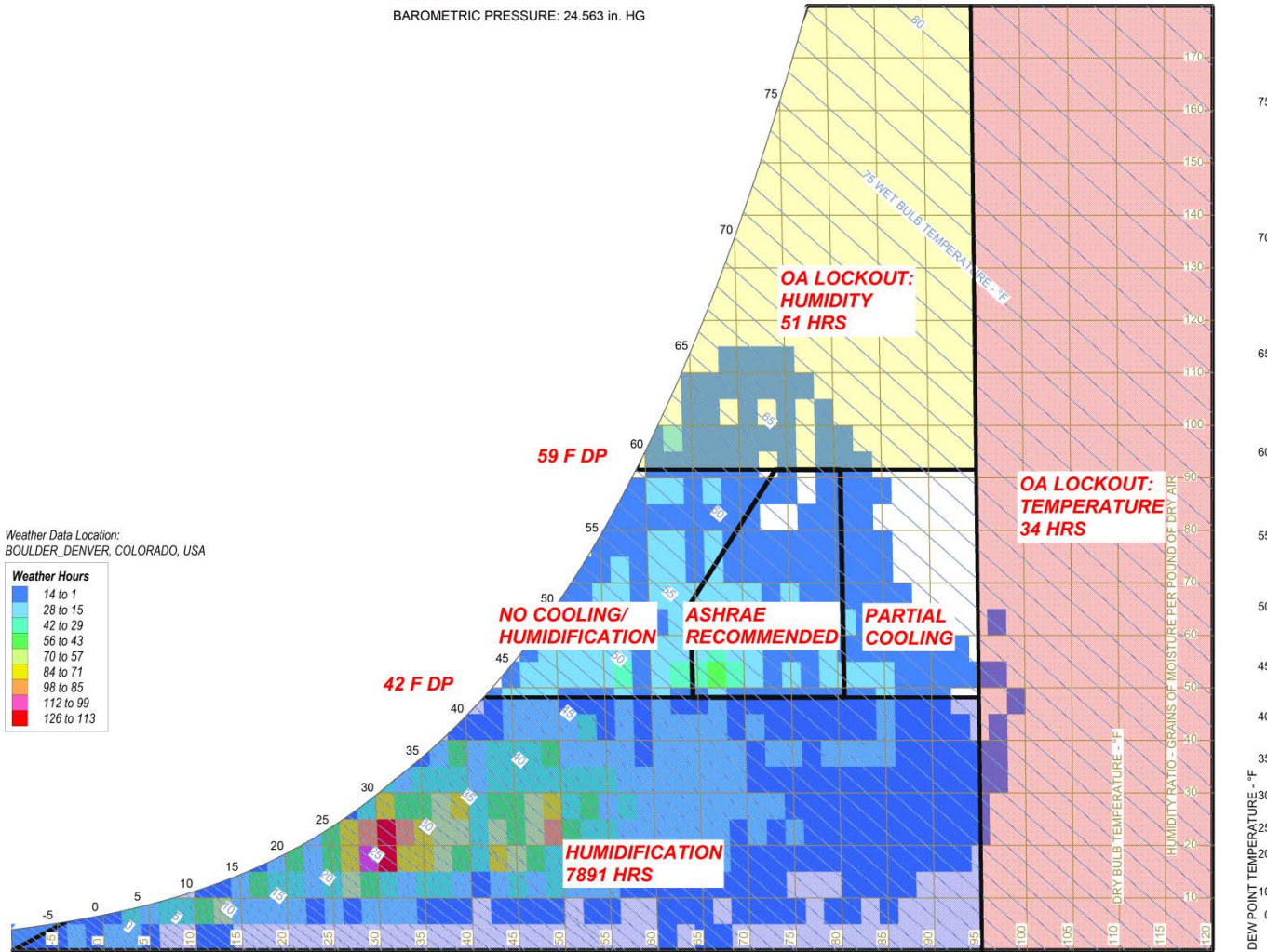


# Air-side Economizer Free Cooling Zones – Denver, CO

PSYCHROMETRIC  
 CHART  
 Normal Temperature  
 I-P Units  
 5360 FEET  
 BAROMETRIC PRESSURE: 24.563 in. HG

Weather Data Location:  
 BOULDER, DENVER, COLORADO, USA

Weather Hours	
Blue	14 to 1
Light Blue	28 to 15
Green	42 to 29
Light Green	56 to 43
Yellow	70 to 57
Orange	84 to 71
Red-Orange	98 to 85
Red	112 to 99
Dark Red	126 to 113



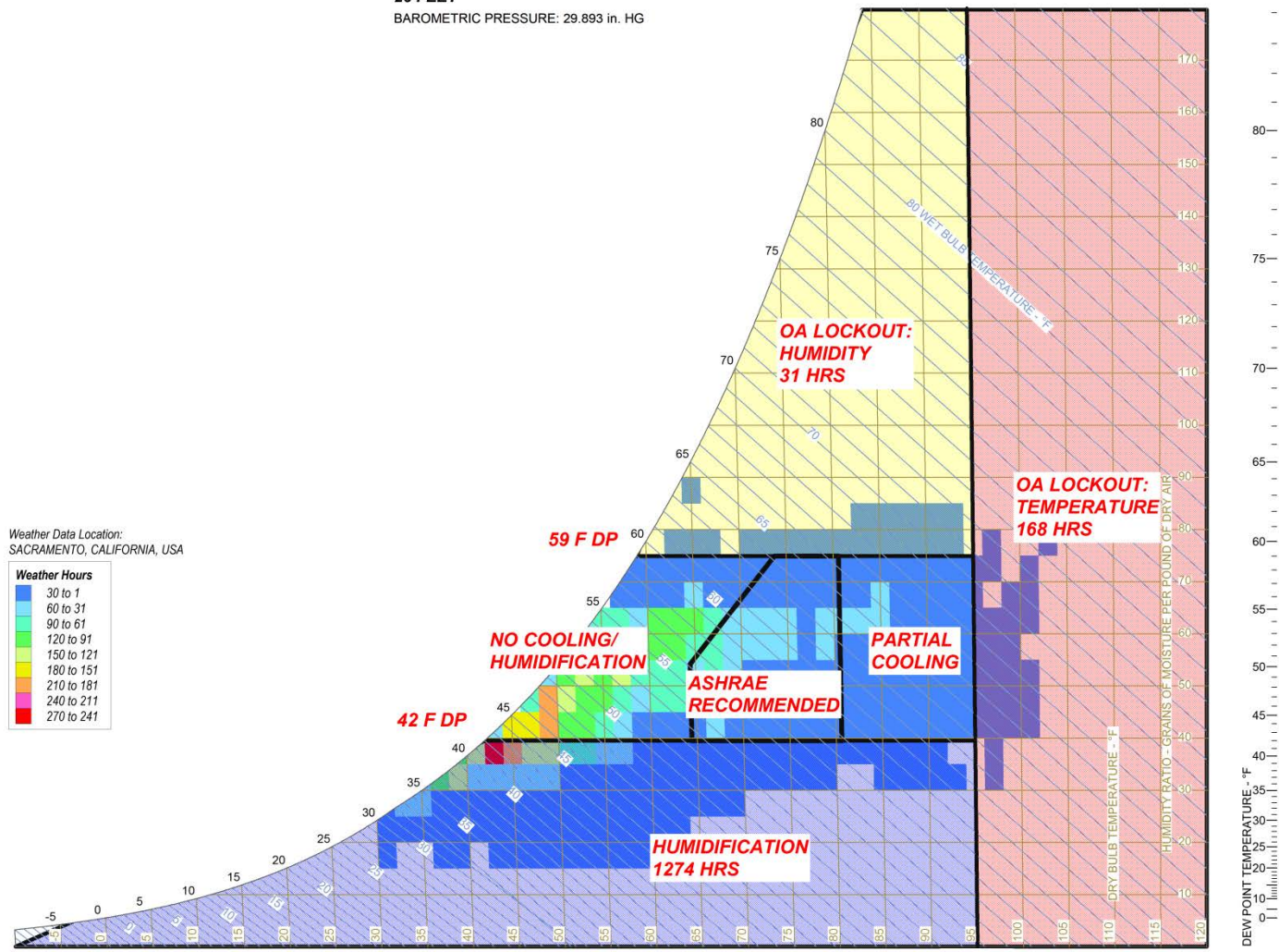
# Air-side Economizer Free Cooling Zones – Sacramento

PSYCHROMETRIC  
 CHART  
 Normal Temperature  
 I-P Units  
 26 FEET  
 BAROMETRIC PRESSURE: 29.893 in. HG

Weather Data Location:  
 SACRAMENTO, CALIFORNIA, USA

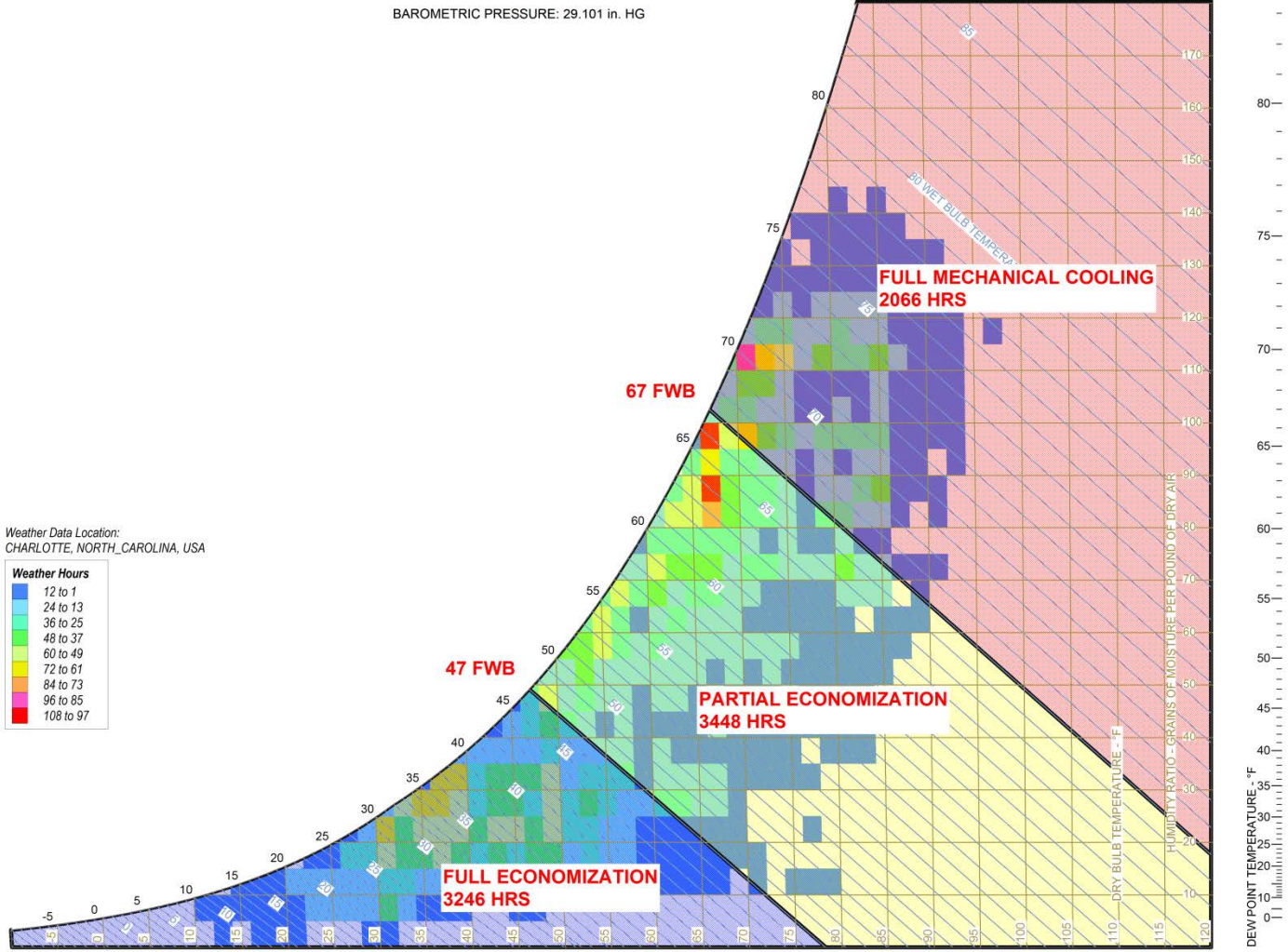
**Weather Hours**

30 to 1
60 to 31
90 to 61
120 to 91
150 to 121
180 to 151
210 to 181
240 to 211
270 to 241



# Water-side Economizer Free Cooling Zones – Charlotte

PSYCHROMETRIC  
 CHART  
 Normal Temperature  
 I-P Units  
 767 FEET  
 BAROMETRIC PRESSURE: 29.101 in. HG



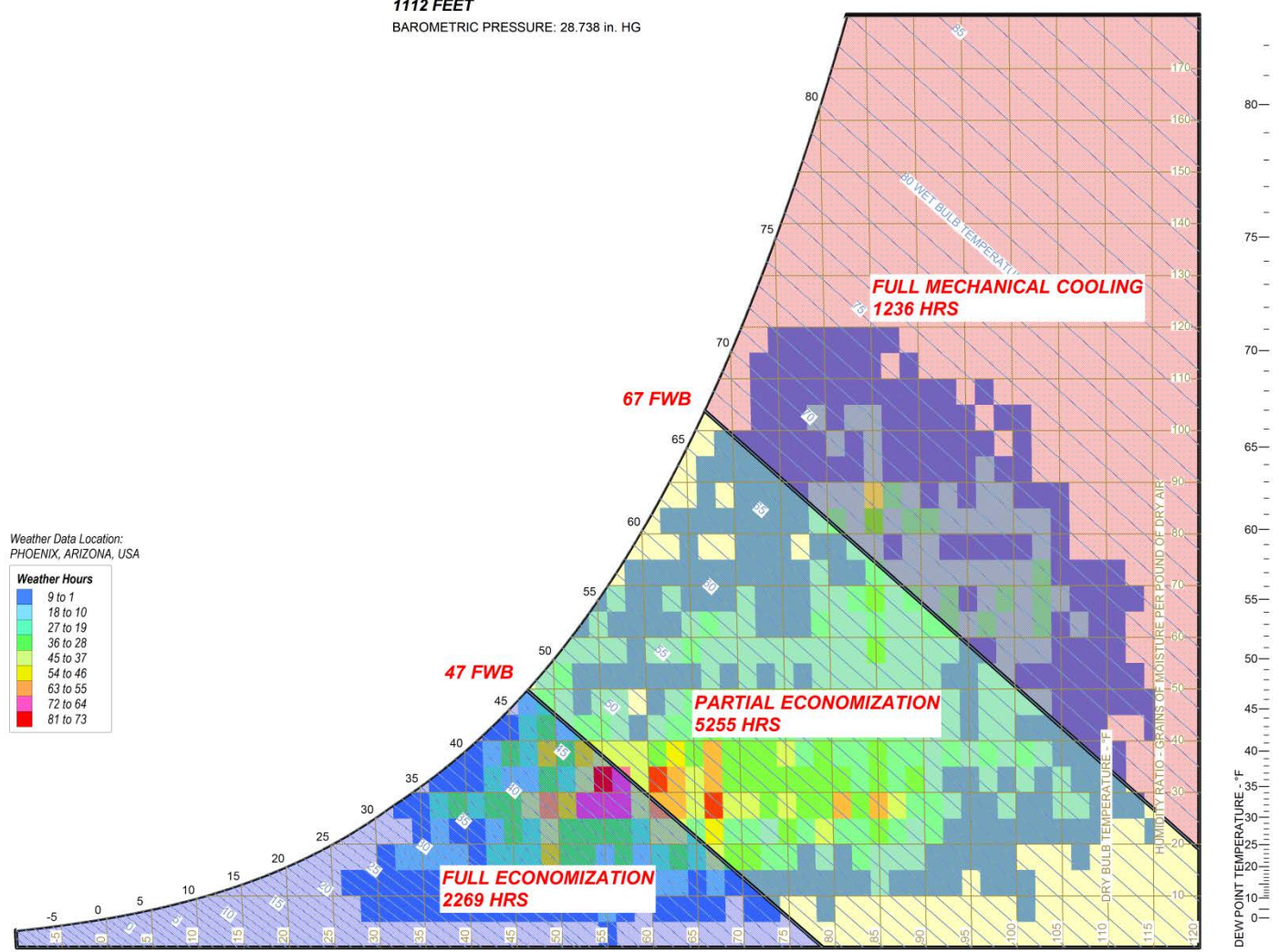
Weather Data Location:  
 CHARLOTTE, NORTH CAROLINA, USA

**Weather Hours**

12 to 1
24 to 13
36 to 25
48 to 37
60 to 49
72 to 61
84 to 73
96 to 85
108 to 97

# Water-side Economizer Free Cooling Zones – Phoenix

PSYCHROMETRIC  
 CHART  
 Normal Temperature  
 I-P Units  
 1112 FEET  
 BAROMETRIC PRESSURE: 28.738 in. HG



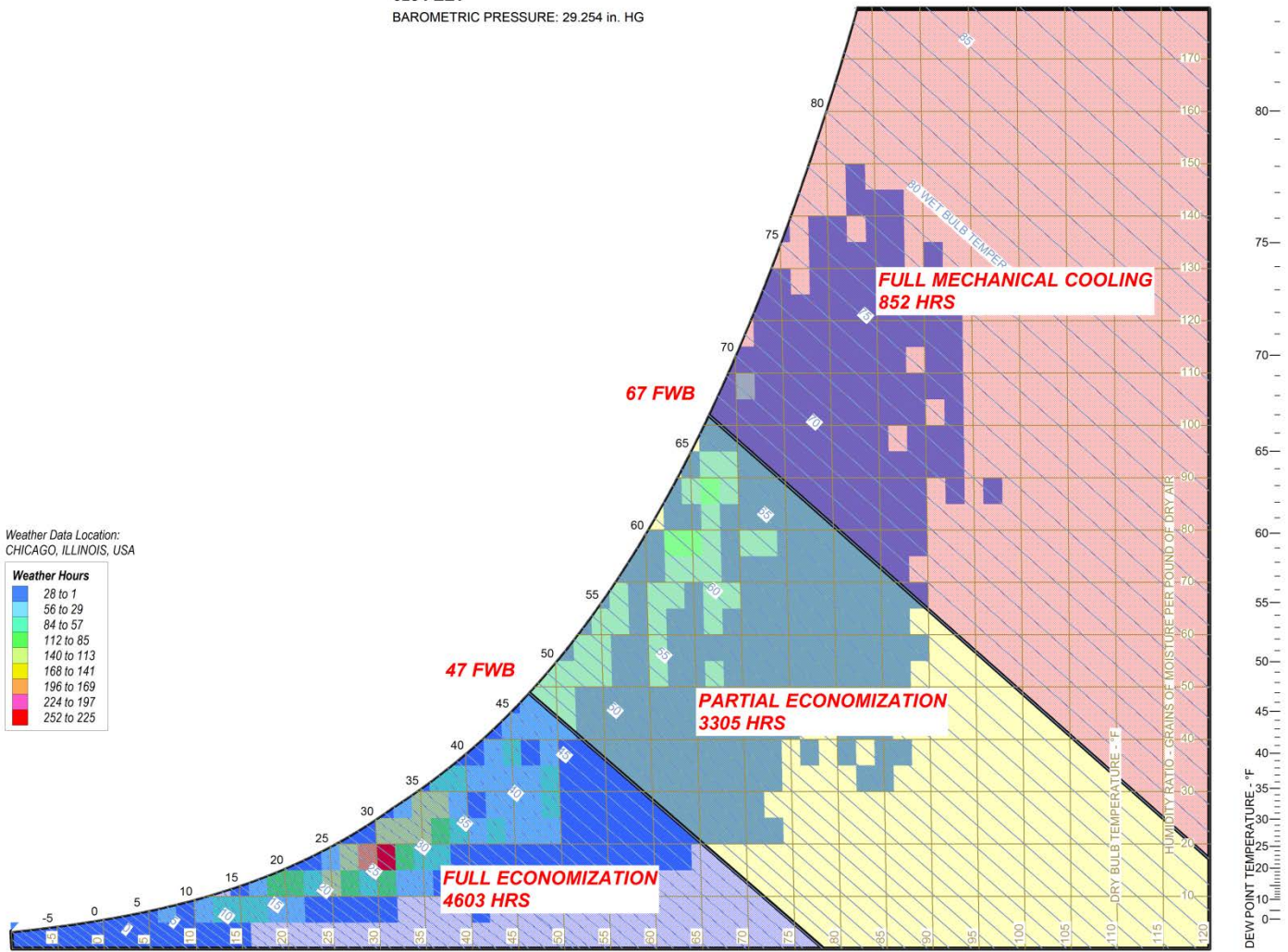
Weather Data Location:  
 PHOENIX, ARIZONA, USA

**Weather Hours**

9 to 1
18 to 10
27 to 19
36 to 28
45 to 37
54 to 46
63 to 55
72 to 64
81 to 73

# Water-side Economizer Free Cooling Zones – Chicago

PSYCHROMETRIC CHART  
 Normal Temperature  
 I-P Units  
 623 FEET  
 BAROMETRIC PRESSURE: 29.254 in. HG



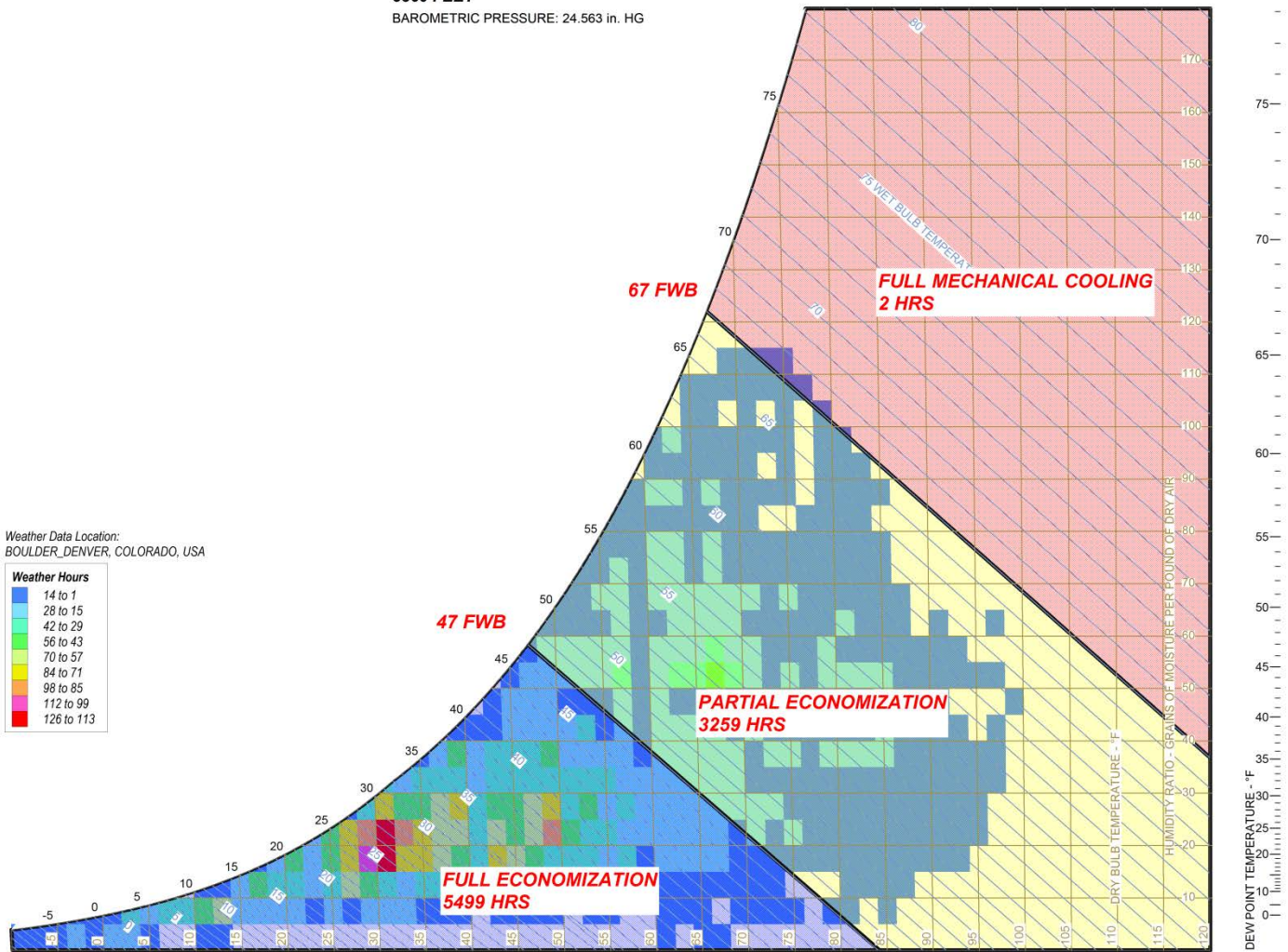
Weather Data Location:  
 CHICAGO, ILLINOIS, USA

**Weather Hours**

Blue	28 to 1
Light Blue	56 to 29
Green	84 to 57
Yellow-Green	112 to 85
Yellow	140 to 113
Orange	168 to 141
Red-Orange	196 to 169
Red	224 to 197
Dark Red	252 to 225

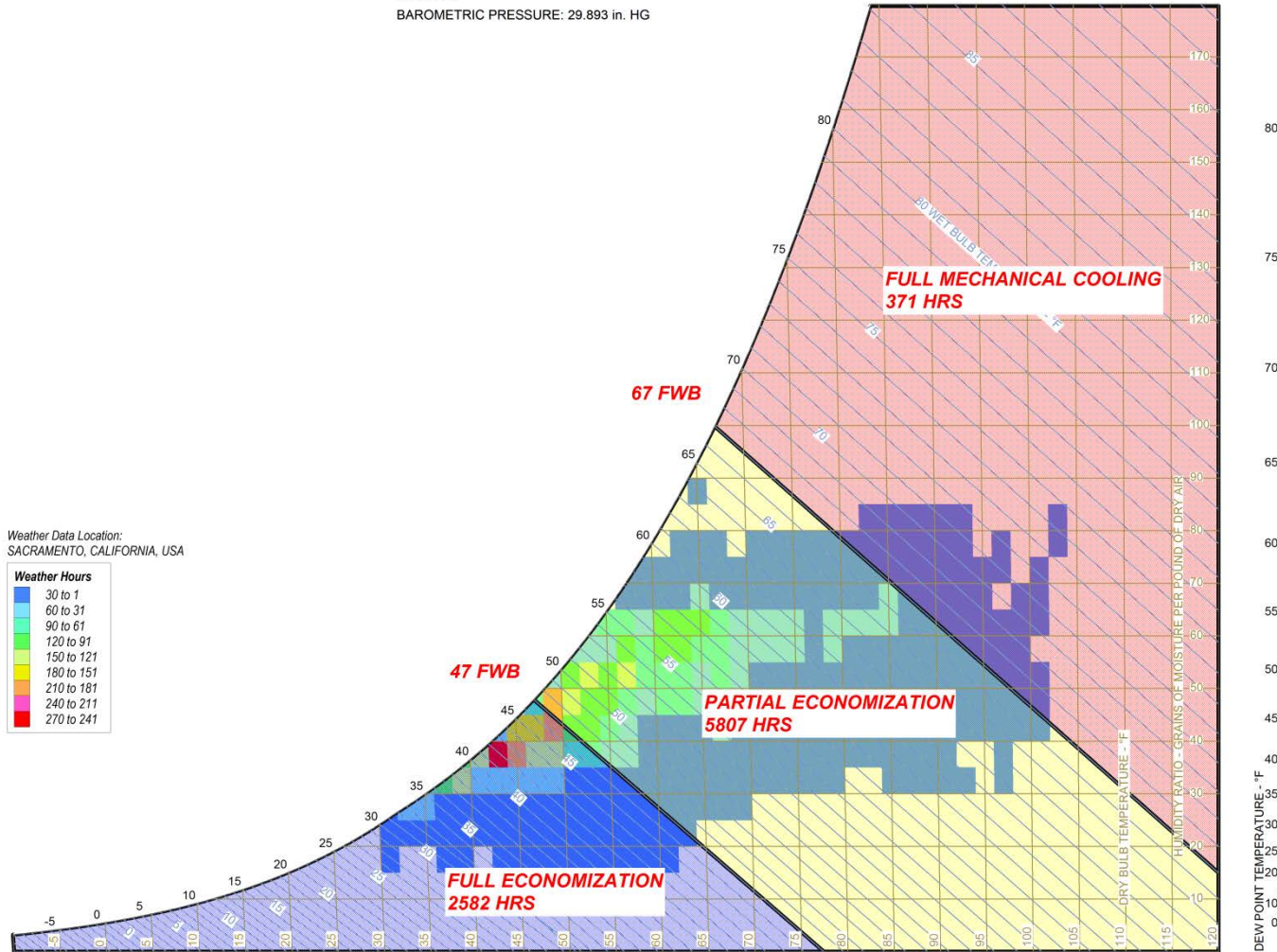
# Water-side Economizer Free Cooling Zones – Denver

PSYCHROMETRIC  
 CHART  
 Normal Temperature  
 I-P Units  
 5360 FEET  
 BAROMETRIC PRESSURE: 24.563 in. HG



# Water-side Economizer Free Cooling Zones – Sacramento

PSYCHROMETRIC  
CHART  
Normal Temperature  
I-P Units  
26 FEET  
BAROMETRIC PRESSURE: 29.893 in. HG



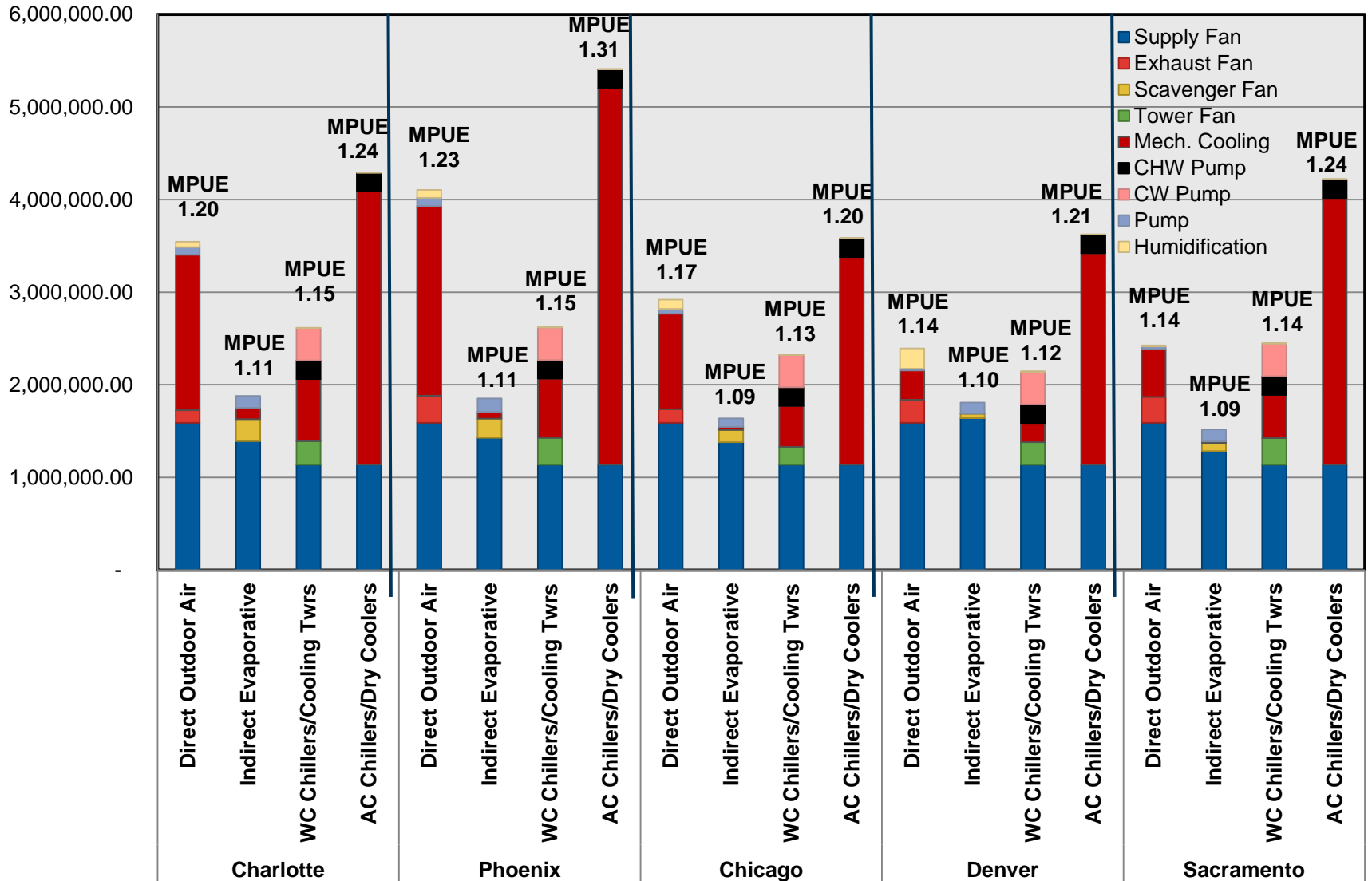
Weather Data Location:  
SACRAMENTO, CALIFORNIA, USA

Weather Hours

Color	Weather Hours
Blue	30 to 1
Light Blue	60 to 31
Light Green	90 to 61
Green	120 to 91
Yellow-Green	150 to 121
Yellow	180 to 151
Orange	210 to 181
Red-Orange	240 to 211
Red	270 to 241

# Annual Power Use Comparison

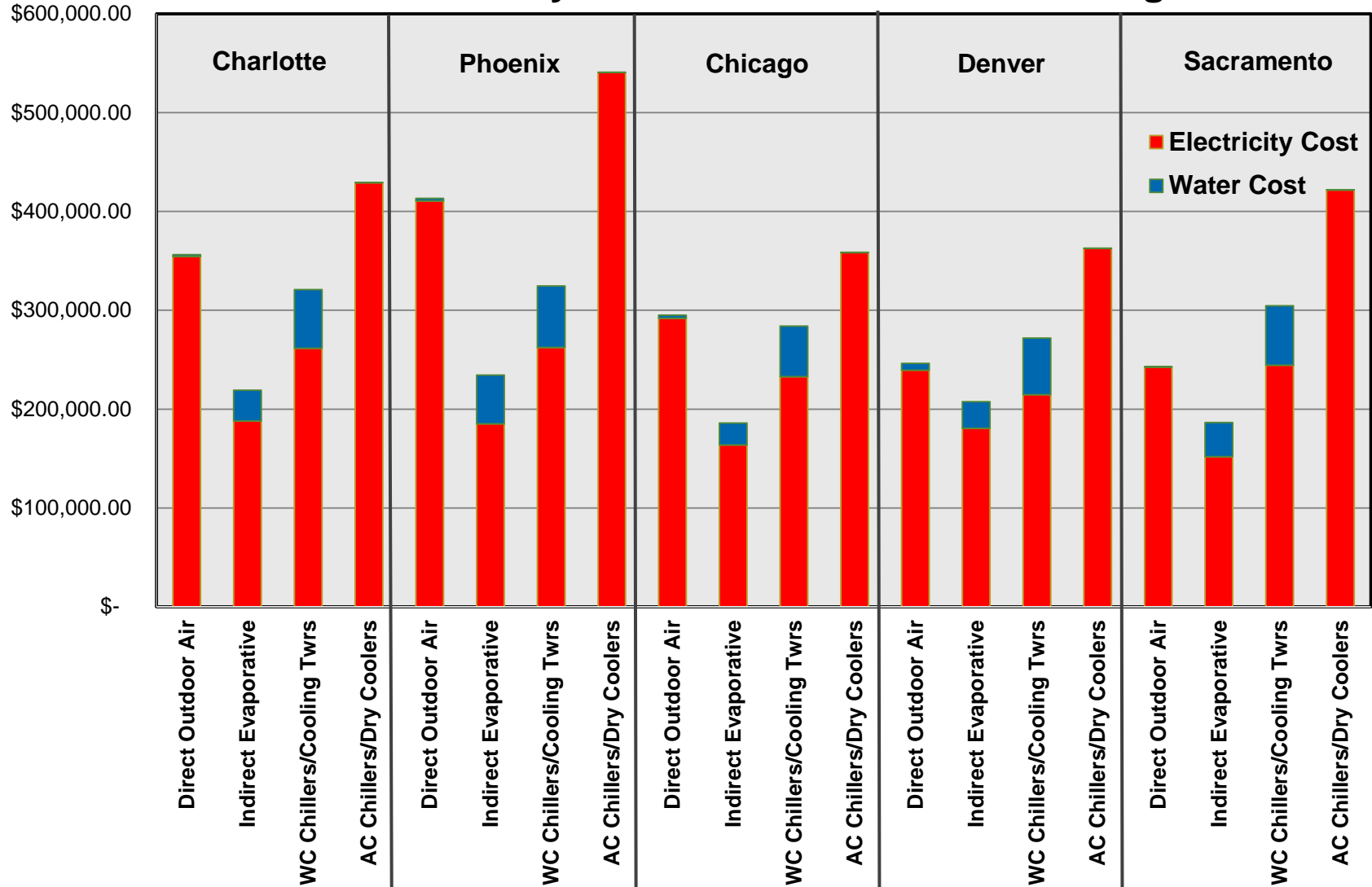
## Annual Power Consumption (kWh) with PUE





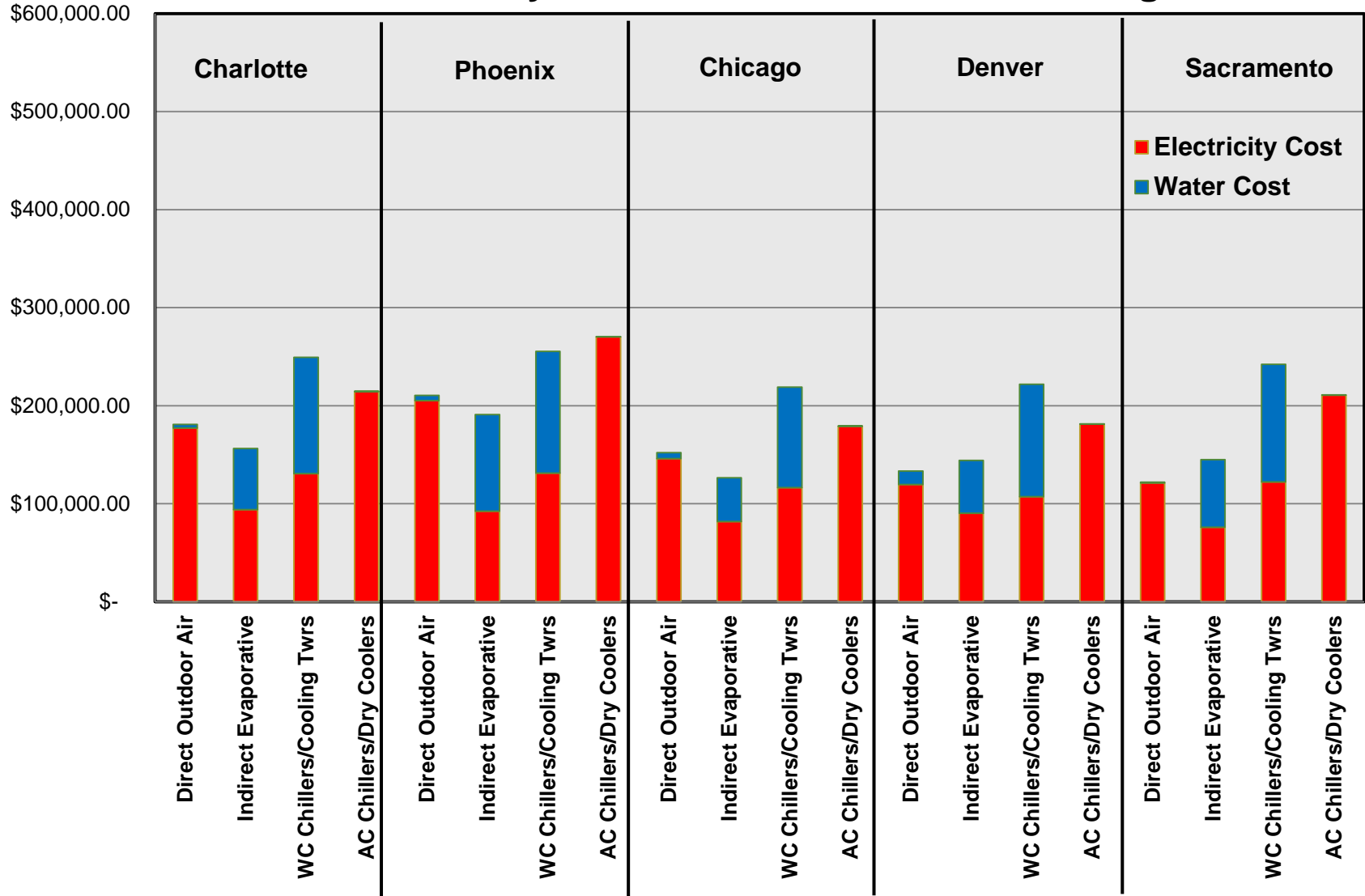
# Annual Utility Cost Comparison - High Electricity Cost / Low Water Cost

**Annual Utility Cost**  
Electricity @ \$.10/kWh Water @ \$5/1000 gal



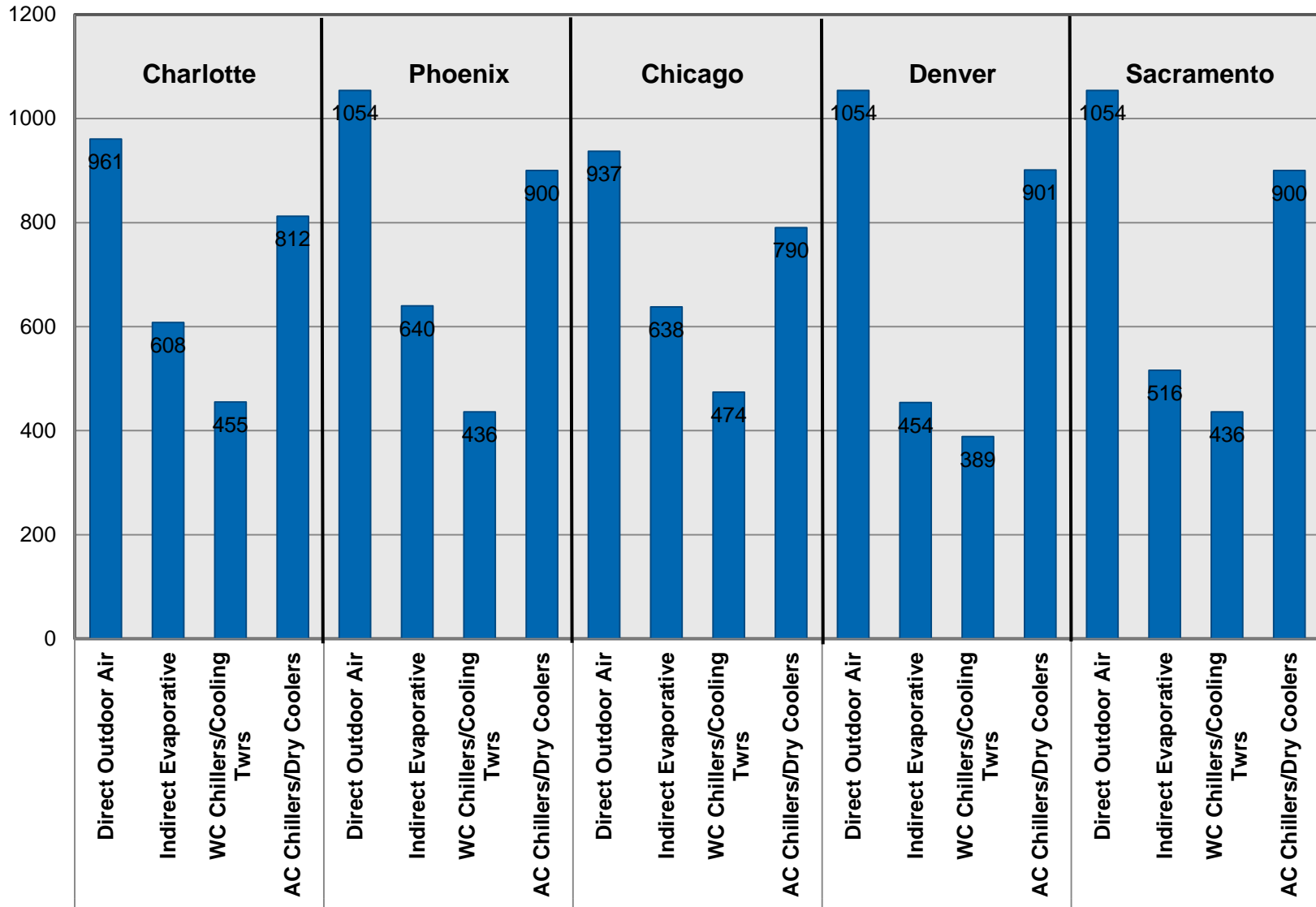
# Annual Utility Cost Comparison - Low Electricity Cost / High Water Cost

**Annual Utility Cost**  
Electricity @ \$.05/kWh Water @ \$10/1000 gal



# Peak Demand Comparison – Power for Mechanical

## Peak Mechanical kW



# Conclusions

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- Though direct outside air economizers are generally considered to be the most efficient way to provide free cooling, there are many factors that may limit their effectiveness, particularly for data centers.
- Indirect evaporative cooling may provide the most attractive solution if water quality, cost and availability is favorable.
- Water-side economizers with efficient chillers can be a very good choice if chillers are optimized for cooler condenser water and access to outside is limited.
- Look closely at the following:
  - Local climate
  - Power and water rates
  - Peak power requirements
  - Filter maintenance
  - Humidity issues