Running a District Cooling Plant Like You Own It

Robert Garcia - Consultant

Eugene Smithart "Smitty" - Director Systems and Solutions, Trane

June 14, 2017

INTERNATIONAL DISTRICT ENERGY ASSOCIATION

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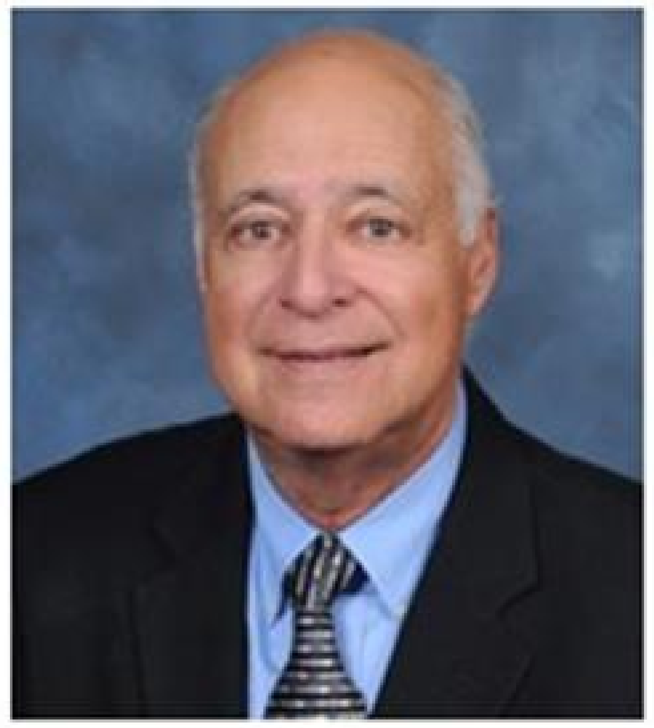
- The webinar will **start promptly at 3:00pm EDT (Boston time) and is scheduled to last ninety (90) minutes; including time for questions.**
- Please **mute your phone** during the webinar. All lines are muted.
- If you are having problems with video or audio, please send a note via the Chat Box function on the right side. Click the Chat box and choose – **"Chat privately to Cheryl Jacques (host)". Or call to IDEA at +1-508-366-9339.**
- **Polling Questions:** There will be a brief participant poll during the presentation transition from presenter #1 to presenter #2. Please answer and "submit" on right side of your screen.
- **Questions to Presenters**: Please enter your **Questions** in the **Q&A** box at the lower right of the screen. These questions will be moderated and addressed as time allows. We plan to handle Q&A at the conclusion of the presentation.
- **Survey**: Please complete the brief on-line survey following the webinar.
- **Webinar Download or Streaming**: Webinar will be recorded and available via download or streaming. Slides will be made available in pdf format. Please visit **www.districtenergy.org.**

Presenters



Robert Garcia

Consultant

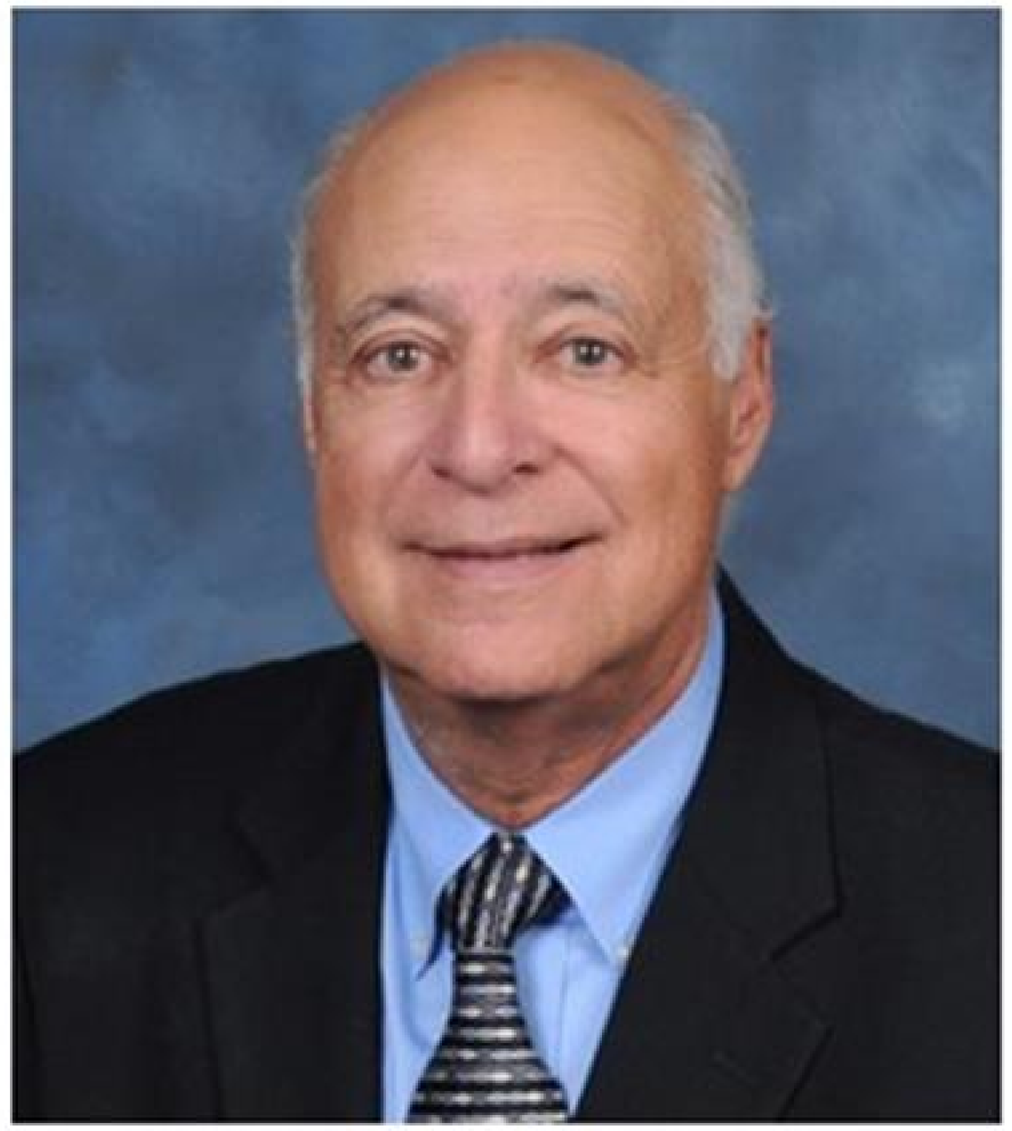
Eugene Smithart - "Smitty"

Director Systems and Solutions, Trane

Robert Thornton, Moderator

President & CEO, IDEA

Robert Garcia



- With over 43 years of HVAC experience, Robert is currently a managing partner of YBOR City District Cooling in Tampa, and a retired senior vice president of Tampa Bay Trane.

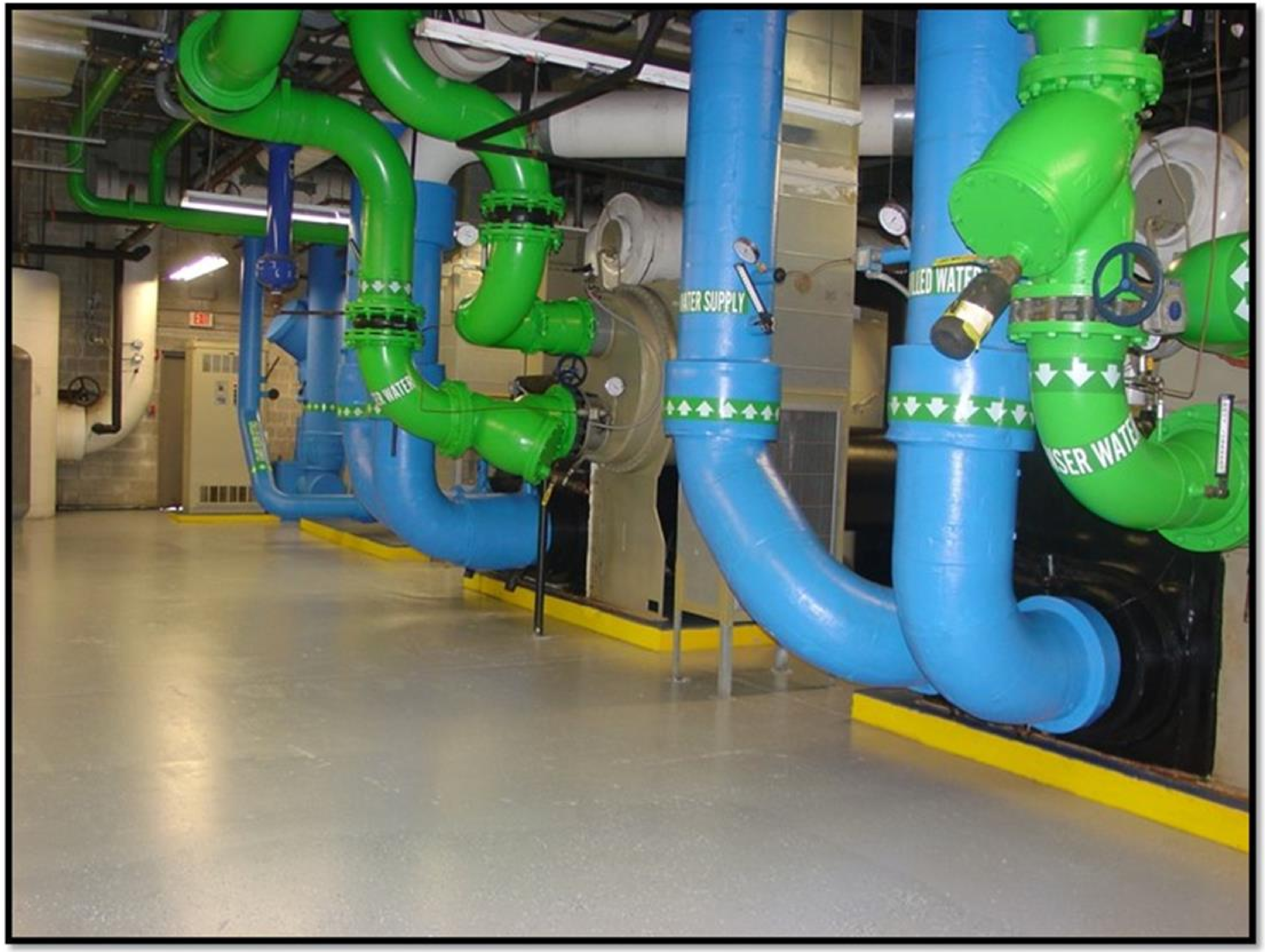
- He will share his experience in achieving optimally efficient district cooling plant design and operation as well as effective metering and billing methods.

District Cooling Plant

Definition of Cooling Plant

Centralized production and distribution of chilled water to multiple buildings for the main purpose to cool the indoor air.

YBOR Chiller Plant



My Definition

- The only legal method in Florida is to own a non-regulated utility

Why?

Because 60% - 70% of operating cost is electricity!

How did we come to own a district cooling plant?

College (Hillsborough Community College)
in YBOR City had a need for A/C

HILLSBOROUGH COMMUNITY COLLEGE 1968 HCC

YBOR City

We negotiated with the city to vacate adjacent land.

We have a 50 year ground lease

We have a 50 year franchise agreement with the City of Tampa

Broke ground in 1998

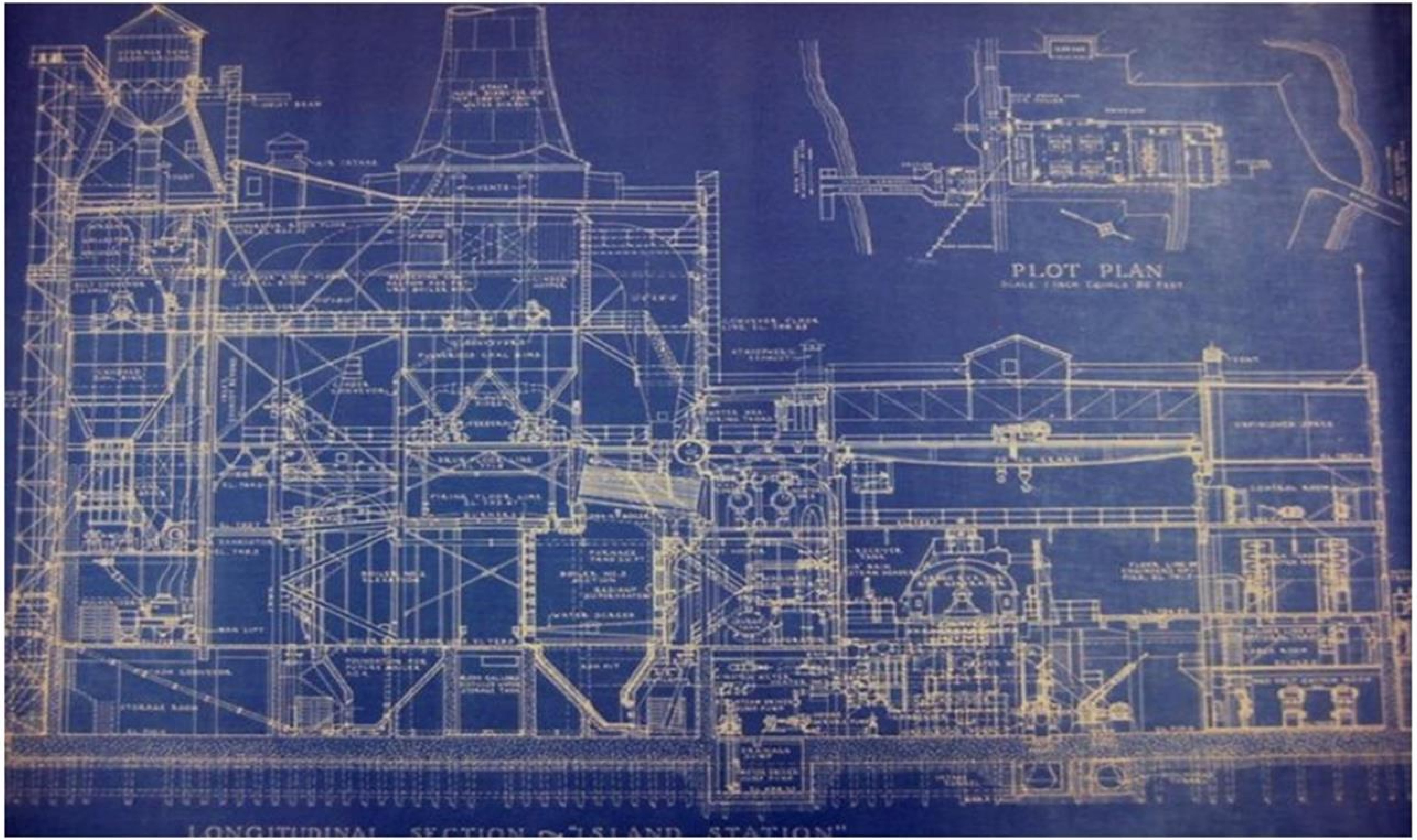
Jointly owned plant with local electric company

(Tampa Electric and AGC of Tampa Bay)

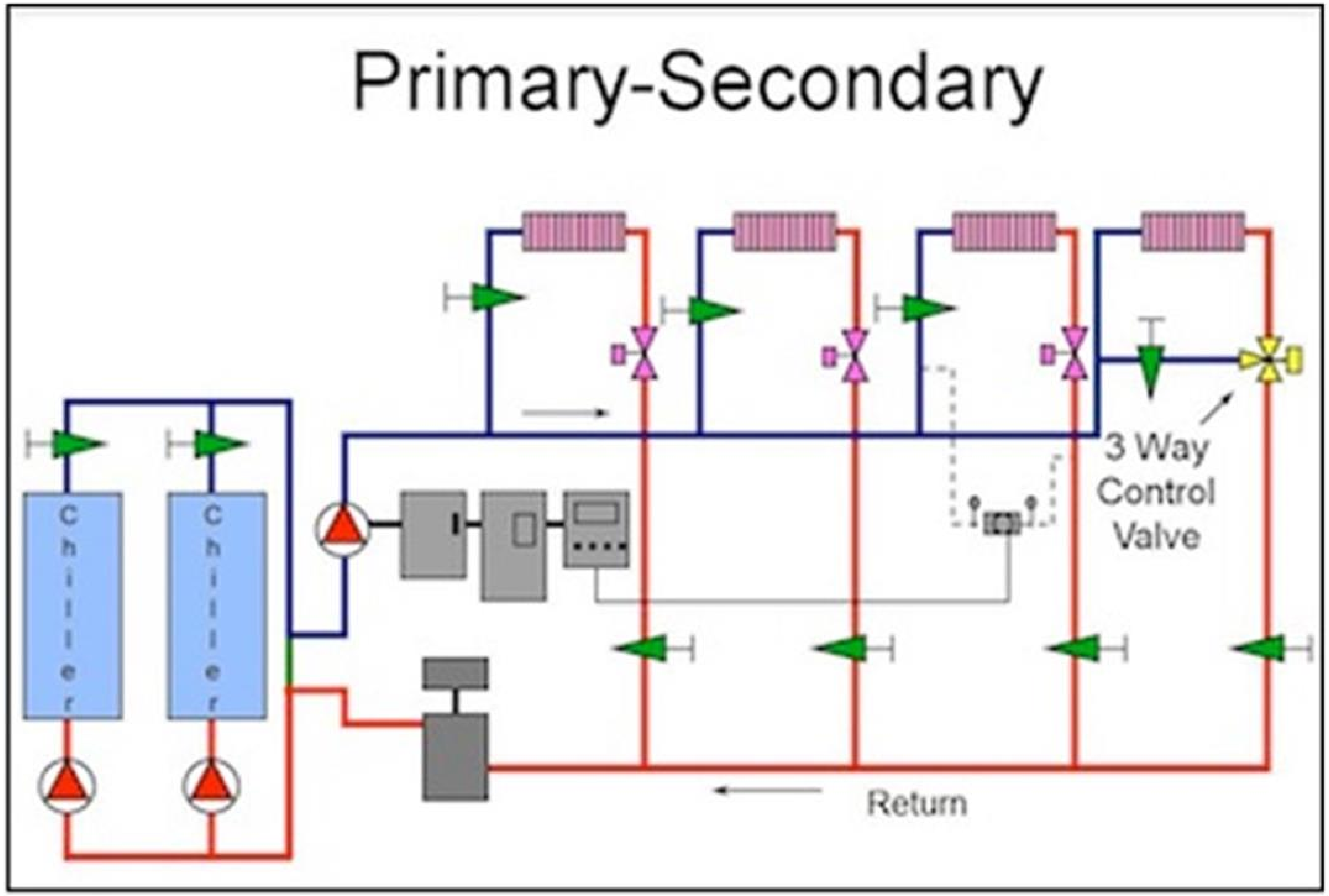
TECO

AN EMERA COMPANY

- The plant's original design had a 1200 ton and a 900 ton CVHF
- Controlled by Tracer



Plant build as primary/secondary configuration



Primary-secondary plants are operationally bullet-proof, but with many undesirable side effects

Primary/Secondary Plants
vs
Variable Primary Flow

VPF (Variable Primary Flow)

plants are more efficient than

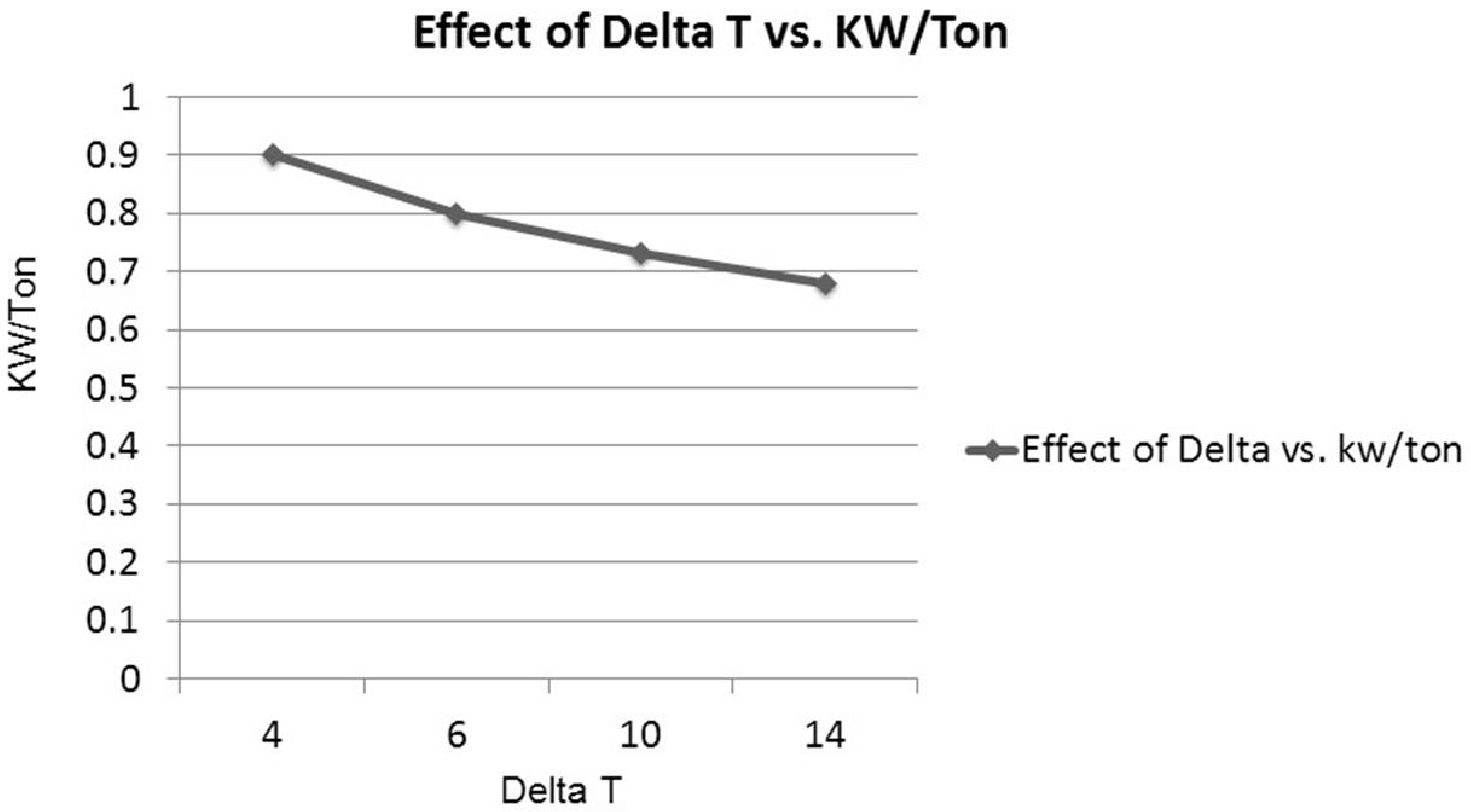
P/S (Primary/Secondary Plants)

We converted YBOR to Variable Primary Flow in 2001 and immediately saw from 9% to 15% improvement in efficiency.

After the conversion –

- The DeltaT went from:

  4-6 degrees F to 9-12 degrees F

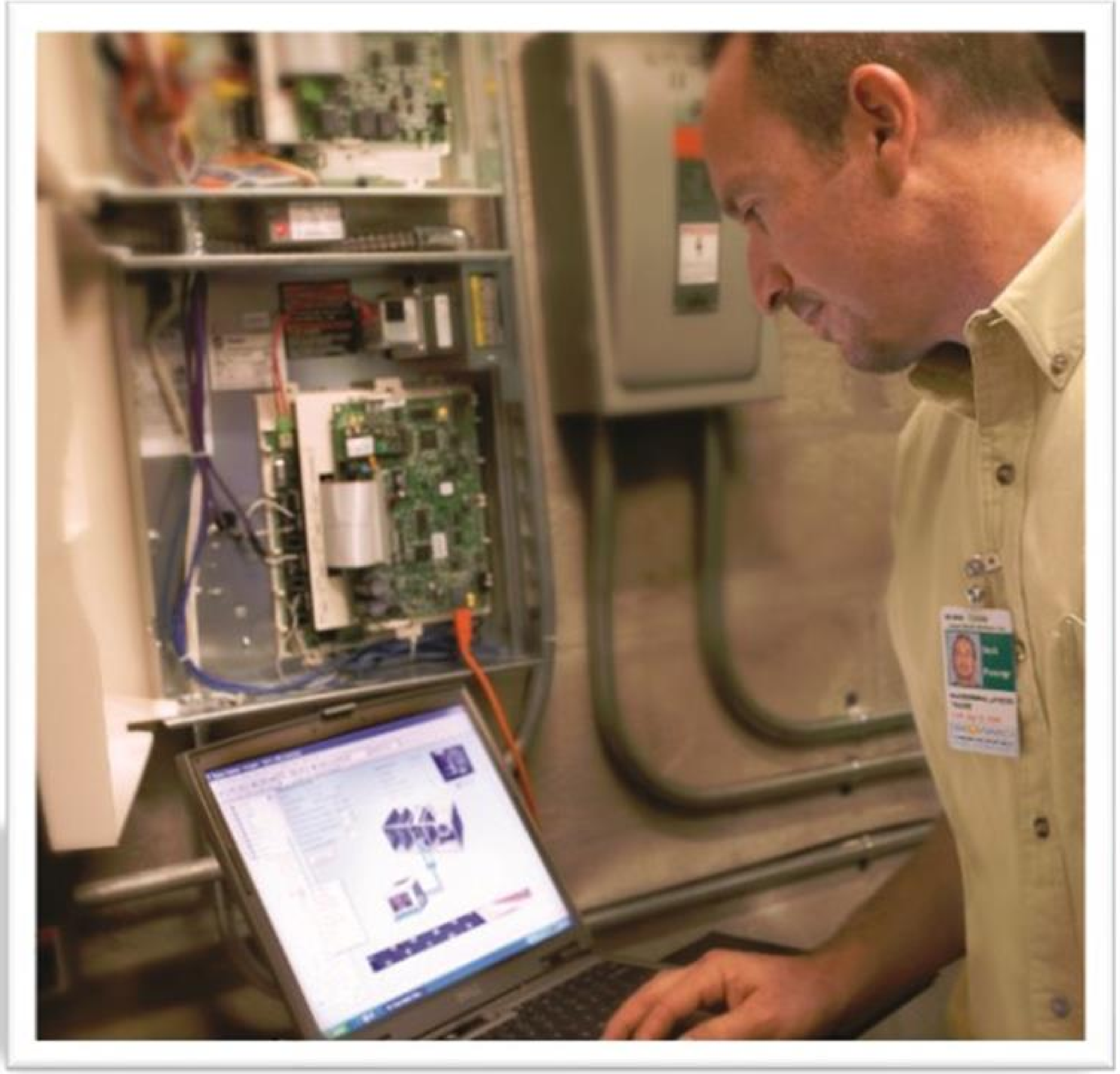

Effect of Delta T vs. KW/Ton
KW/Ton
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
4
6
10
14
Delta T
Effect of Delta vs. kw/ton

Asymmetrical
vs
Symmetrical Plants

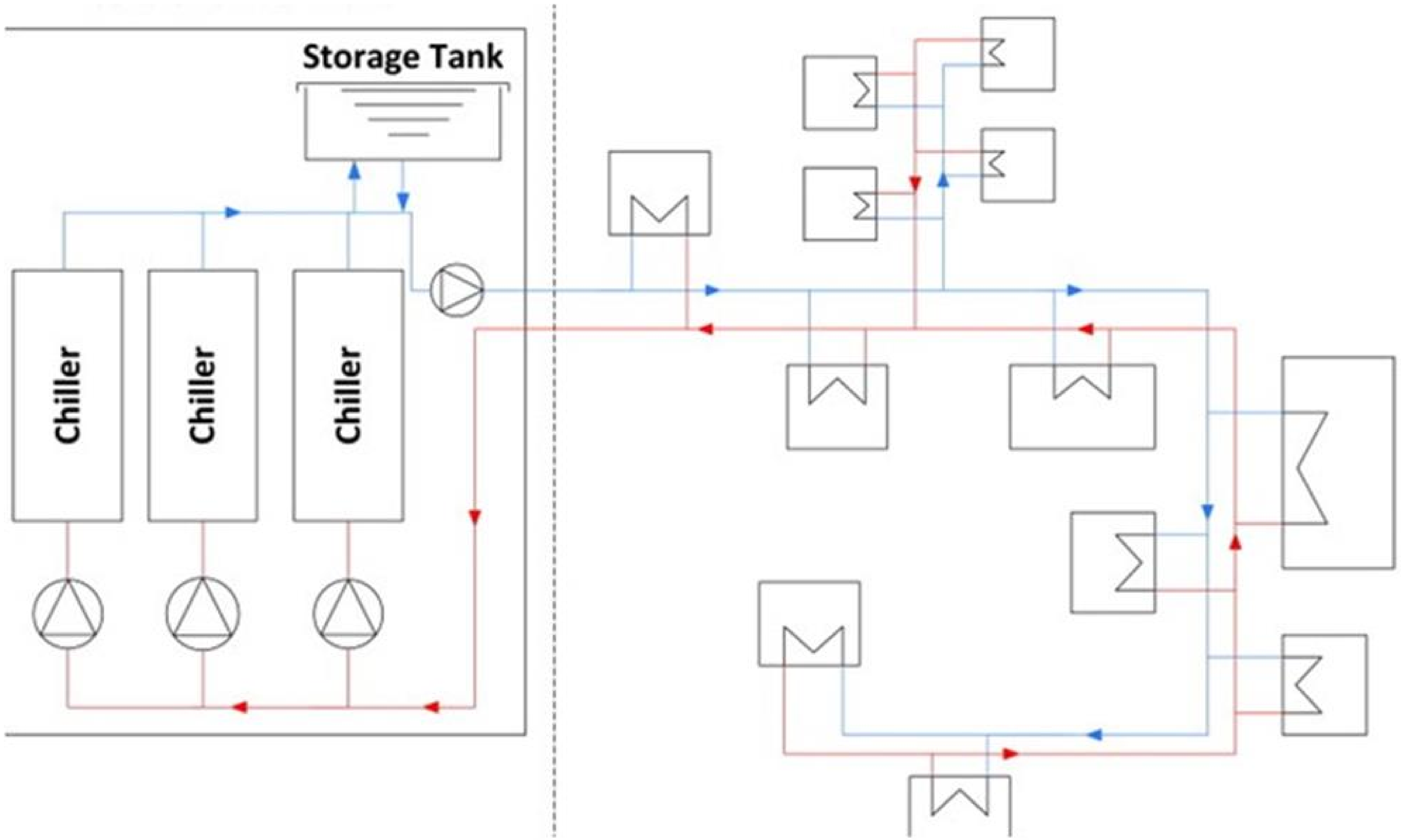
YBOR is an asymmetrical plant, but it is an exception to the rule

An asymmetrical plant sounds like the perfect solution, but in reality they are troublesome

Asymmetrical plants are **very difficult** to operate, especially when adding or subtracting chillers



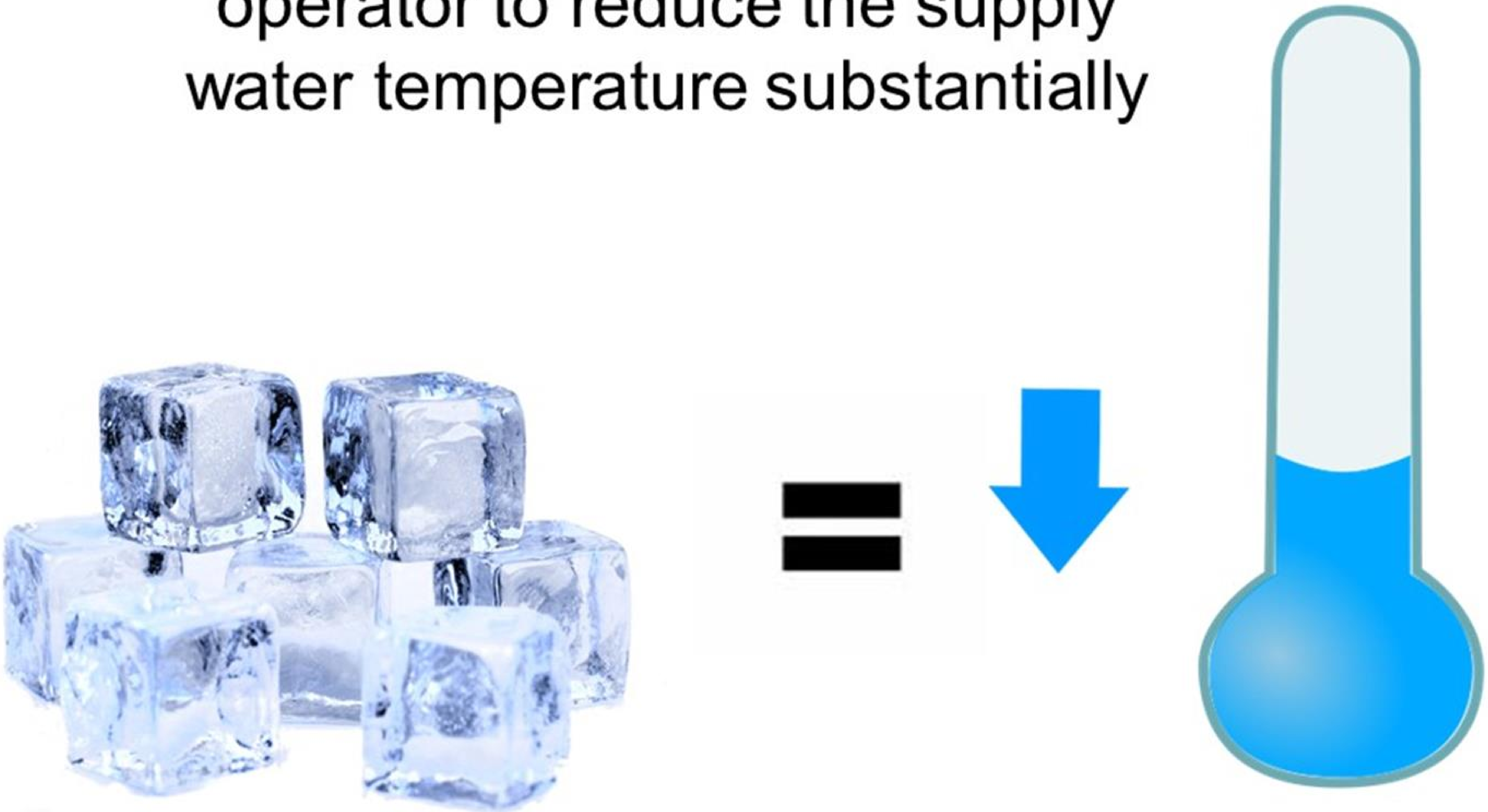
A better design approach is a symmetrical plant with equal size chillers



However, the best design approach is an ice-enhanced symmetrical plant

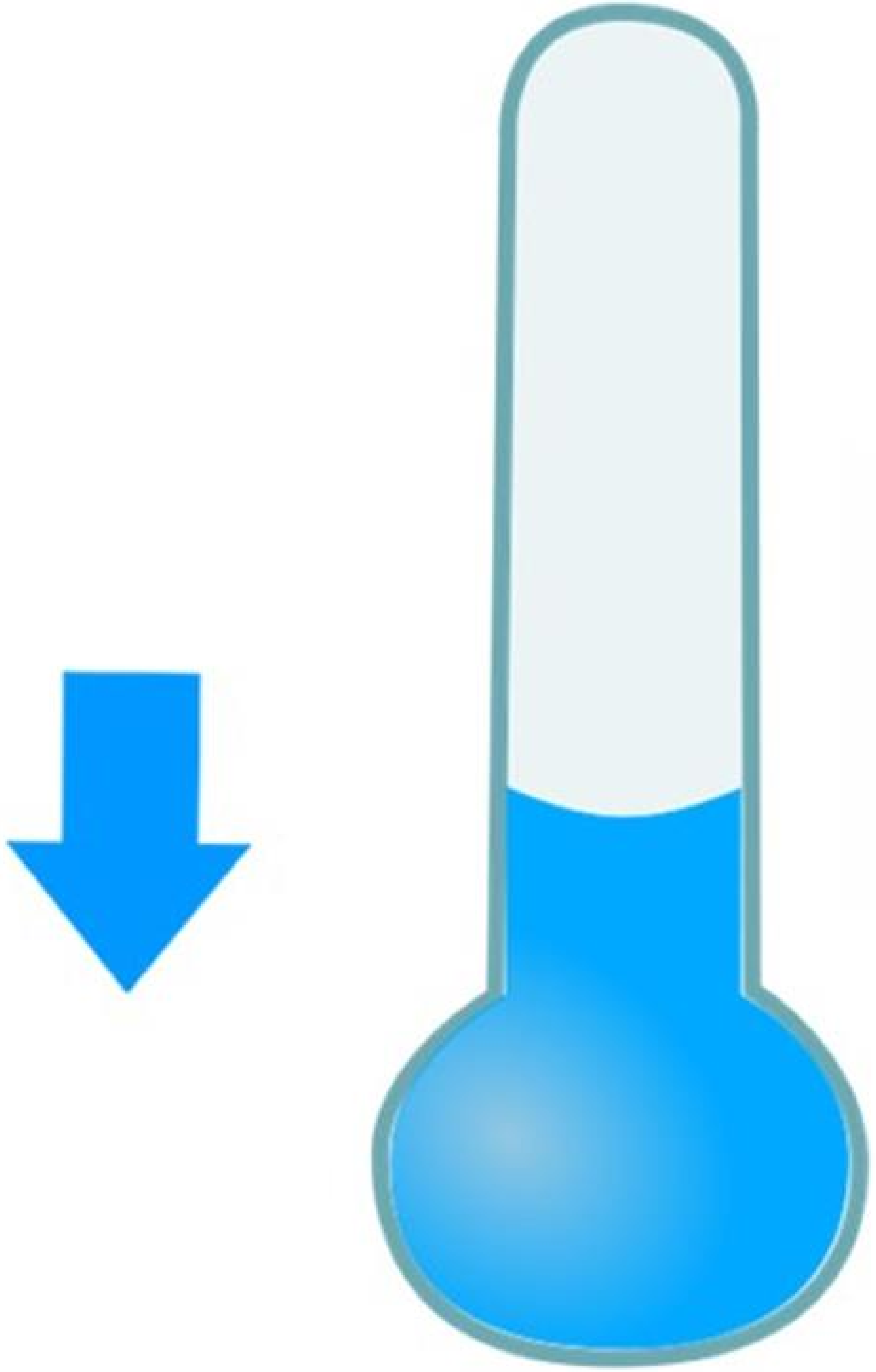

With an ice-enhanced symmetrical plant, the system can add or subtract any size of capacity which would be a problem with a chiller-only plant (YBOR)

An ice-enhanced plant allows the operator to reduce the supply water temperature substantially



Why low temperature supply water?

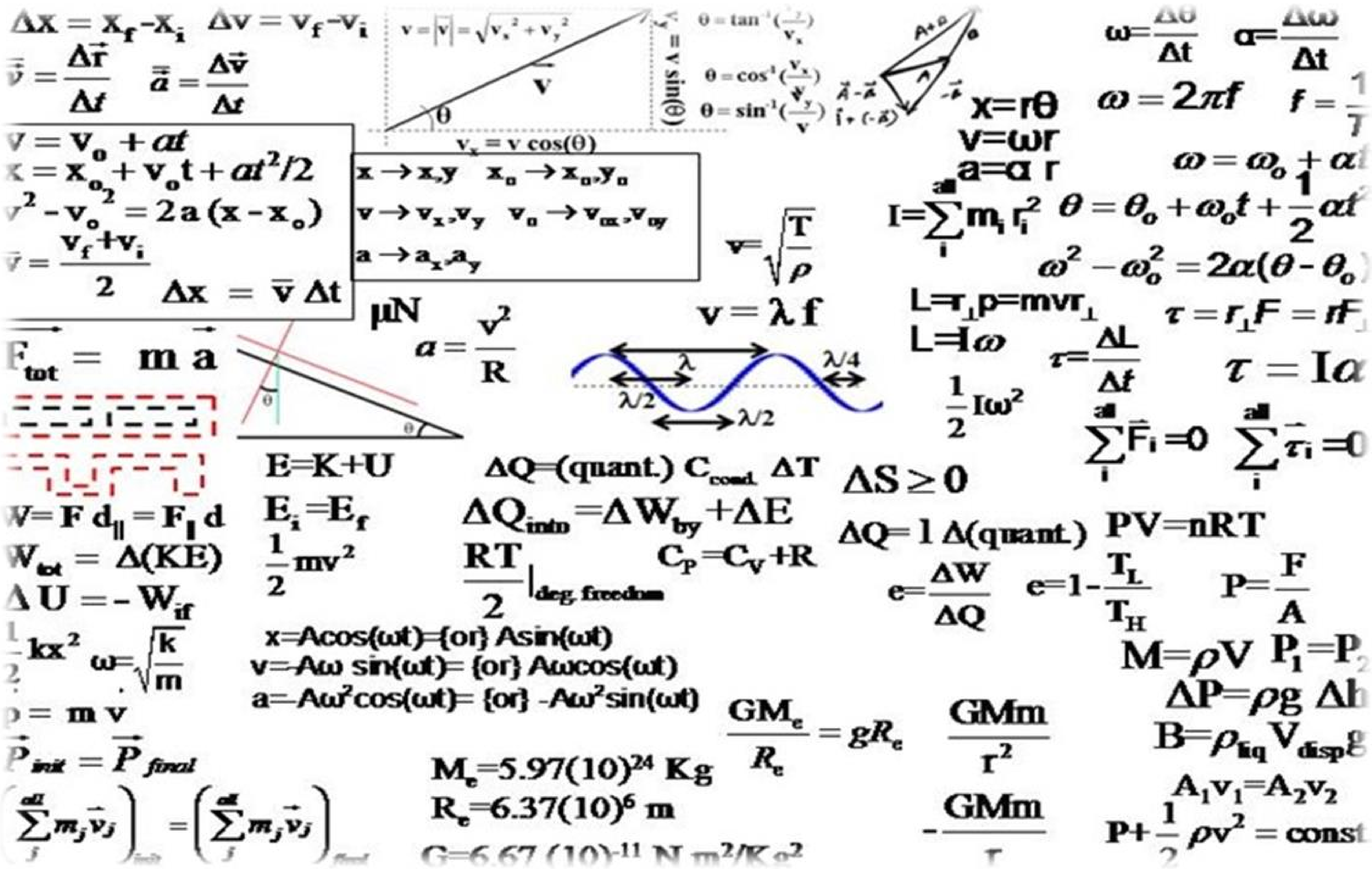
The lower the supply water temperature the higher the plant efficiency.



How is that possible?

Think of the formula for:

TONS = DeltaT x GPM x C



Where:

- DeltaT is created by the chiller(s)

- GPM is created by the pump(s)

- COP = coefficient of performance

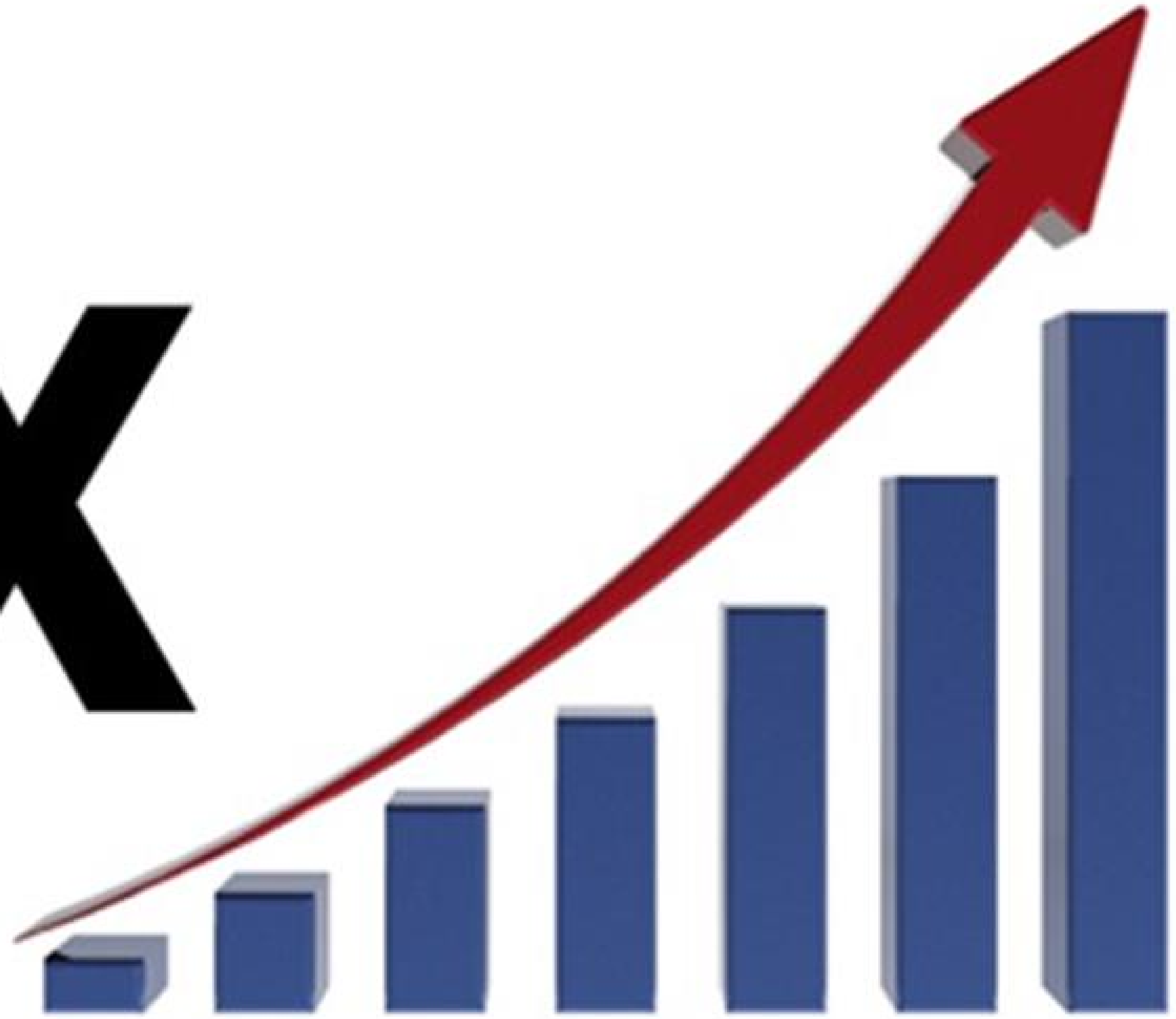
  ✓An average chiller COP = 6.0

  ✓An average pump COP = 0.60

$$\textbf{COP} = \frac{\textbf{Energy Output}}{\textbf{Energy Input}}$$

What that says is that the chiller is 10 times more efficient in doing its work than the pump

10X



In other words, make the chiller work harder and pump less water…

<u>The end result is lower KW/Ton and larger DeltaT</u>

Comparing Plants…..

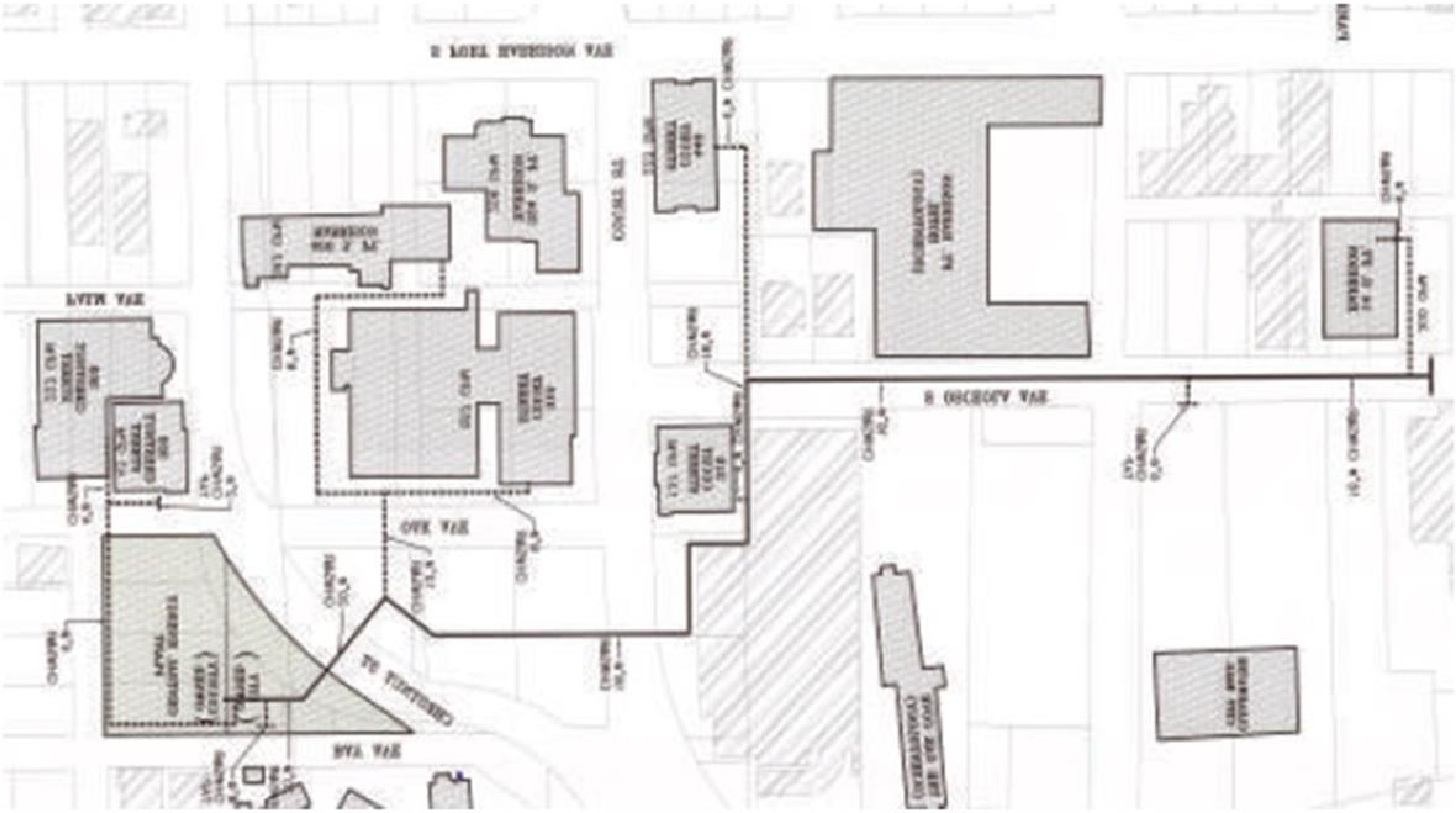
- Comparing ice-enhanced plants versus chiller-only plants.
- The traditional method of comparing plants based on KW/Ton does not work
- Ice plants use more kwh than chiller-only plants, but the total cost is lower due to on-peak and off-peak strategies (utility rates)
- The most accurate measure is the cost of generating the ton hour ($/ton hr) monthly.

Distribution System…

"The infamous pipe selection"

Pipe sizing and route selection is a difficult process with very little immediate feedback

Size the main trunk to at least equal to the maximum capacity of the plants' eventual build out



A pre–insulated steel pipe will last over 50 years

This photo of a section of steel pipe is from YBOR that was installed 18 years ago. It was dug out 2014. It looks like new!

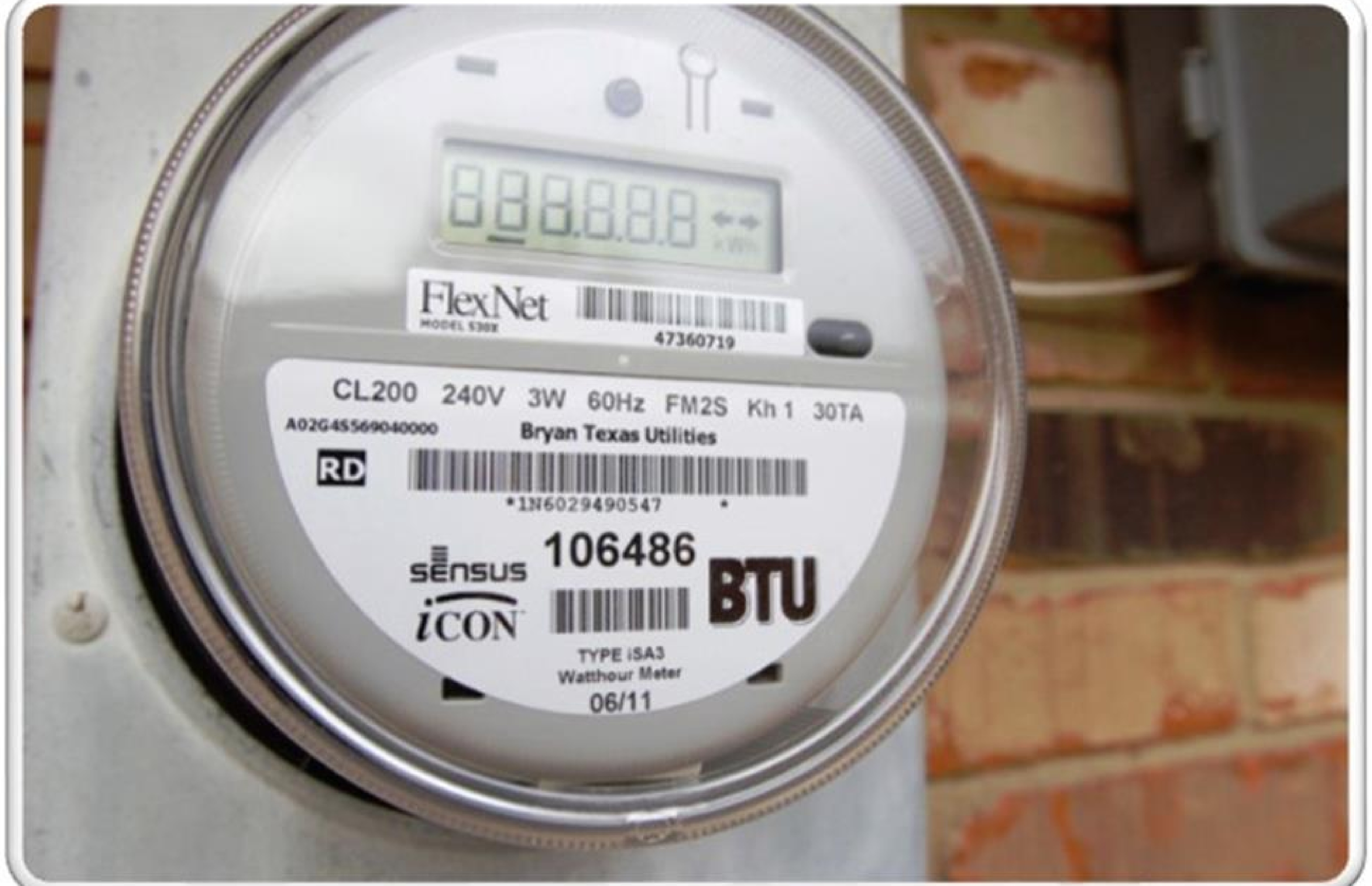
Metering and billing methods for chilled water consumption

The Billing Mechanism

Comprised of 3 parts:

1. Capacity charge (or customer charge)
   - This is a constant charge paid monthly by the end user and it is a function of the return of capital based on the connected load by that end user
2. Demand charge
   - Maximum peak demand of each connected load during specified 15 or 30 minute interval in a month (ton/hr)
3. Consumption charge
   - Total recorded ton hour usage of each connected load during the month
     - » Ton hour / month

Each customer location will have a BTU meter connected to the building automation system



- The BTU meter transmission to the BAS could be a wired or wireless connection

- We have found satisfactory results with both approaches

Meter calibration & verification

- Each BTU meter must be calibrated and verified at least once a year
- Accurate records must be kept in case of conflict with a customer surfaces

Lastly, a successful district plant must have a thorough customer entitlement contract

As you can see owning a district plant is a complex business with almost no available reference material to be guided by

Questions?

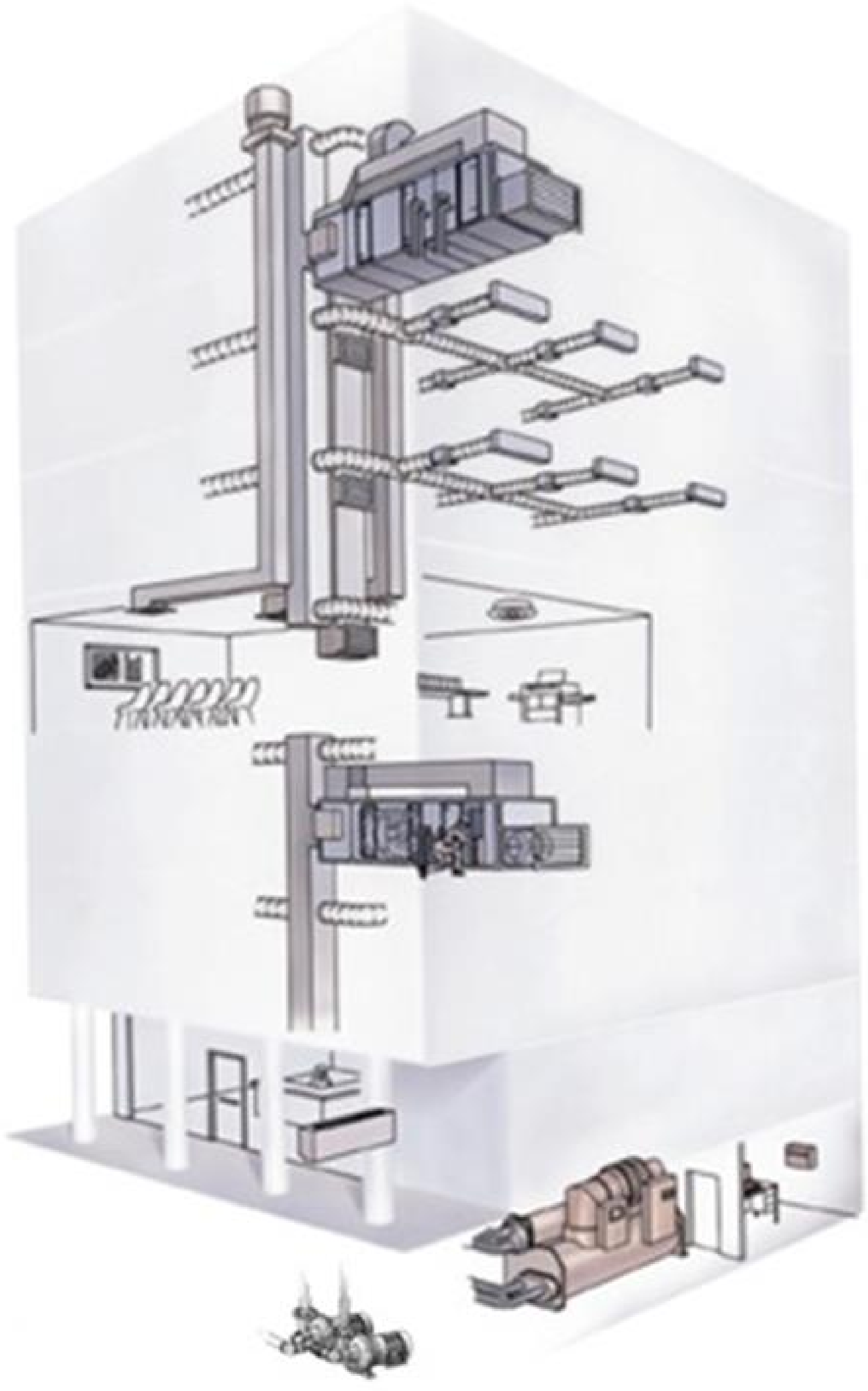
Polling Questions

1. What is the design temperature for Chilled Water Supply to the customer?
2. What is the design differential temperature (Delta T) for your system?
3. What is the actual Delta T on your system and does it vary month to month by seasonal conditions?

Eugene Smithart

- With over 40 years of industry experience, “Smitty” is currently the Director of Systems and Solutions for Trane.
- His presentation will focus on the airside aspects of district cooling and the benefits of lower supply temperature

Low Flow, Low Temperature, High Efficiency Systems



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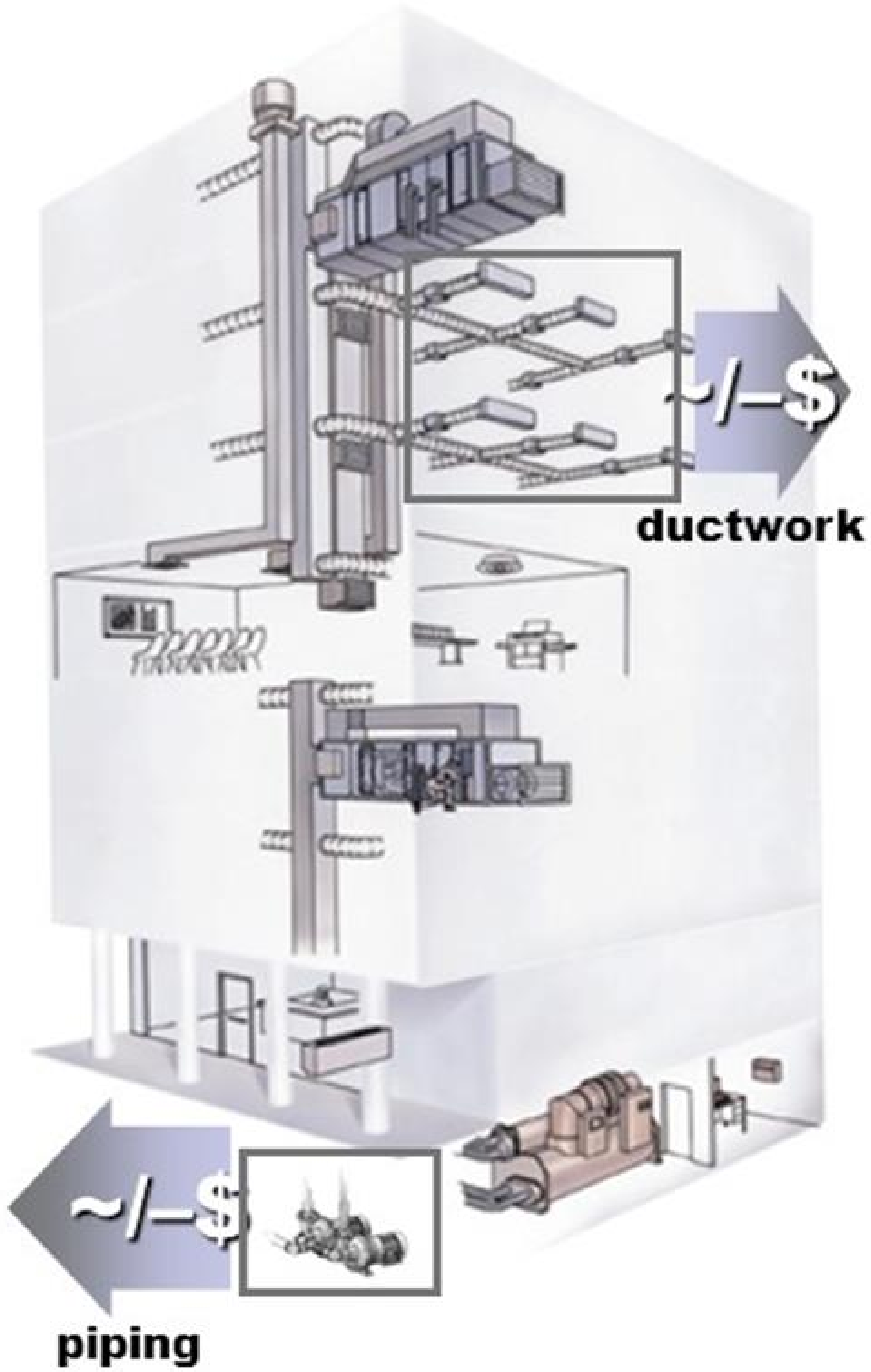

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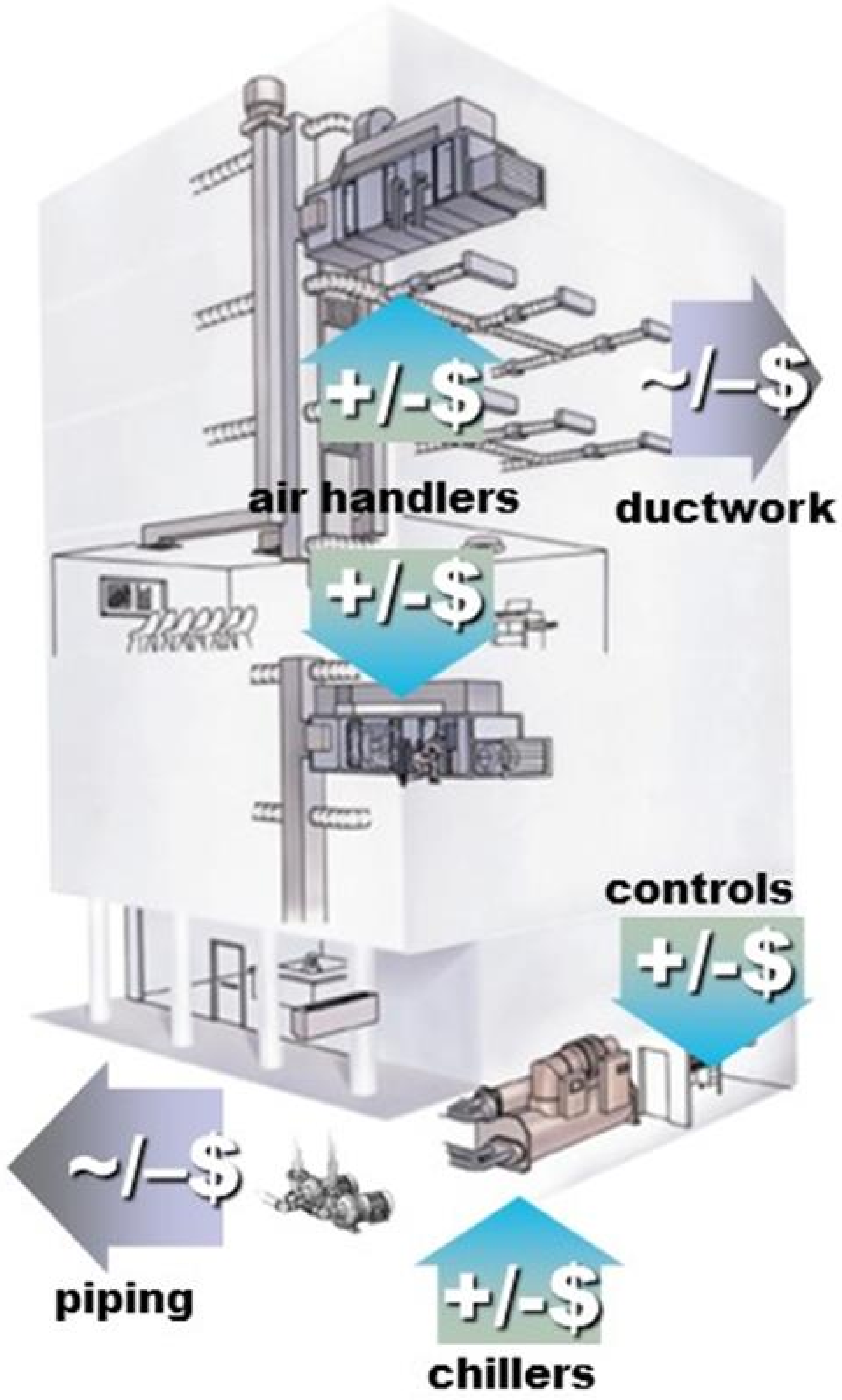

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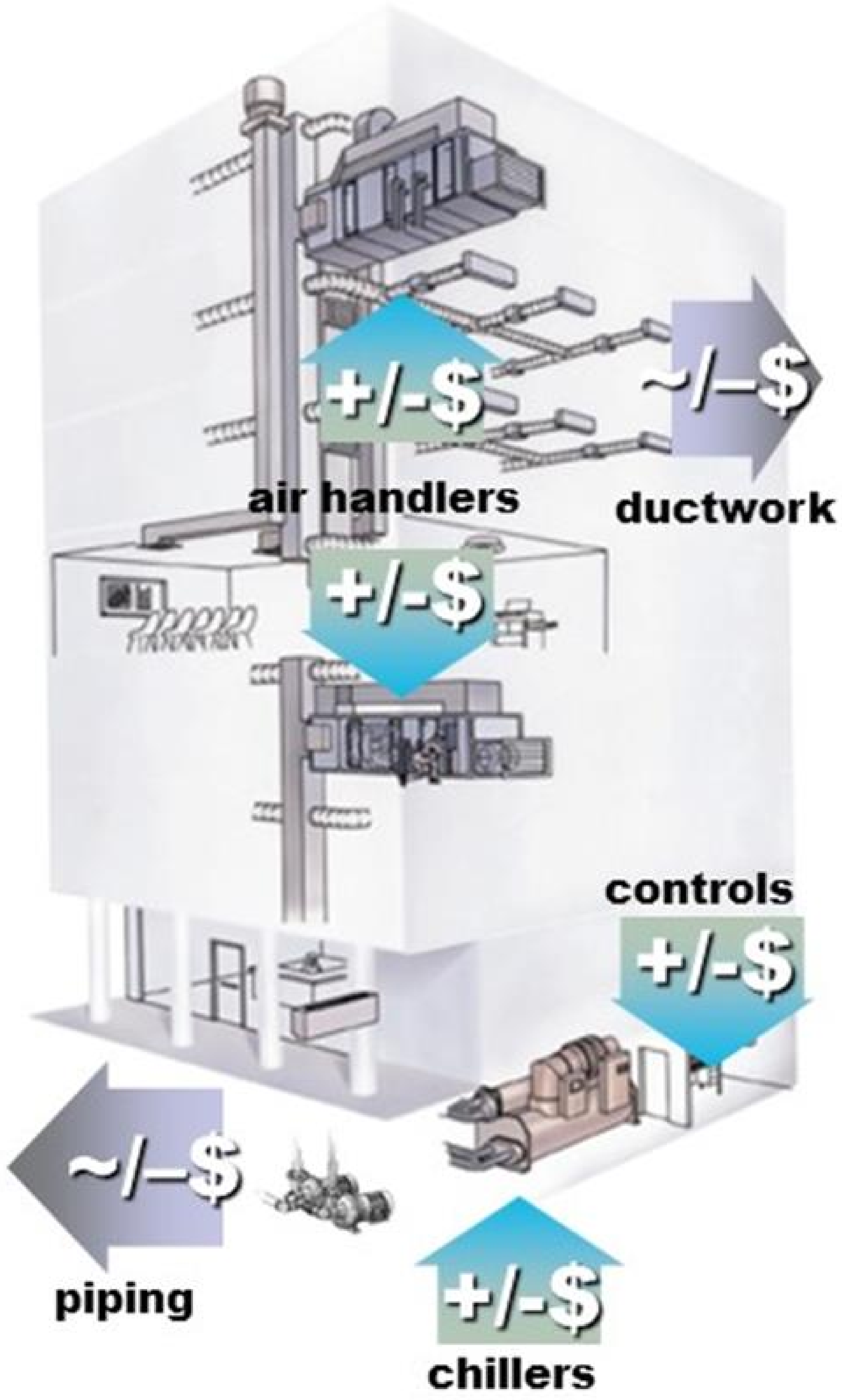
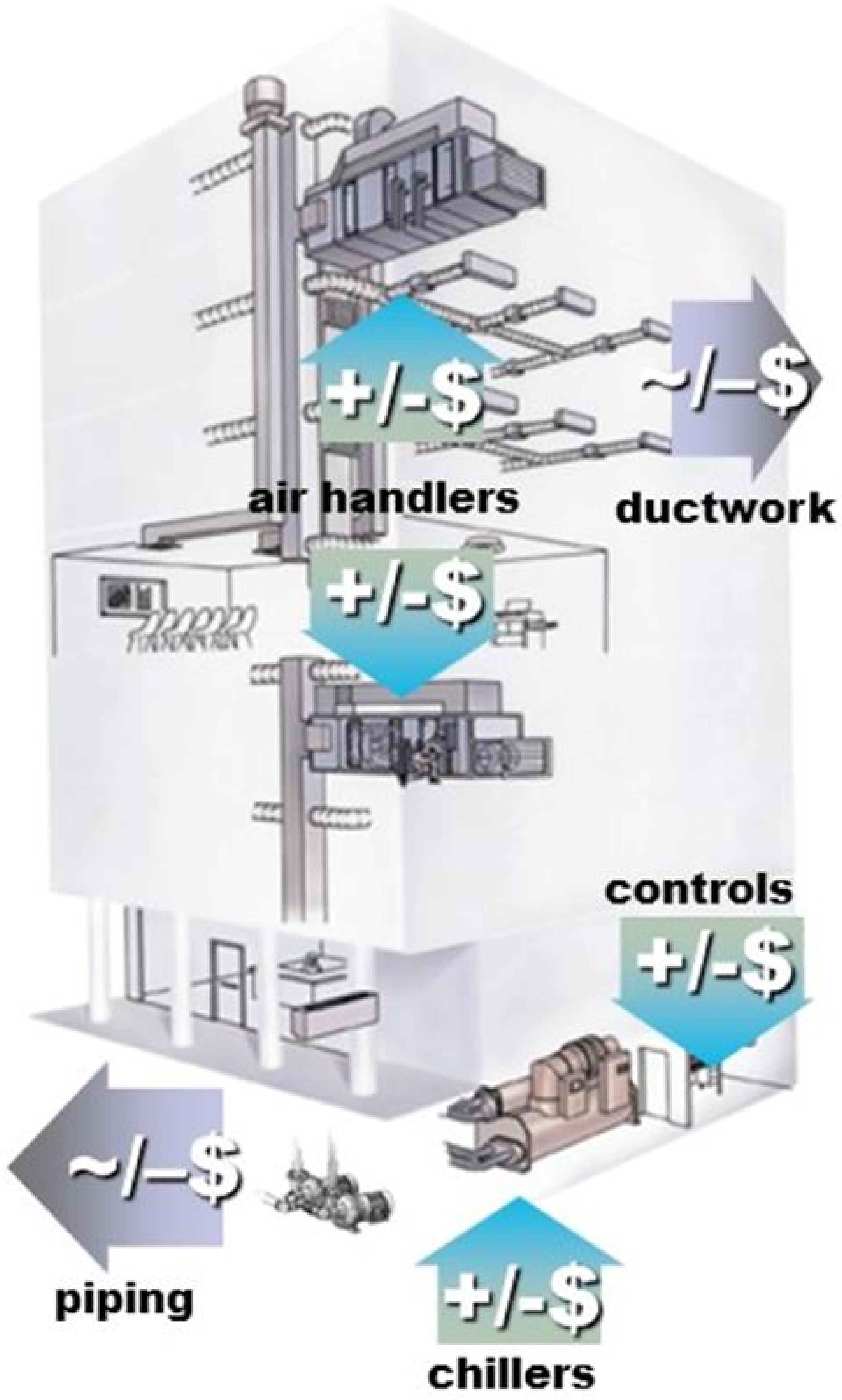


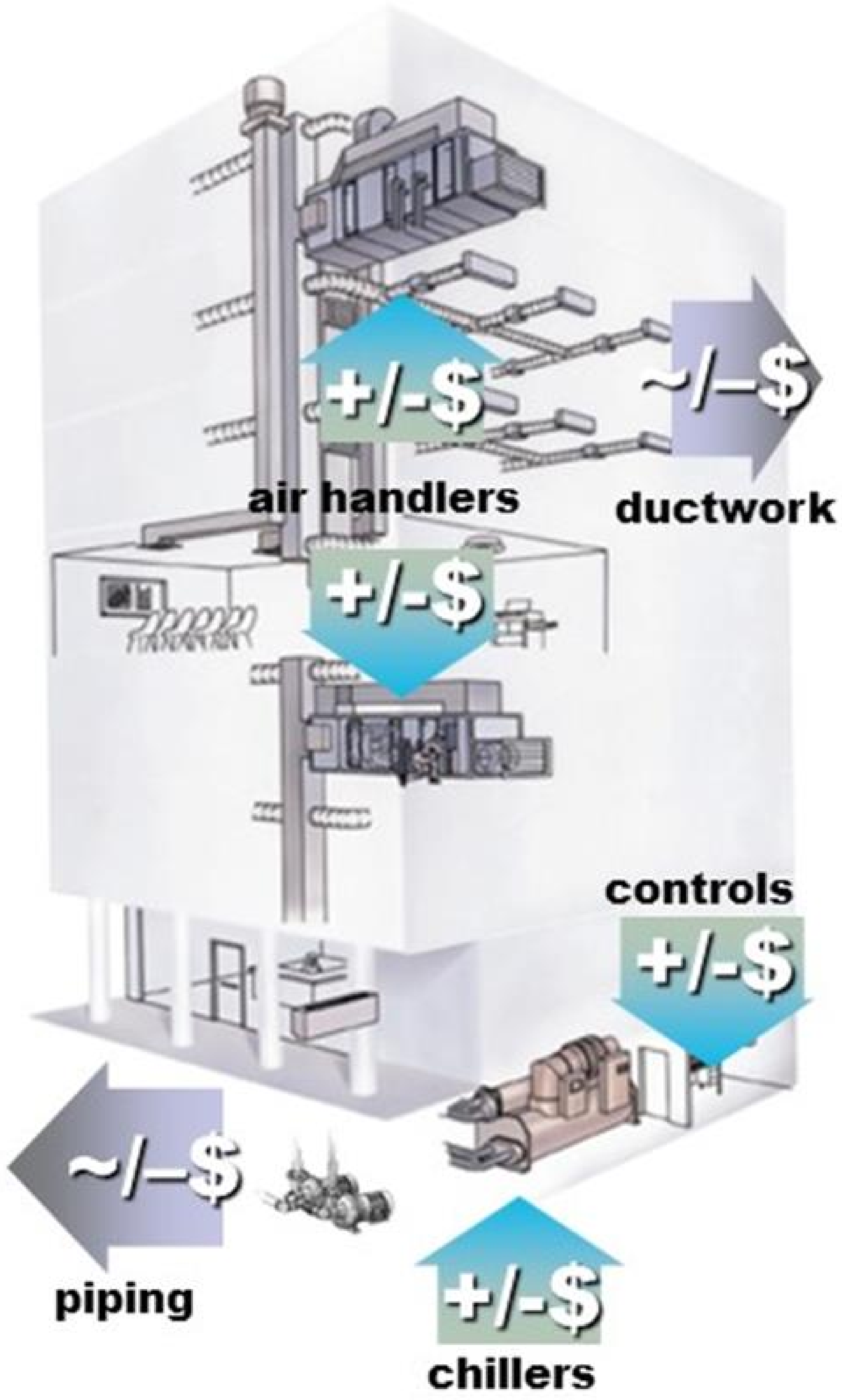
- First Cost

Low Flow, Low Temperature, High Efficiency Systems



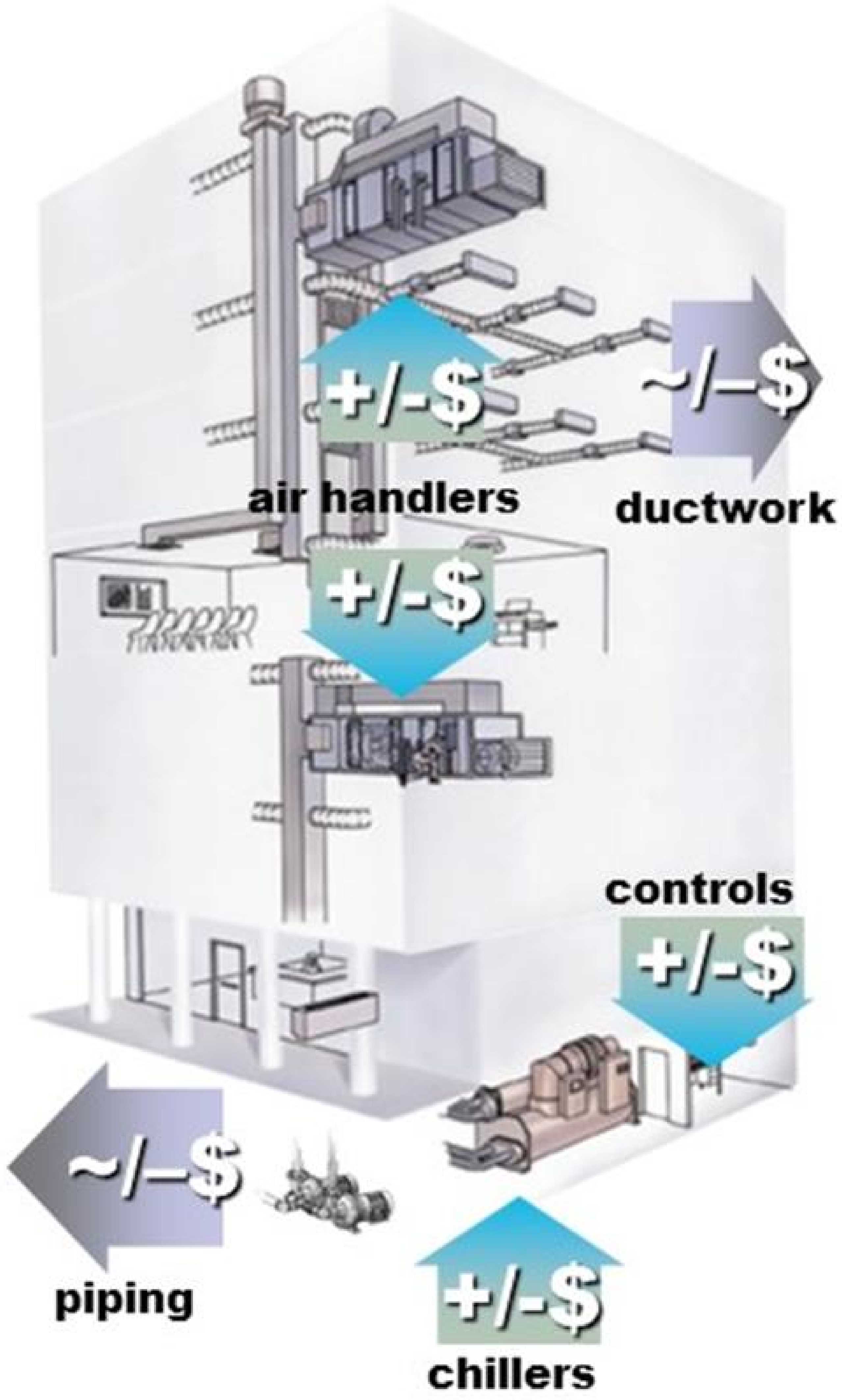
- First Cost
- Operating Cost

Low Flow, Low Temperature, High Efficiency Systems



- First Cost
- Operating Cost
- HVAC Footprint

Low Flow, Low Temperature, High Efficiency Systems



- First Cost ↓
- Operating Cost ↓
- HVAC Footprint ↓

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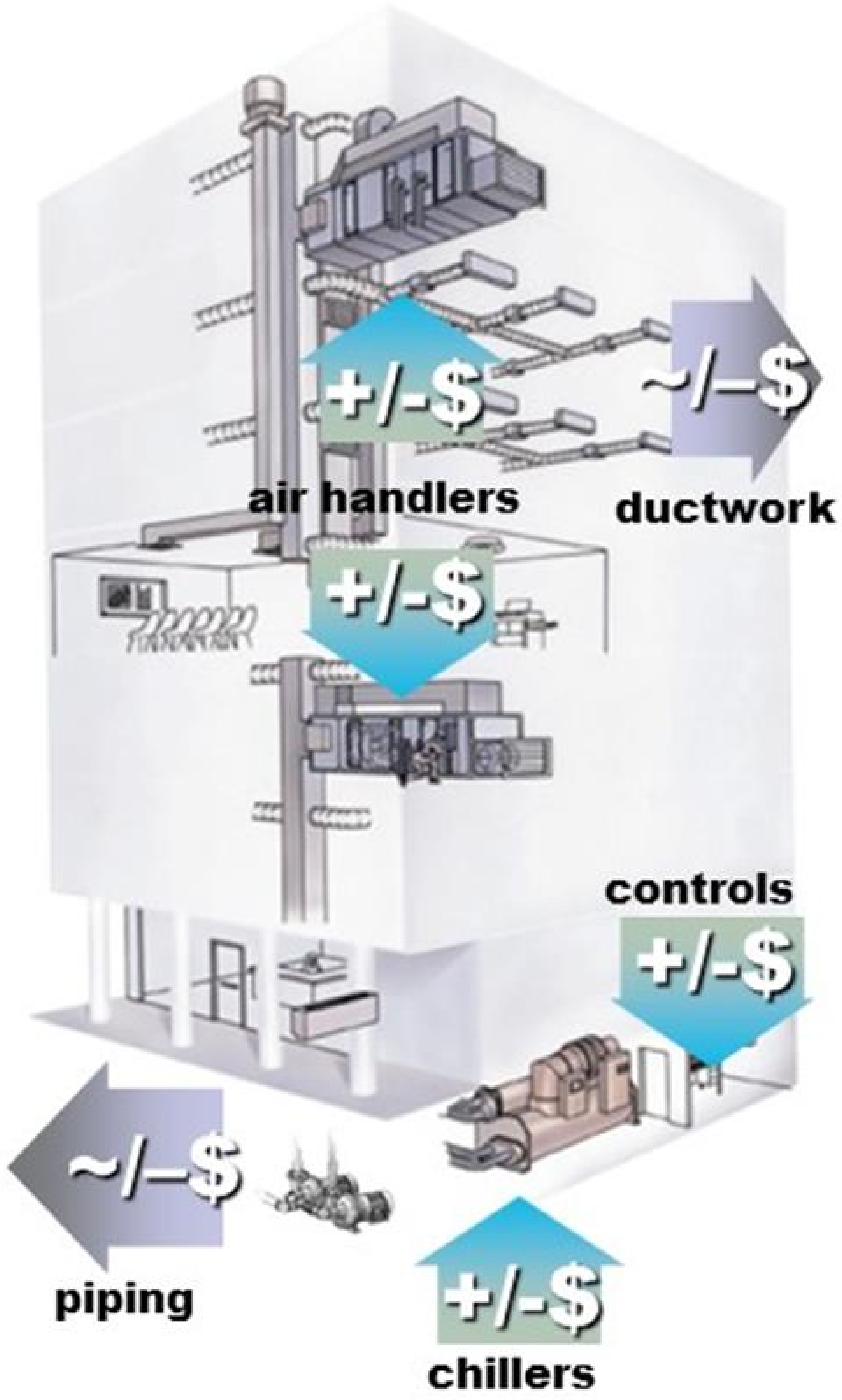
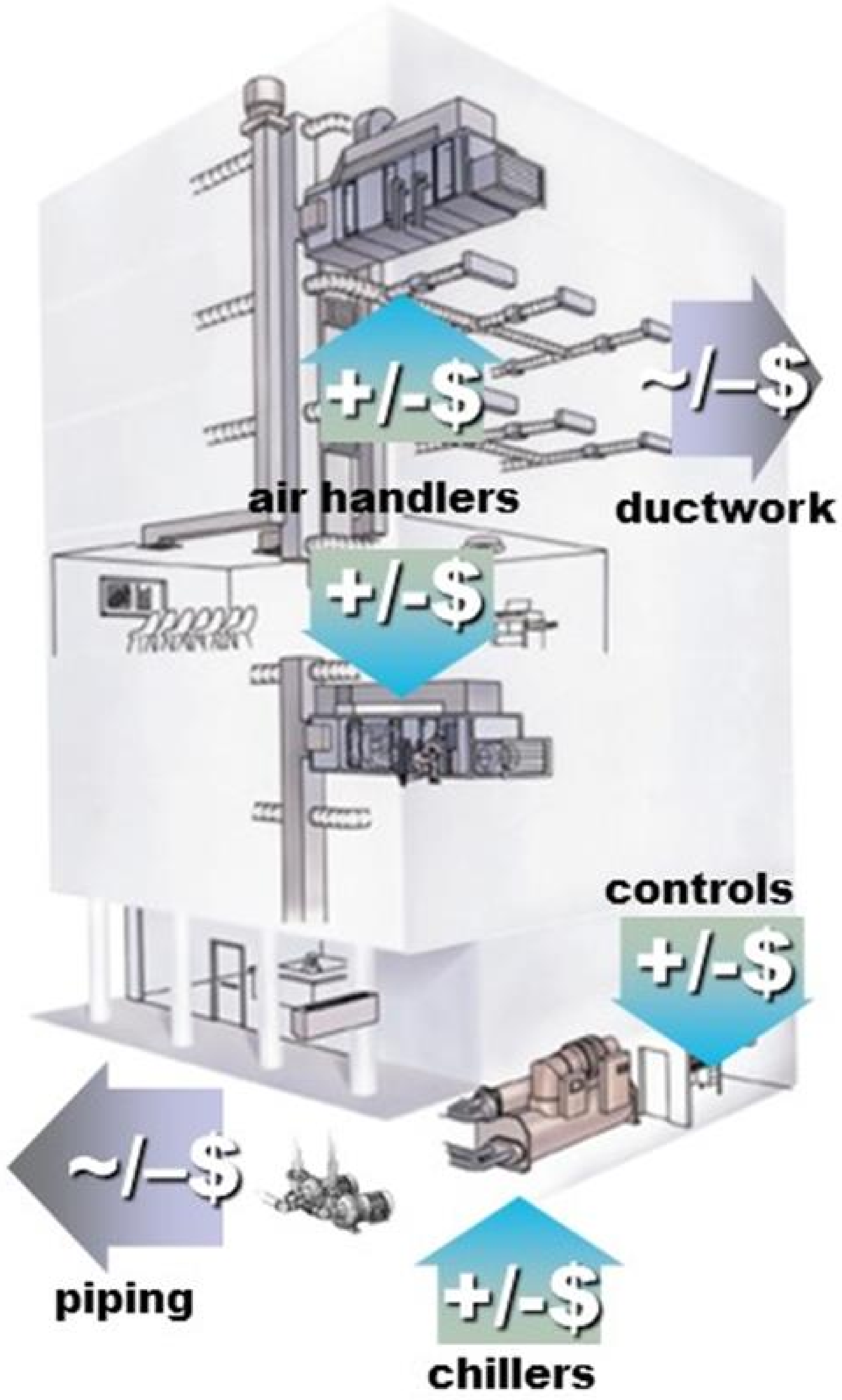


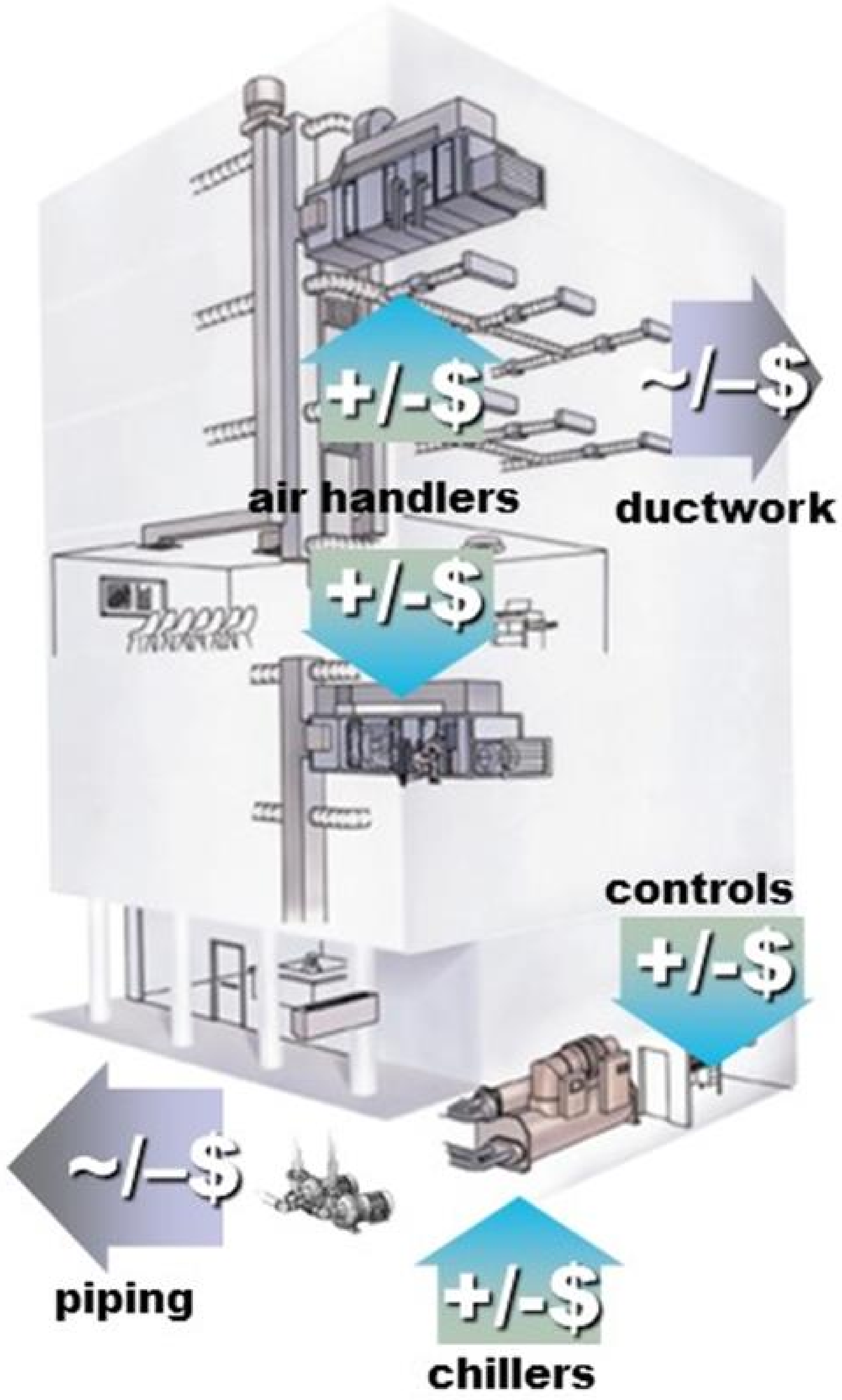
- First Cost ↓
- Operating Cost ↓
- HVAC Footprint ↓
- Comfort

Low Flow, Low Temperature, High Efficiency Systems



- First Cost ↓
- Operating Cost ↓
- HVAC Footprint ↓
- Comfort
- Indoor Air Quality

Low Flow, Low Temperature, High Efficiency Systems



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- Operating Cost ↓
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- Comfort
- Indoor Air Quality
- Acoustics

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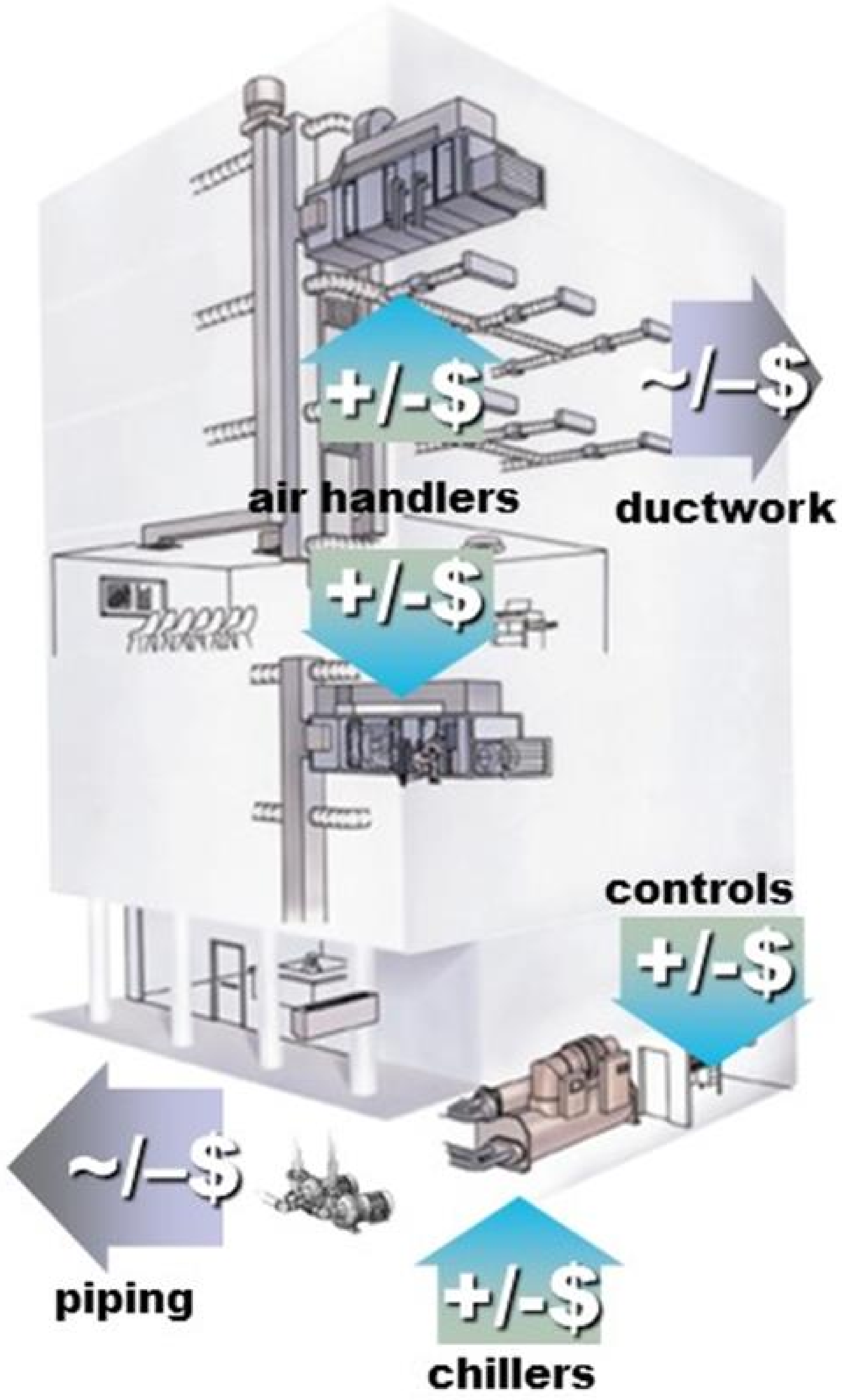
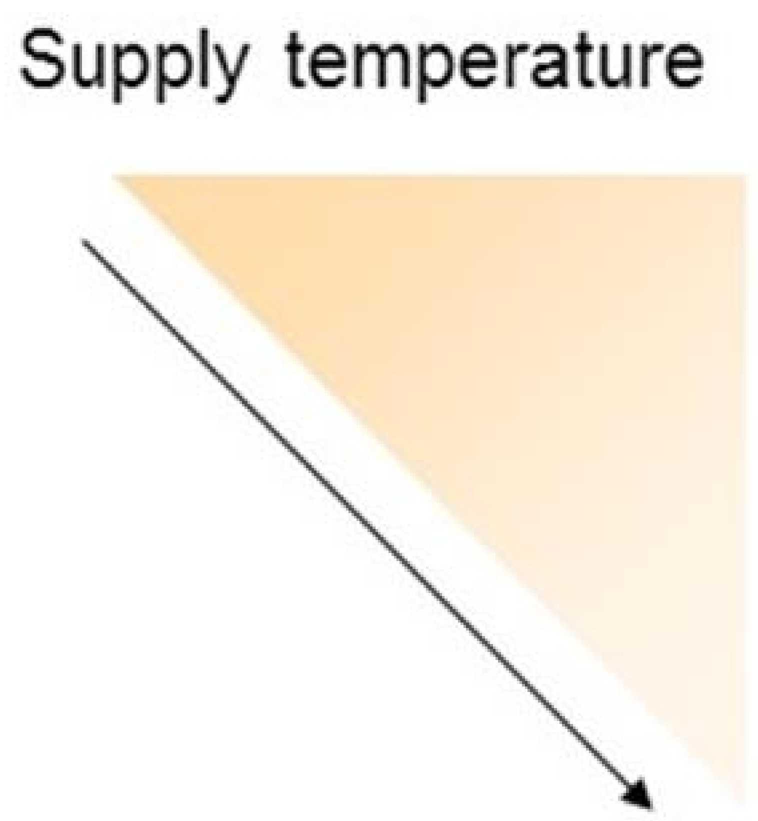


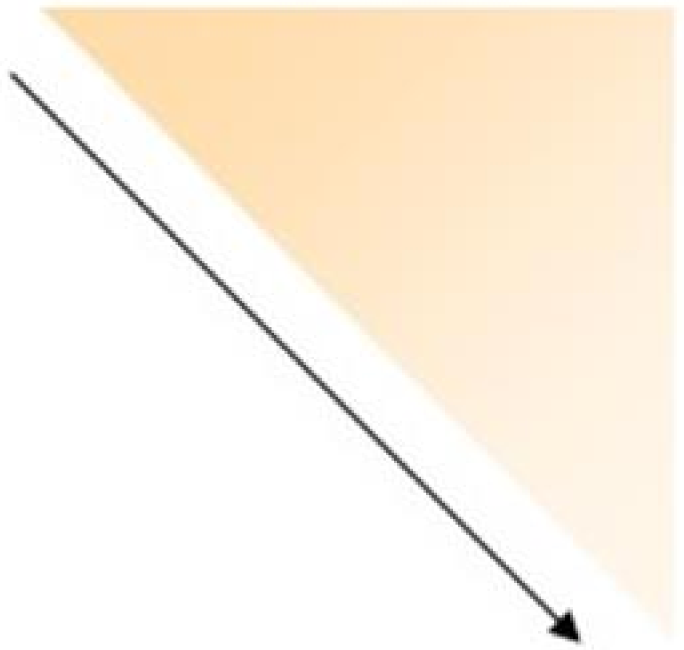
- First Cost ↓
- Operating Cost ↓
- HVAC Footprint ↓
- Comfort ↑
- Indoor Air Quality ↑
- Acoustics ↑

How?

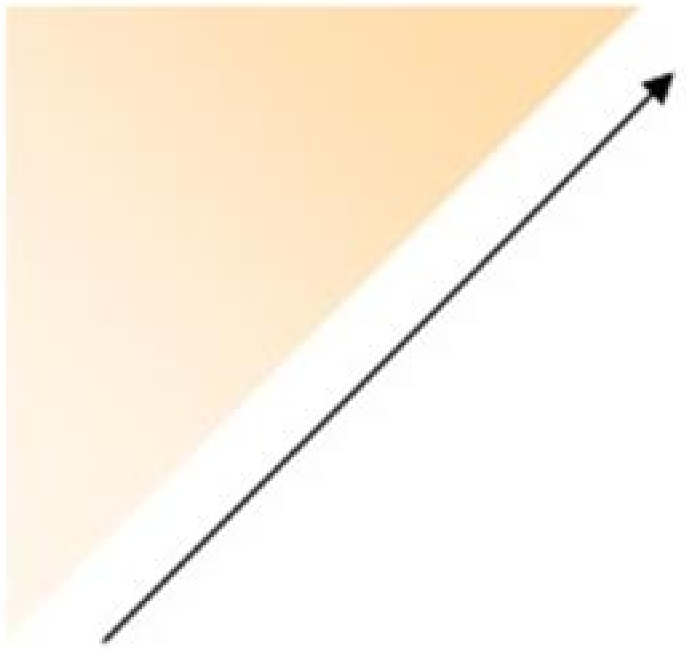


How?

Supply temperature



Temperature differential



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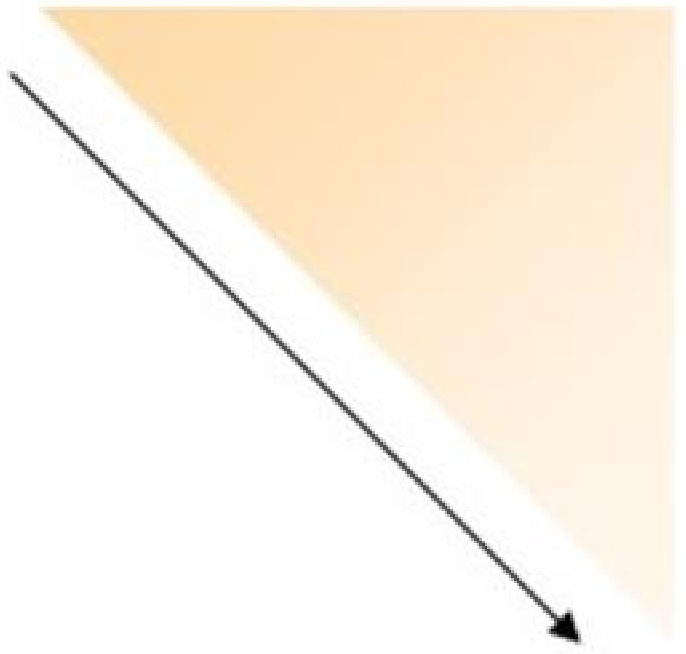

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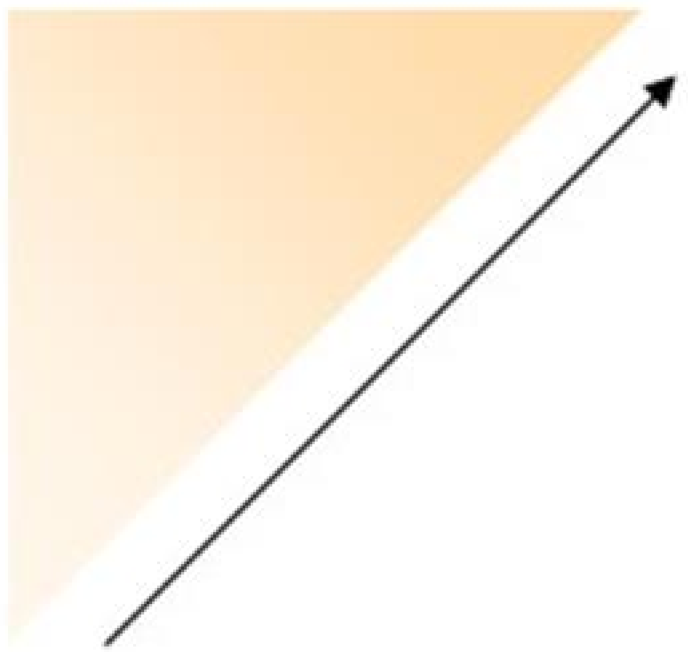
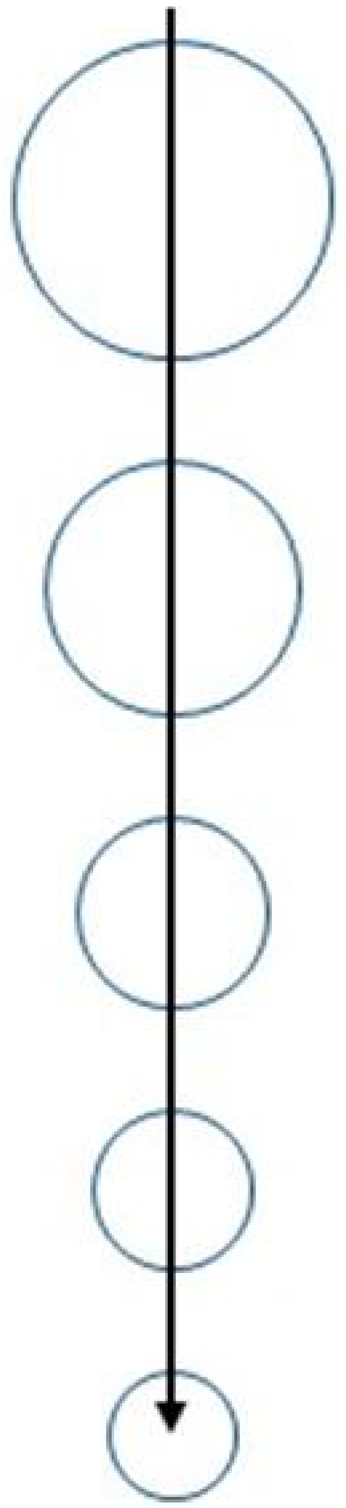


Flow rates



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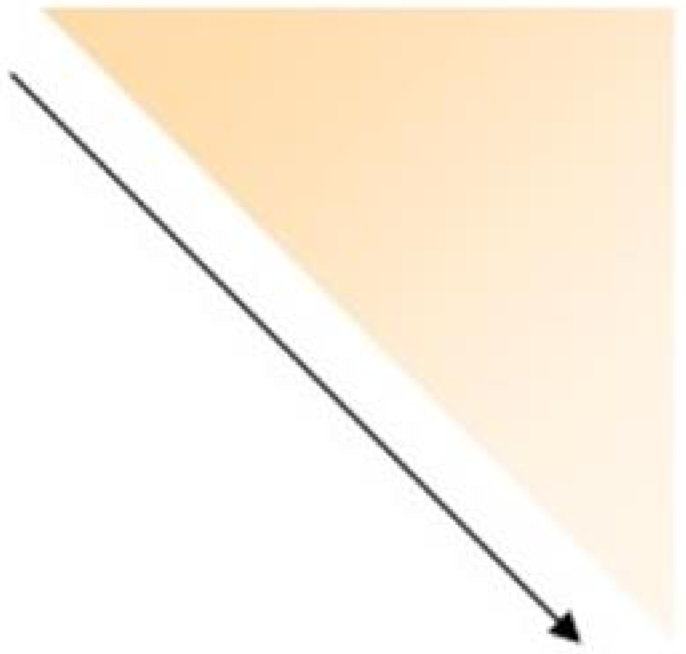

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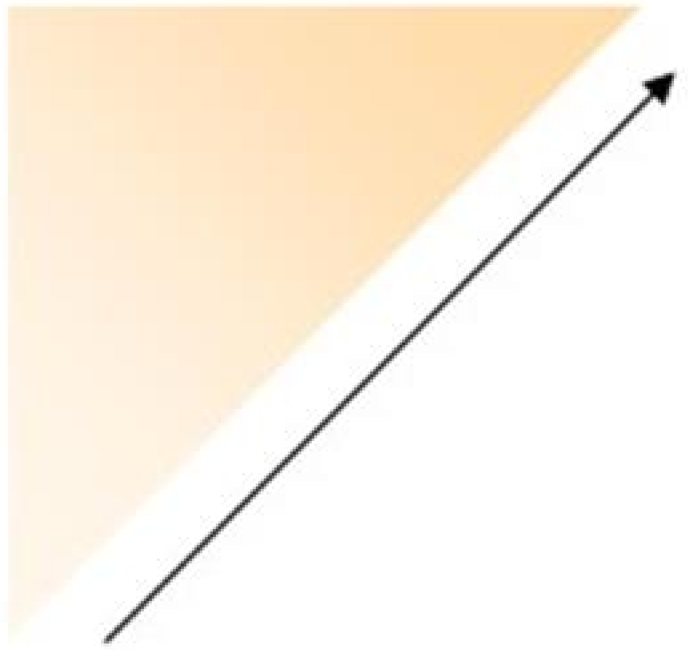

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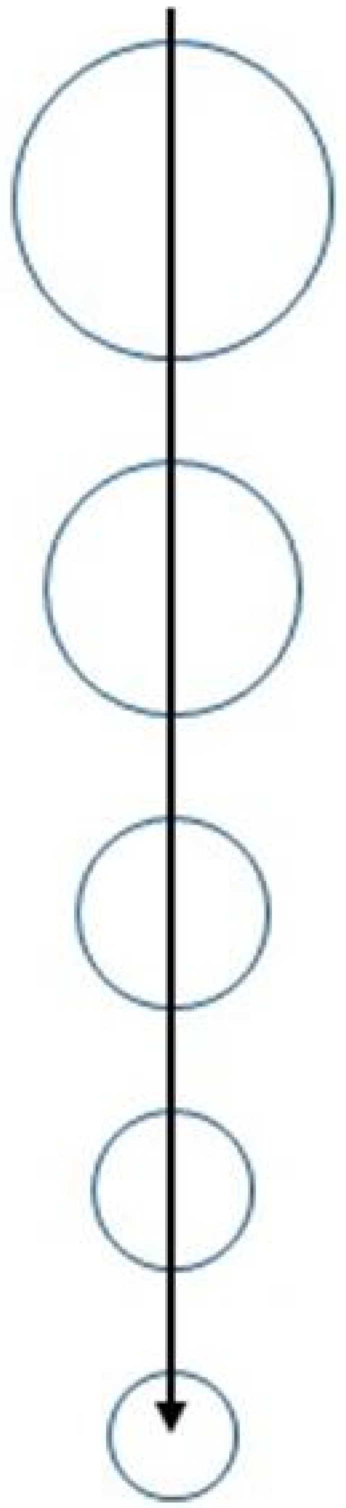
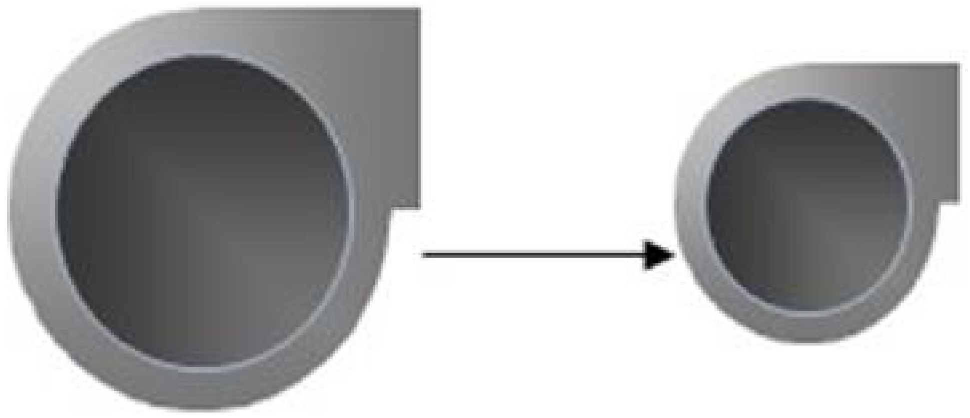


Fans



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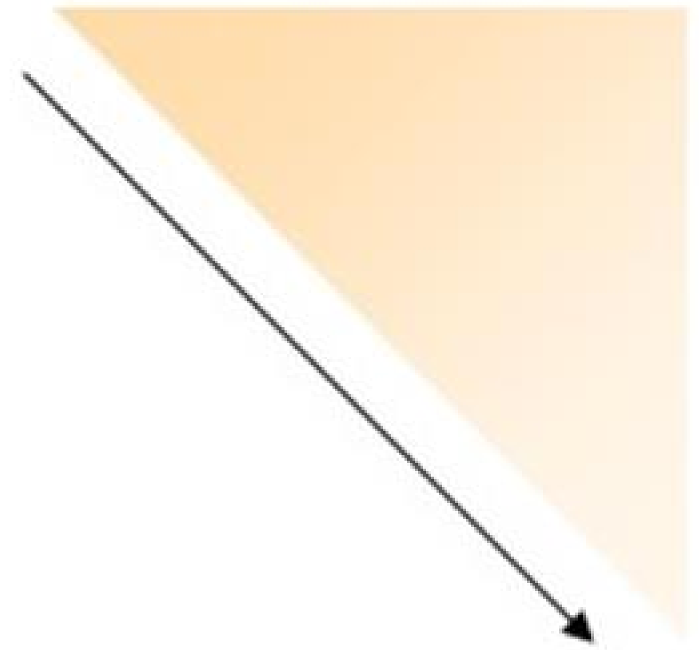
Supply temperature



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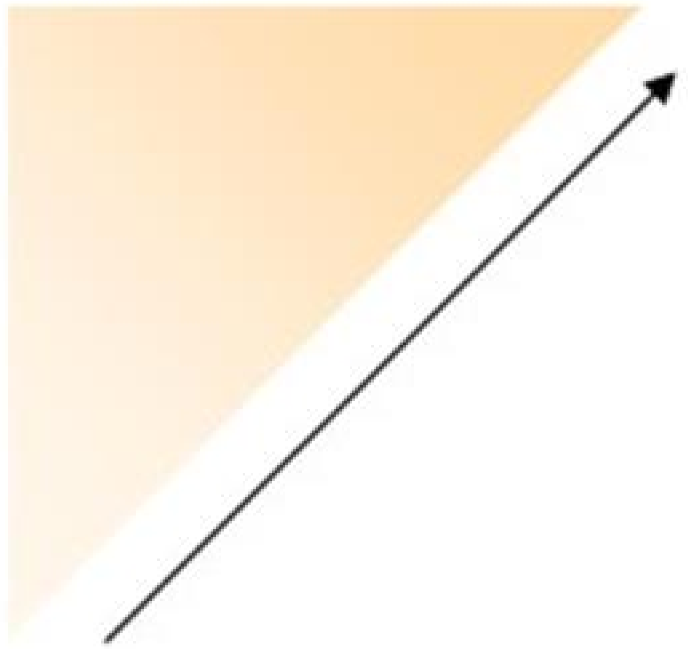

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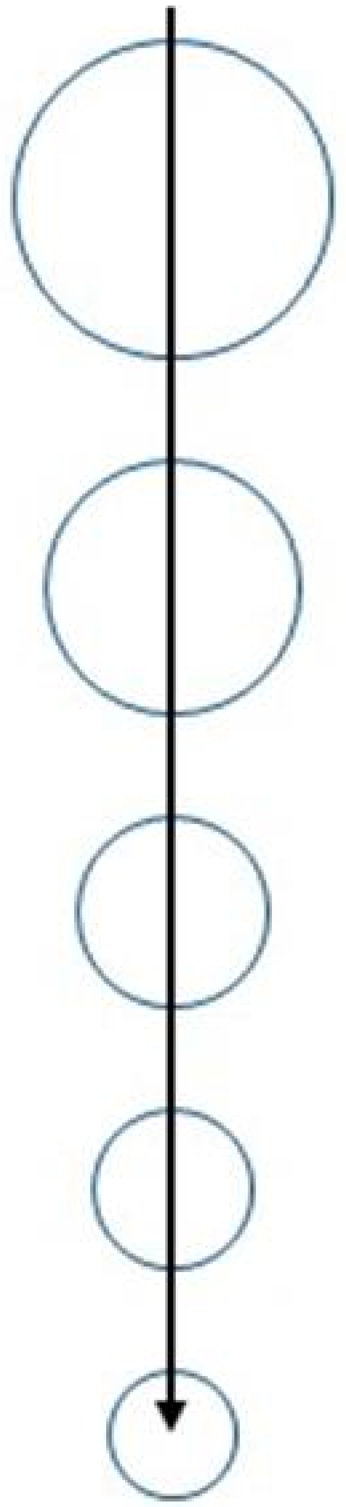

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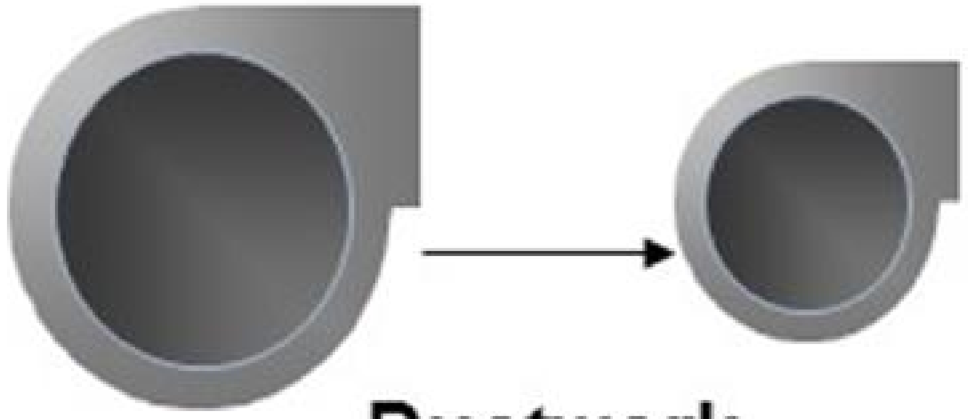
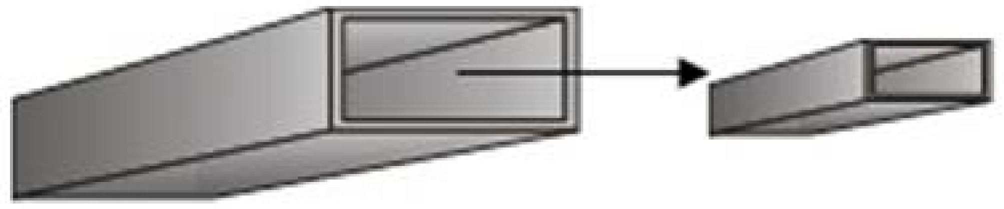


Ductwork



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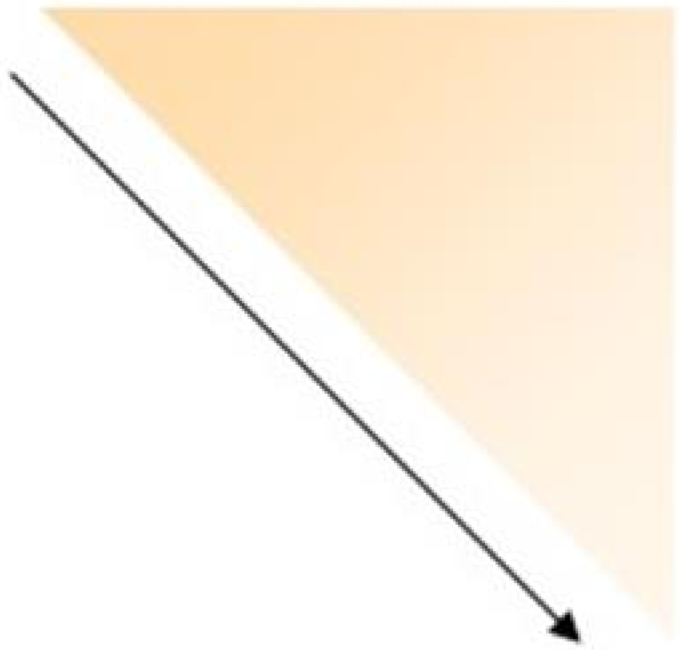

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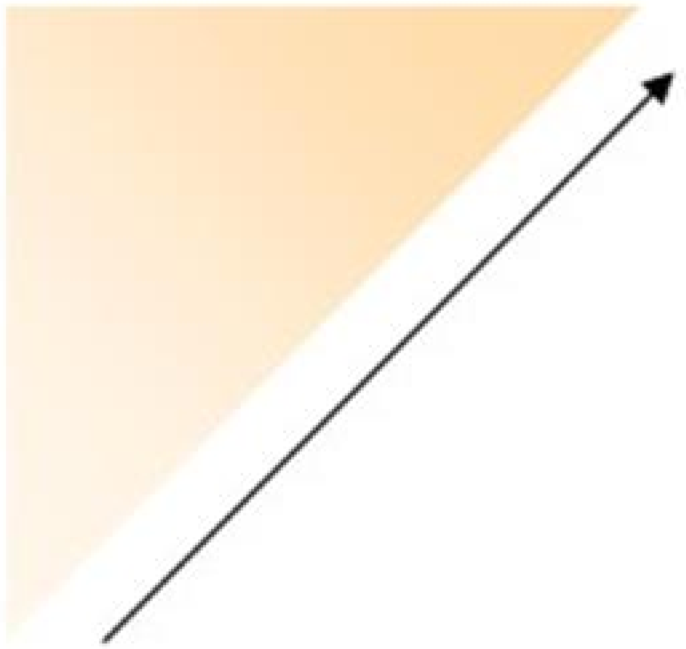

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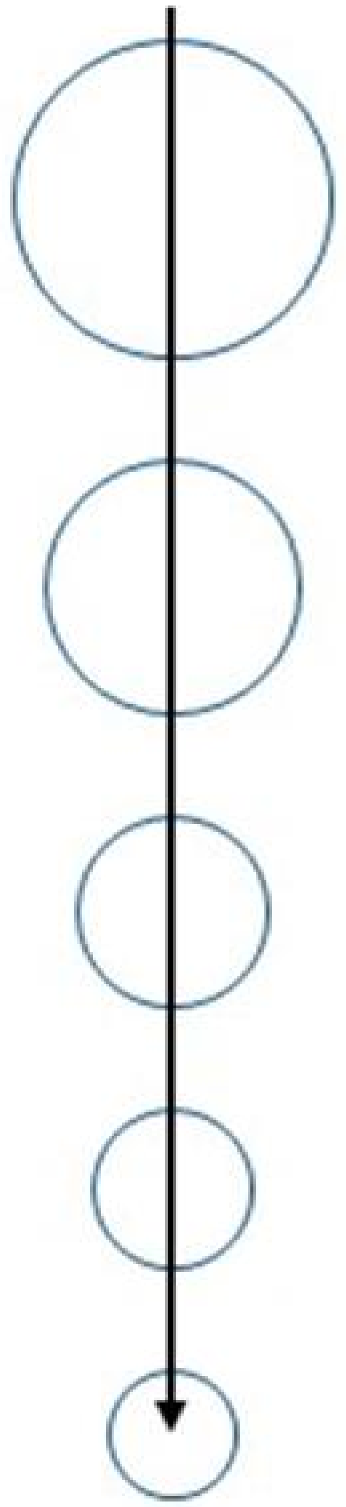

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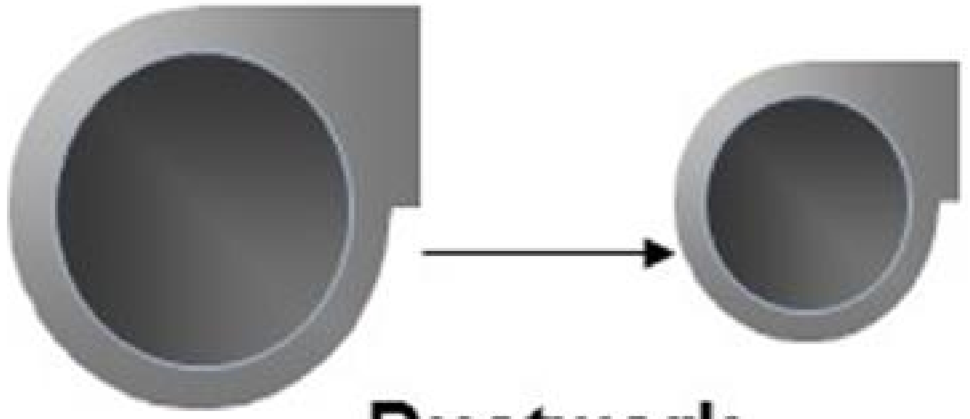

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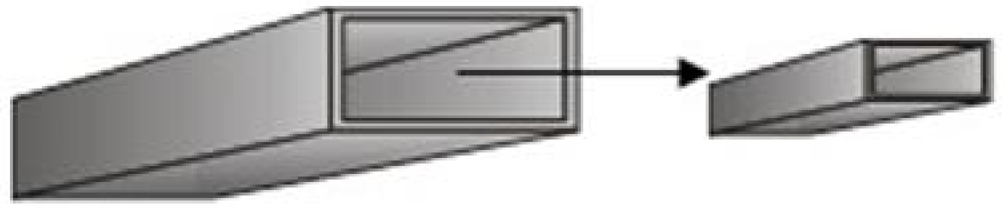
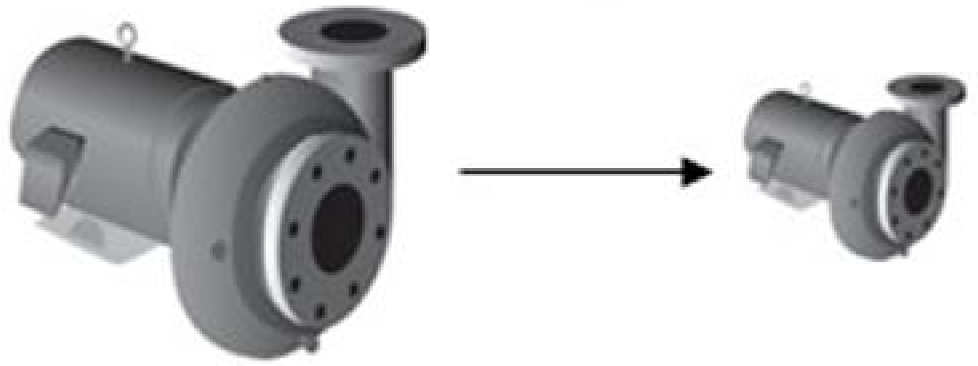


Pumps



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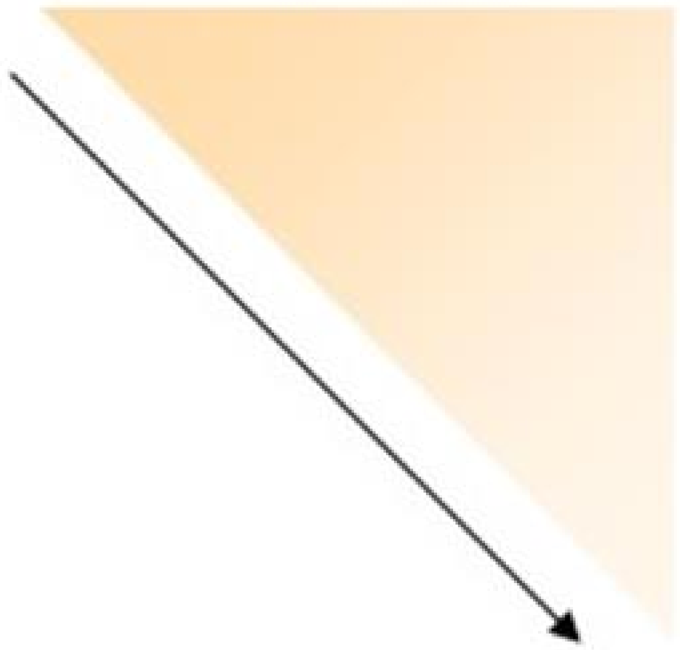

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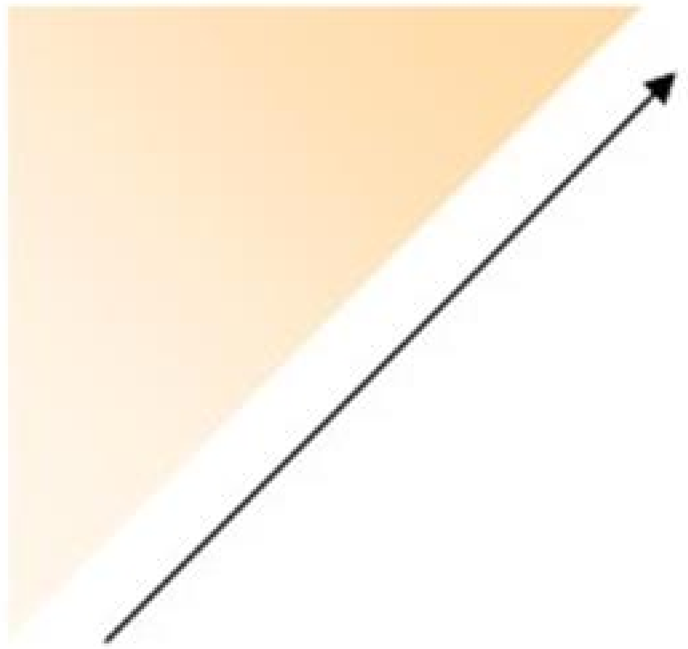

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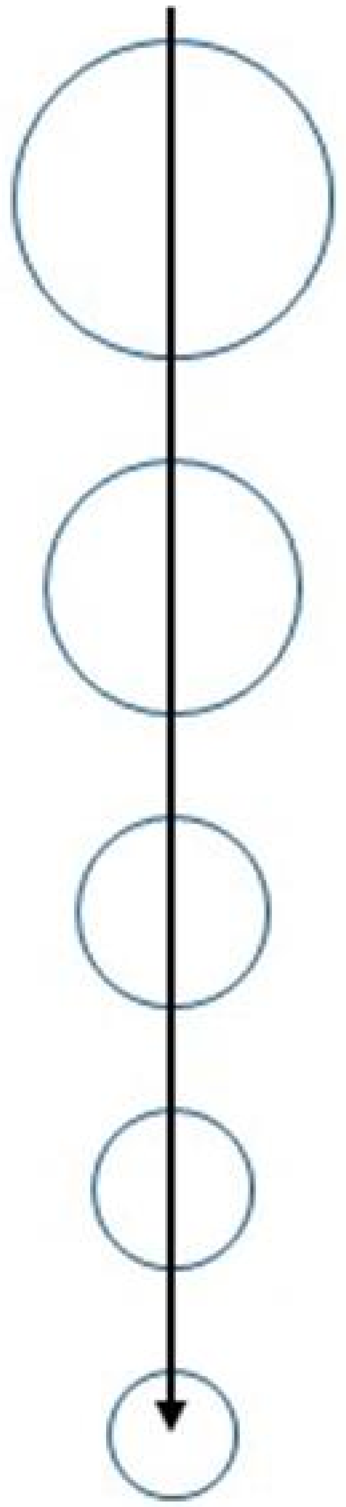

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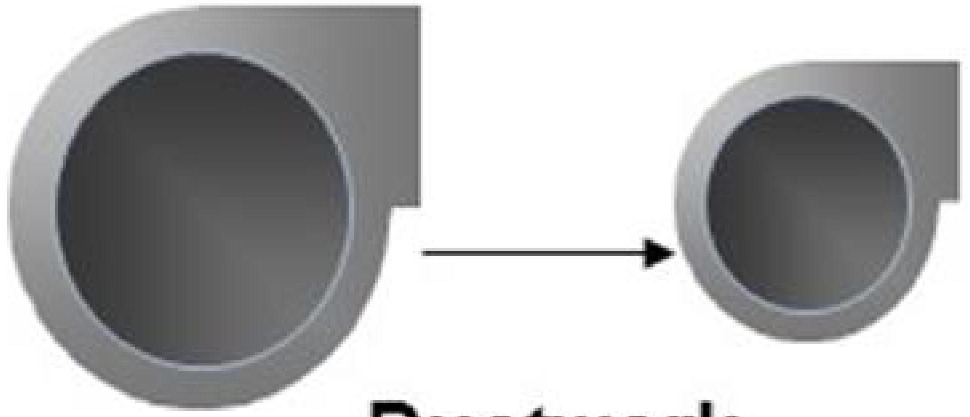
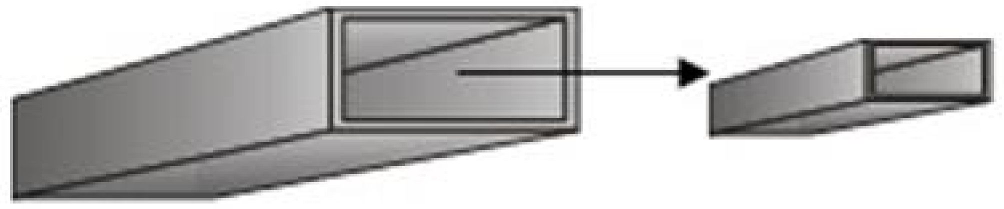


Ductwork



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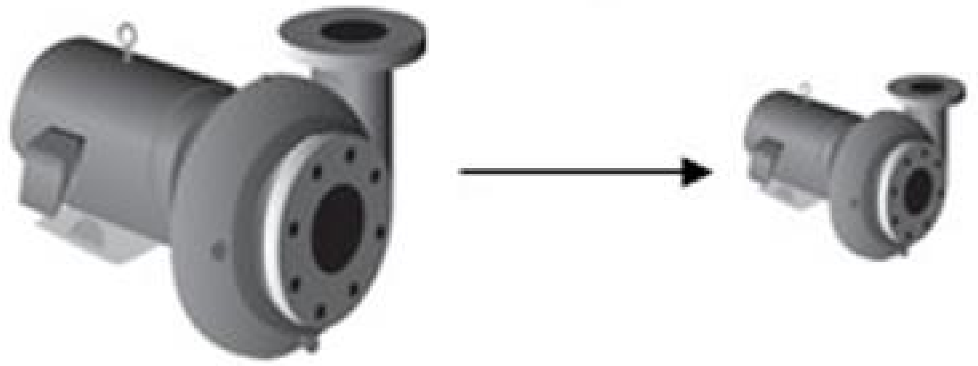
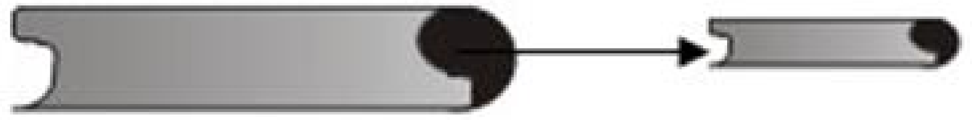


Piping



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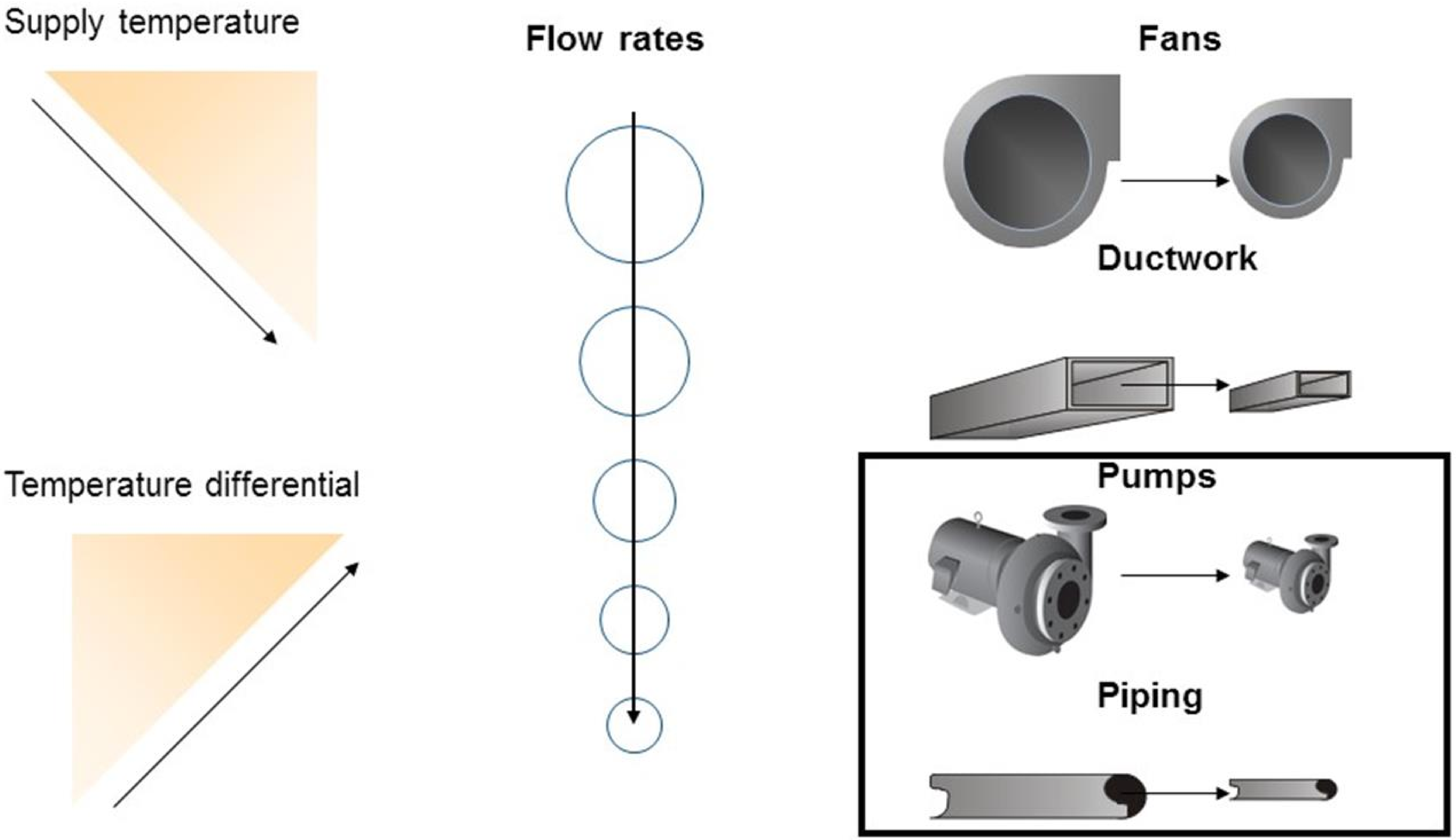
Supply temperature
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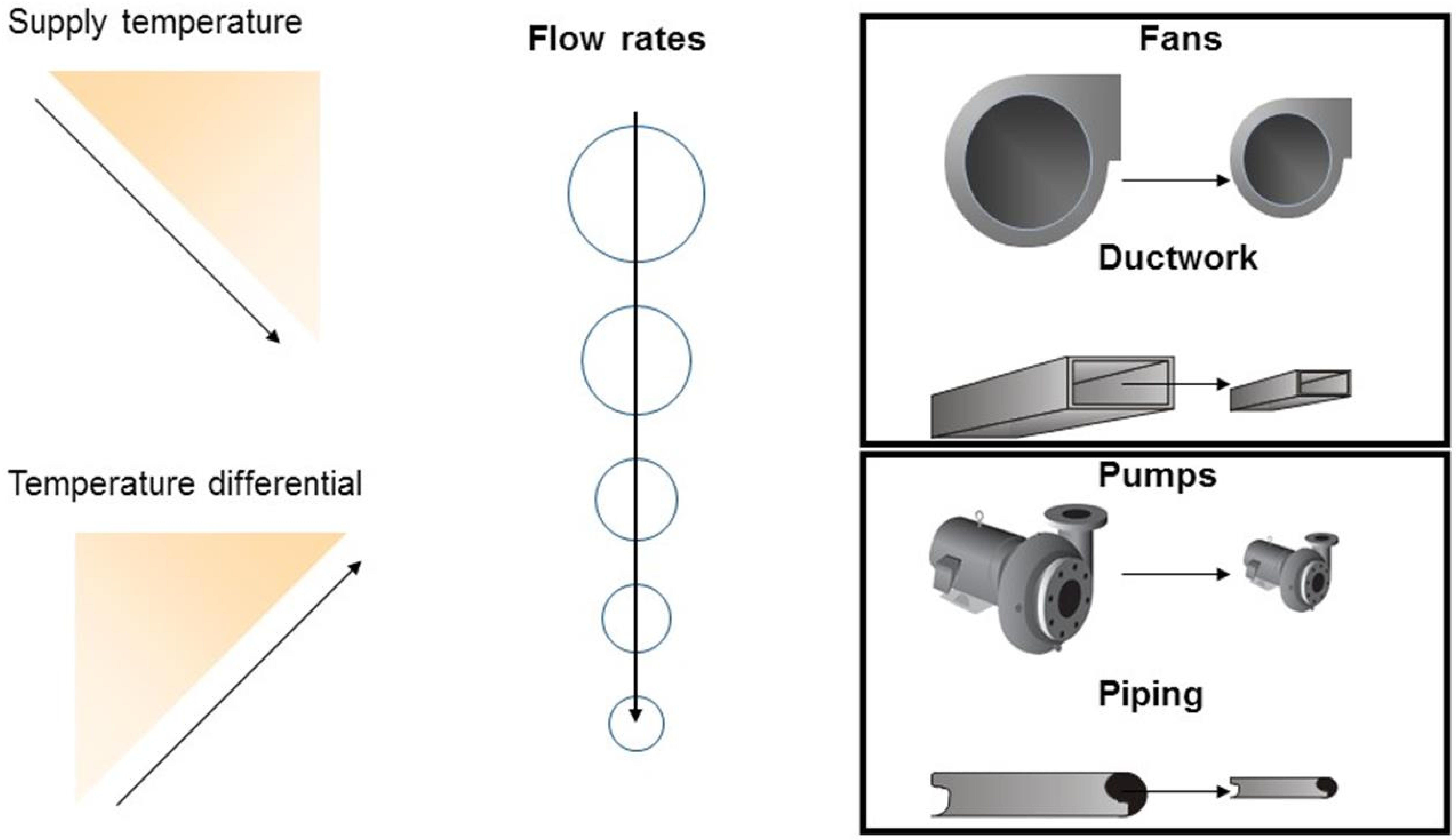
How?


Supply temperature
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Show Me the Money!!!

Example of Low Temp Air Unit
First Cost Savings-Chicago School

SYSTEM	SENS	ZONE GAINS		ZONE	COIL	AHU	SA	OA
	LOSS	SENS	LATENT	LOAD	LAT	LAT	CFM	CFM
Cafeteria	344,292	1,247,306	75,600	1322906	53.659	55	57746	14,400
Auditorium	292,863	664,050	114,870	778920	53.766	55	30743	16410
Band/ Choir	189,109	440,997	77,430	518427	53.606	55	20417	8017
Fine Arts Rooms	196,028	647,233	90,380	737613	53.648	55	29964	8858
Administration	147,622	410,089	66,229	419,686	53.571	55	18986	4302
Ist Flr Gym Classes	132,203	322,833	57,181	380014	53.704	55	14946	5552
Gymnasium	398798	1191266	359352	1550618	53.902	55	55151	33120
2nd Flr Gym Classe	292,610	1,014,475	373,597	1388072	53.761	55	46966	19,410
AREA E	362,369	926,737	109,943	1036680	53.635	55	42904	14139
West Ed Wing	324,801	819,437	97,008	916445	53.691	55	37937	11606
East Wing	320,153	900,273	148,146	1048419	53.691	55	41679	16886
Servery	0	75,090	41,208	116298	54.118	55	3476	2483
TOTAL	3000848	8,584,696	1569736	10097800			397440	152700

Example of Low Temp Air Unit First Cost Savings-Chicago School

397440

SYSTEM	SENS	ZONE GAINS		ZONE	COIL	AHU	SA	OA
	LOSS	SENS	LATENT	LOAD	LAT	LAT	CFM	CFM
Cafeteria	344,292	1,247,306	75,600	1322906	53.659	55	57746	14,400
Auditorium	[illegible]	[illegible]	[illegible]	778920	53.766	55	30743	16410
Band/ Choir	[illegible]	[illegible]	[illegible]	[illegible]18427	53.606	55	20417	8017
Fine Arts Rooms	[illegible]	[illegible]	[illegible]	737[illegible]13	53.648	55	29964	8858
Administration	[illegible]47,622	410,089	66,229	419,686	53.571	55	18986	4302
Ist Flr Gym Classes	132,208	322,833	57,181	380014	5[illegible].704	55	14946	5552
Gymnasium	398798	11[illegible]1266	359352	1550618	53.9[illegible]2	55	55151	33120
2nd Flr Gym Classe	292,610	1,014,475	373,597	1388072	53.761	55	46966	19,410
AREA E	362,369	926,737	109,[illegible]43	1036680	53.635	55	42904	14139
West Ed Wing	324,801	819,437	97,008	[illegible]16445	53.691	55	[illegible]7937	11606
East Wing	320,153	900,273	148,146	104841[illegible]	53.691	55	41[illegible]79	16886
Servery	0	75,090	41,208	116298	54.[illegible]18	55	3476	2483
TOTAL	3000848	8,584,696	1569736	10097800			397440	152700

Example of Low Temp Air Unit First Cost Savings-Chicago School

SYSTEM	SENS	ZONE GAINS		ZONE	COIL	AHU	SA	OA	%OA
	LOSS	SENS	LATENT	LOAD	LAT	LAT	CFM	CFM	
Cafeteria	344,292	1,247,306	75,600	1322906	45.122	47	41247	14,400	0.35
Auditorium	292,863	664,050	114,870	778920	45.272	47	21959	16410	0.75
Band/ Choir	189,109	440,997	77,430	518427	45.048	47	14583	8017	0.55
Fine Arts Rooms	196,028	647,233	90,380	737613	45.108	47	21403	8858	0.41
Administration	147,622	410,089	66,229	419,686	53.571	55	18986	4302	0.23
Ist Flr Gym Classes	132,203	322,833	57,181	380014	45.186	47	10676	5552	0.52
Gymnasium	398798	1191266	359352	1550618	45.463	47	39394	33120	0.84
2nd Flr Gym Classes	292,610	1,014,475	373,597	1388072	45.266	47	33547	19,410	0.58
AREA E	362,369	926,737	109,943	1036680	45.089	47	30646	14139	0.46
West Ed Wing	324,801	819,437	97,008	916445	45.167	47	27098	11606	0.43
East Wing	320,153	900,273	148,146	1048419	45.167	47	29771	16886	0.57
Servery	0	75,090	41,208	116298	54.118	55	3476	2483	0.71
TOTAL	3000848	8,584,696	1569736	10097800			289310	152700	

Example of Low Temp Air Unit
First Cost Savings-Chicago School

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	LOSS	SENS	LATENT	LOAD	LAT	LAT	CFM	CFM	
Cafeteria	344,292	1,247,306	75,600	1322906	45.122	47	41247	14,400	0.35
Auditorium	[illegible]	[illegible]	[illegible]	778920	45.272	47	21959	16410	0.75
Band/ Choir	[illegible]	[illegible]	[illegible]	518427	45.048	47	14583	8017	0.55
Fine Arts Rooms	[illegible]	[illegible]	[illegible]	737613	45.108	47	21403	8858	0.41
Administration	[illegible]	[illegible]	[illegible]	419,686	53.571	55	18986	4302	0.23
Ist Flr Gym Classes	132,203	322,833	57,181	380014	45.186	47	10676	5552	0.52
Gymnasium	398798	1191266	359352	1550618	45.463	47	39394	33120	0.84
2nd Flr Gym Classes	292,610	1,014,475	373,597	1388072	45.266	47	33547	19,410	0.58
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Example of Low Temperature Air First Cost Savings-Chicago School

- Reducing Supply Air from 55 to 47 deg

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  - CFM decreased from 397,439 to 289,309 cfm

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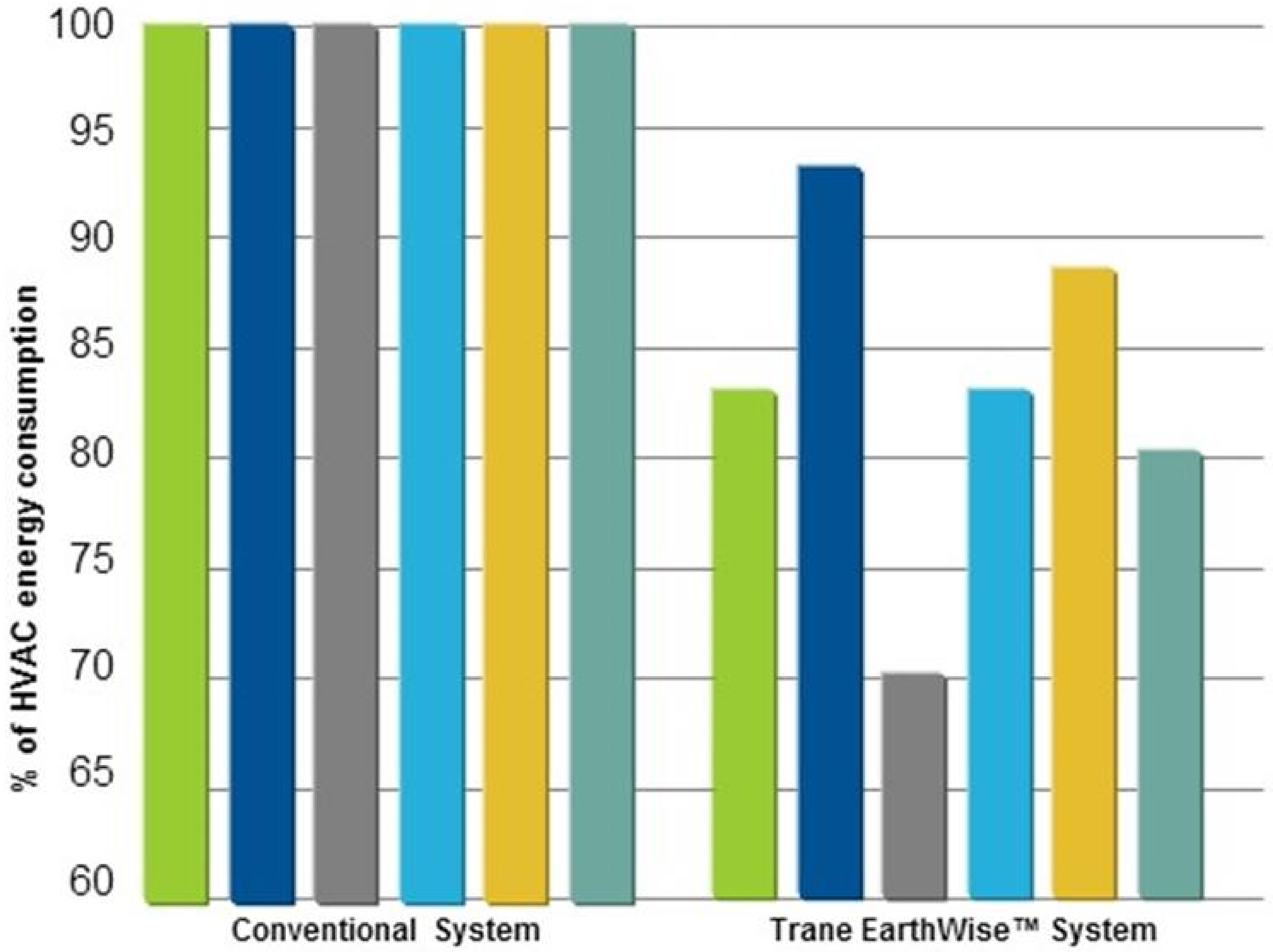
  - Actual Installed Cost for AHU Equipment was $2.90 per cfm.

Example of Low Temperature Air First Cost Savings-Chicago School

- Reducing Supply Air from 55 to 47 deg
  - CFM decreased from 397,439 to 289,309 cfm
  - Actual Installed Cost for AHU Equipment was $2.90 per cfm.
  - Cost Savings was $313,577 <u>just on AHUs</u> ($.68/sq ft). *[Note, this does not include the sheet metal and labor savings!]*

But At What Efficiency?



	Conventional System	Trane EarthWise™ System
Atlanta	100%	83%
Minneapolis	100%	93%
Los Angeles	100%	70%
Denver	100%	83%
Philadelphia	100%	89%
Portland	100%	80%

TRACE

Airside: What is different?

	Common practice
Supply air	55°F
Room setpoint	75°F
Airside delta T	20°F
Interior zone SAT	55°F

Airside: What is different?

	Common practice	Low air temp.system
Supply air	55°F	45 – 52°F
Room setpoint	75°F	77°F
Airside delta T	20°F	32°F
Interior zone SAT	55°F	55 – 60°F

Airside: What is different?

	Common practice	Low air temp.system
Supply air	55°F	45 – 52°F
Room setpoint	75°F	77°F
Airside delta T	20°F	32°F
Interior zone SAT	55°F	55 – 60°F

- Lowers the required air flow by 30-40%

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Supply air	55°F	45 – 52°F
Room setpoint	75°F	77°F
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Interior zone SAT	55°F	55 – 60°F

- Lowers the required air flow by 30-40%
- Can cut your fan BHP by nearly 50%

Air Handler Options

Supply Air	CFM	Coil area	Fan discharge velocity	Coil face velocity	Fan hp

Air Handler Options

Supply Air	CFM	Coil area	Fan discharge velocity	Coil face velocity	Fan hp
55°F	18,750	34.1	2514	550	17.8

Air Handler Options

Supply Air	CFM	Coil area	Fan discharge velocity	Coil face velocity	Fan hp
55°F	18,750	34.1	2514	550	17.8
45°F	11,360	20.8	2225	546	12.8

Air Handler Options

Supply Air	CFM	Coil area	Fan discharge velocity	Coil face velocity	Fan hp
55°F	18,750	34.1	2514	550	17.8
45°F	11,360	20.8	2225	546	12.8
45°F	11,360	24.4	1803	466	9.6

Yeah, but….

- Cold downdrafts

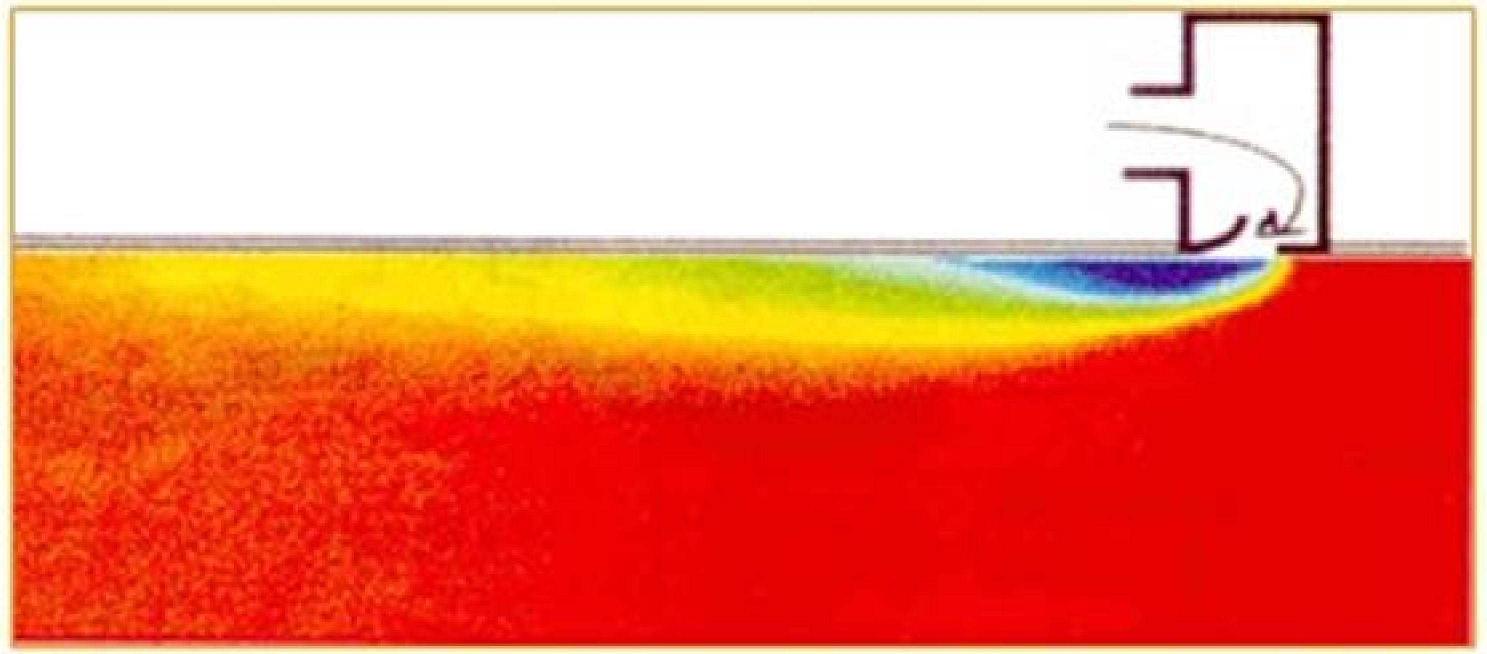
Yeah, but….

- Cold downdrafts
- Condensation

Three keys to…

Eliminating Cold Downdrafts

- Parallel fan-powered DDC/VAV boxes on the perimeter…
- Cooling-only DDC/VAV boxes on the interior…
- Both with linear slot aspirating diffusers...



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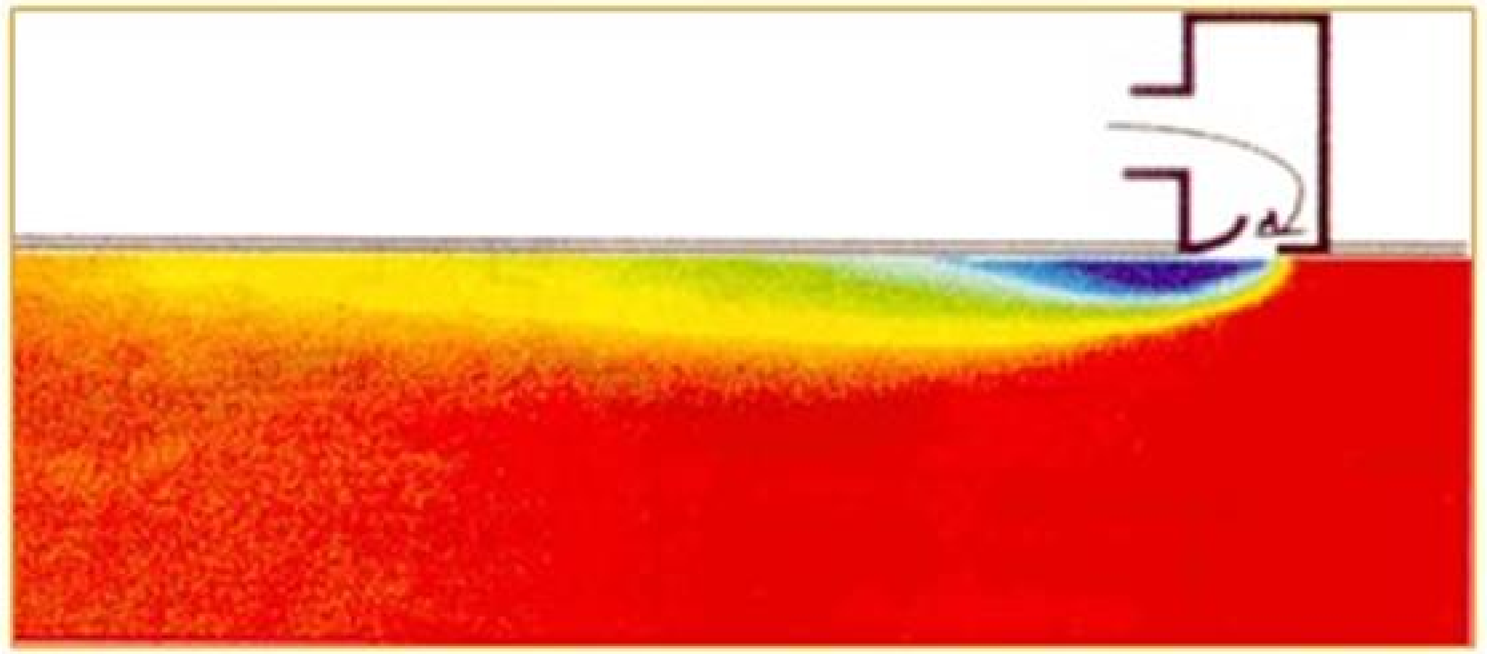
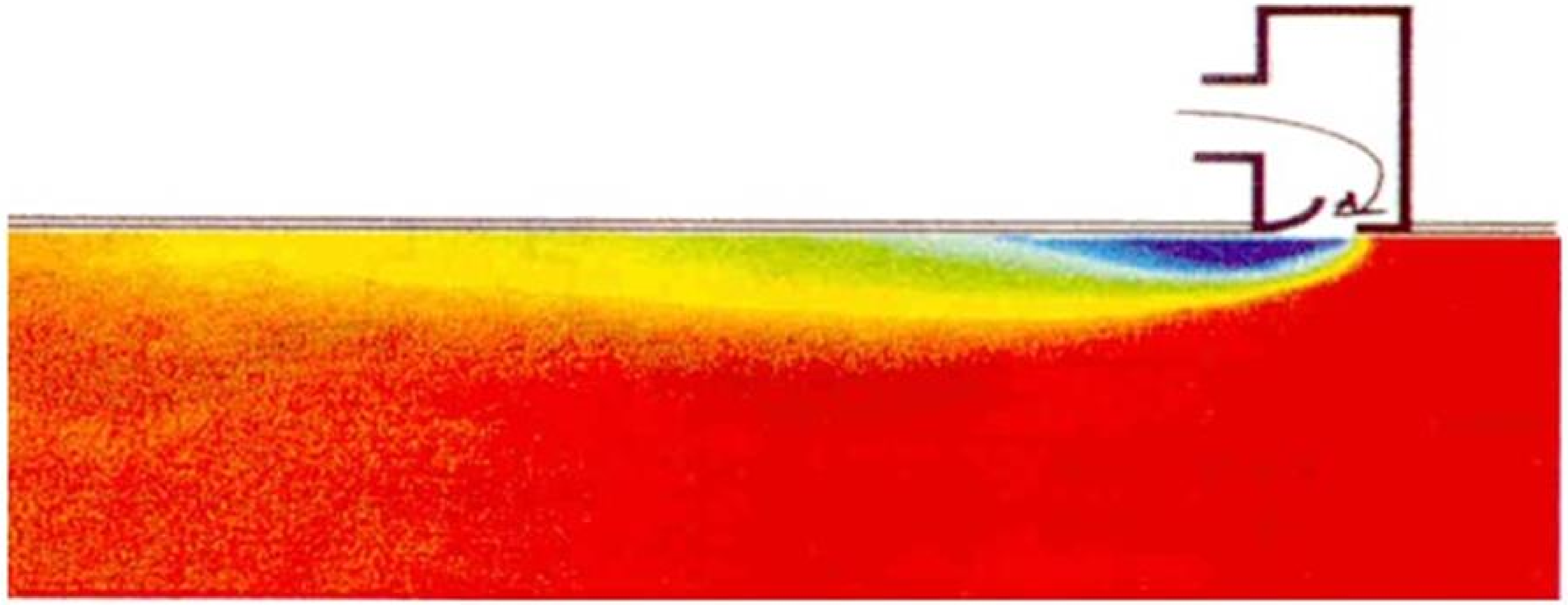
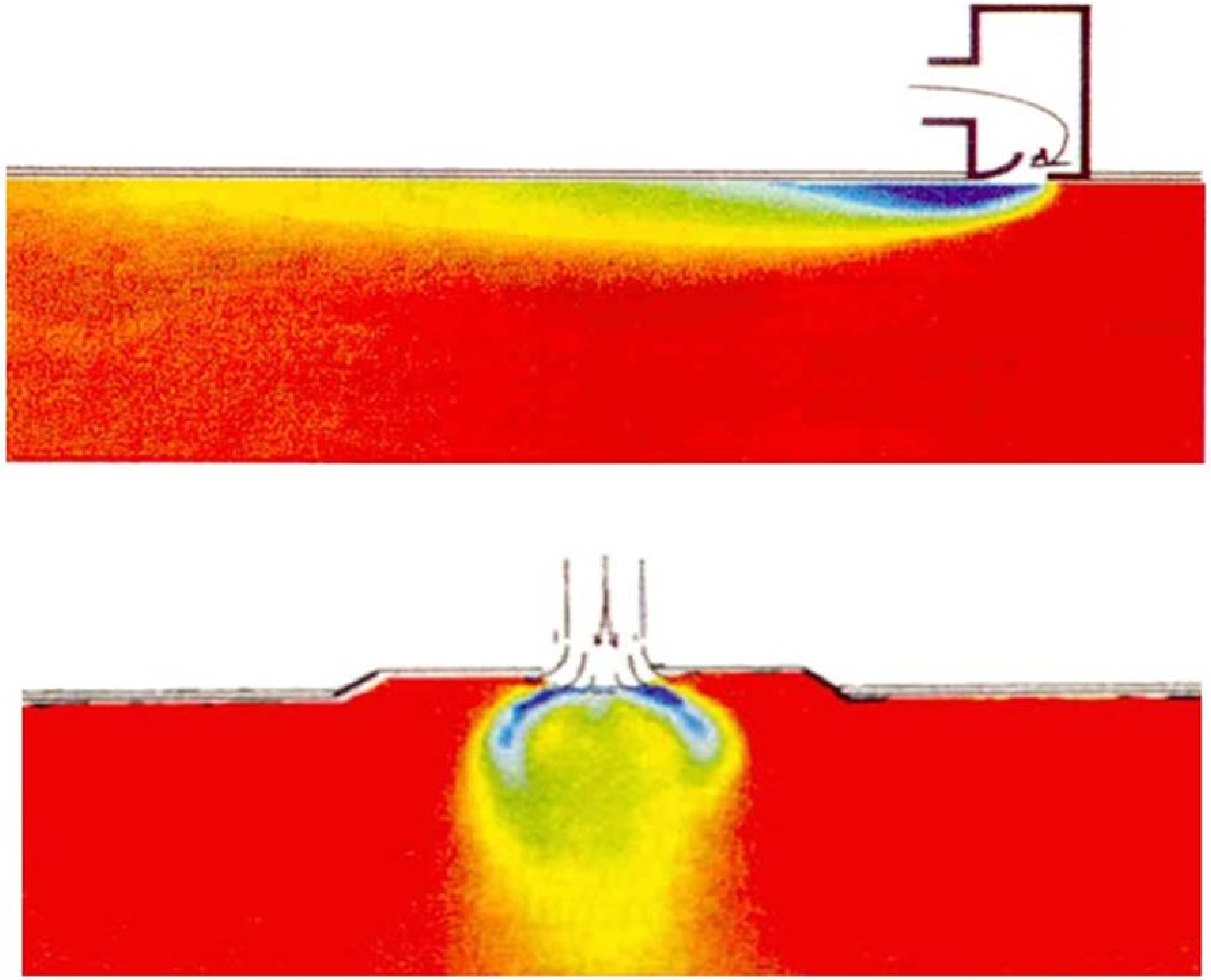


Linear Slot Diffuser vs. Typical



Linear Slot Diffuser vs. Typical



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- Cold surfaces must be kept inside the humidity-controlled envelope

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- Install a vapor barrier with reasonable construction

What about Condensation?

- Cold surfaces must be kept inside the humidity-controlled envelope
- Night set-back and morning pull down controlled off of interior dew point sensor
- Positive building pressure is critical for "no" condensation and IAQ
- Install a vapor barrier with reasonable construction
- Design the "P" traps and pitch the condensate drains correctly

One Key Takeaway:

- Looking for something new and innovative yet proven; something that will lower both operating and first cost?– Low Air Temperature is it

One Key Takeaway:

- Looking for something new and innovative yet proven; something that will lower both operating and first cost? – Low Air Temperature is it
- And it ties nicely to the low water temperatures normally supplied by District Chilled Water Systems

Questions?

Thank you for attending

To contact speakers:

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