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Boston Green Tourism / Mandarin Oriental Hotel April 28, 2016

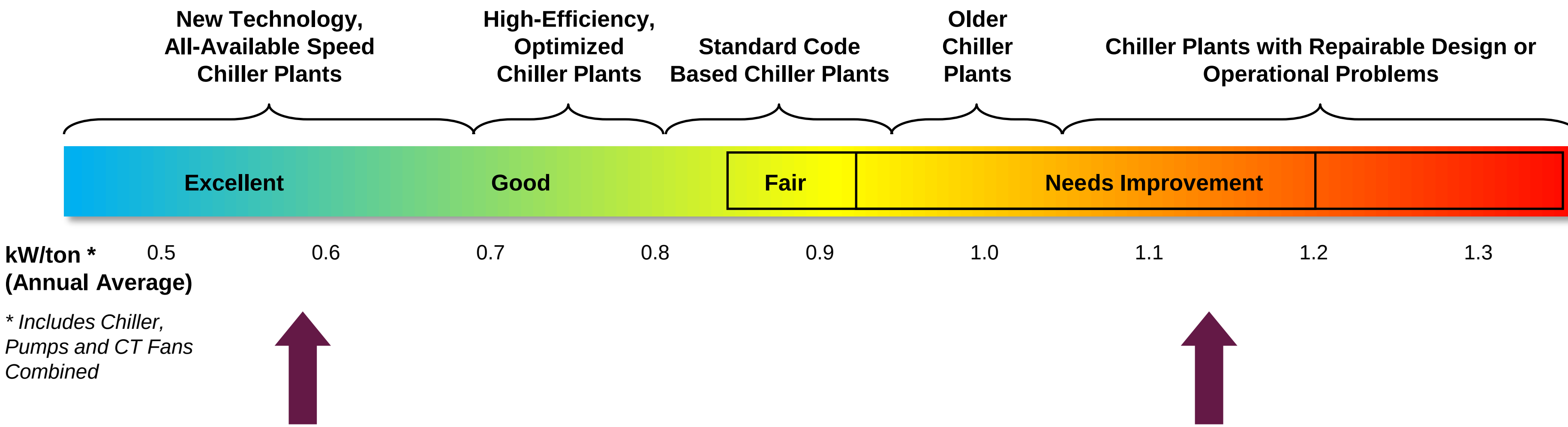
Siemens Demand Flow®

A unique and proven energy and operational cost saving application for water-cooled, central chilled water systems

Importance of Chiller Plants to Hotels

- Crucial to guest comfort, business success
- Chiller plant is a major capital asset, reliability and extended plant life are key
- Cooling energy can be as much as 20-25% of a hotel's electricity consumption
- Plants run 24 x 7 throughout cooling season, with widely variable loads
- Year-round operation is common in hotels with CHW fan coils in guest rooms, light loads mean poor efficiency. Plate and frames often don't work properly.
- **High electricity costs, inefficient plant operations = pressure to reduce operating expenses from ownership**

Overview: Why Chiller Plant Optimization?



Post-Optimization
(Annual Average can range from 0.5 – 0.75 kW/Ton)

Pre-Optimization
(Annual Average typically ≥ 0.8 kW/Ton)

Source: "All Variable Speed Chiller Plants", ASHRAE Journal, September 2001

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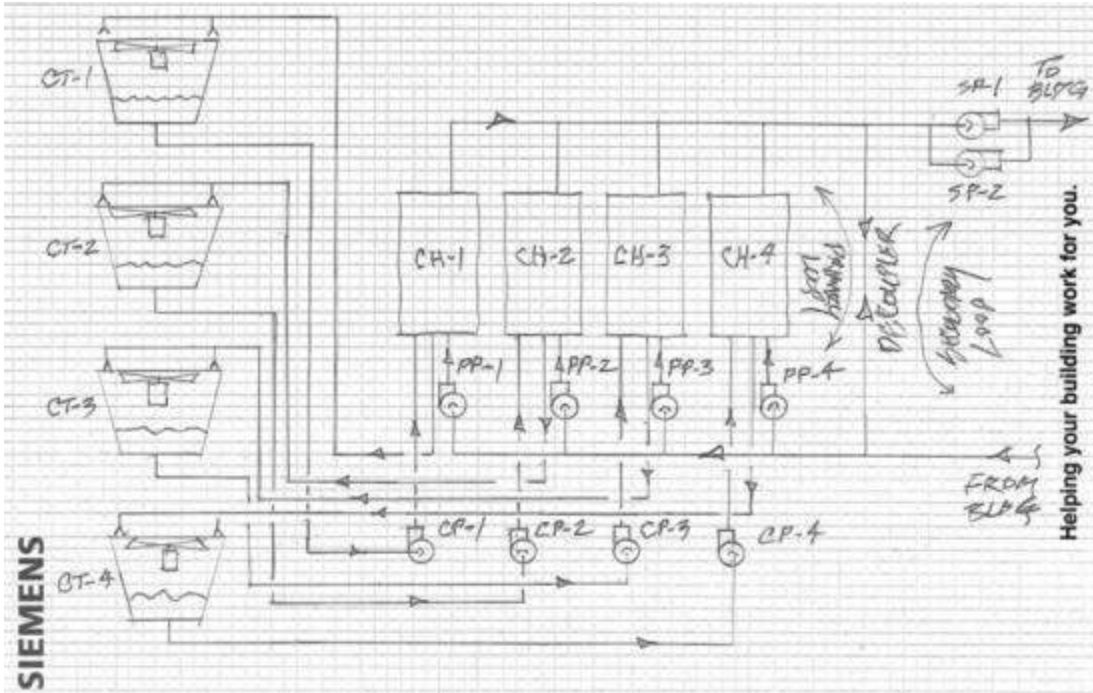
Overview: Common CHW System Characteristics

Typical Characteristics	Inherent Shortcomings
Chillers not operating at design temperature splits	Plagued with "Low Delta-T Syndrome"
Excessive bypass of chilled water flow	Excessive pumping / chiller energy and shaft-miles
Constant volume pumping (both CHW and CW)	Excessive pumping / chiller energy and shaft-miles
Efficiency is often sacrificed to maintain comfort	Higher utility costs
Total plant energy performance not fully measured	Not measured can't be controlled
Operate at design intent conditions only 5% of the time (per ARI standards)	Inefficient and costly plant operations 95% of the time (per ARI standards)
Continuous full speed operation of some plant equipment	Decreased equipment life

Overview:
What is Chilled Water System Optimization?



Fundamental energy consuming sub-systems that influence deliverable capacity:

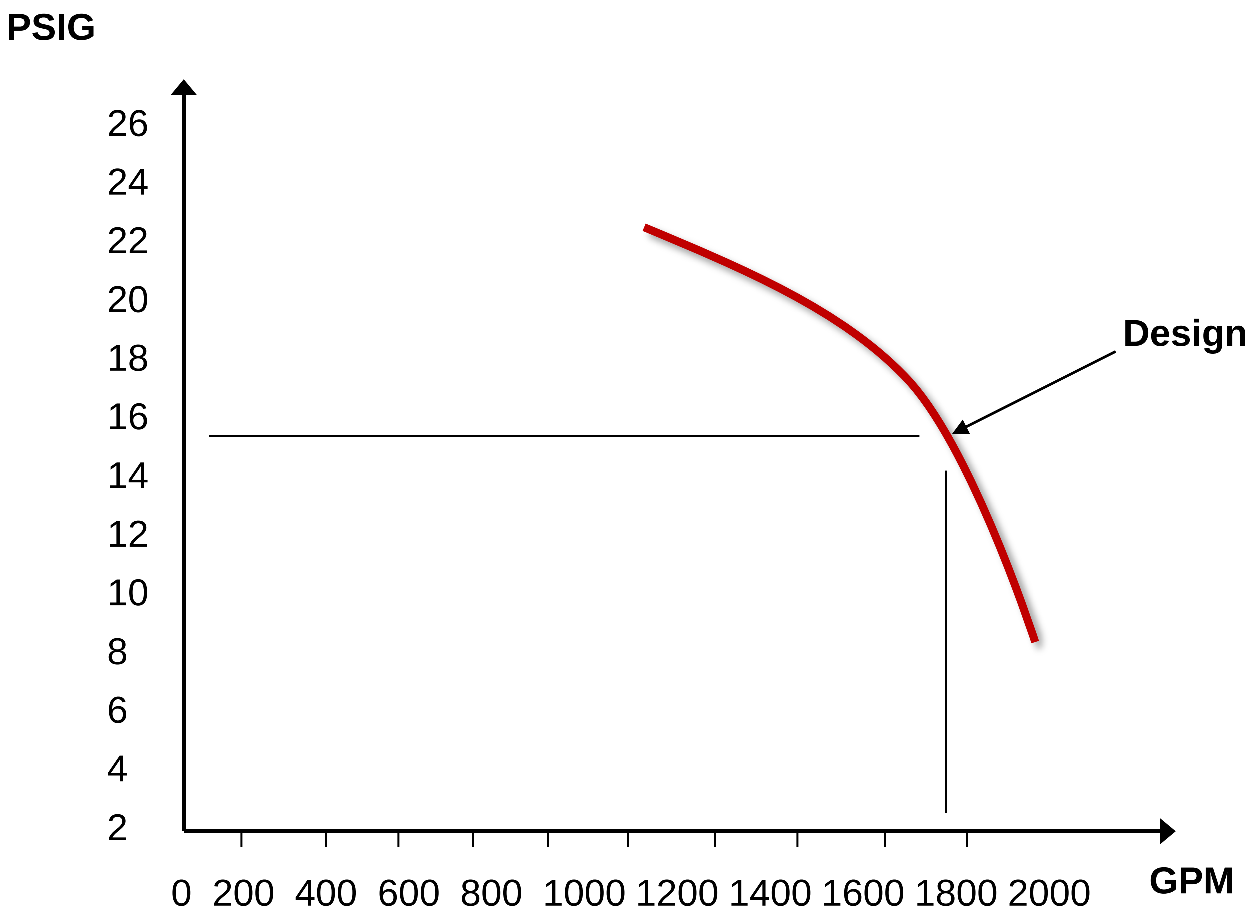
1. Chillers
2. Chilled Water Pumping
3. Condenser Water Pumping
4. Cooling Tower Fans
5. Air Side (Chilled Water Coils)

These 5 subsystems are interdependent

- Energy and deliverable capacity are interdependent
- Often "conservation methods" reduce deliverable capacity
- Often energy conservation methods result in a "transfer of energy" among the 5 subsystems

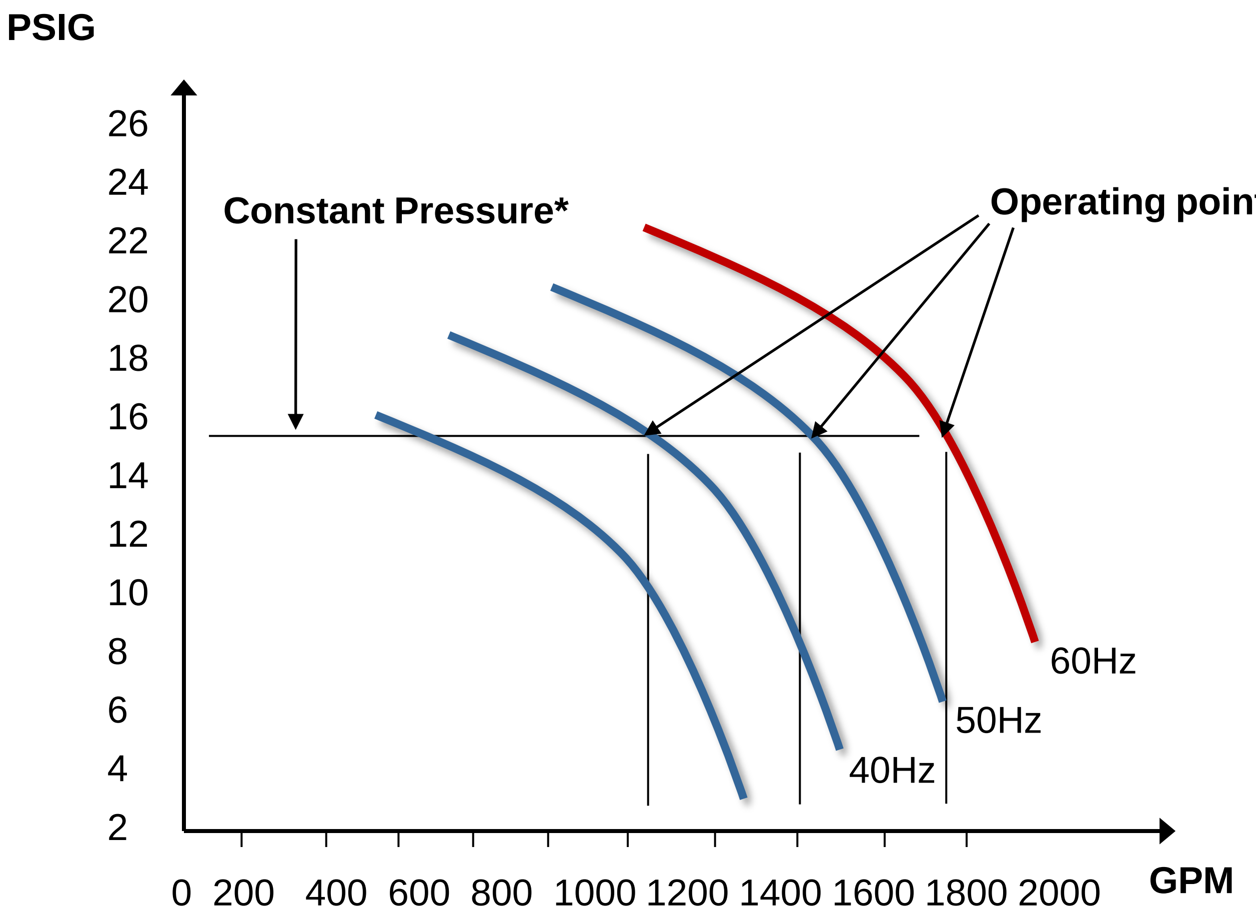
Siemens understands these technical relationships, delivering a "holistic" approach to CPO

Constant Speed Pumping



Selection of a pump curve that intersects the Design Point

Variable Speed Pumping

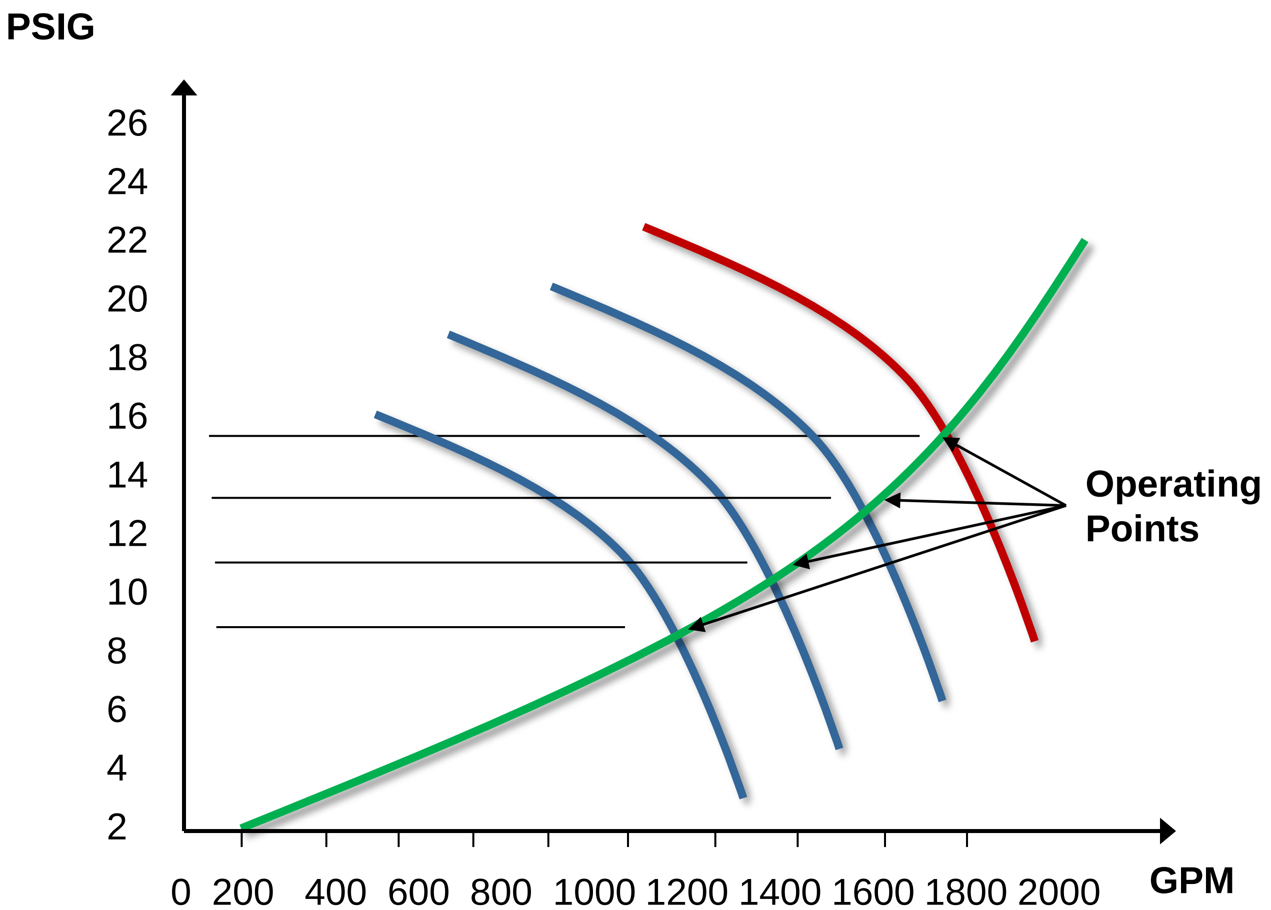


A typical control strategy is to control to a constant differential pressure in the loop

With the application of a variable speed drive, the pump curve shifts as motor speed decreases

Demand Flow Control Strategy:
Variable Pressure Curve Logic (VPCL)

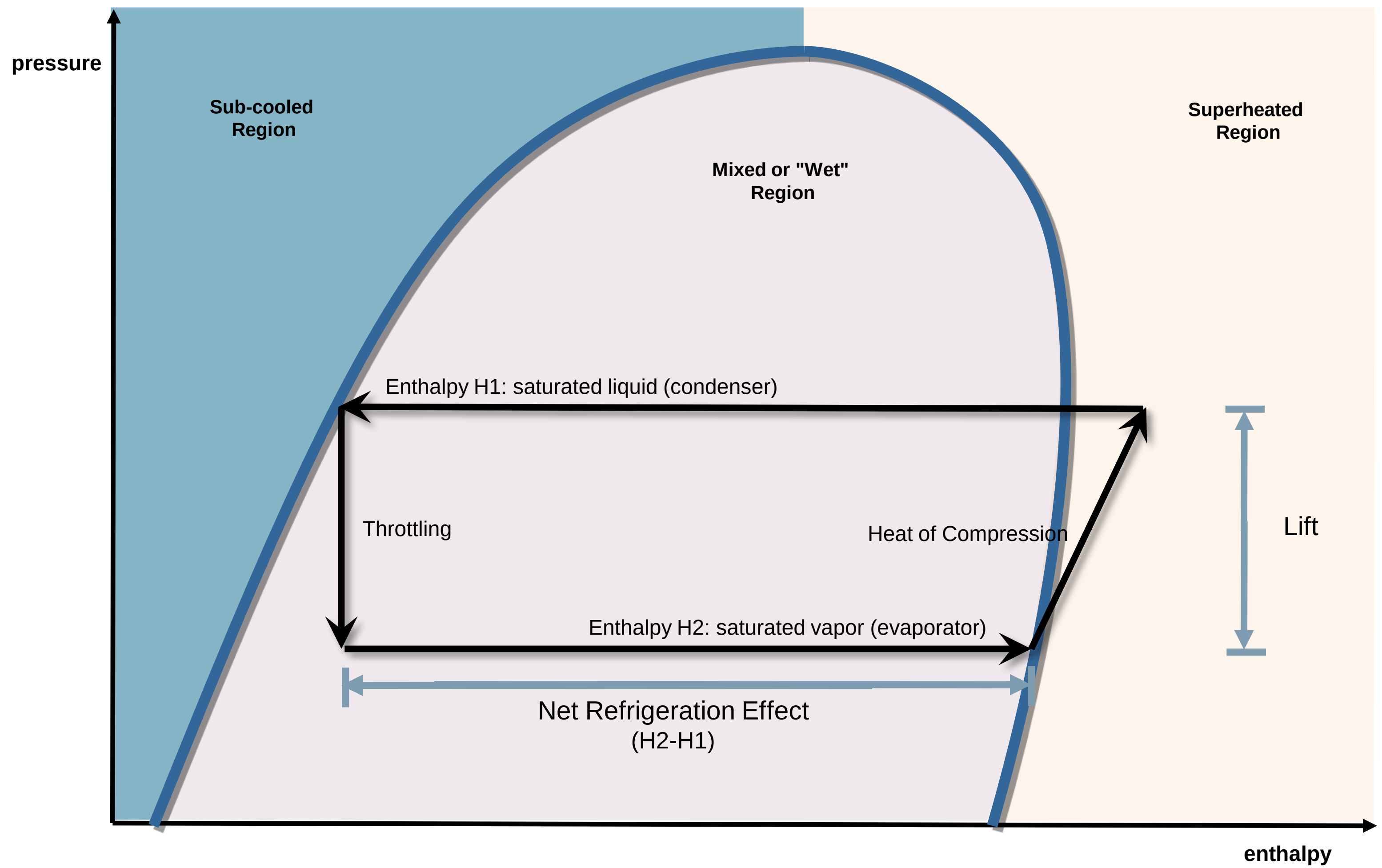
Calculated Dynamic Variable System Pressure Curve



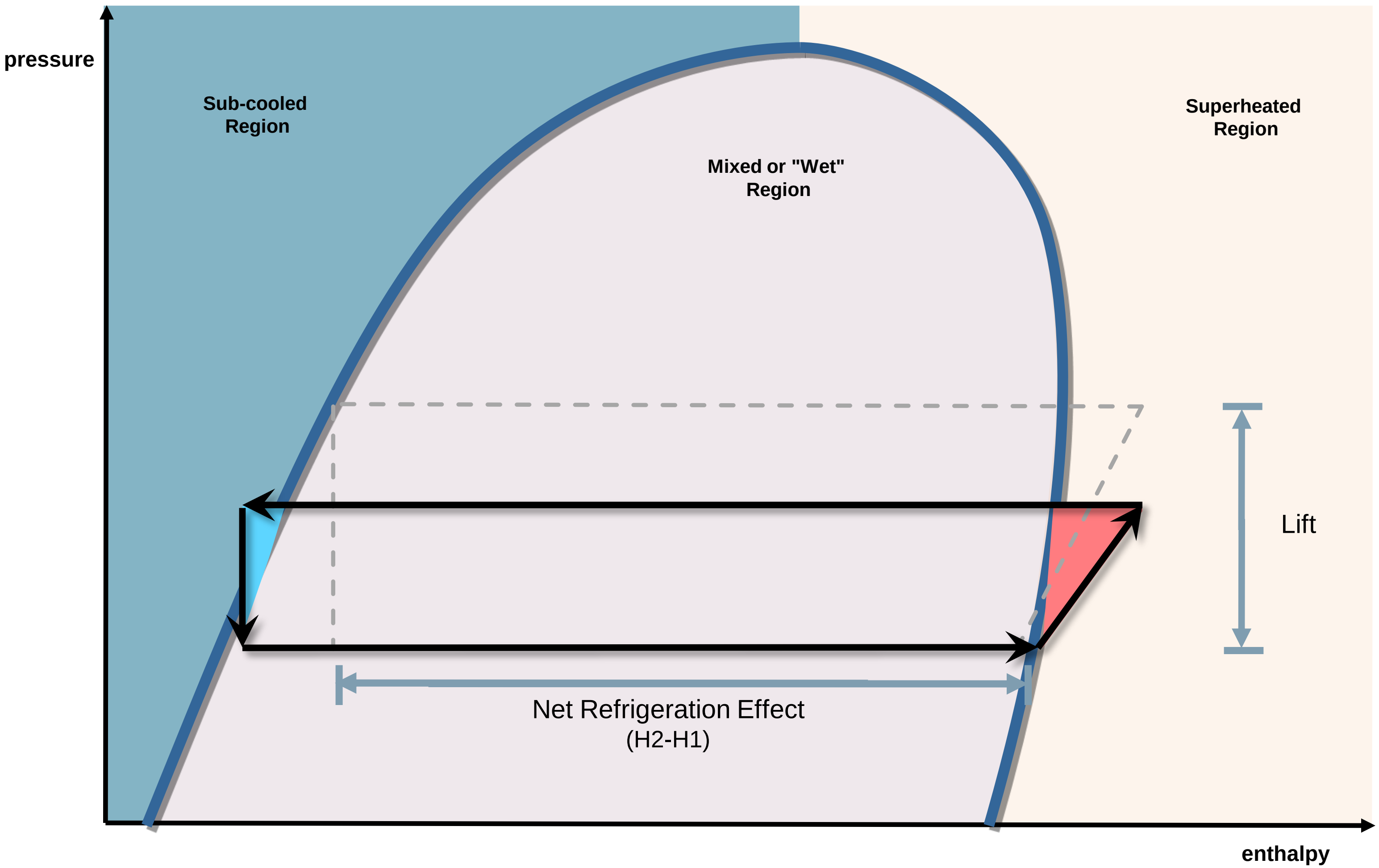
Demand Flow continuously resets system differential pressure along calculated curve

Demand Flow Patent-Pending Variable Pressure Curve Logic (VPCL)

Refrigeration Cycle and Mollier Curve



Impact on Lift and Refrigeration Effect



Impact on Chiller Compressor Energy

Compressor Energy = Mass Flow of Refrig. x Differential Pressure or ‘Lift’

Mass Flow of Refrigerant = 200 / Refrigerant Effect x Effective Tonnage

Compressor Energy = $\frac{200}{RE}$ x Effective Tonnage x ‘Lift’

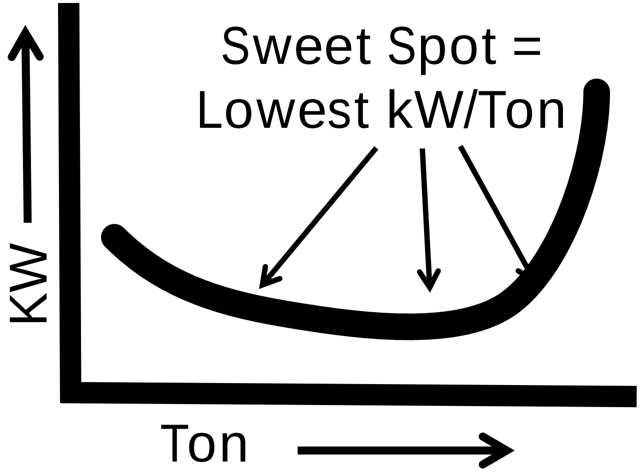
Demand Flow improves chiller efficiency by increasing the Refrigeration Effect, and by reducing Lift while preventing surging.

Demand Flow manages Lift by controlling condenser water temperatures and condenser water flow through the chillers.

Simplified Chiller Sequencing

Traditional methods of optimization

- Reset chilled water temperature up
- Chillers sequenced via a database of load profiles
- They all try to find a "sweet spot"
- Kw/ton based on historical data not necessarily in real-time



Demand Flow Sequencing

- Demand Flow widens "sweet spot"
- Wider "sweet spot" = increased efficiency through the entire tonnage range
- Increased deliverable tonnage
- Less start/stop = less wear and tear
- Chillers sequenced lead / lag based on run-time
- Most efficient system kw/ton in real-time

Siemens Demand Flow®
Chilled Water System optimization

What's Different

- VFDs installed on all CHW and CW Pumps and CT Fans
- Water Flow Varies thru Chiller Evaporator and Condenser
- Virtually no CHW/CW bypass
- Optimize Pressure and Temperature set-points based on system dynamics
- VFDs are **not** required on the Chillers (Will work with or without VFDs on chillers)
- Turn-key Installation and Commissioning
- Pre and Post Measurement and Verification

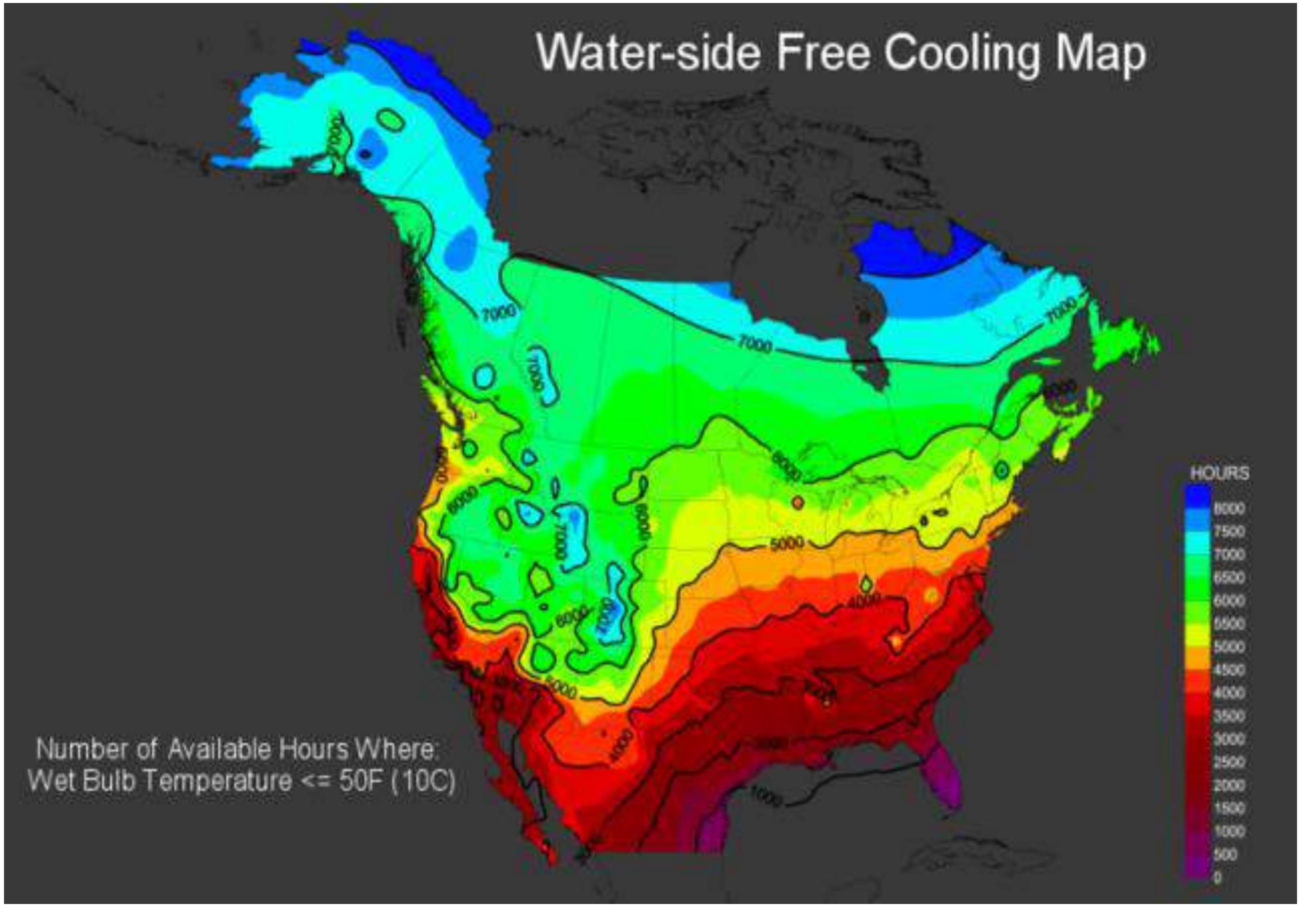
System Effects

- Solves Low Delta T Syndrome
- Increases system deliverable tonnage (where low Delta-T is present)
- Manages chiller "Lift", effectively eliminates refrigerant flow issues at low load conditions
- Stable Chiller Refrigerant loop performance at virtually all tonnage loads

Demand Flow Enables Water-Side Economizer

Demand Flow & Free Cooling

- Reliable switch-over to Water-Side Economizer, key consideration for hotels with year round cooling loads. 4,500 to 5,000 hours of "free cooling" operation available.
- Variable CW flow and reductions in CHW flow improve W-S E efficiency.
- Enables simultaneous operation of plate and frame and chiller in Demand Flow mode w/o the need for a variable speed chiller



(Source: The Green Grid)

Primary Benefits of Demand Flow

- **Reduced energy consumption and greater performance**
  - Typically 15-50% total Chilled Water System energy savings
    - 2-4 year simple payback
  - Requires less energy to deliver potentially colder chilled water temperatures
  - Improves System *Deliverable* Cooling Capacity

- **Extended equipment Life**
  - Increased *Deliverable* tonnage means more redundancy
  - Reduced run-time = less maintenance
  - Less wear and tear on system components

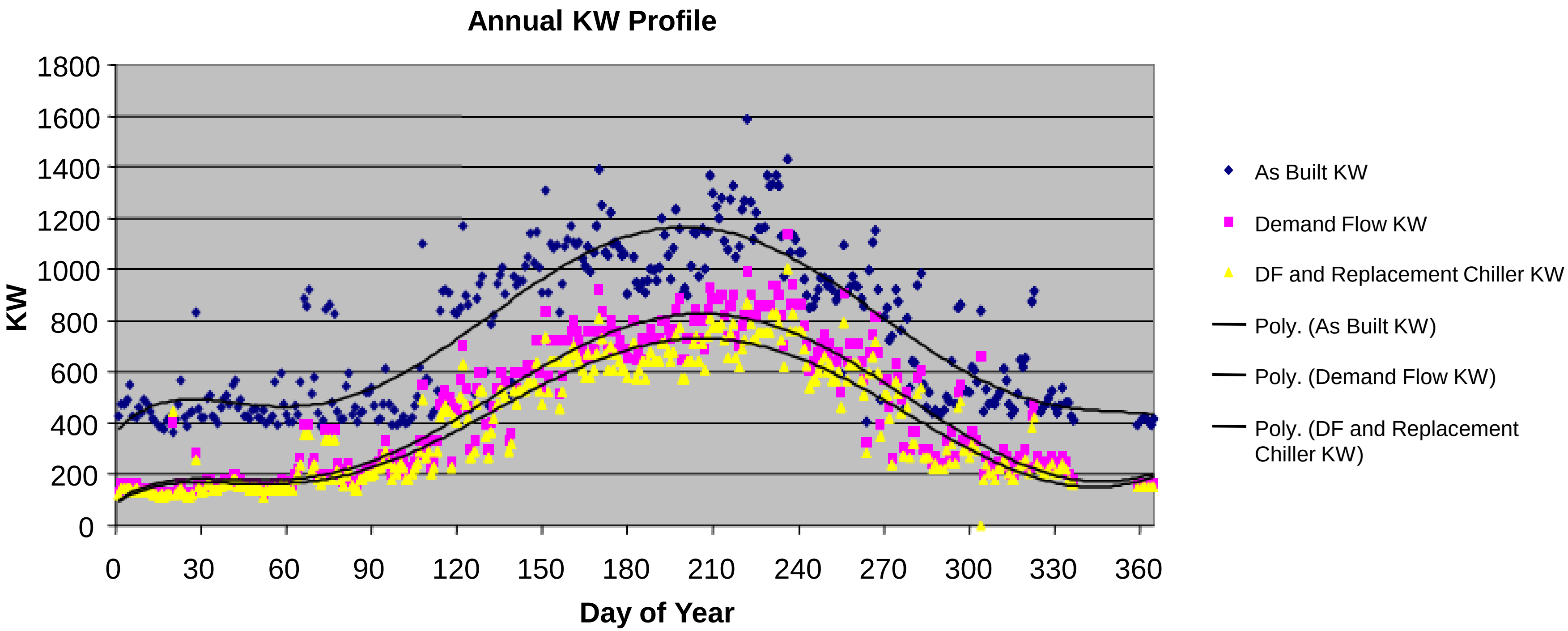
- **Improved indoor environmental quality**
  - Occupant comfort is not sacrifices to provide energy savings
  - More effective humidity control

- **Simplified system operation**
  - Sequencing chillers is typically Lead/Lag based on run-hours (can be customized)
  - More intuitive sequencing of equipment
  - Improved system reliability and control

Demand Flow results in significant energy savings and improved comfort

Statistical Energy Modeling

Siemens utilizes 12 months of customer's historical chiller logs to develop base-line energy consumption vs. optimized energy consumption



Establishing an accurate baseline is <u>critical</u> to determining the savings accurately, and to securing incentive support.

Financial Analysis: What Can You Expect

Example: Avg 1,800 Ton Plant

Typical Sell Price: $ 300k	**MBCx & "Service": $ 15k/yr**
Typical Savings: $100k/yr	**CPI: 2% escalation**

Year	DF Savings ($)	Project Cost ($)	Incentives Received ($)	MBCx & Service ($)	Annual Cash Flow ($)	Cumulative Cash Flow ($)
0					**-300,000**	
1	+100,000	-300,000	0	-15,000	**+85,000**	**-215,000**
2	+102,000	-		-15,300	+86,700	**-128,300**
3	+104,040	-		-15,606	+88,434	**-39,866**
4	+106,121	-		-15,918	+90,203	**50,337**
5	108,243	-		16,236	+92,007	**142,343**
6	110,408	-		16,561	+93,847	**236,190**
7	112,616	-		16,892	+95,638	**331,914**
8	114,869	-		17,230	+97,638	**429,552**
9	117,166	-		17,575	+99,591	**529,143**
10	119,509	-		17,926	+101,583	**630,726**

Break-even point (Year 4)

Total Cost: $ 300,000	**Total Benefit: $630,726**
IRR: 27.2%	**ROI: 210.2%**

3.4 Year Payback

Financial Analysis: What Can You Expect

DF sell price: $ 300k	MBCx & "Service": $ 15k/yr
DF savings: 100k/yr	CPI: 2% escalation

Example: Typical 1,800 Ton Chiller Plant

Year	DF Savings ($)	Project Cost ($)	Incentives Received ($)	MBCx & Service ($)	Annual Cash Flow ($)	Cumulative Cash Flow ($)
0					-300,000	
1	+100,000	-300,000	100,000	-15,000	+185,000	-215,000
2	+102,000	-		-15,300	+86,700	-128,300
3	+104,040	-		-15,606	+88,434	60,834
4	+106,121	-		-15,918	+90,203	150,337
5	108,243	-		16,236	+92,007	242,344
6	110,408	-		16,561	+93,847	336,190
7	112,616	-		16,892	+95,638	431,914
8	114,869	-		17,230	+97,638	529,552
9	117,166	-		17,575	+99,591	629,145
10	119,509	-		17,926	+101,583	730,728

Break-even point

Total Cost: $ 300,000	Total Benefit: $730,726
IRR: 37.5%	ROI: 243.5%

2.3 Year Payback

Utility Rebates to Improve ROI (partial list)

Utility	Service Territory	Project Site
Duke Energy	• Indiana Kentucky • North Carolina • Ohio • South Carolina	• IBM 401 Data Center • P&G Cincinnati
EVERSOURCE	• Eastern Massachusetts	• Novartis, Gillette, Spaulding Rehab
nationalgrid	• Massachusetts • New Hampshire • Rhode Island • New York Upstate	• Twin River
ui	• New Haven and Bridgeport, CT	• Bluestone
nyserda Energy. Innovation. Solutions.	• New York State	• IBM Fishkill
conEdison	• New York City • Westchester County	• Financial Customer
Xcel Energy	• Colorado • Kansas • Michigan • Minnesota • New Mexico • North Dakota • Oklahoma • South Dakota, Texas	• USPS Data Center • Ameriprise Financial • Methodist Hospital
PSEG	• New Jersey	• Data Center Customer

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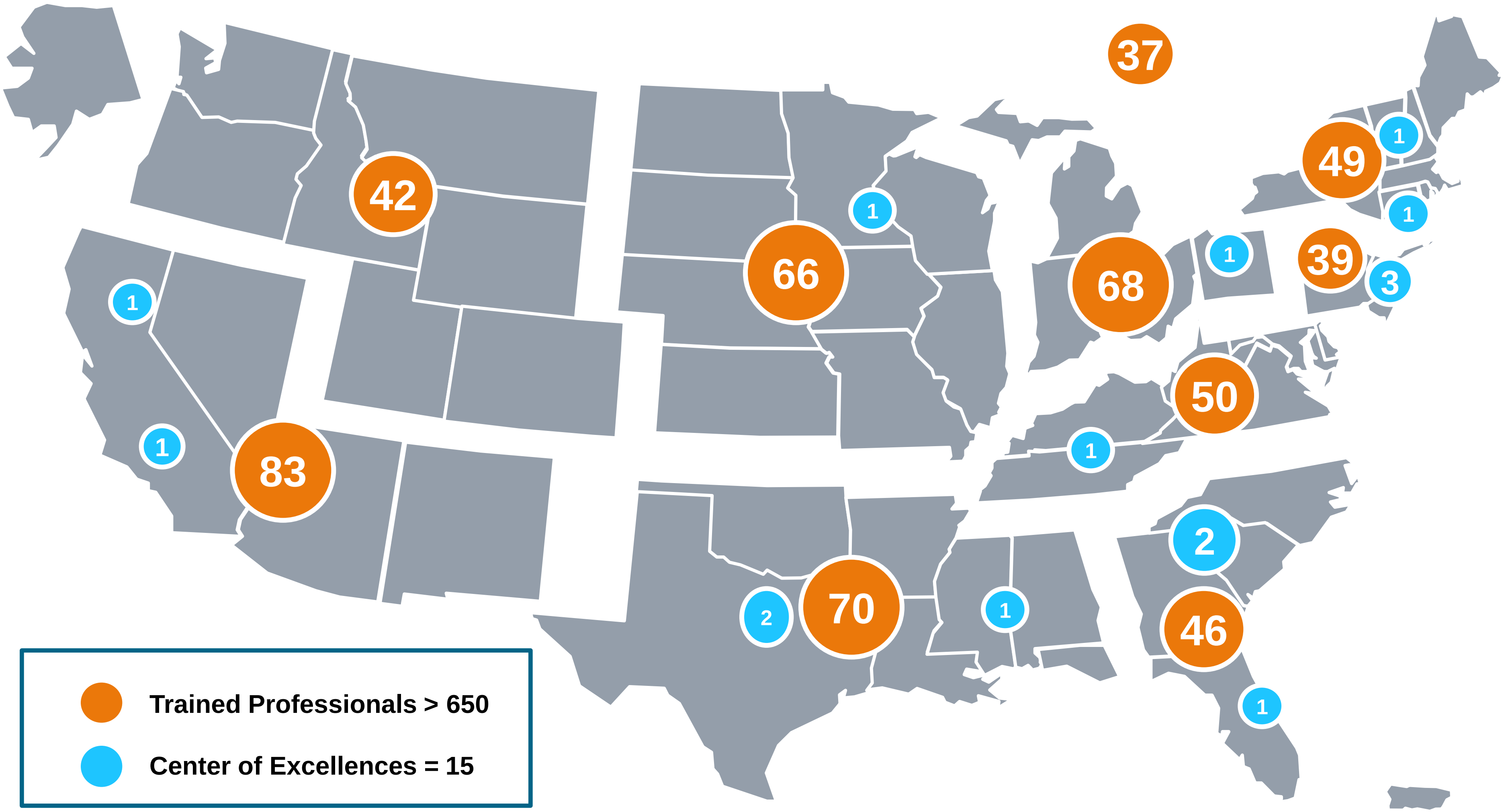
EXPERTISE – DF Center of Excellence Team – Branch Office Support



Demand Flow® Installations in the Hospitality Industry

Hotels

- Hyatt Center, Chicago IL
- Hyatt Regency, New Orleans LA
- Imperial Palace, Biloxi MS
- Four Seasons, Grand Hyatt, Hyatt Regency, Atlanta GA
- Dolphin Hotel, Swan Hotel, Orlando FL
- Sunset Marquis Hotel, Los Angeles CA
- Marriott Grand Chateau, Las Vegas NV

Casinos

- The Cosmopolitan, The Venetian, MGM Grand, Las Vegas NV
- L'Auberge Casino, Lake Charles LA
- Twin River Casino, Lincoln RI

Stadiums and Arenas

- TD Garden, Boston MA
- MetLife Stadium, Rutherford NJ
- BB&T Stadium, Miami FL
- Superdome, New Orleans LA

Demand Flow® at the Mandarin Oriental

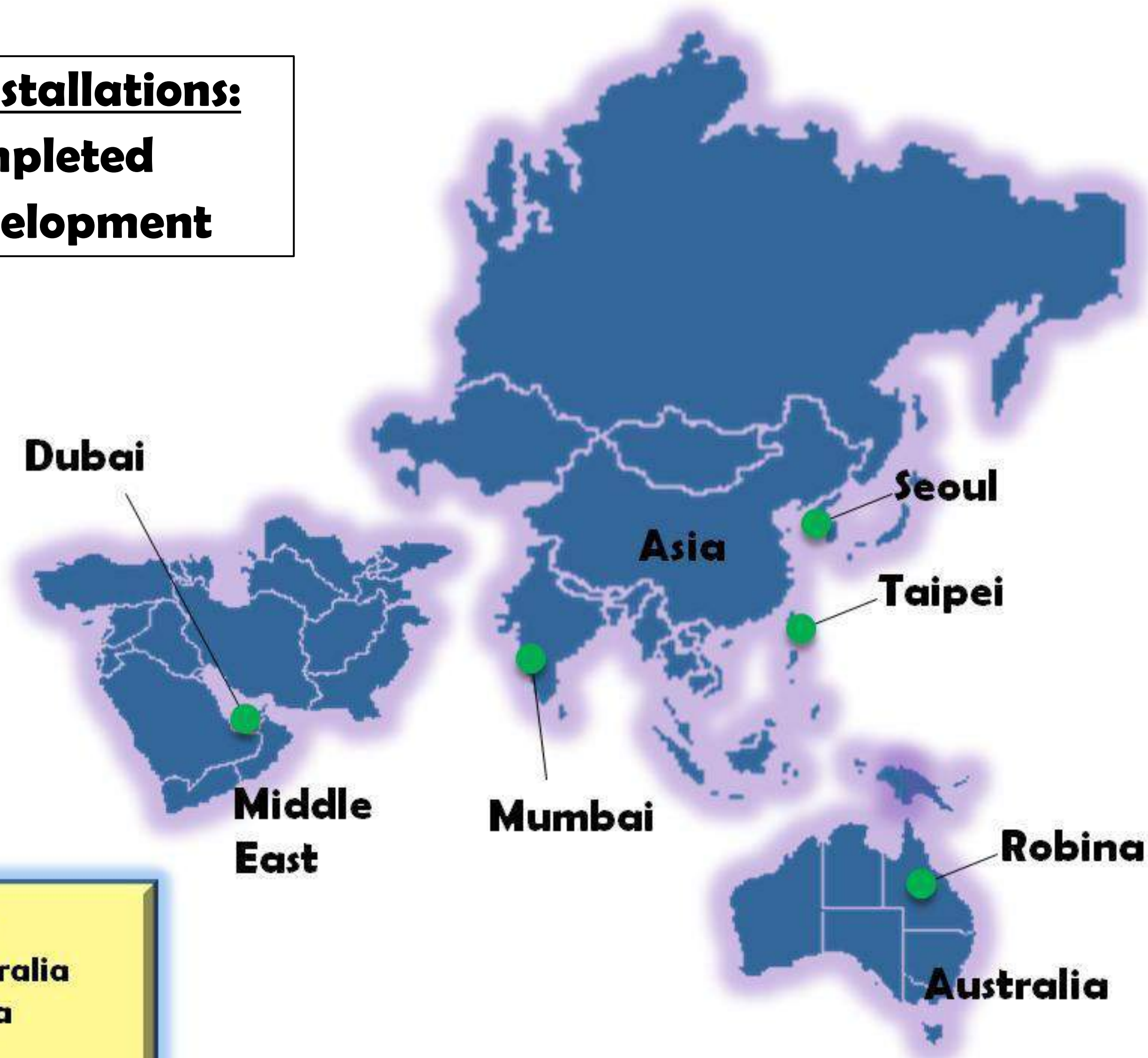
- Relatively modern, 1500 ton plant with two Trane VSD 750 ton centrifugal chillers
- Roughly 1000 ton peak summer load, 200 ton winter baseload
- Variable primary chilled water pumping,
- Plate and Frame HX for Water Side Economizer
- Constant flow condenser water pumping
- Year-round operation to provide chilled water for guest room fan-coils

Case Details

Baseline and Projected Results

- 2,281757 average ton-hours annual plant chilled water production
- Estimated baseline consumption of 2,141,200 kWh/yr
- Baseline plant efficiency of 0.938 kW/ton
- Projected kWh with Demand Flow of 1,883,095
- Projected plant efficiency of 0.791 kW/ton (conservative projection)
- Projected kWh reduction of 337,205 kWh annually
- Projected Energy Cost Savings of $49,232 annually
- Avoided CO2 emissions of 512,619 lbs annually

Global Installations:
5 completed
5 in development



Coming soon:
- Melbourne, Australia
- Sydney, Australia
- Singapore,
- Hong Kong, China
- Macau, China

Siemens Building Performance and Sustainability

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Questions?