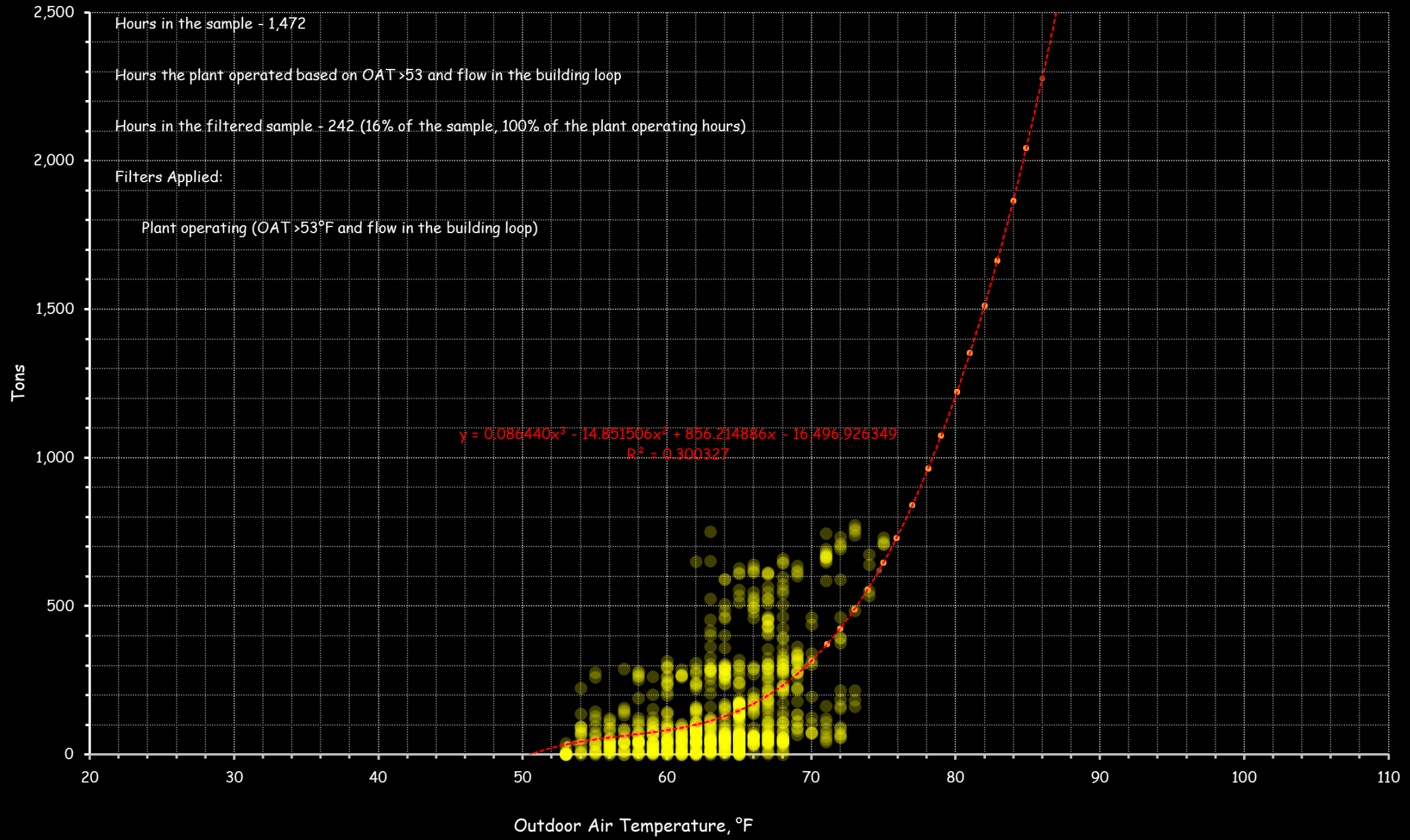
A Low Delta-T Event

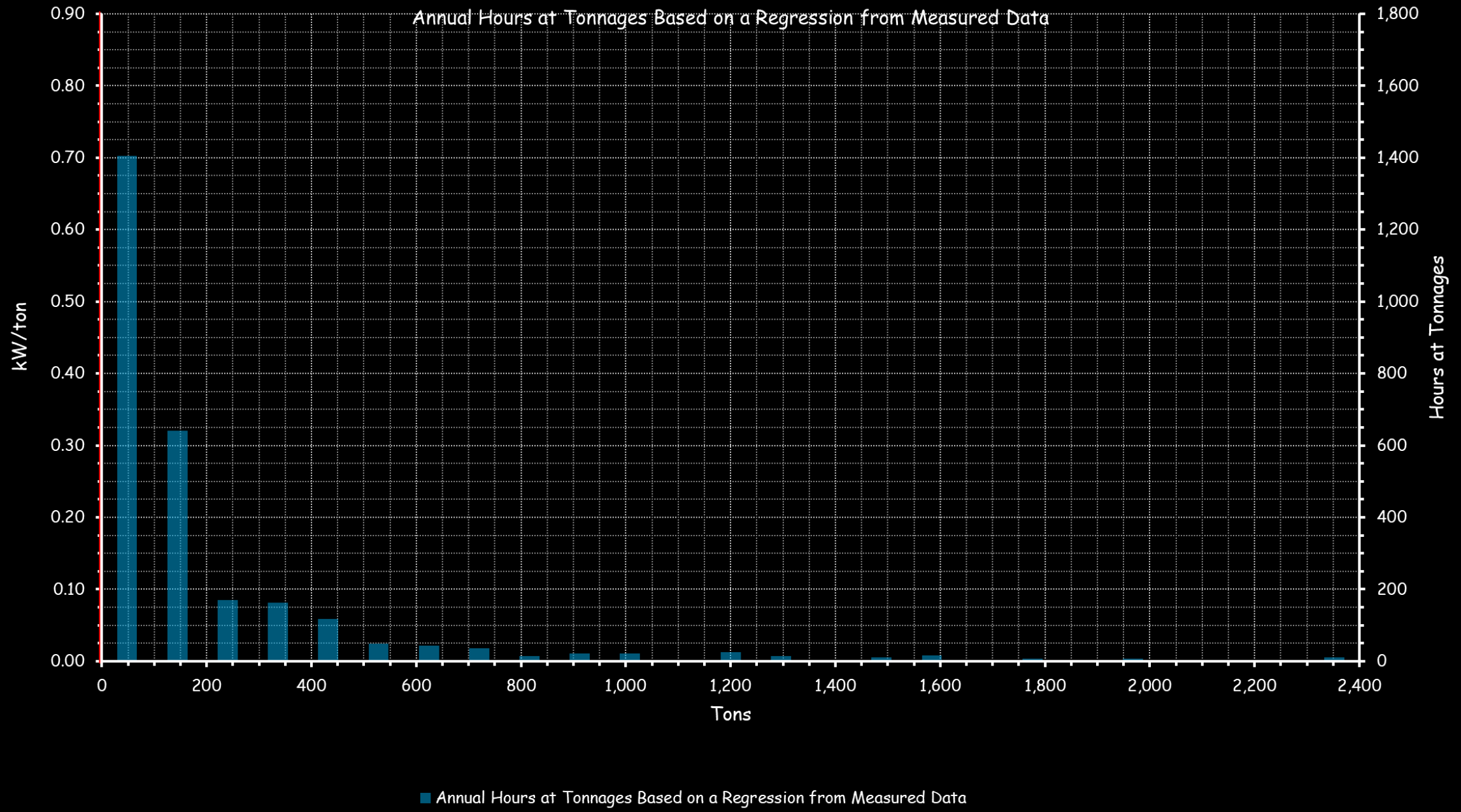


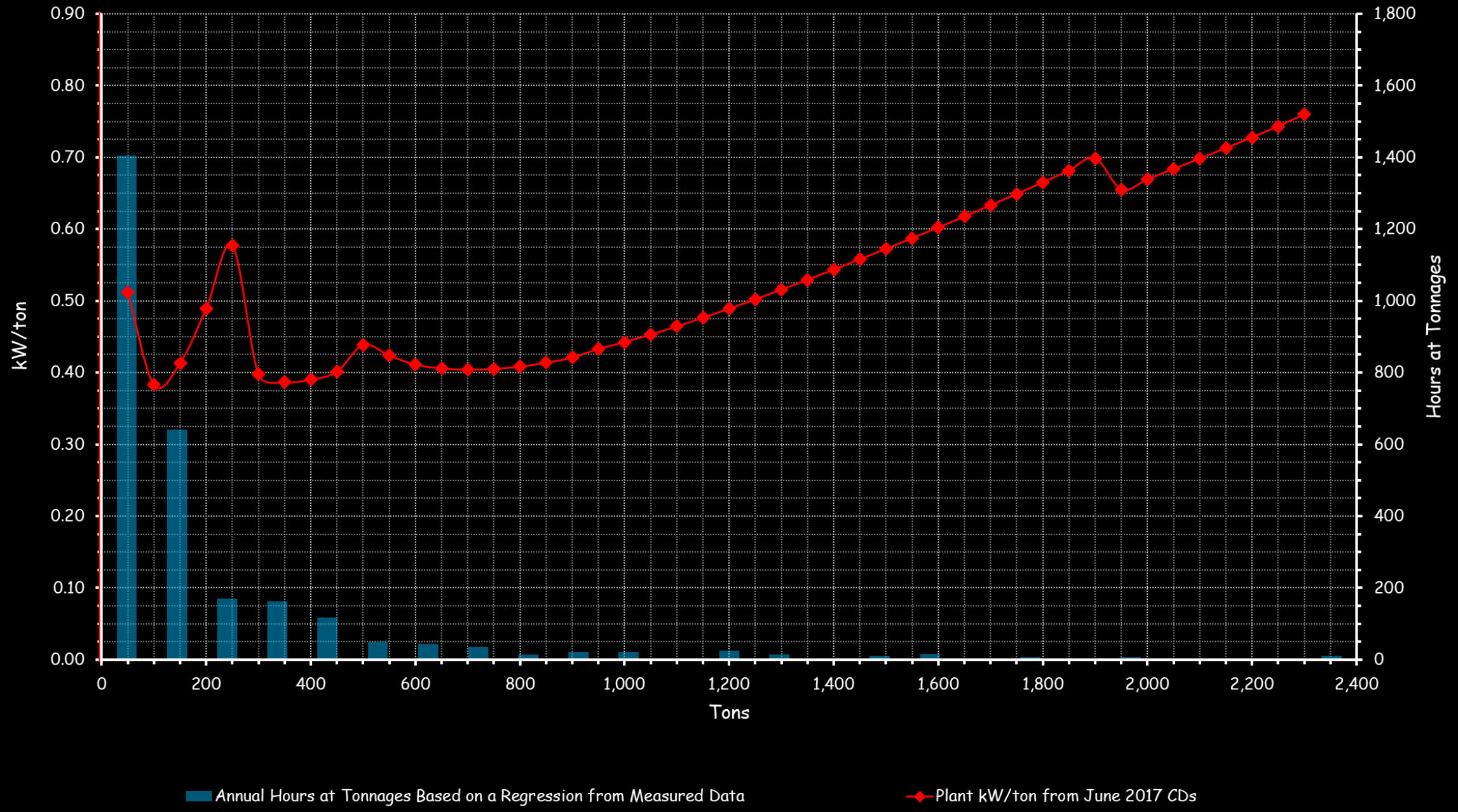

Chilled Water Plant Tendency to Over-Flow
on the Building Loop (Low Δt Syndrome)
Building Loop Δ t, °F
Chiller Loop Δ t, °F
Building CHW Supply, °F
Corrected Primary CHW Supply, °F
Vaisala OA Temperature, °F
Total Tons, Note 1
Building CHW Flow, gpm
gpm per ton; Δt, °F, Temperature, °F
Flow, gpm; Tons
80
75
70
65
60
55
50
45
40
35
30
25
20
15
10
5
0
3,600
3,375
3,150
2,925
2,700
2,475
2,250
2,025
1,800
1,575
1,350
1,125
900
675
450
225
0
Thu 09/24/15 12 AM
Thu 09/24/15 06 AM
Thu 09/24/15 12 PM
Thu 09/24/15 06 PM
Fri 09/25/15 12 AM

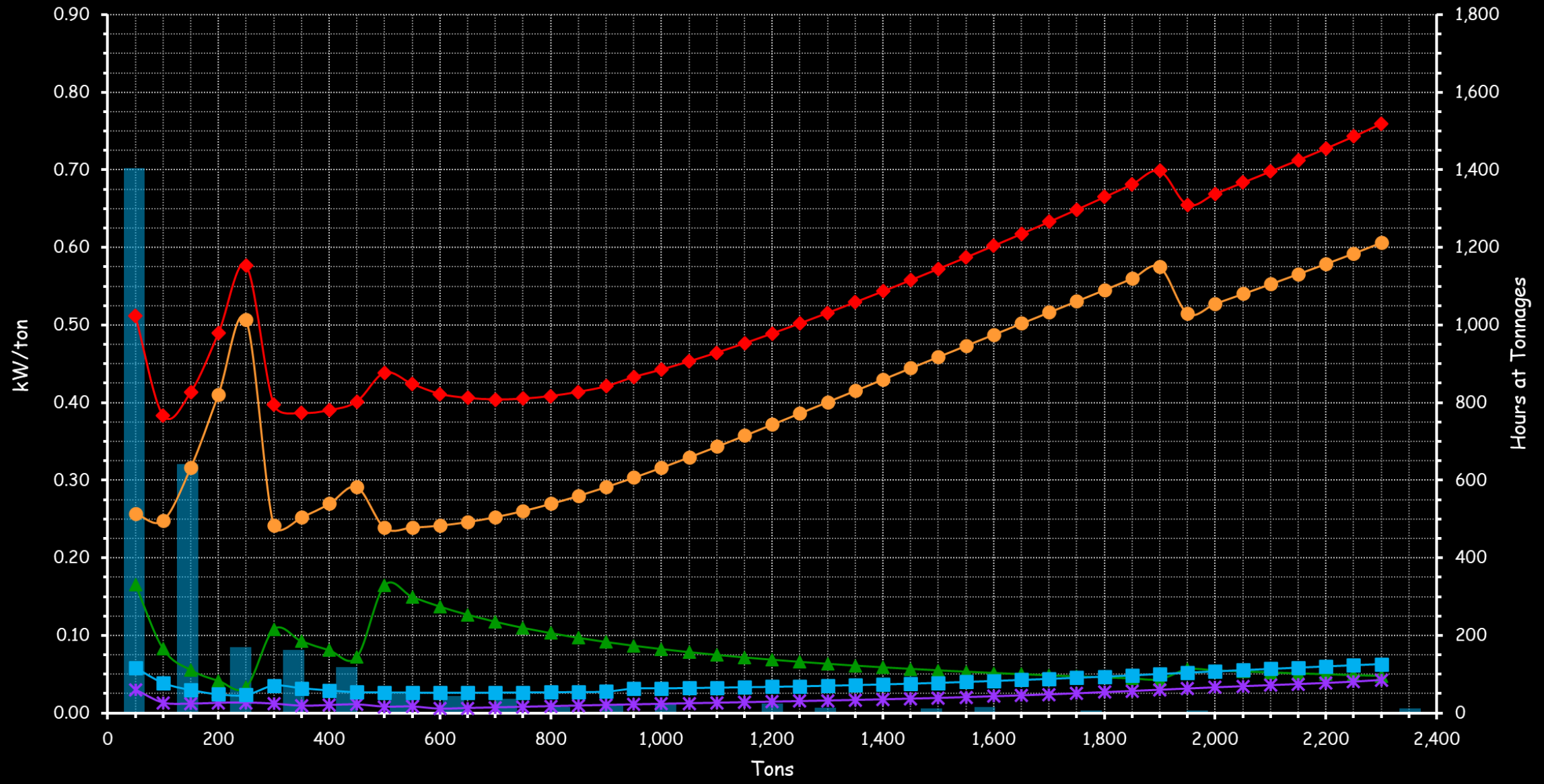
Central Plant Tons vs. Outdoor Temperature

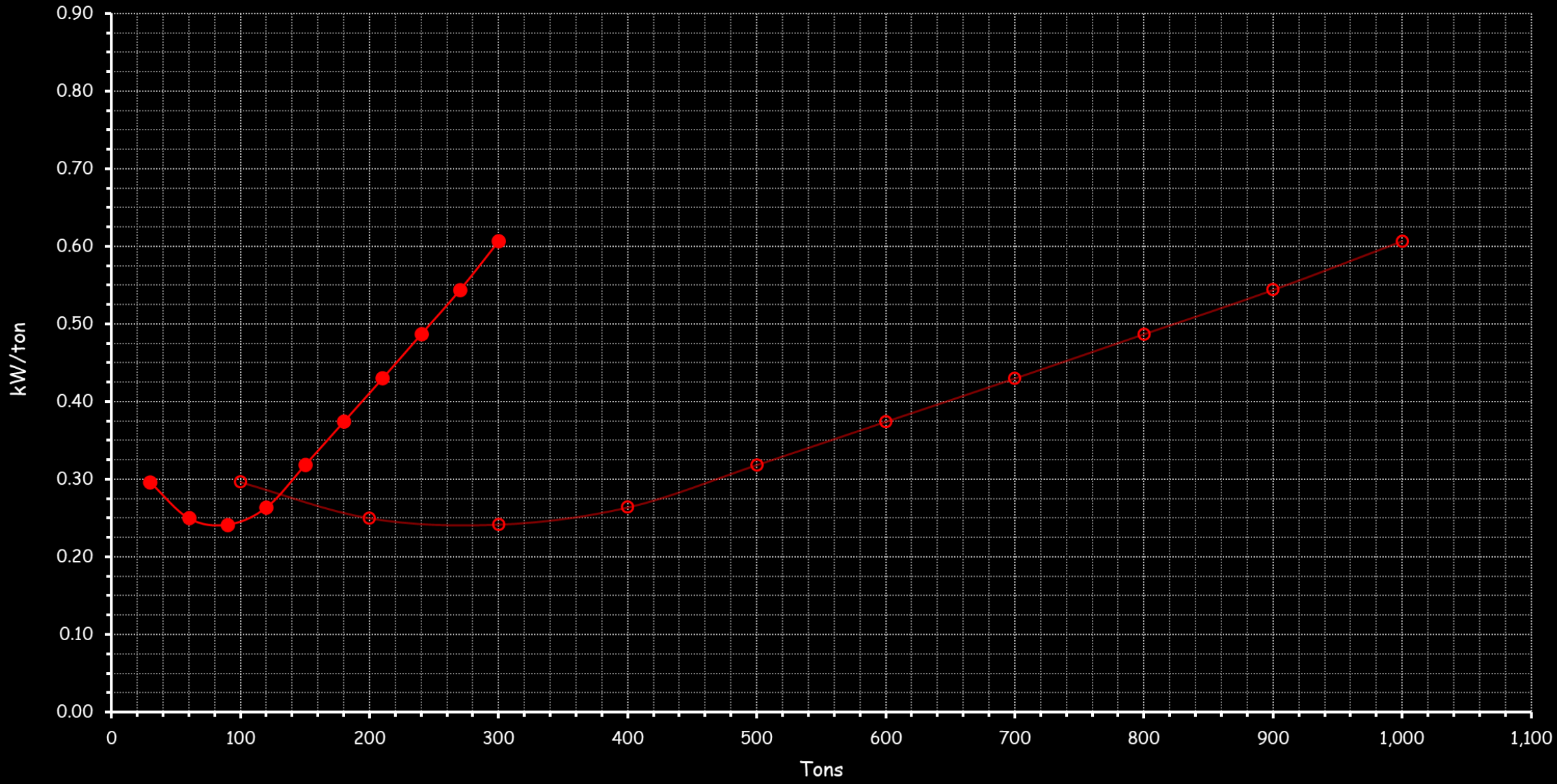
Thursday 09/24/15 12:00 AM through Monday 12/07/15 11:45 PM

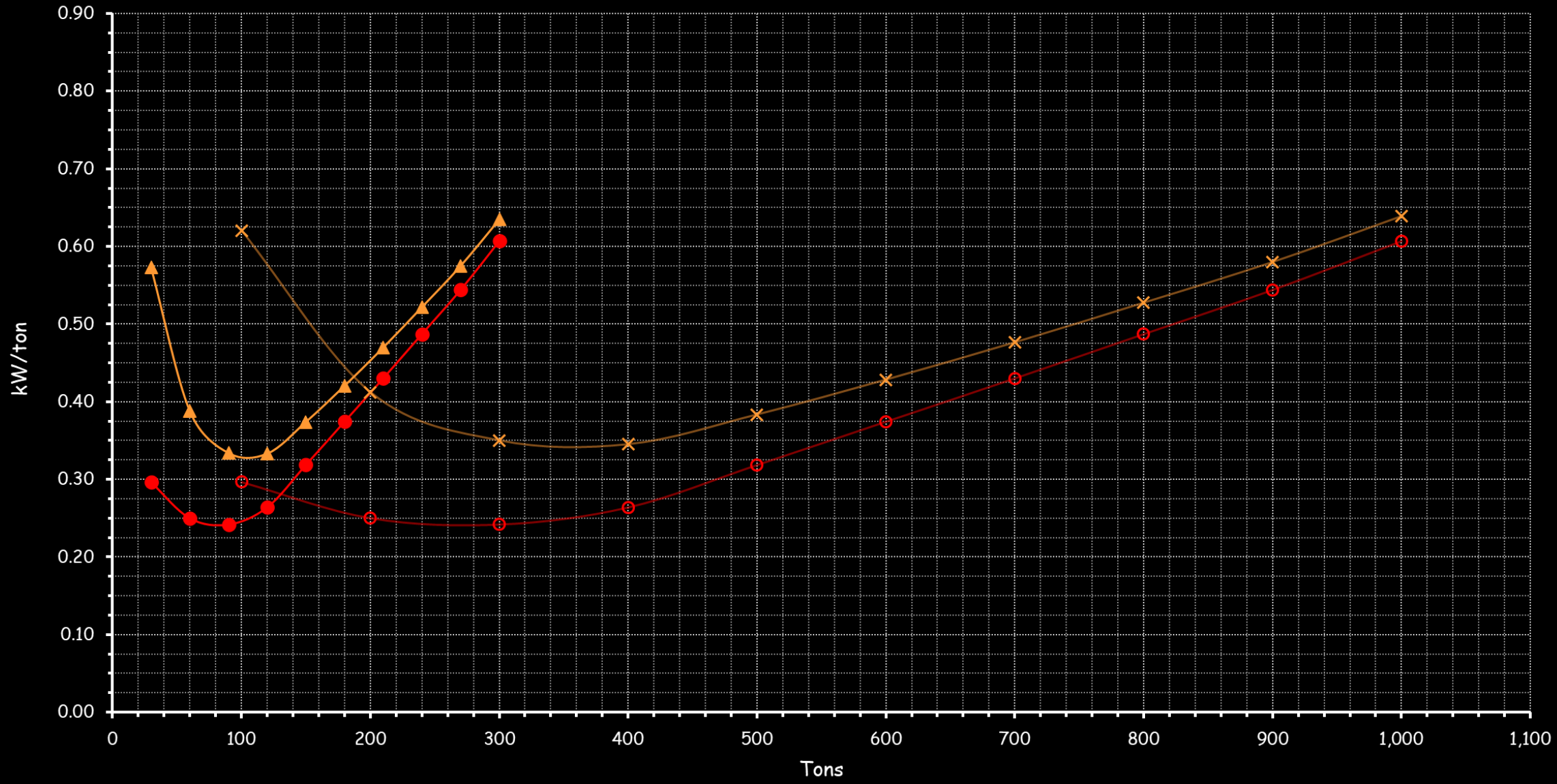


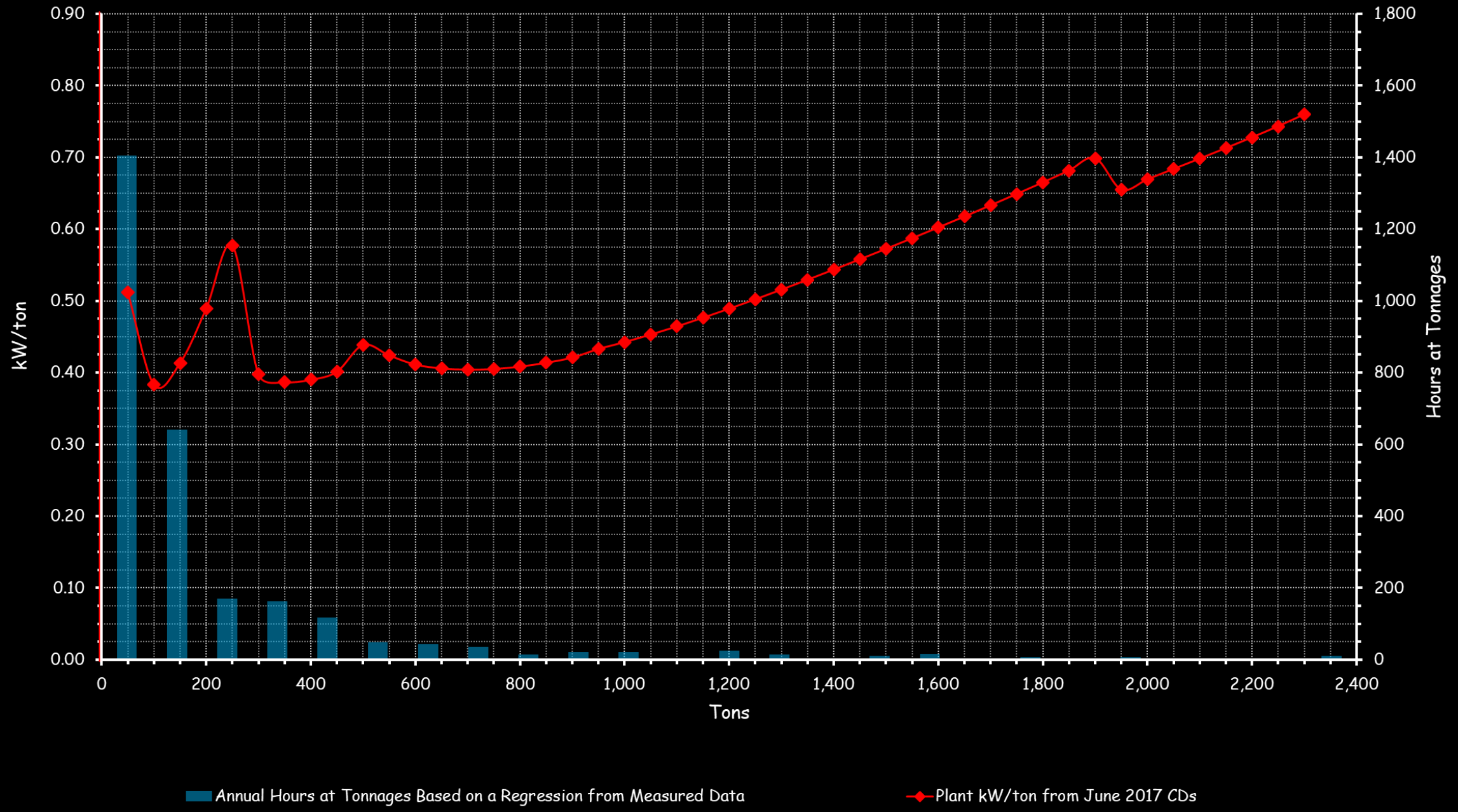

Annual Hours at Tonnages Based on a Regression from Measured Data
kW/ton
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
Hours at Tonnages
1,800
1,600
1,400
1,200
1,000
800
600
400
200
0
0
200
400
600
800
1,000
1,200
1,400
1,600
1,800
2,000
2,200
2,400
Tons
Annual Hours at Tonnages Based on a Regression from Measured Data

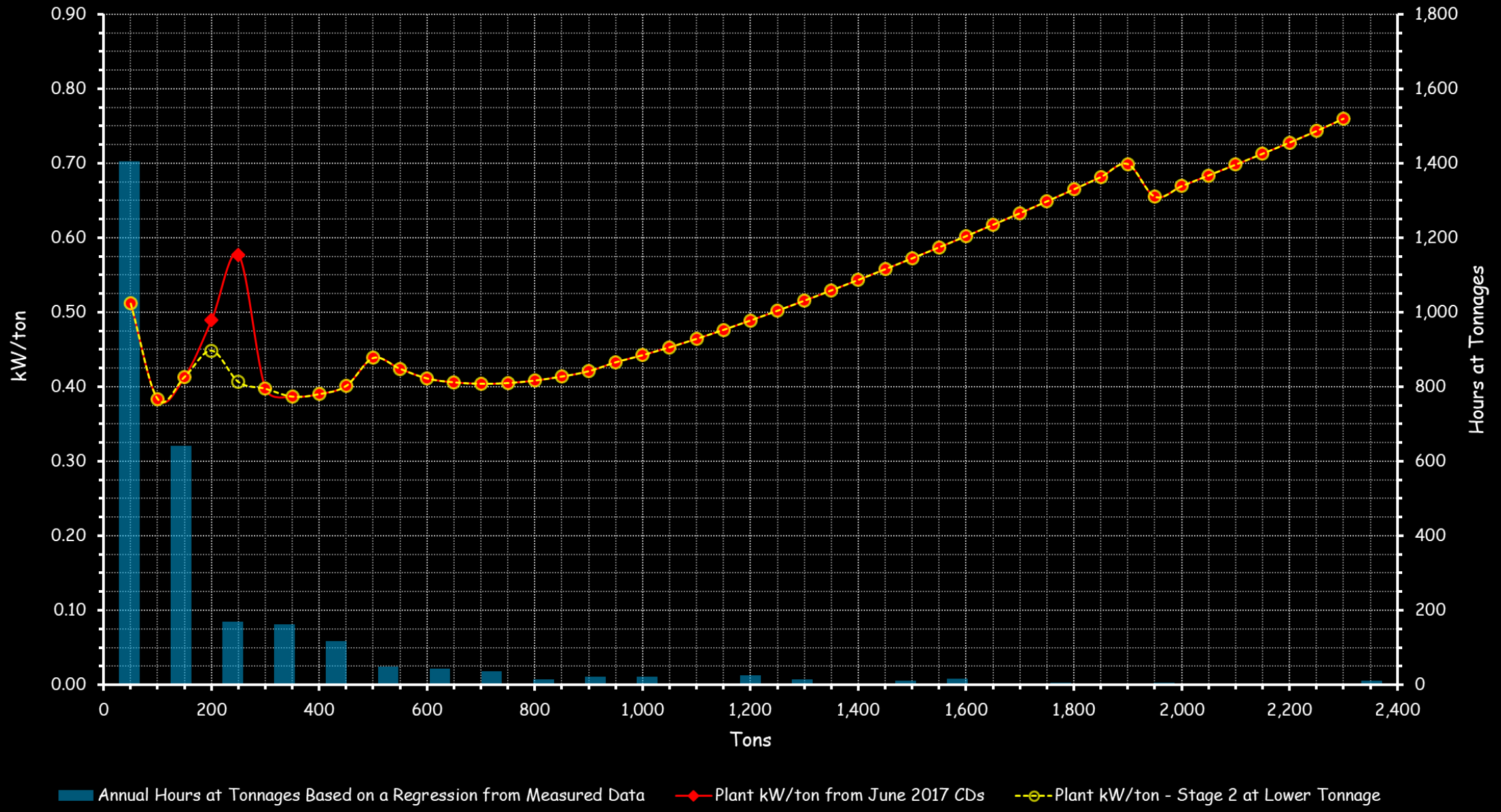

0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
kW/ton
1,800
1,600
1,400
1,200
1,000
800
600
400
200
0
Hours at Tonnages
0
200
400
600
800
1,000
1,200
1,400
1,600
1,800
2,000
2,200
2,400
Tons
Annual Hours at Tonnages Based on a Regression from Measured Data
Plant kW/ton from June 2017 CDs

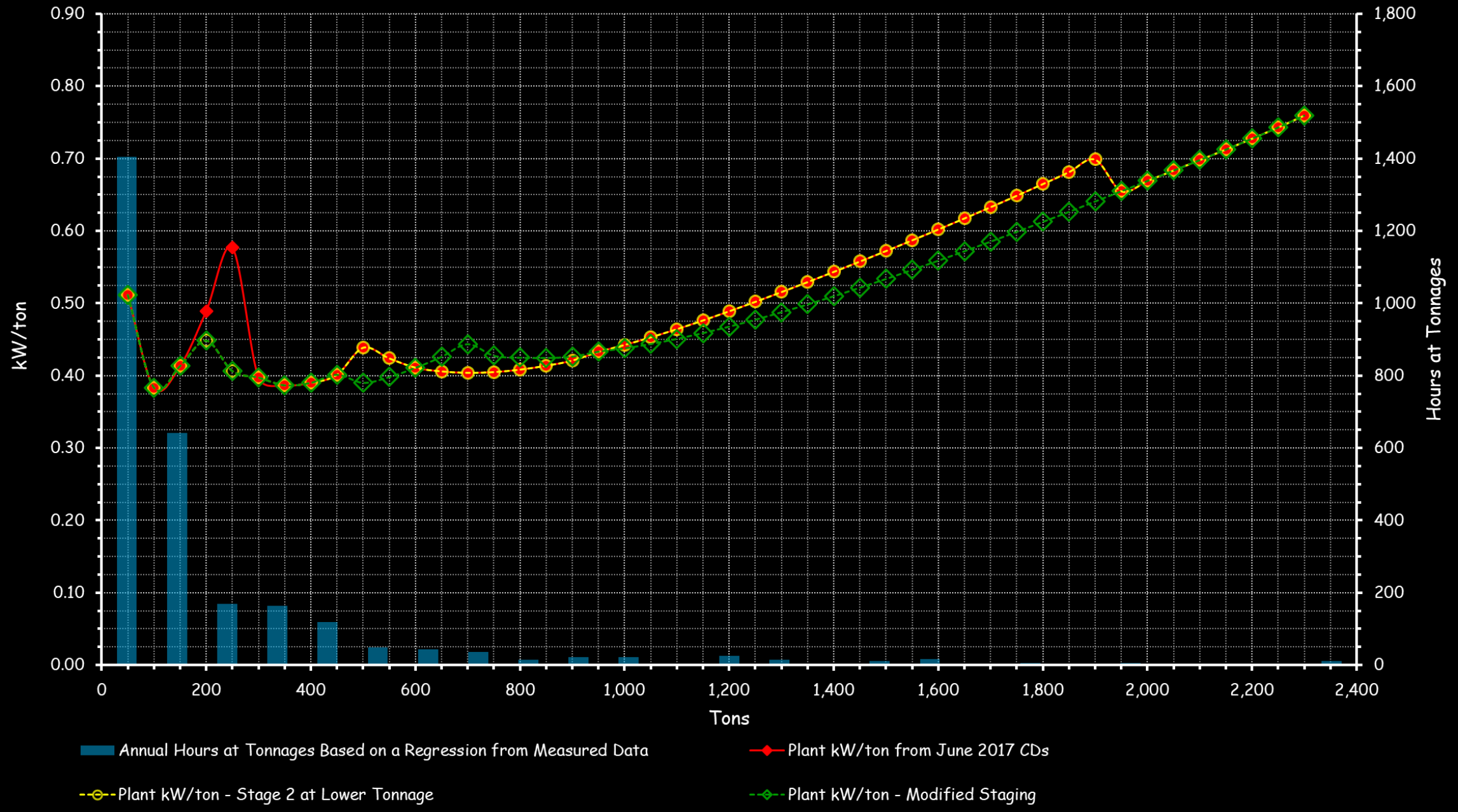

0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
kW/ton
1,800
1,600
1,400
1,200
1,000
800
600
400
200
0
Hours at Tonnages
0
200
400
600
800
1,000
1,200
1,400
1,600
1,800
2,000
2,200
2,400
Tons
Annual Hours at Tonnages Based on a Regression from Measured Data
Plant kW/ton from June 2017 CDs
Compressor kW/ton
CW Pumps kW/Ton
Cooling Tower Fan kW/Ton
CHW Pump kW/Ton


0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
kW/ton
0
100
200
300
400
500
600
700
800
900
1,000
1,100
Tons
Chiller 1 Compressor kW/ton
Chiller 1 Running with All Chillers kW/ton with CW Pumps
Chiller 1 Running Alone kW/ton with CW Pump
Chiller 1 Running with Chiller 2 or 3 kW/ton with CW Pumps
Chiller 2 Running with Chiller 3 kW/ton with CW Pumps
Chiller 2 or 3 Compressor kW/ton
Chiller 2 or 3 Running with All Chillers kW/ton with CW Pumps
Chiller 2 or 3 Running Alone kW/ton with CW Pump
Chiller 2 or 3 Running with Chiller 1 kW/ton with CW Pumps


0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
kW/ton
0
100
200
300
400
500
600
700
800
900
1,000
1,100
Tons
Chiller 1 Compressor kW/ton
Chiller 2 or 3 Compressor kW/ton
Chiller 1 Running with All Chillers kW/ton with CW Pumps
Chiller 2 or 3 Running with All Chillers kW/ton with CW Pumps
Chiller 1 Running Alone kW/ton with CW Pump
Chiller 2 or 3 Running Alone kW/ton with CW Pump
Chiller 1 Running with Chiller 2 or 3 kW/ton with CW Pumps
Chiller 2 or 3 Running with Chiller 1 kW/ton with CW Pumps
Chiller 2 Running with Chiller 3 kW/ton with CW Pumps


0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
kW/ton
1,800
1,600
1,400
1,200
1,000
800
600
400
200
0
Hours at Tonnages
0
200
400
600
800
1,000
1,200
1,400
1,600
1,800
2,000
2,200
2,400
Tons
Annual Hours at Tonnages Based on a Regression from Measured Data
Plant kW/ton from June 2017 CDs


0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
kW/ton
1,800
1,600
1,400
1,200
1,000
800
600
400
200
0
Hours at Tonnages
0
200
400
600
800
1,000
1,200
1,400
1,600
1,800
2,000
2,200
2,400
Tons
Annual Hours at Tonnages Based on a Regression from Measured Data
Plant kW/ton from June 2017 CDs
Plant kW/ton - Stage 2 at Lower Tonnage


0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
kW/ton
1,800
1,600
1,400
1,200
1,000
800
600
400
200
0
Hours at Tonnages
0
200
400
600
800
1,000
1,200
1,400
1,600
1,800
2,000
2,200
2,400
Tons
Annual Hours at Tonnages Based on a Regression from Measured Data
Plant kW/ton from June 2017 CDs
Plant kW/ton - Stage 2 at Lower Tonnage
Plant kW/ton - Modified Staging