The Design Envelope

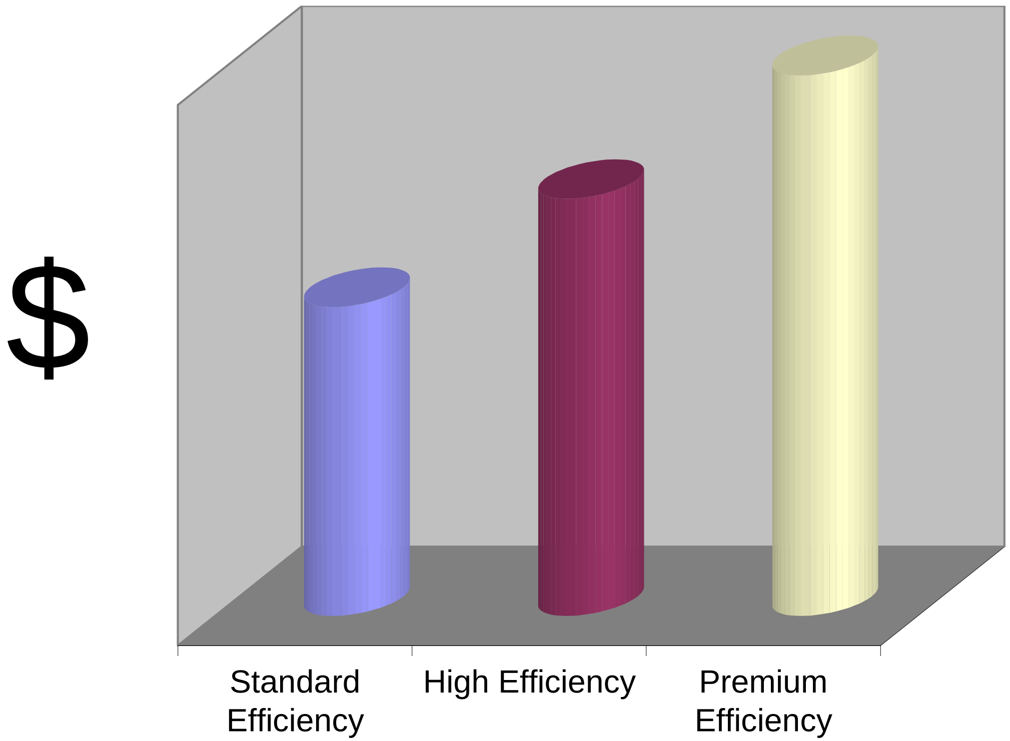
The Integrated Demand Based Answer for Innovative Energy Efficient HVAC and Pumping Systems

Rajmohan – Manager, Energy & Retrofit Solutions - Armstrong

MAKING ENERGY MAKE SENSE

The Cost Efficiency Paradox

- The traditional mindset



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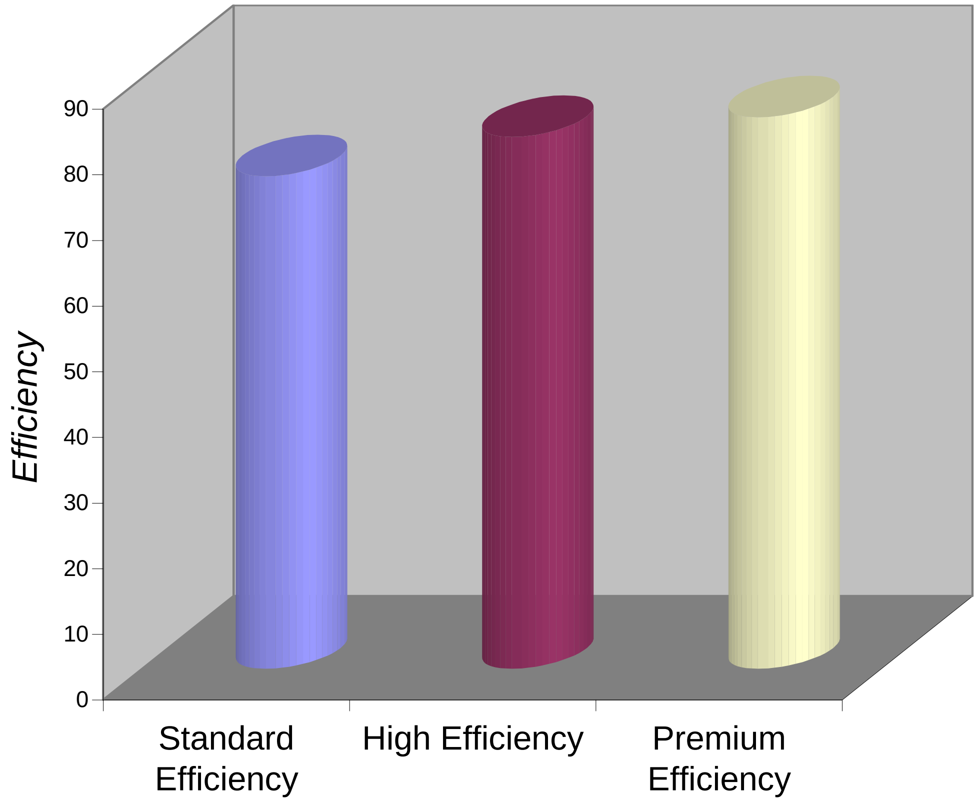

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Some Non-Intuitive Data

- What impact have the following had?

New mechanical technologies in the market

Installation of VFDs (variable freq drives)

Integrated Control Technology

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What Impact Have the Following Had?

	Savings
New mechanical technologies in the market	15%
Installation of VFDs (variable freq drives)	30%
Integrated Control Technology	40-60%

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Integrated Control Technology

Other Benefits;

-Lower installed cost

-Lower life-cycle cost

-Paybacks of <6 months

-Better Occupant Comfort

-Reduced Project Risk

-Ability to incorporate Renewable Technologies Efficiently

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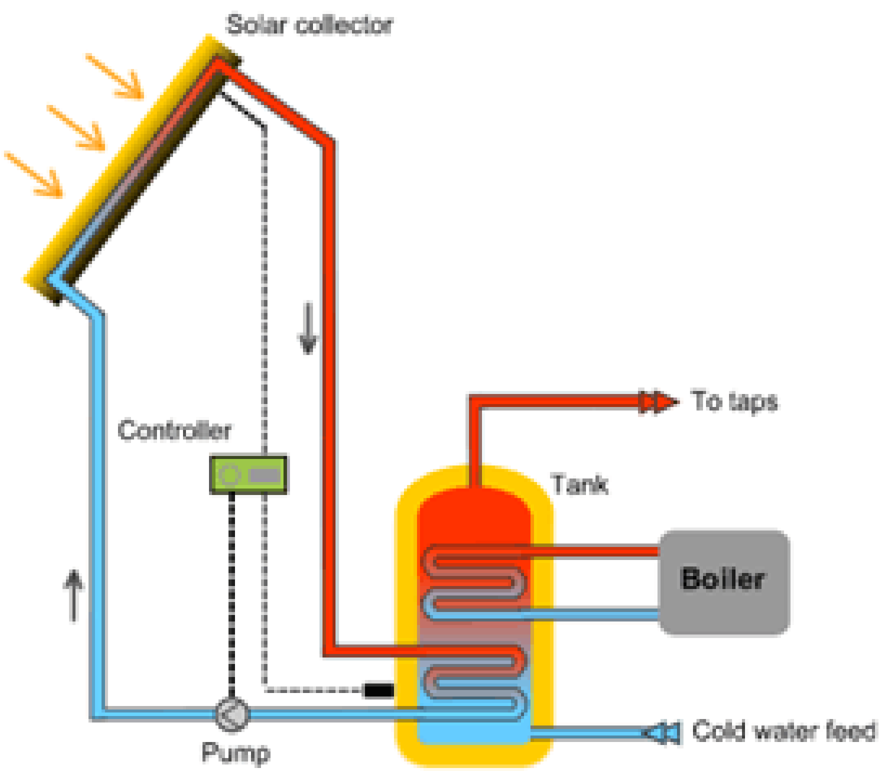

Specific Energy Figures

ASHRAE Standard 90.1

1975	65000 btu/sqft/year
1999	53000 btu/sqft/year
2004	47000 btu/sqft/year
2010	36000 btu/sqft/year
2020	18000 btu/sqft/year

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Specific Energy Figures

ASHRAE Standard 189.1

Design of High-performance Green buildings

2007	**33000**	**btu/sqft/year**
2010	**25000**	**btu/sqft/year**
2020	**12500**	**btu/sqft/year**
2030	**net zero**	**btu/sqft/year**

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HVAC Is A Variable Load World

How can we develop the "best sized" solution when we know and need to accommodate for future changes to the building loads?

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Rate of change with buildings (new and existing building stock)

- Today, designs finalized during construction
- Mechanical systems redesign 3-4 times, +/-15%
- Tenant "refit" for new mix (data servers example)

Our HVAC world is recognized as "variable load",

- The expectation today is that equipment will come as variable speed,
- VFDs have become cost economic and reliable,
- a great deal of benefit is gained from an "integrated" approach to determining how that VFD is controlled to it's connected load / mechanical equipment.

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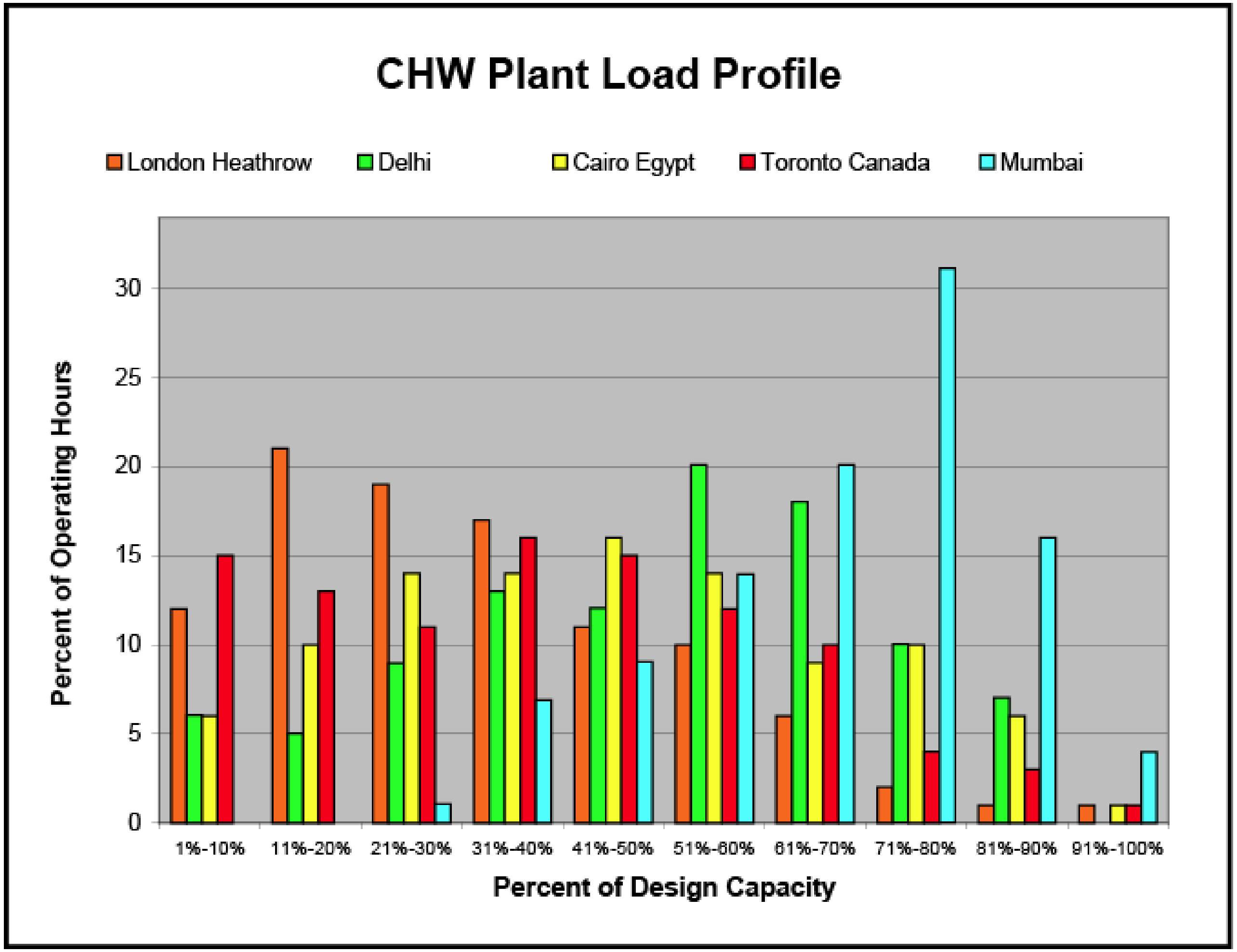
Part Load Performance is key!



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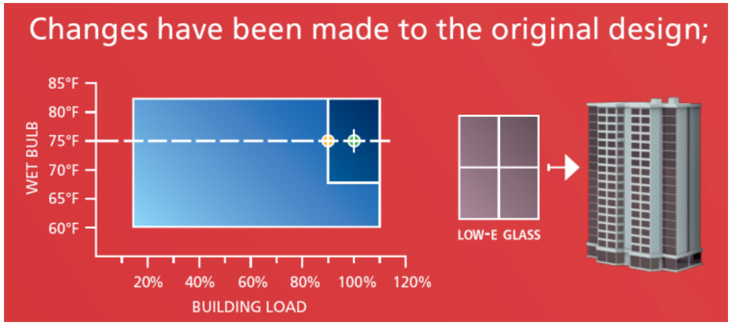
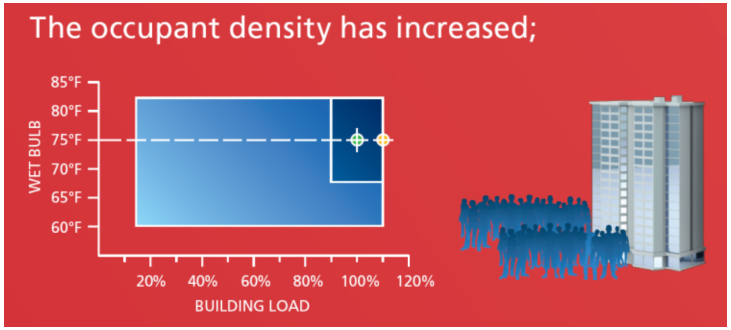
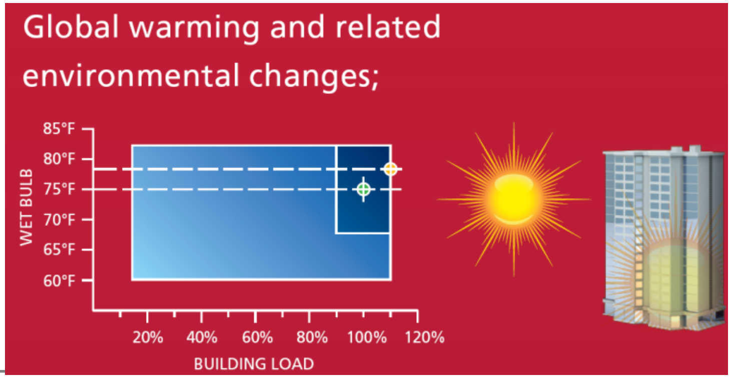
The Challenge… provide a new approach to:

- optimize for the variable load world
- accommodate new causes of change without additional time, expense and risk
- prevent "over-sizing"
- provide an "integrated" factory approach that is intended for tuning to site conditions, thereby offering "future proofing"







Design Envelope

Fixed Speed World thinking;
- Mechanically tuned equipment at the factory and then mechanically tune the system on site

Variable Load / Speed World Thinking with Design Envelope
- A fixed range of mechanical gear with integrated control enabling factory tuning by controls, and further site system tuning by controls.

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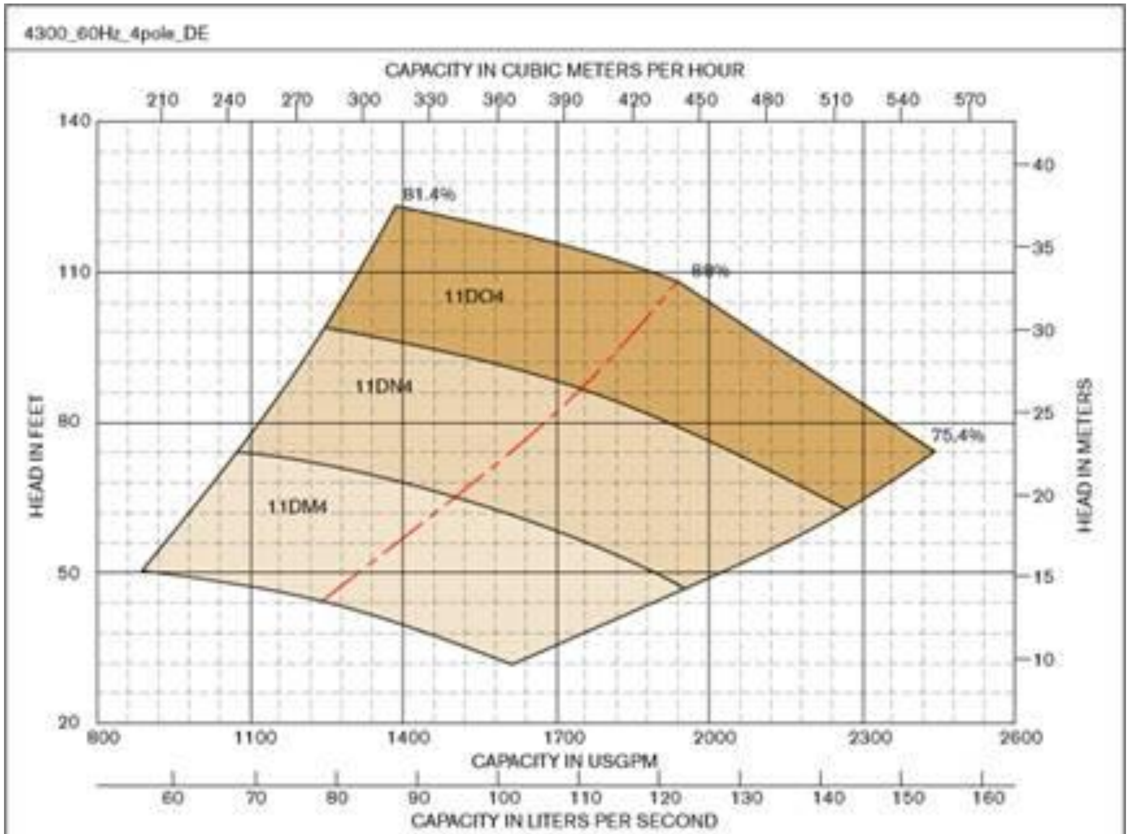
Design Envelope

Easy selection, Lower Project Risk



3.

IVS INTELLIGENT VARIABLE SPEED PUMP

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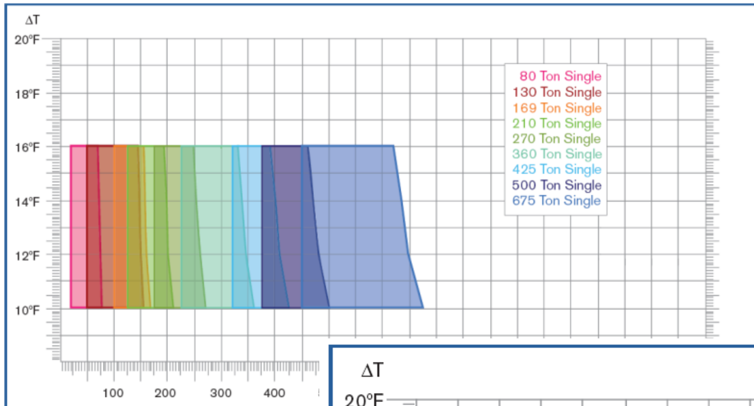
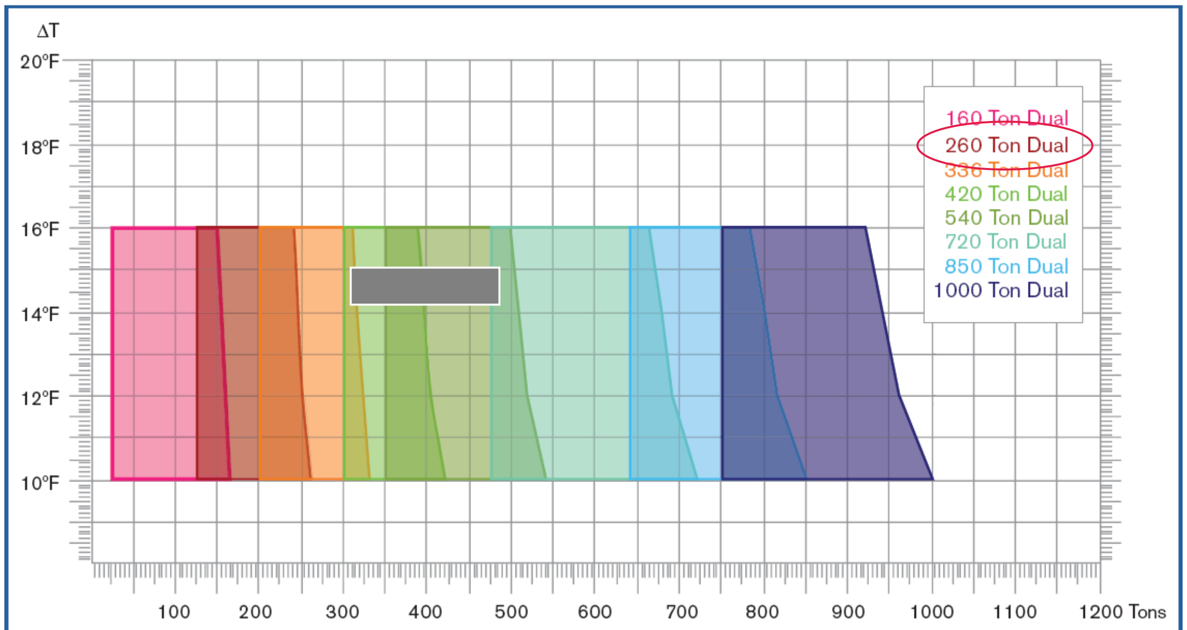
The Ultra-Efficient Option – Cooling plants

Design Envelope Solution Range





Capable for future load and today's efficiency

Pre-engineered

Low Project Risk

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Easy Selection, Lower Project Risk

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ECO:nomics

Applying today's existing operating Budget

Towards the payout of an energy and maintenance saving with Integrated Control and Integrated Design

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Performance Integration; Design Envelope

What is the difference between:

1. Assembled / Field Designed

And

2. Integrated Design Envelope Solutions

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Performance Integration; Design Envelope

Integrated Design Envelope Solutions:

1. Components are mechanically and electrically matched for optimized performance based on a specific design envelope

2. The performance curves of the mechanical equipment, electrical VS inverters (drives), are entered into the automation algorithms for control, based on the mechanical optimization

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Performance Integration; Design Envelope

Integrated Design Envelope Solutions:

3. In the field, on site at the project, the equipment is tuned to the requirements on site through "electronics", as opposed to alteration of the mechanical equipment (impeller trim, throttling balance valve …)

4. The optimized components with integrated automation typically enables smaller mechanical components, lowering the cost of components to enable the addition of the automation costs, all bringing better efficiency throughout the operation range

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Performance Integration, Design Envelope

Integrated Design Envelope Solutions:

1. Optimized Equipment combinations
2. Automation is component specific
3. Field equipment is tuning by electronics
4. Optimized integrated solution has smaller components that cover automation for better efficiency

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Performance Integration, Design Envelope

When a designer lays out a project, they cannot specify this type of field developed solution

It requires advanced knowledge of the equipment performance data, how the equipment interacts, and a significant amount of algorithm development around the application

The best the design is likely to do is leave the options For mechanical equipment open to the lowest of qualified Equipment bidders (doesn't lead to optimized match)

The contractor doesn't have the motivation to pursue the additional knowledge to implement such solutions in the field, if they could for a "one-off"
(this integrated control is a Manufacturer's approach)

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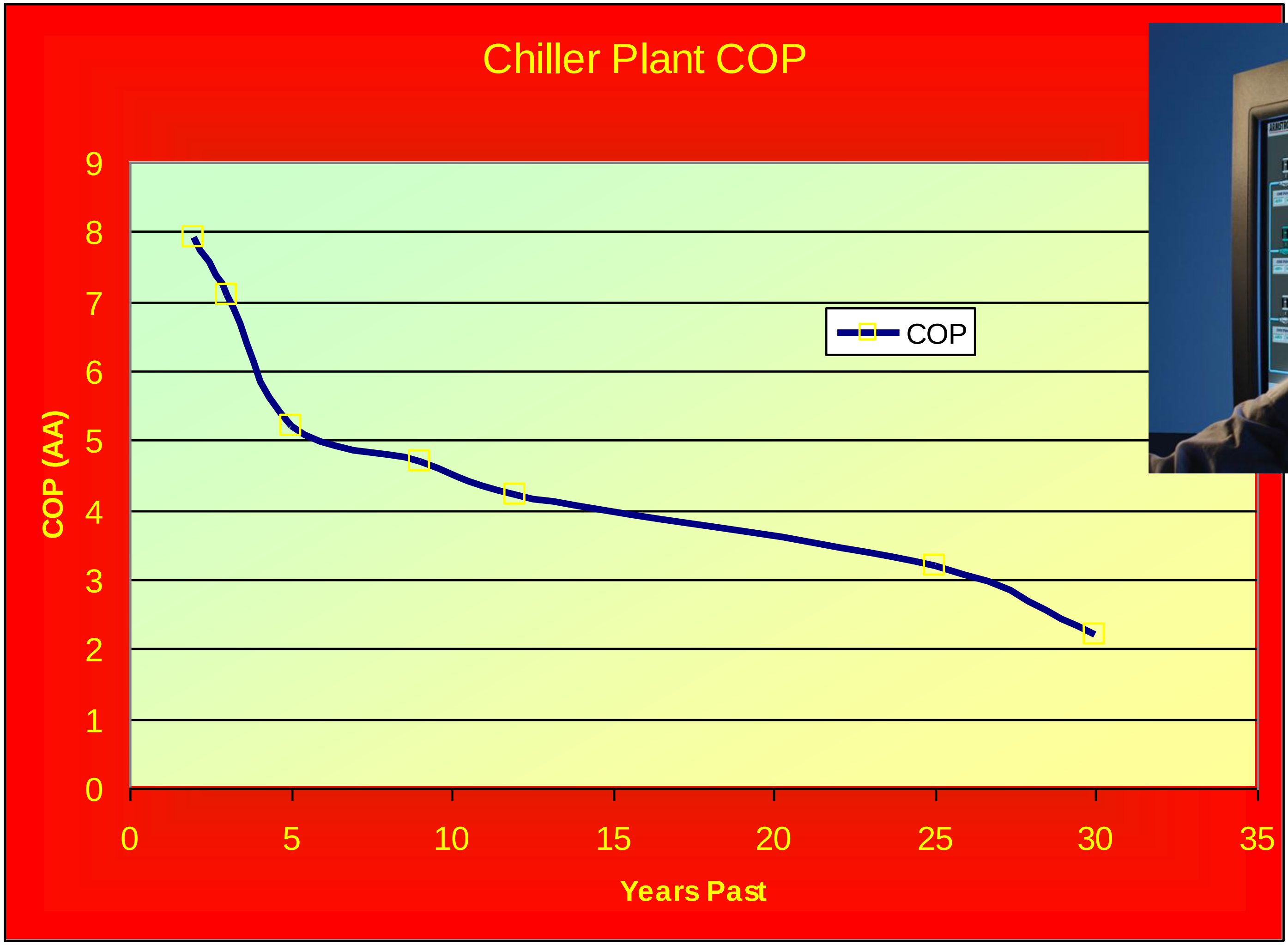
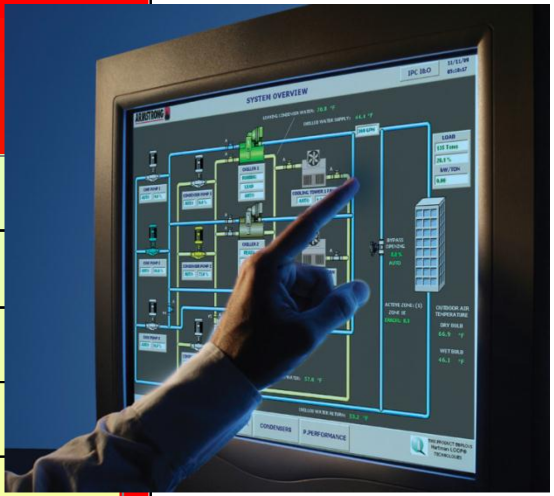
Consider the Impact of CHW Plant Efficiency





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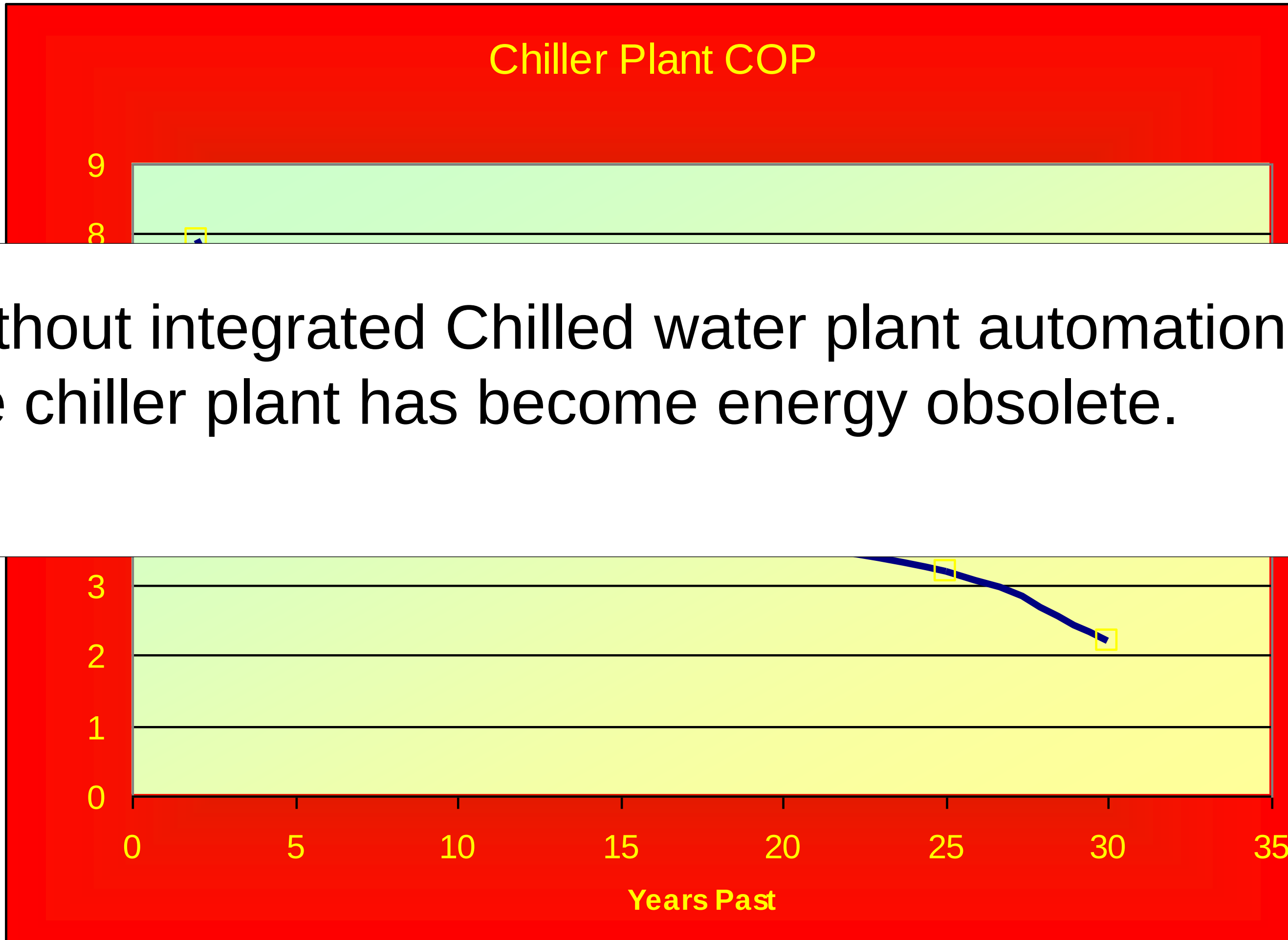
Consider the Impact of CHW Plant Efficiency



Without integrated Chilled water plant automation the chiller plant has become energy obsolete.

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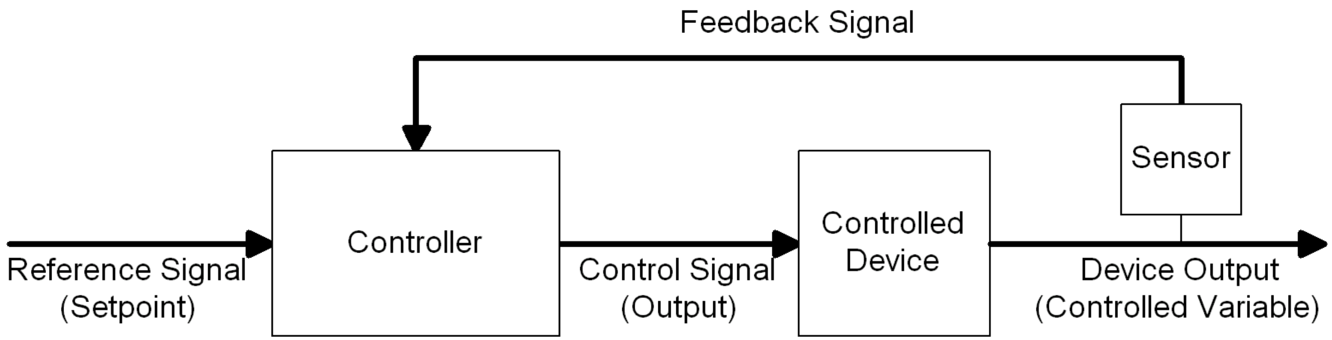
"PID" Control Loop



P = Proportional

I = Integral

D = Derivative

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Demand Based Control

Demand Based Control is a method of relational control developed for systems that incorporate multiple modulating components to achieve a desired result or condition. It replaces multiple stand alone PID loops that operate each component independently.

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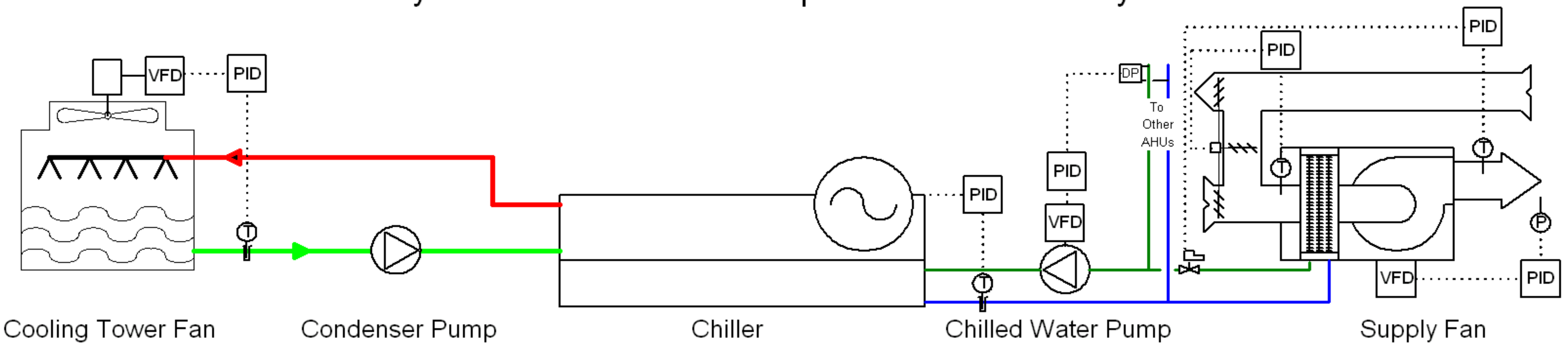
Conventional HVAC Central System Control

Under PID control, each system component is operated independently to maintain an intermediate setpoint (usually temperature or pressure) - that does not necessarily directly reflect the current requirements of the system



PID provides a primitive means of modulation control. Controllability and stability are almost always issues with PID control. Energy optimization over any range of conditions requires a separate step that adds to controllability and stability issues. Furthermore energy optimization opportunities are constrained by precision and accuracy of intermediate temperature and pressure instrumentation .

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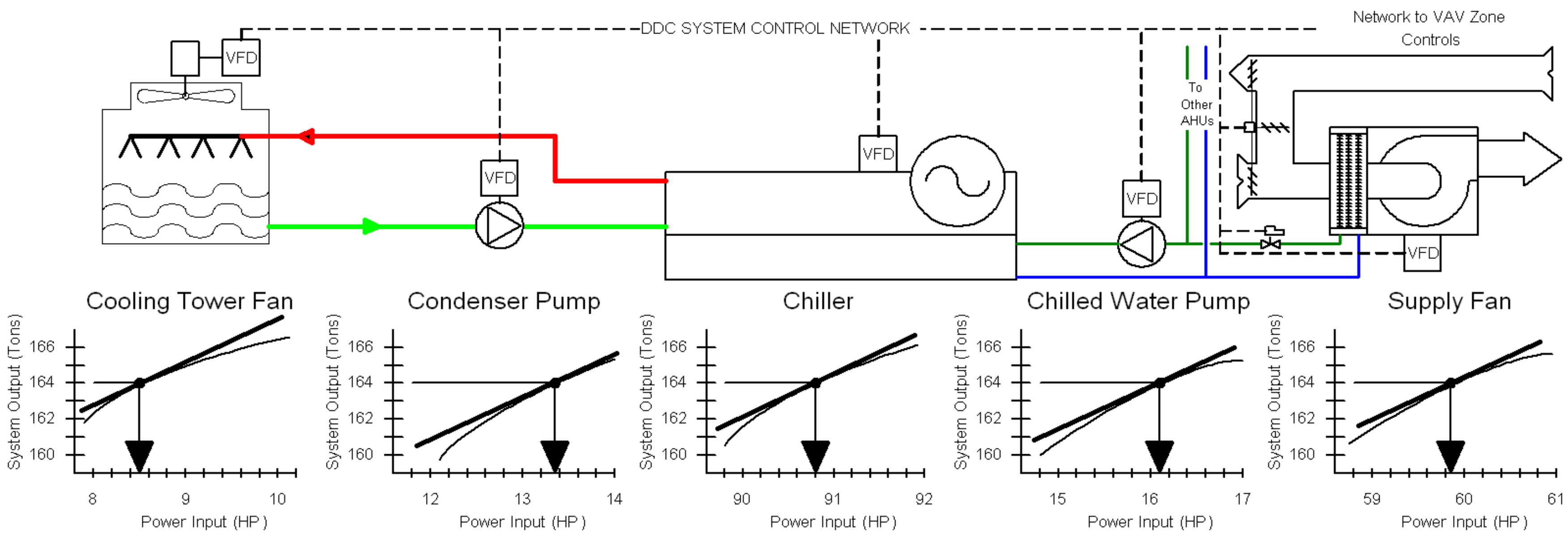
Demand Based Control

Demand based control is a relational method of control that has been developed from the Equal Marginal Performance Principle. Demand based control operates individual components based on relative power input rather than to maintain an intermediate temperature or pressure setpoints.



Because continuous error correction is not an essential element of demand based control, operating stability is almost never an issue. The above system is optimized at the relative power settings shown by the arrows because, in accordance with the Equal Marginal Performance Principle, the marginal performance (slope of the curve of total system output per unit input for the component) is the same for all system components.

Why Implement Relational Control?

1 Efficiency Improvements

2 Performance Improvements

3 Simpler Configurations and Simpler Control

4 More Stable Operation

5 Reduced Maintenance Requirements

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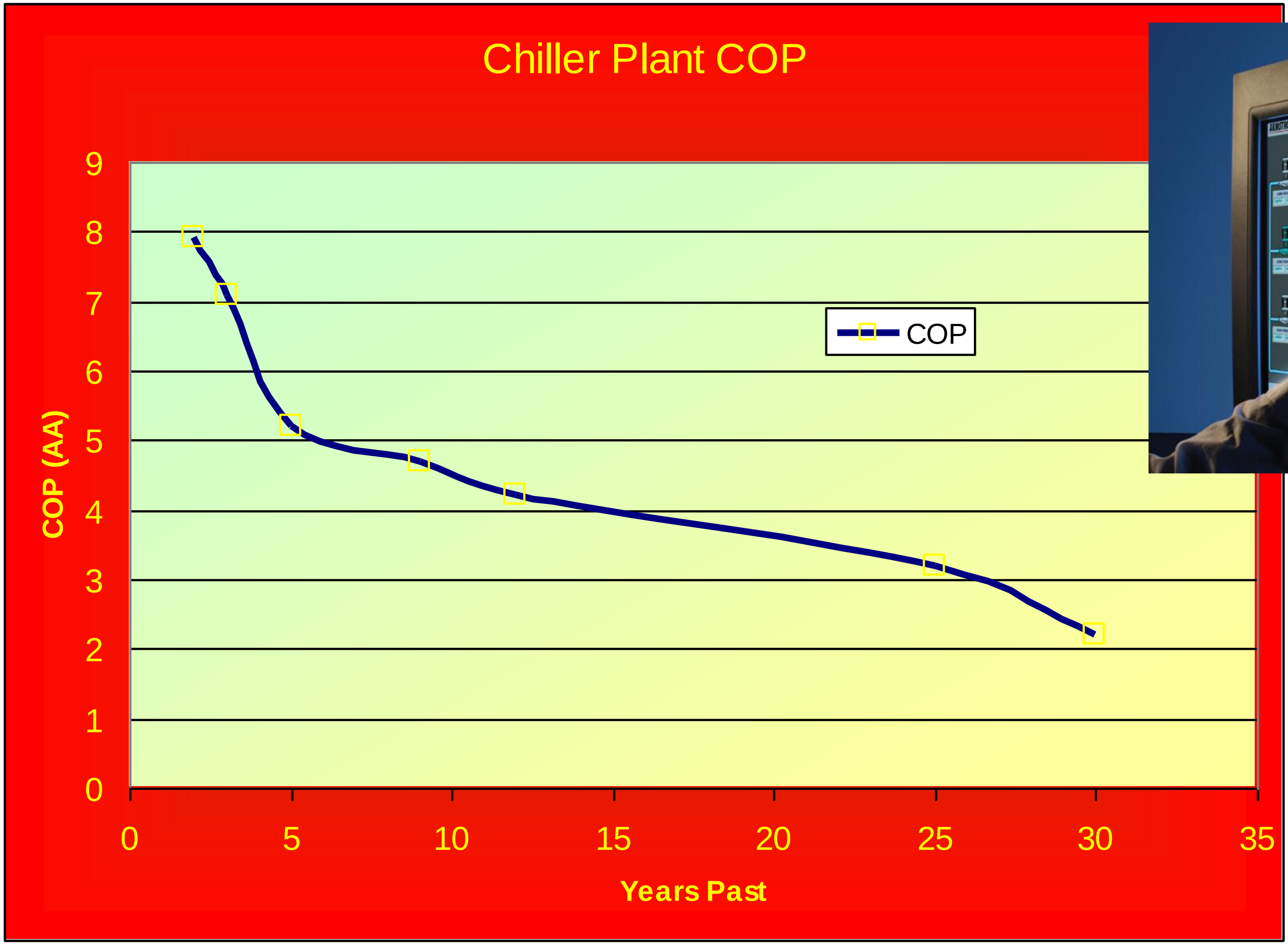
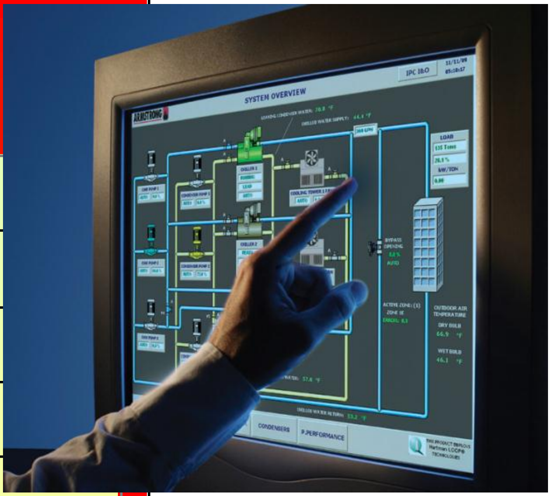
Consider the Impact of CHW Plant Efficiency





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Variable Speed Pump Specifications for your Buildings

- Does the industry select in the same manner as a constant speed pump and specify a VFD for it?
- Are life cycle costs calculated from design point efficiency?
- Do you suspect that you cannot truly lower the carbon footprint without extra costs?

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Taking “Premium” out of Efficiency

- What constitutes the highest (Pumping Unit) customer value proposition in our business?

  - Lowest equipment cost?
  - Lowest installed cost?
  - Highest equipment efficiency?
  - Lowest energy costs?
  - Lowest Life Cycle (LLC) costs?

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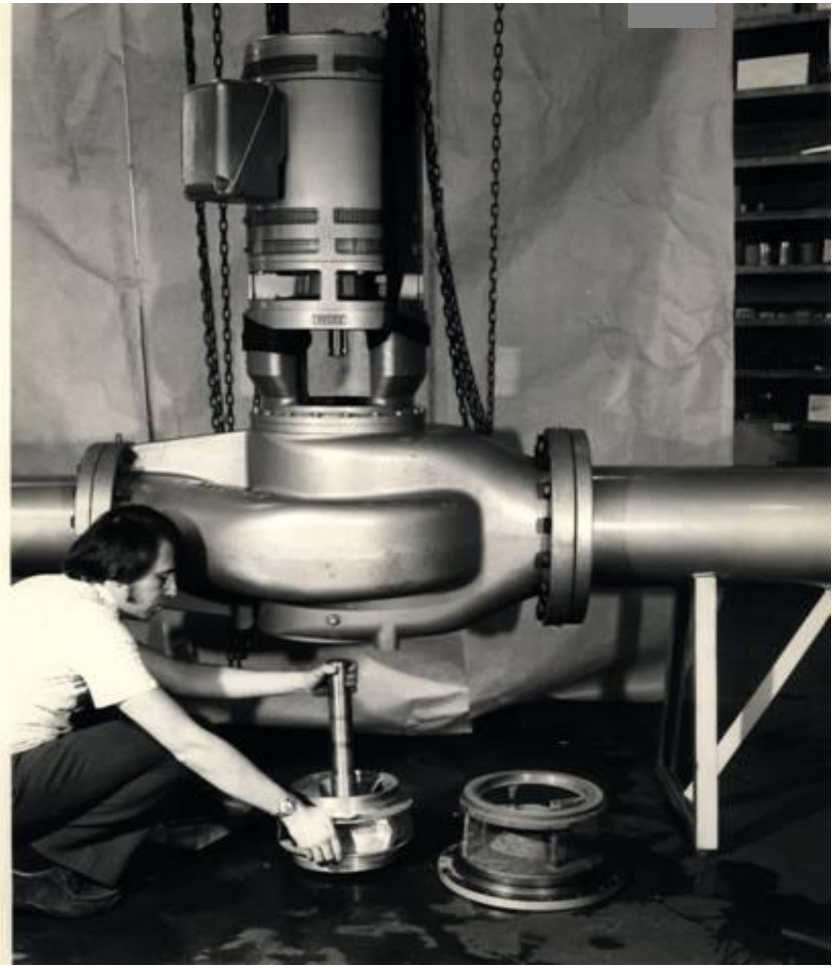
HVAC customer needs – 1960's

- Smaller footprint
- Easy to install
- Easy to maintain
- Reliable
- (Flexibility of use)



Vertical In-Line (VIL) Pump. Circa: 1970

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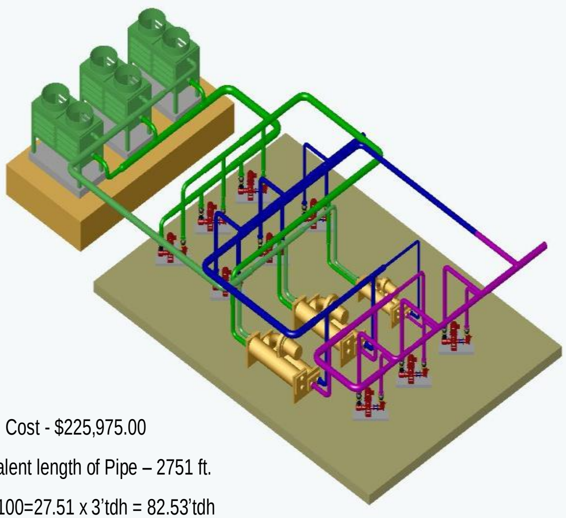
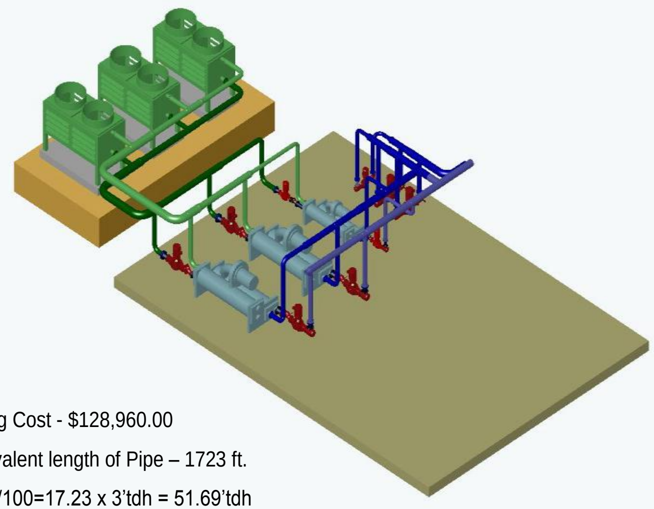
Best Practice



Piping Cost - $225,975.00

Equivalent length of Pipe – 2751 ft.

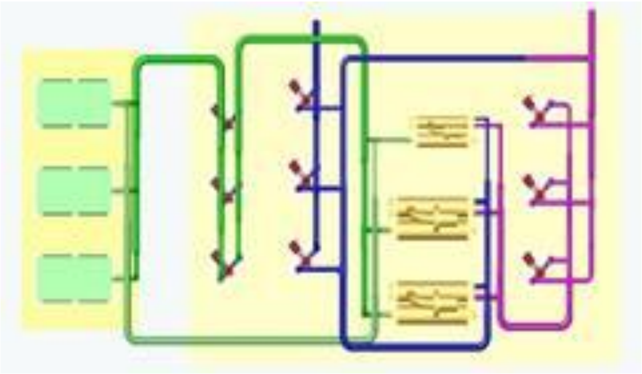
2751/100=27.51 x 3'tdh = 82.53'tdh



Piping Cost - $128,960.00

Equivalent length of Pipe – 1723 ft.

1723/100=17.23 x 3'tdh = 51.69'tdh



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SENSORLESS IVS – THE MENTAL DEVIDE

WE MEASURE

Power
&
Speed

WE CONTROL

Head
&
Flow

SENSORLESS IVS – MISSING LINK (1)

WE MEASURE

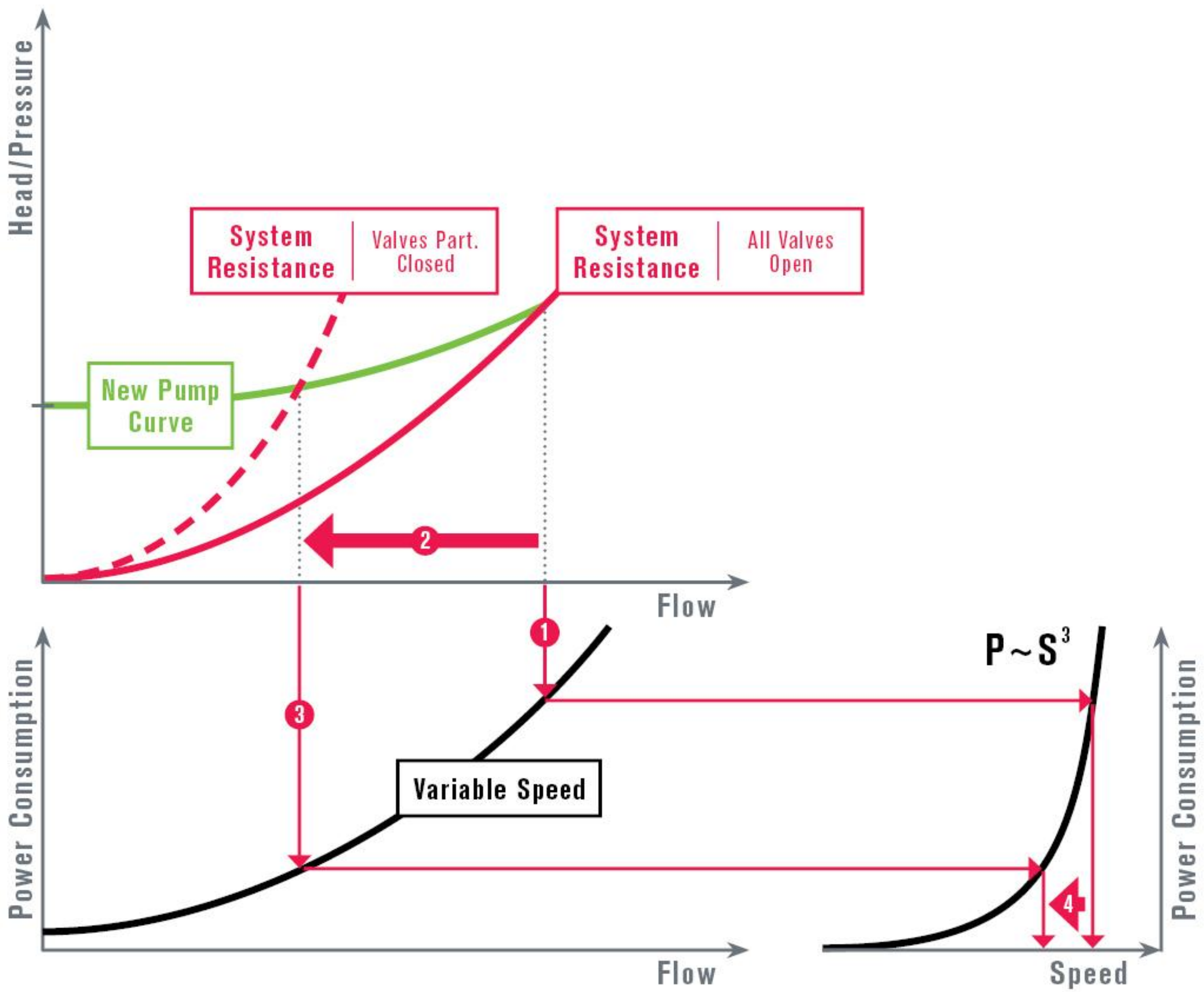
Power
&
Speed

FLOW-POWER CORRELATION

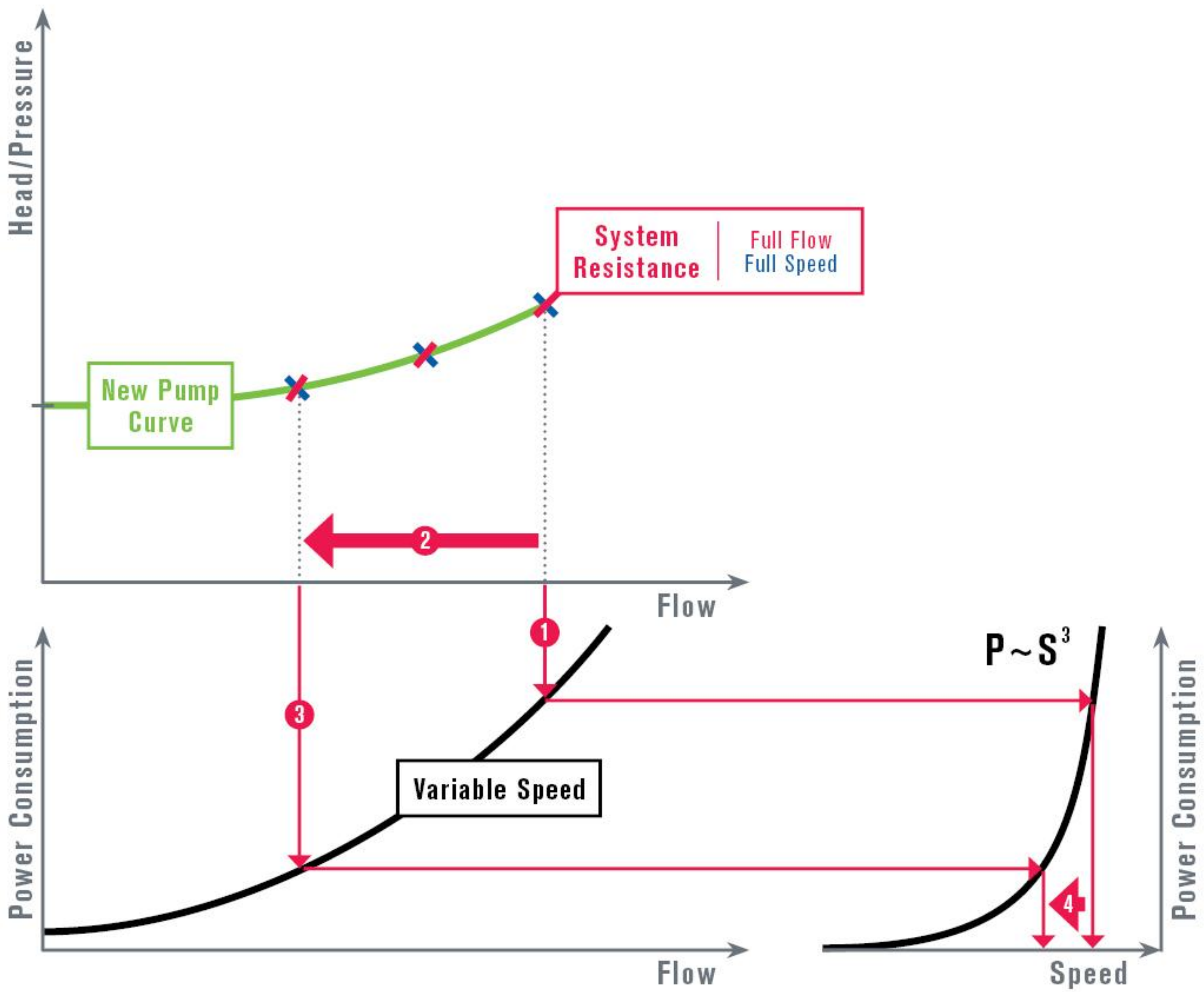
WE CONTROL

Head
&
Flow

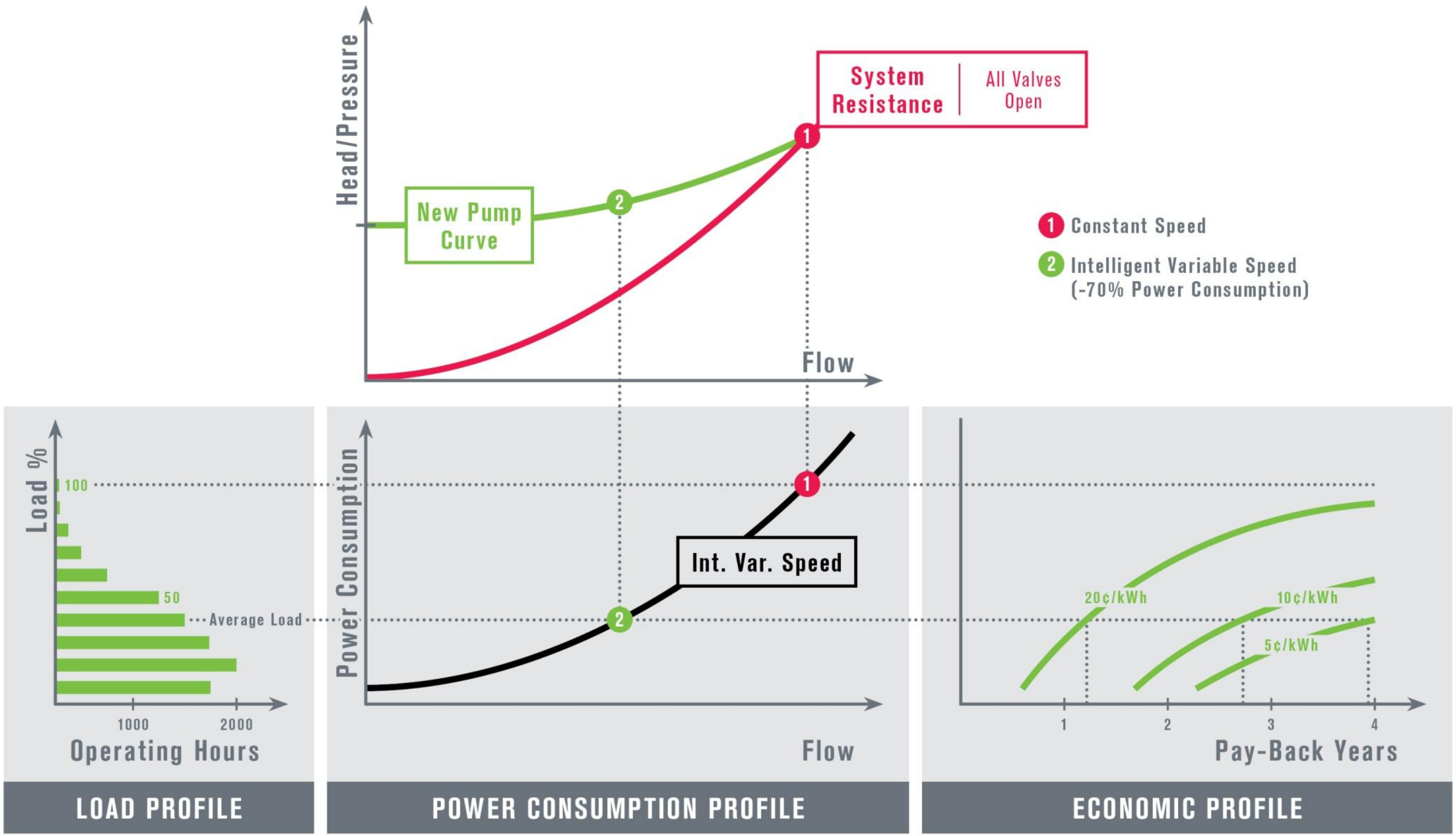
SENSORLESS CONTROL PRINCIPLE



SENSORLESS CONTROL PRINCIPLE

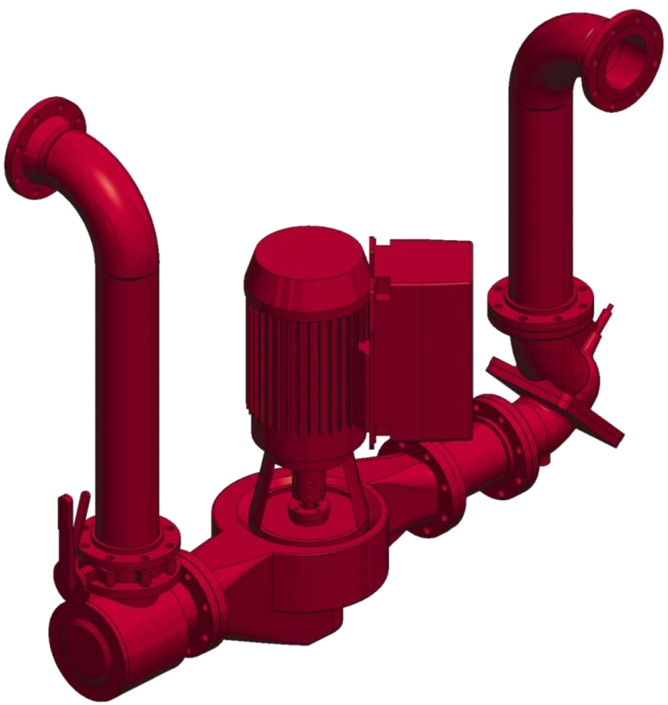


WHY IVS IS PROFITABLE

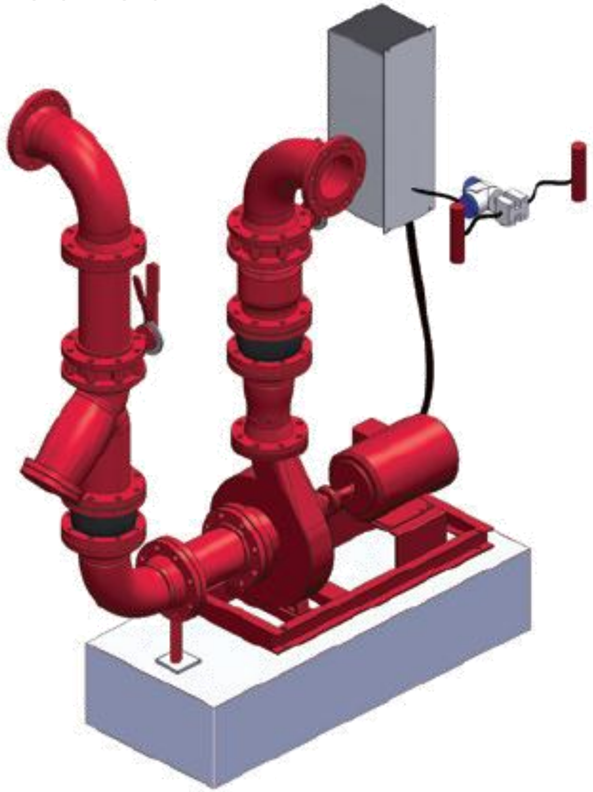


Value Proposition data IVS VIL & ES-RMT CTRLS

- Vertical In-Line – Integrated Controls
  - Save 30% installed cost
  - Save 35% LCC

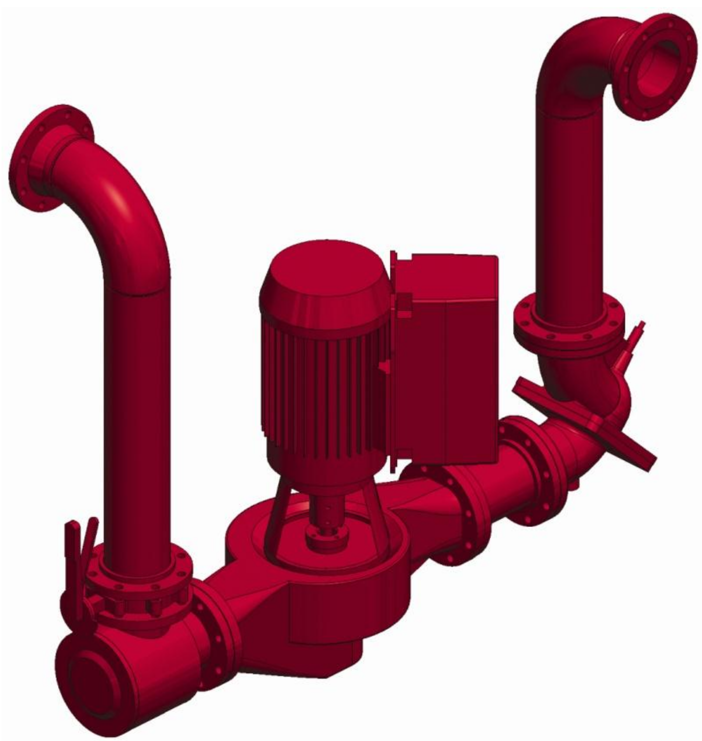


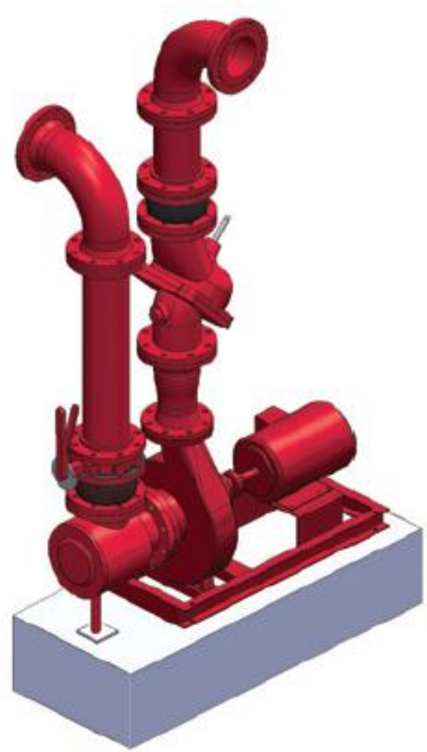
- End Suction – wall mounted VFD & remote sensor



Value Proposition

- Vertical In-Line with SG & FTV with or without Integrated Controls really has no alternate peer
- Lowest Carbon Footprint at ~~NO extra~~ lower cost





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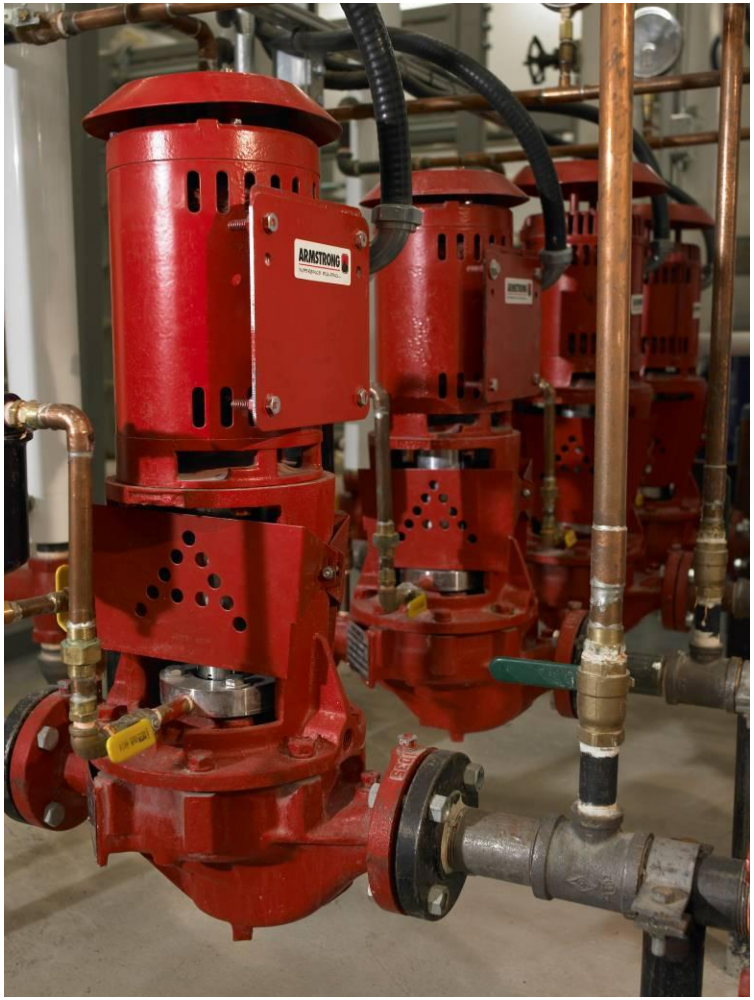
Pump Type



- Can pump type as well as pump selection influence energy costs?

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Summary

- HVAC Technologies readily available today
  - Design Envelope / Part Load World Thinking
  - Use of variable speed and integrated design and controls
    - Variable speed chillers / pumping vs constant speed
    - Demand based chiller controls vs PID loop
      - Complete chiller plant COP's > 7.0 vs 5.0

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Summary

- HVAC Technologies readily available today
  - Vertical Inline pumps with integrated control vs end suction pumps with wall mounted standard controls
    - Suction guides / triple duty valves
    - 30% installed cost savings
    - 35% life cycle savings
    - Additional mechanical room pipe savings and pipe energy savings (37% savings)

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We must Ask Ourselves

Are we using the best technologies

In Every New and Existing Building!

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Our obligation to use Best Technologies

For our customers

The public

Professional Ethics

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