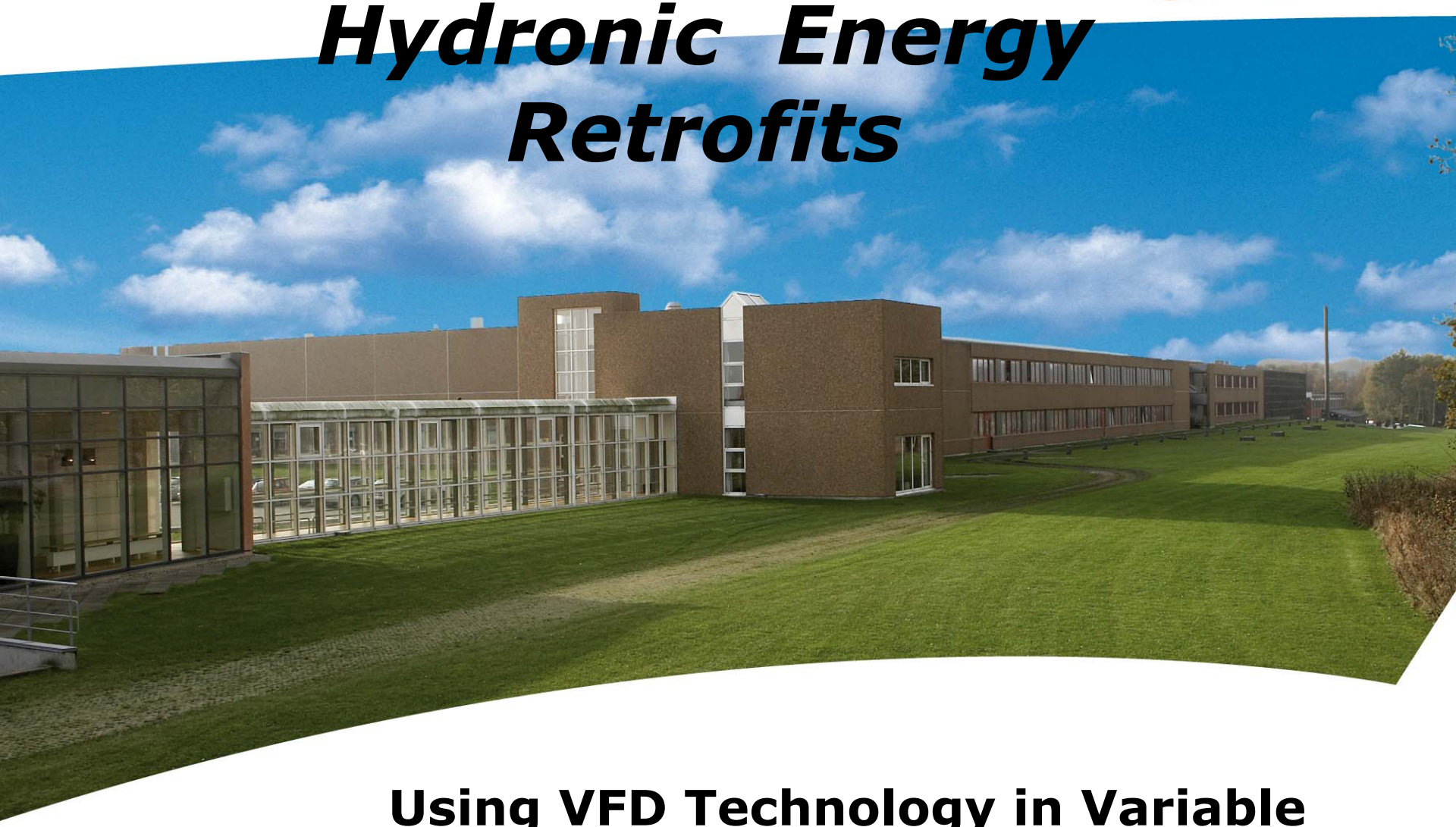
MAKING MODERN LIVING POSSIBLE

Hydronic Energy Retrofits



Using VFD Technology in Variable Torque HVAC Applications

VLT
THE REAL DRIVE

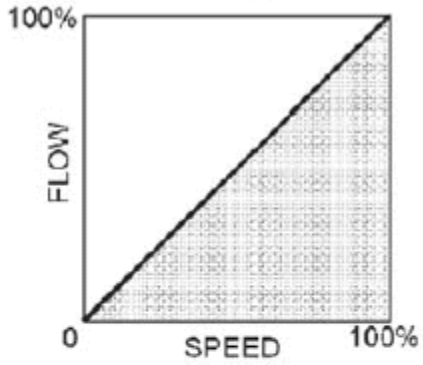
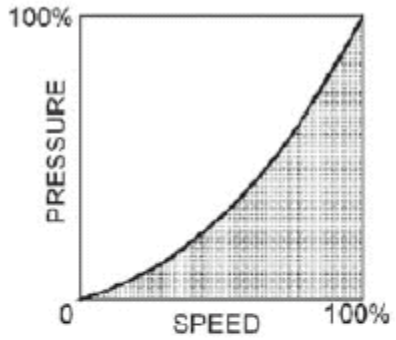
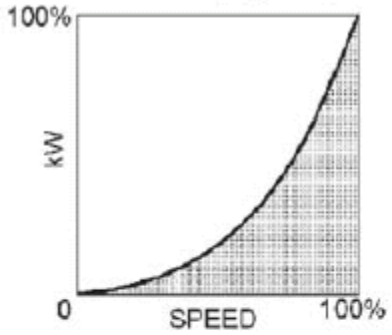
Agenda Discussion

- **VFD Overview**
  - **Affinity Laws-Mathematical**
  - **Pumps Applications**
    - **Constant and Variable Flow**
  - **Graphic–Pump Curve**
  - **Pressure Sensor Location**
- **Question Period**
- **Reference Material**

Affinity Laws

Fans and pumps operate under a predictable set of laws concerning speed, power and pressure. A change in speed (RPM) of any fan or pump will predictably change the pressure rise and power necessary to operate it at the new RPM.

Affinity Laws-Fans and Pumps

Flow α Speed	Pressure α (Speed)^2	Power α (Speed)^3
		
$\frac{Q_1}{Q_2} = \frac{N_1}{N_2}$	$\frac{SP_1}{SP_2} = \left(\frac{N_1}{N_2}\right)^2$	$\frac{kW_1}{kW_2} = \left(\frac{N_1}{N_2}\right)^3$
Varying the RPM by 10% decreases or increases air delivery by 10%.	***Reducing the RPM by 10% decreases the static pressure by 19% and an increase in RPM by 10% increases the static pressure by 21%***	***Reducing the RPM by 10% decreases the power requirement by 27% and an increase in RPM by 10% increases the power requirement by 33%***

Where Q – flow, SP – Static Pressure, kW – Power and N – speed (RPM)

Pump Laws- Ashrae Handbook

Table 1 Pump Affinity Laws

Function	Speed Change	Impeller Diameter Change
Flow	$Q_2 = Q_1\left(\frac{N_2}{N_1}\right)$	$Q_2 = Q_1\left(\frac{D_2}{D_1}\right)$
Head	$h_2 = h_1\left(\frac{N_2}{N_1}\right)^2$	$h_2 = h_1\left(\frac{D_2}{D_1}\right)^2$
Horsepower	$\text{bhp}_2 = \text{bhp}_1\left(\frac{N_2}{N_1}\right)^3$	$\text{bhp}_2 = \text{bhp}_1\left(\frac{D_2}{D_1}\right)^3$

Water Horsepower

$$\text{whp} = \frac{Q\Delta h}{3960}$$

where

Q = fluid flow rate, gpm
3960 = units conversion, ft·gpm per hp

Affinity Laws-Quiz

- 80% Speed/RPM
  - Flow-80%
  - Pressure-65%
  - Power/Energy-50%

- 70% Speed/RPM
  - Flow-70%
  - Pressure-50%
  - Power/Energy-35 %

What are good potential energy saving applications?

- **What is Energy?**
  - Energy α $\frac{(Flow) \times (Pressure) \times (Time)}{(Efficiency)}$
- **So, a good potential application is one where**
  - **Flow** can be reduced
  - **Pressure** produced can be lowered
  - Present running **time** is long
    (Being able to reduce running time is a plus)
  - The **efficiency** of some part of the system can be improved

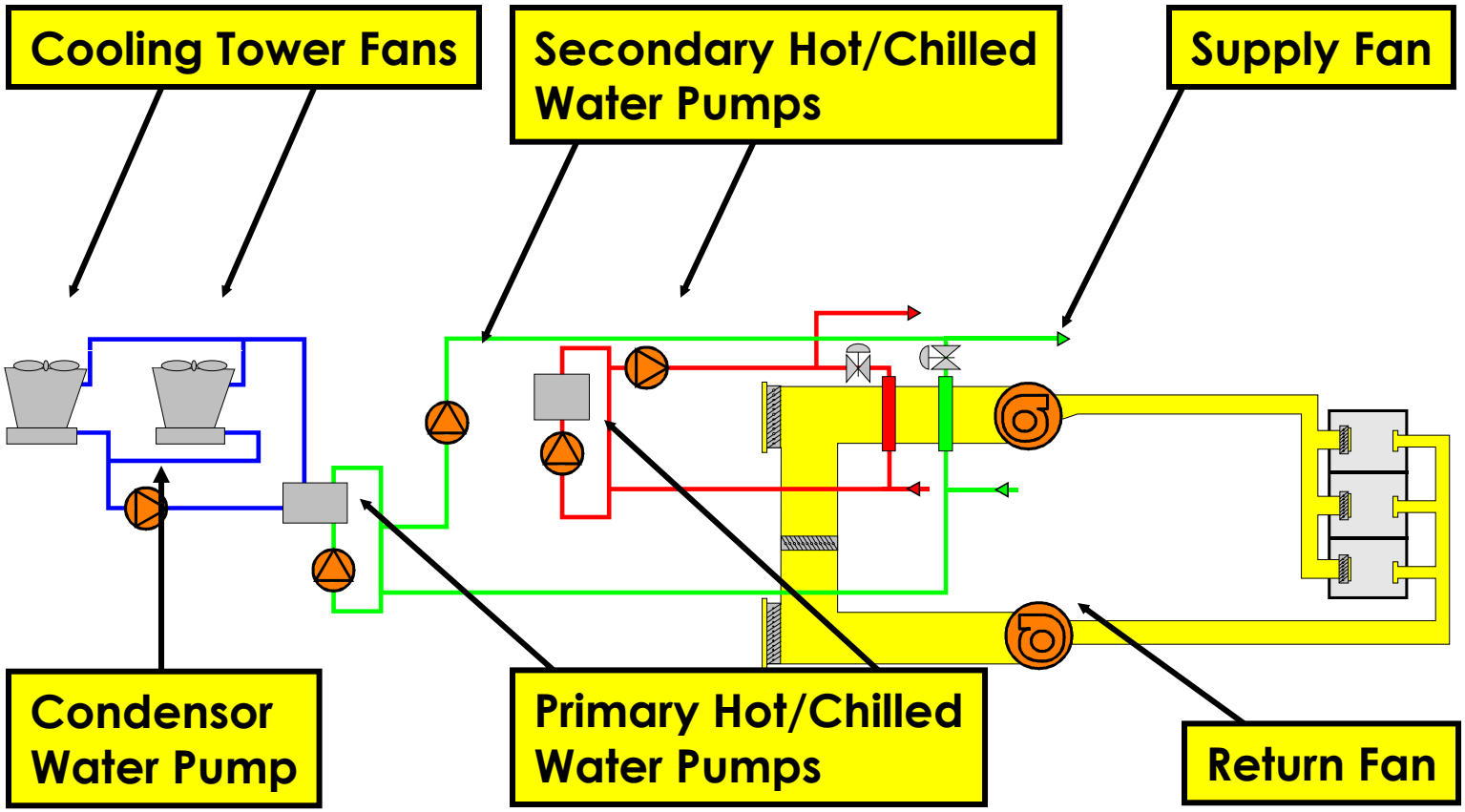
Sounds like a PUMP !!!!!

Why Flow Control?

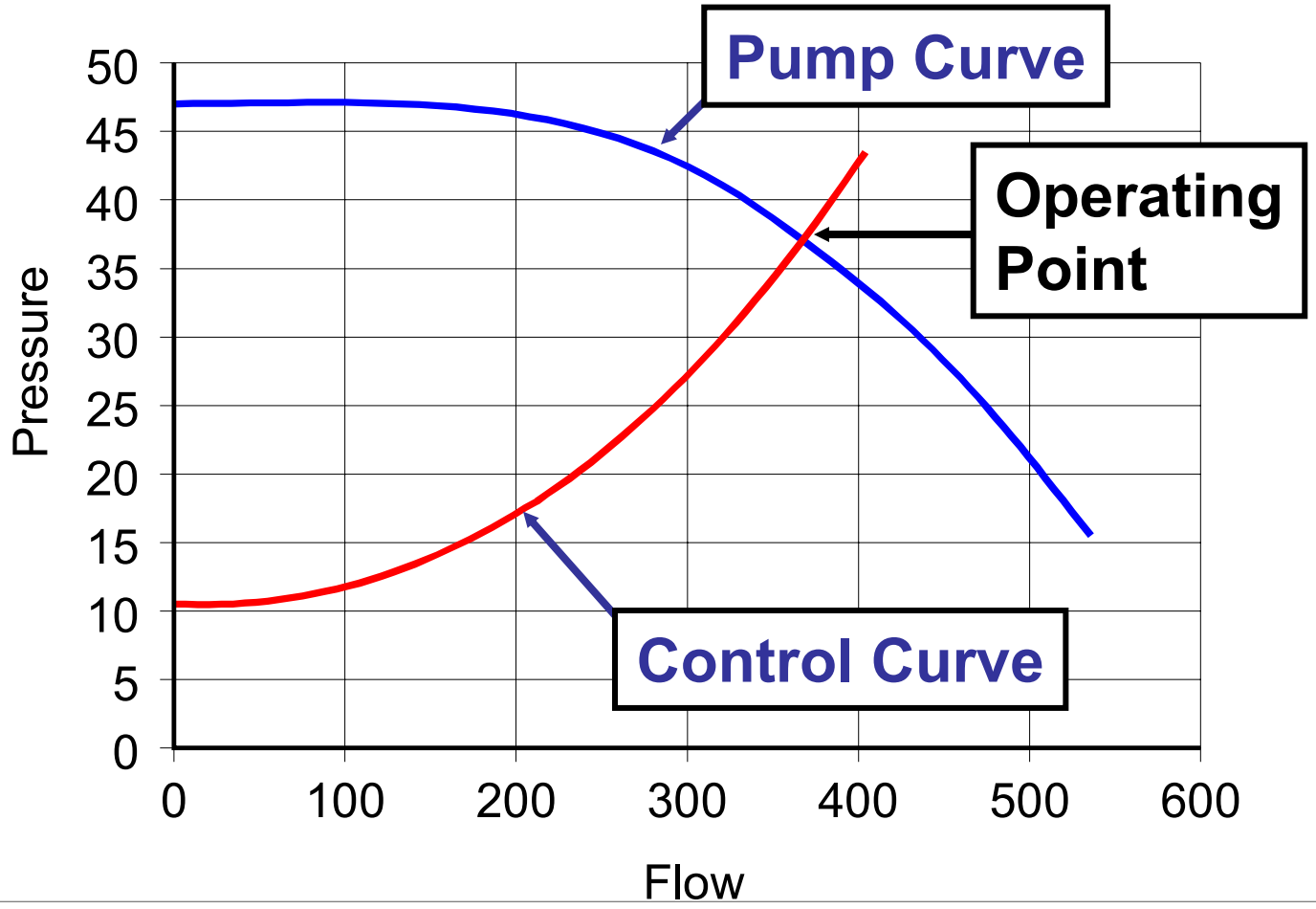
- ***HVAC systems are designed for "worst case" design situations. Most of the time they have excess capacity.***

- ***Controlling flow…***
  - ***Saves energy***
  - ***Improves occupant comfort***

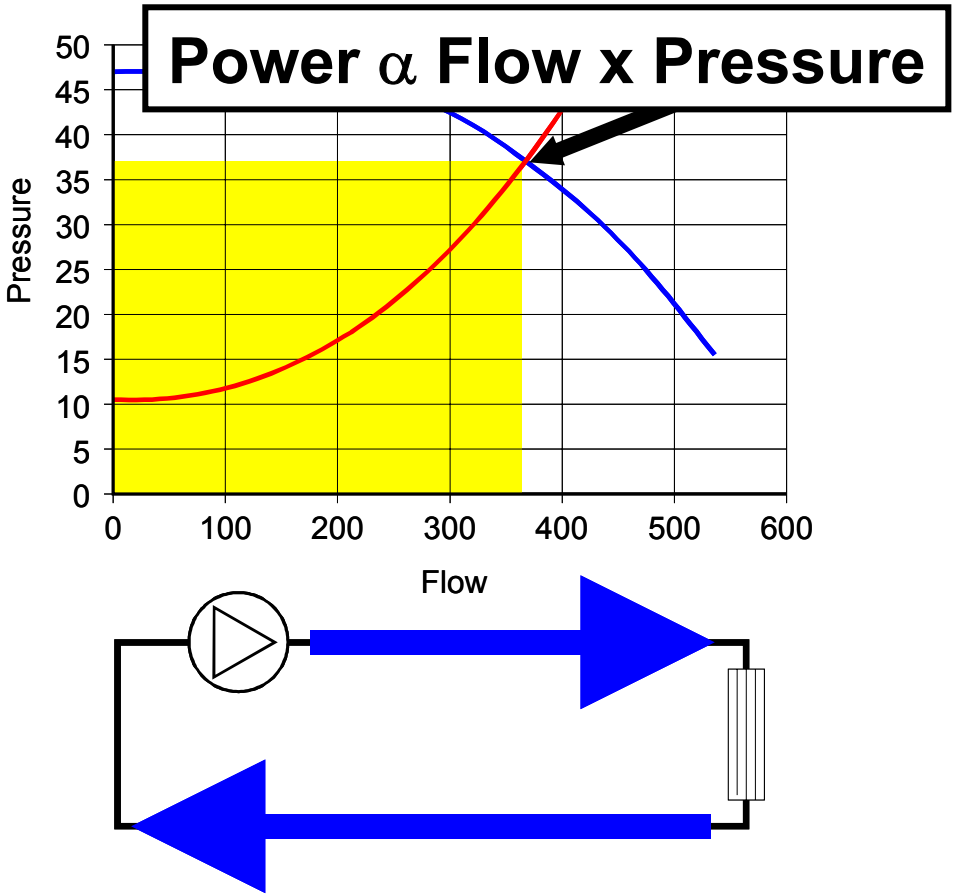
Variable Torque Applications



Pumps- Energy Savings



Energy Savings – VFD vs Throttling Valve



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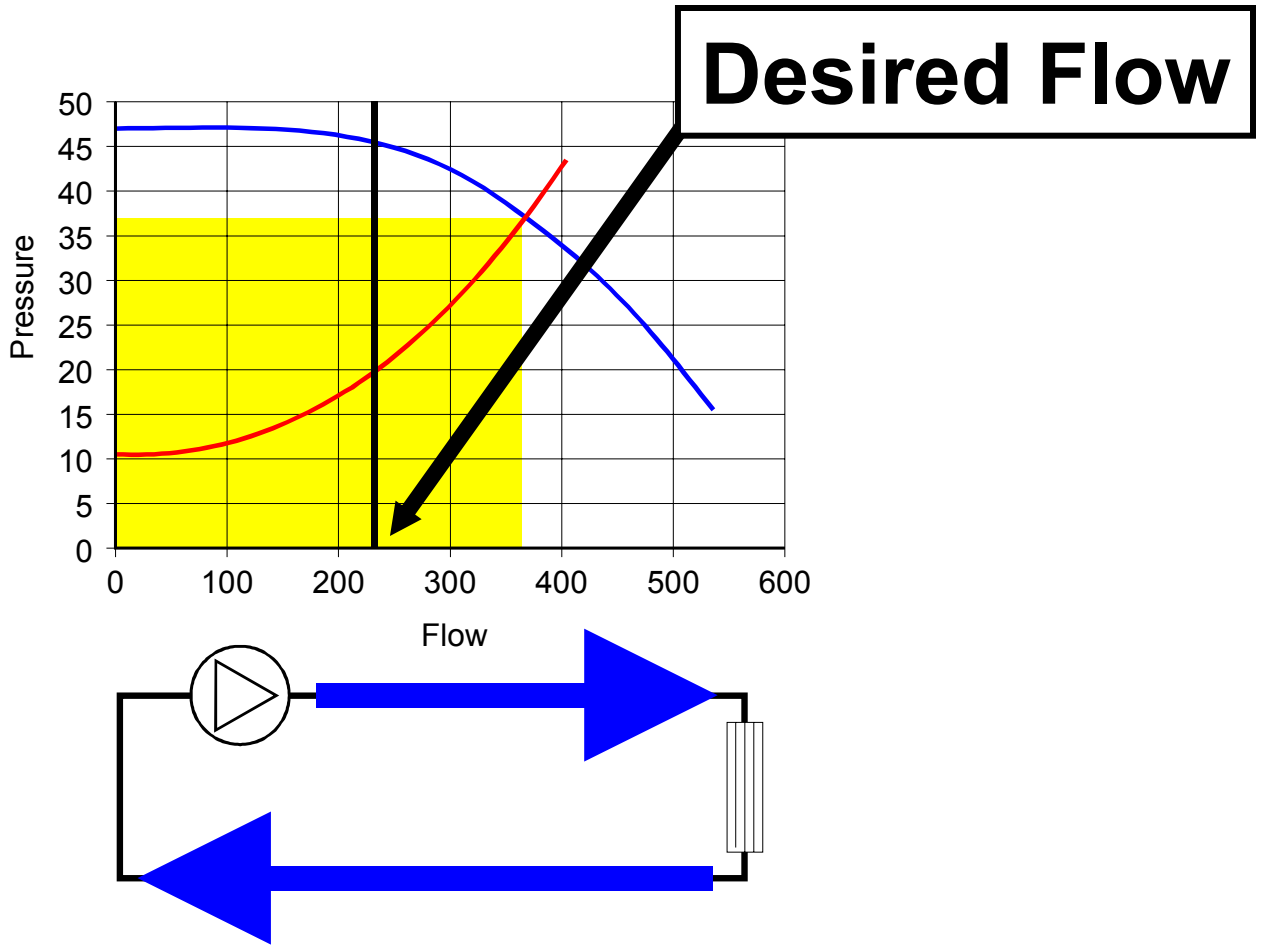

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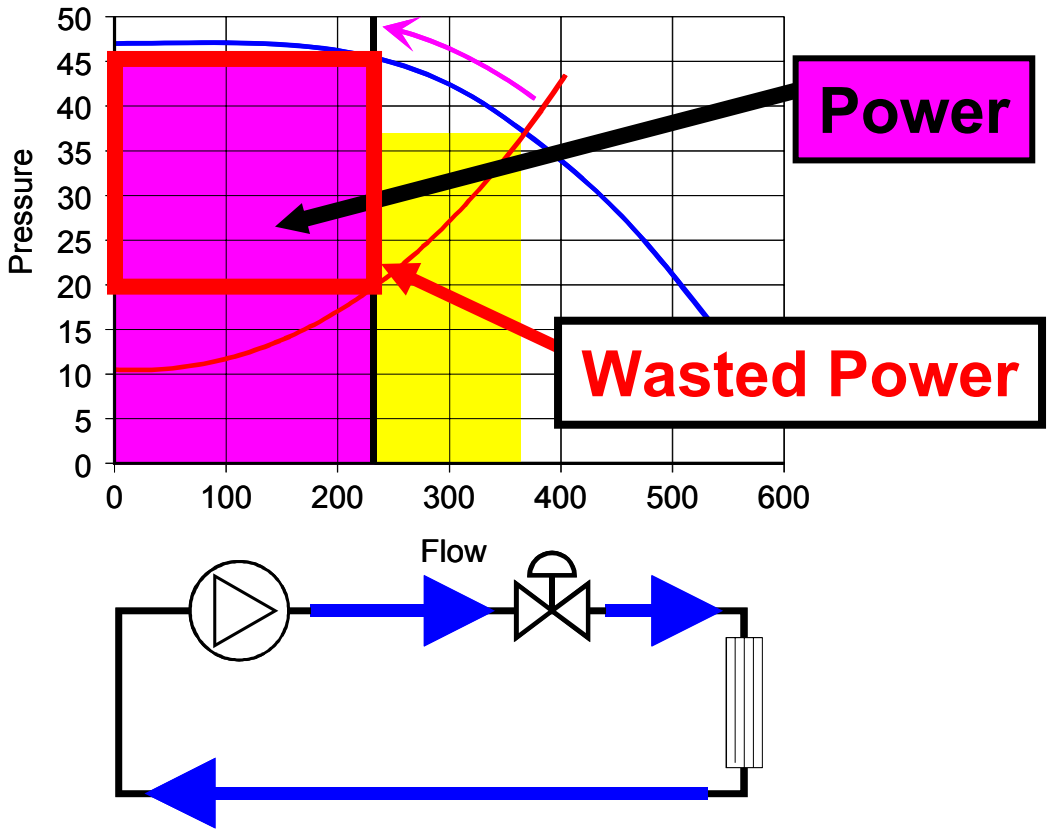
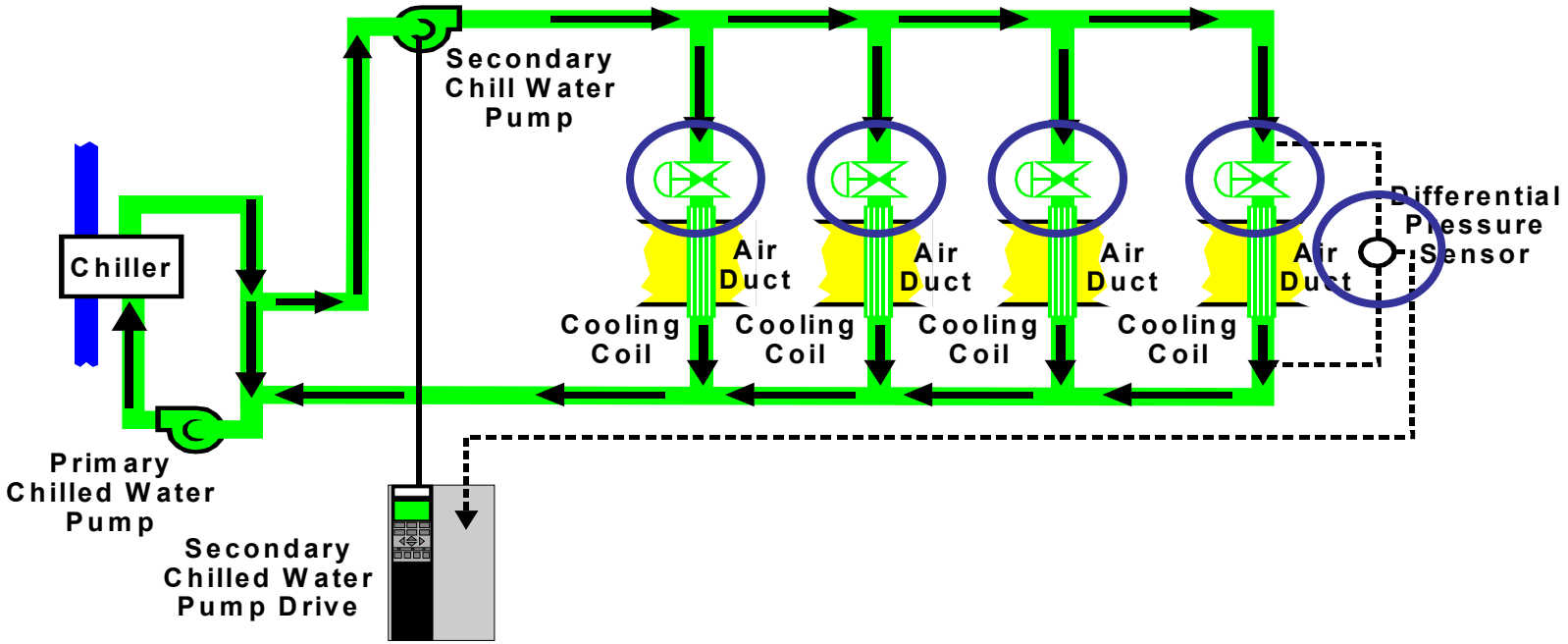


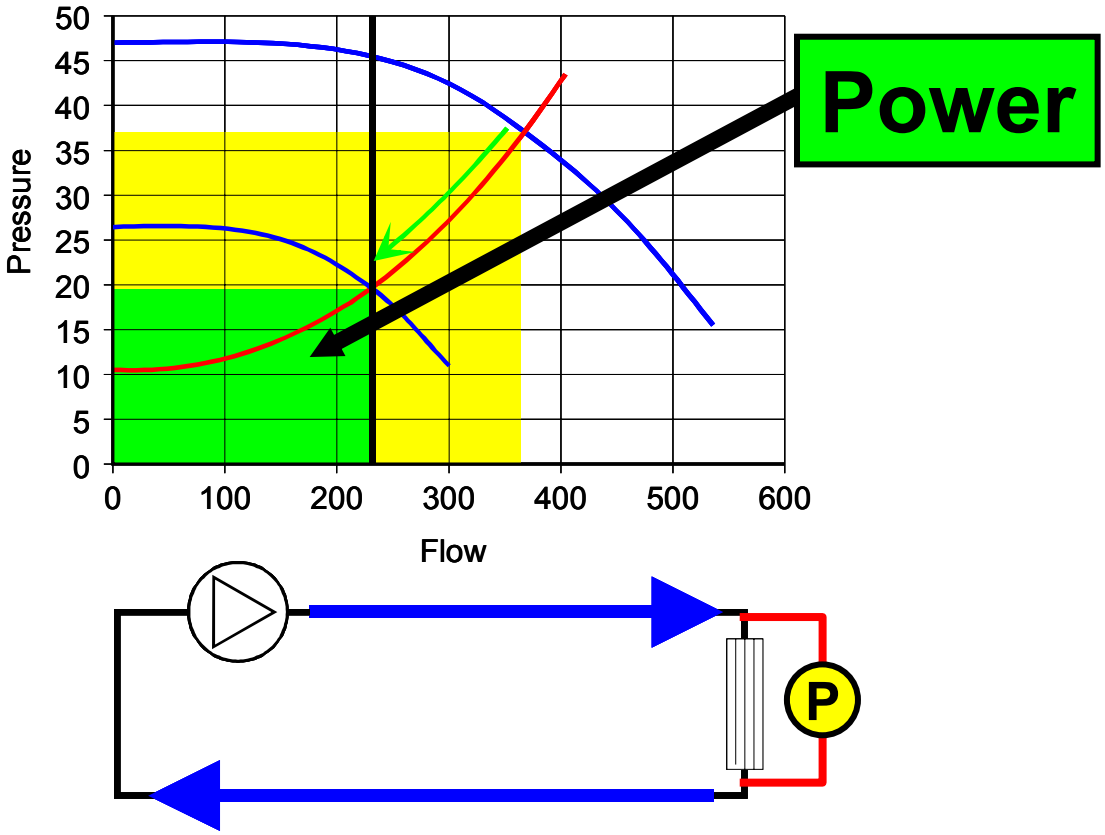
How to Retrofit Constant Flow Application

- *Remove pressure drop*
- *Add a VFD and Flowmeter*
- *Program VFD or BMS to control speed to maintain desired GPM*
- *Applications*
  - *Cooling Tower-Condenser Pumps*
  - *Heat Exchanger-Dedicated Pump*
  - *Heat Pump Systems-Main Loop Pumps*

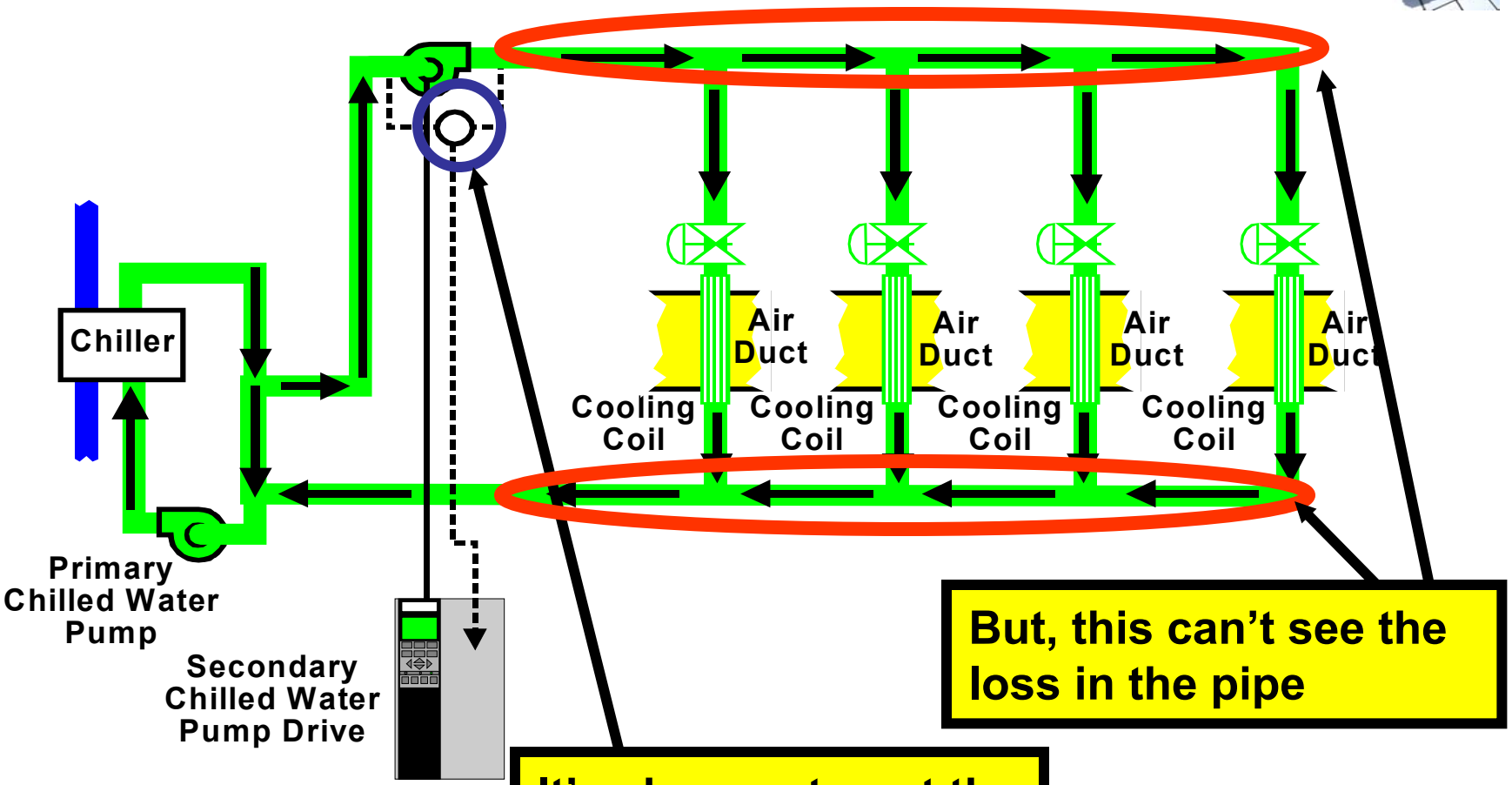
Controlling Secondary Pumps



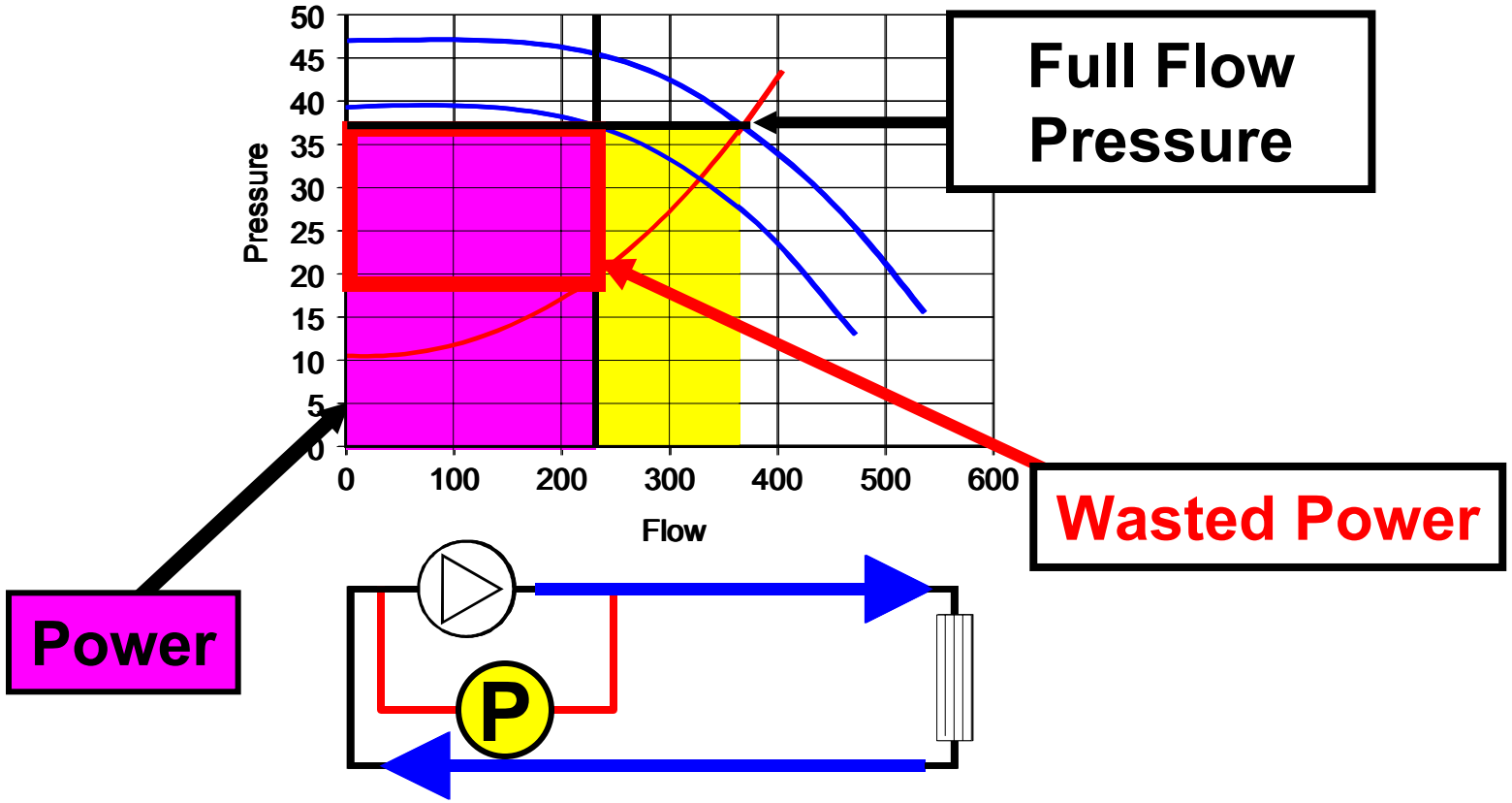
Energy Savings – VFD



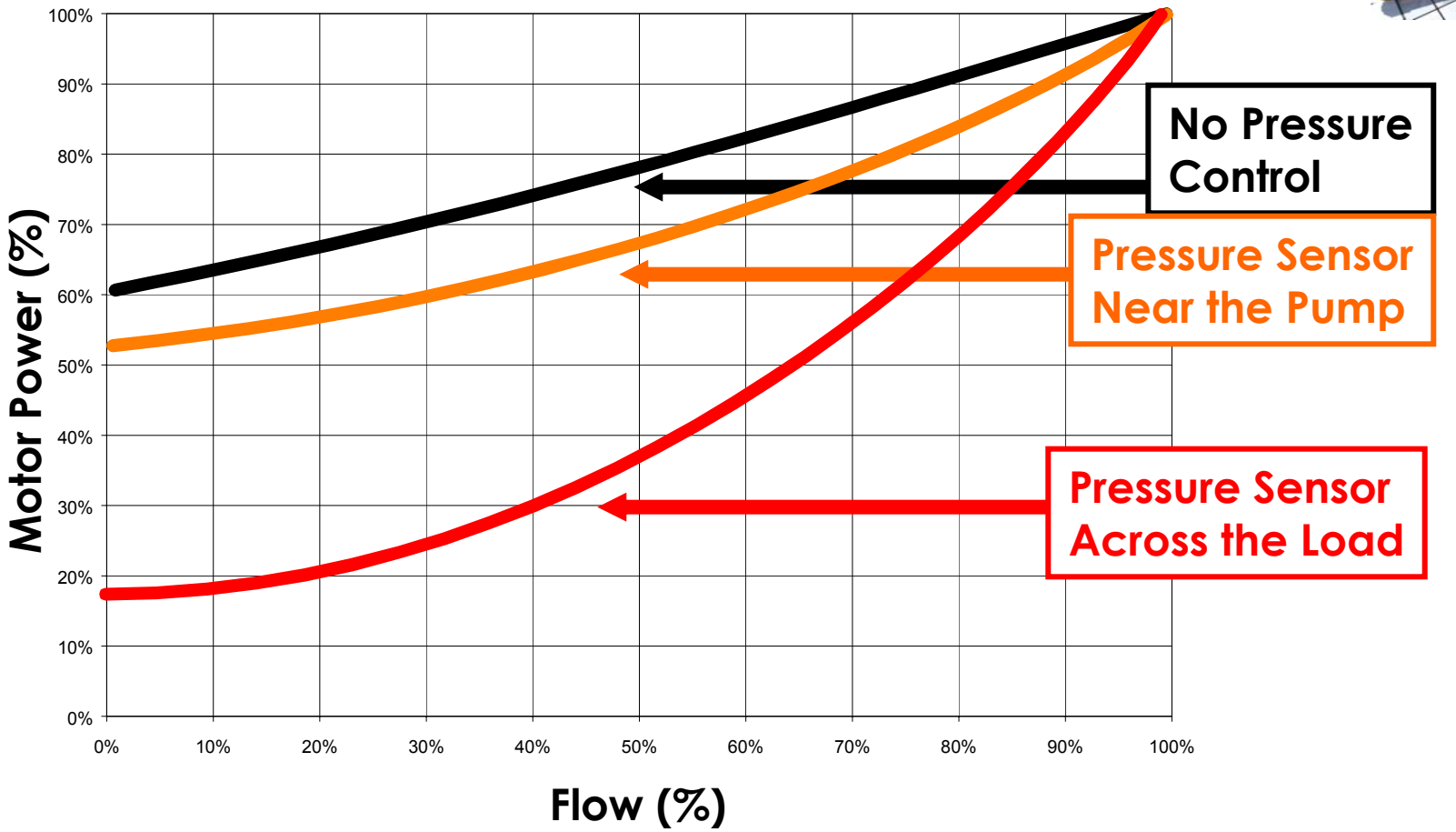
Effect of Sensor Location



Effect of Sensor Location



Effect of Sensor Location



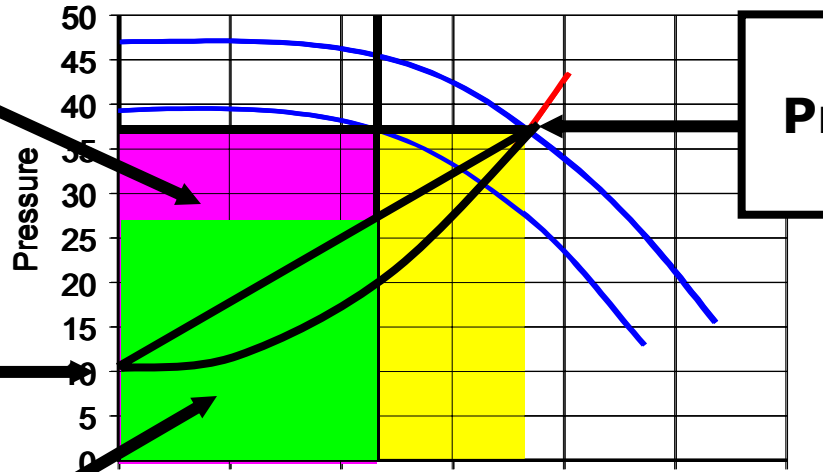
Compensating for Sensor Location

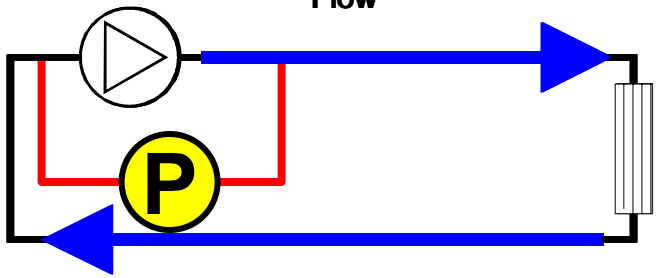
Power

Zero Flow Pressure and Speed

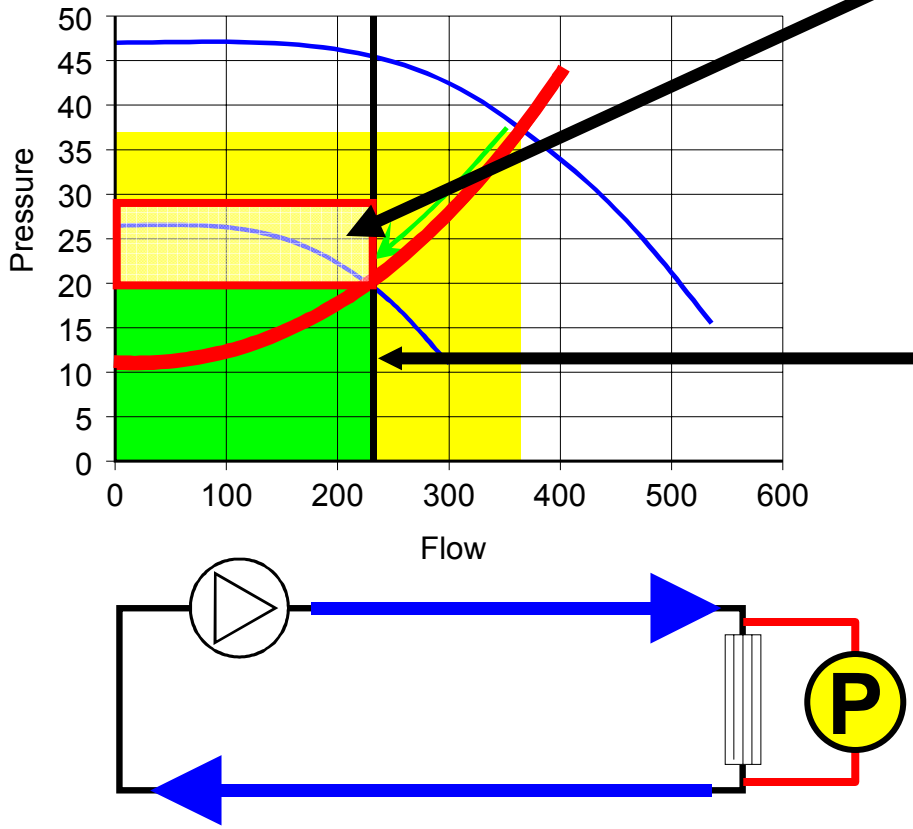
Power

Full Flow Pressure and Speed





Effect of Pressure Setpoint



Reference Material

- *Ashrae 2008 Handbook –Chapters 43&44*
- *Ashrae Journal – Monthly*
- *Danfoss*
  - *The Drive To Manual*
  - *http://hvacity.danfoss.com/fast%20path.html*
- *Danfoss VLT Energy Box Toolbox*