Welcome to tonight's
AIRAH QLD Division Meeting

Where to use drives & VSDs

Where to use drives & VSDs

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In this session we will cover:

- Drive types
- HVAC applications for VSDs
- Regulatory requirements
- Energy efficiency benefits
- Benefits of VSDs in commissioning and system tuning
- Application of VSDs in staged installations
- Design and installation futureproofing
- Upgrade and retrofit opportunities and applications
- Control options
- Fire mode applications and considerations
- VSD Do’s and Don’ts

Drive types

What are VSD's?

- Variable Speed Drives are devices commonly used in HVAC applications to regulate the speed and rotational force (Torque output) of an electric motor
- Typically 3Ø 50hz supply, 3Ø variable frequency out
- There are also 1Ø to 1Ø and 1Ø to 3Ø three phase versions
- Different terminologies and acronyms are used for devices that control or alter the speed of electrical motors.
- The most commonly used terms are:
  - Frequency Converter (FC)
  - Variable Speed Drive (VSD)
  - Adjustable Speed Drive (ASD)
  - Adjustable Frequency Drive (AFD)
  - Variable Frequency Drive (VFD)

Drive types

- VSD's began mass manufacture in the late 1960s.
- Whilst the principle of converting fixed mains voltage and frequency into variable quantities has remained virtually the same, there have been many improvements from the first FC's, which featured thyristors and analogue technology, to today's microprocessor-controlled, digital units.
- VSDs are typically applied to the most common form of electric motors, the so-called "squirrel-cage" three-phase asynchronous motor.
- Historically VSD has been used to refer to a drive controlling an ac motor.
- The industry has seen the recent emergence of EC (electrically commutated) motors also, used mainly in fan motors, that is a DC motor providing variable speed motor control.
- For today's session I will use the term **VARIABLE SPEED DRIVE** in a general sense, that being an electric motor that is capable of operating at variable speeds or duties.

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AutomationDrive
Danfoss


CAUTION


ABB

HVAC applications for VSDs

- Control the duty of a motor that is driving a piece of equipment such as fans, pumps, compressors etc.
- Drive a motor at a pre-set fixed speed, typically less than synchronous or full speed - **static mode or control**
- Modulate the speed of the motor to control a desired parameter to a target control point – **dynamic or active control**
- For the purposes if this presentation I have grouped the application of VSDs into 3 main areas:
  - Airside
  - Waterside and main plant
  - Life safety

HVAC applications for VSDs

Main benefits of drives:

- Improved comfort control
- Operating duties matched to required loads - optimising operating conditions
- Achieve improved energy efficiency
- Reduced wear and tear and increase service life
- Lower life cycle installation cost
- Ease of commissioning
- Ease of system tuning

HVAC applications for VSDs

Most basic application – any kit

- Commissioning aid for fixed duty systems of any type where the VSD is set at a pre-set fixed speed, typically less than full speed - static mode

Airside

- AHU supply air fans and return air fans where used.
- Typically used to modulate (**Dynamic Control**) the fan duty to achieve a variable flowrate maintaining target duct static pressure in response to changing demands
- Typical system is a VAV system

HVAC applications for VSDs

- Exhaust air or supply air ventilations fans when variability in load exists:
  - Carpark exhaust air fans to achieve acceptable CO levels
  - Other air quality/maximum concentration levels of contaminants
  - Modulation of flowrate in response to varying temperature demands

HVAC applications for VSDs

- Critical spaces pressure control to avoid contamination and to control directionality of air flow
  - PC2 and PC3 laboratories
  - clean rooms
  - pharmaceutical manufacturing
  - switch rooms or equipment rooms

HVAC applications for VSDs

- Critical spaces pressure control to avoid infection control and to control directionality of air flow
  - operating theatres
  - sterile stores
  - isolation rooms etc.
- Dehumidification applications with reduction in coil air flows to increase dehumidification effect

HVAC applications for VSDs

Refrigeration – Main Plant

- Variable capacity of refrigeration compressors:
  - condensing units
  - packaged air conditioning units
  - air and water cooled chillers
  - Both HVAC and refrigeration applications
  - External driven compressors or complete proprietary compressor/motor units

HVAC applications for VSDs

Refrigeration – Main Plant

- Variable duty primary and/or secondary chilled water pump operation to match changing chilled water system load requirements
- Variable duty condenser water pump operation to match changing cooling tower/condenser water system duty requirements
- Variable condenser fan operation to provide stable and optimised refrigeration system operation in air conditioning and refrigeration condensing equipment

HVAC applications for VSDs

Life Safety

- Stair well pressurisation and lobby relief fans
- Smoke exhaust and smoke control system fans

HVAC applications for VSDs

- To summarise, variable speed drives are typically used to provide pressure or flow control, or more basically to match a variable load by way of modulating the speed of an electrically driven fan or pump motor.

Regulatory requirements

J 5.2 Air-conditioning systems of the NCC 2016 requires that an air-conditioning system (other than a packaged system) must have a variable speed fan when its supply capable of being varied.

J 5.2 Air-conditioning systems of the NCC 2016 also requires that an air-conditioning system pump that is rated at more than 3 kW of pump power and circulates water at more than 2 L/S must be capable of varying its speed in response to varying load

J 5.4 Miscellaneous exhaust systems of the NCC 2016 also requires that a miscellaneous exhaust system with an air flow rate of more than 1000 L/s, that is associated with equipment having a variable demand, must have a variable speed fan or the like

AS1668.1 and AS3000 contains various requirements for the use of VSDs in smoke control systems and stairwell pressurisation systems

- Positioning and FRL of VSDs
- Overriding of safety devices to ensure continuous operation
- Signage

Regulatory requirements

AS1668.1 and AS3000 contains various requirements for the installation and operation of VSDs used in smoke control systems and stairwell pressurisation systems

- Positioning and FRL of VSDs
- Overriding of safety devices to ensure continuous operation
- Signage
- Screened cabling between the drive and the motor to control Electromagnetic Interference (EMI)

Energy efficiency benefits

Pump and Fan Energy Law Fundamentals

- Pump and fan applications are typically variable torque applications
- This means that energy saving opportunities are very high as these machines follow the Affinity Laws, also known as Fan and Pump Laws.

Energy efficiency benefits

Law 1 for the same diameter fan or impeller

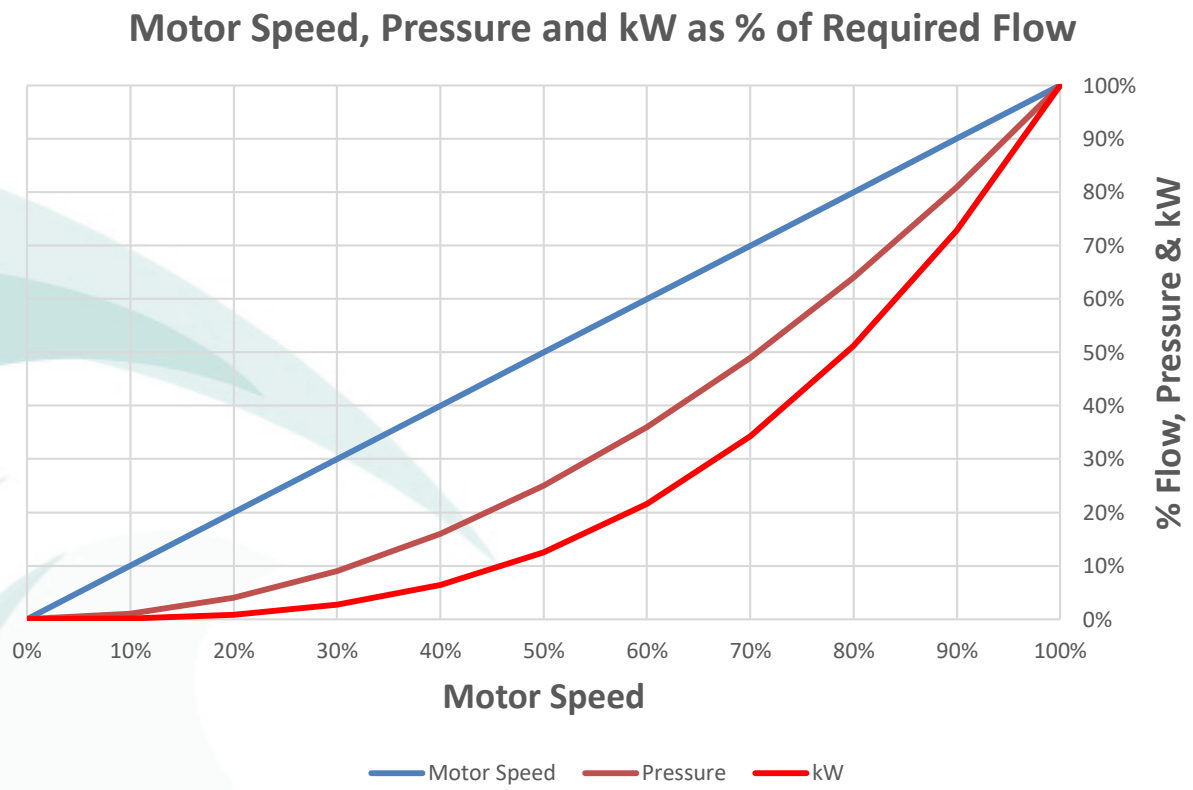
$$\frac{Q_1}{Q_2} \sim \left(\frac{n_1}{n_2}\right)$$ Flow (Q) is proportional to speed (n)

$$\frac{H_1}{H^2} \sim \left(\frac{n_1}{n_2}\right)^2$$ Pressure (H) is proportional to square of speed (n)

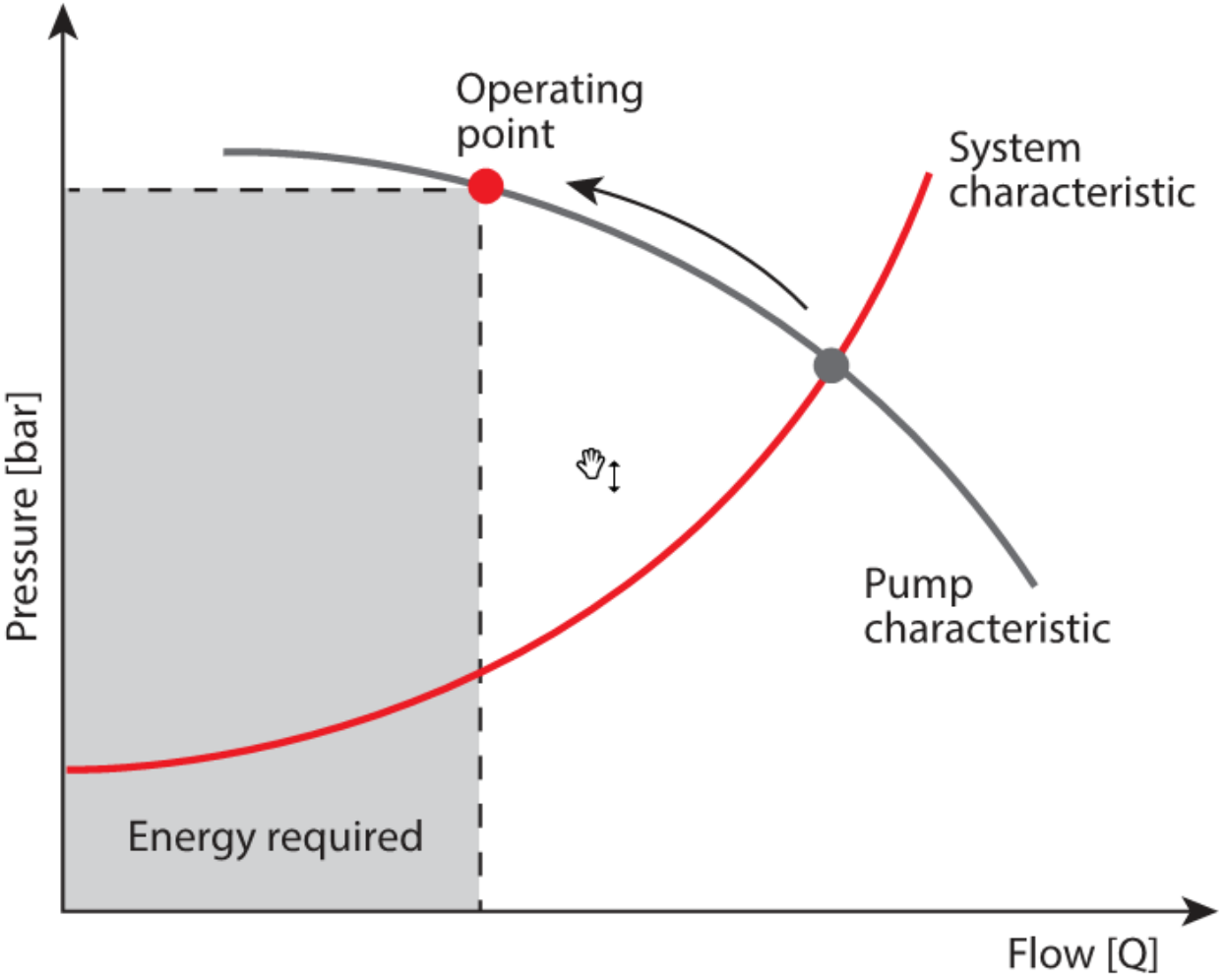
$$\frac{P_1}{P_2} \sim \left(\frac{n_1}{n_2}\right)^3$$ Power (P) is proportional to cube of speed (n)

Flow (Q) increases linearly with increasing speed (n), while the pressure/head (H) increases quadratically, and the power consumption (P) increases cubically.

Energy efficiency benefits

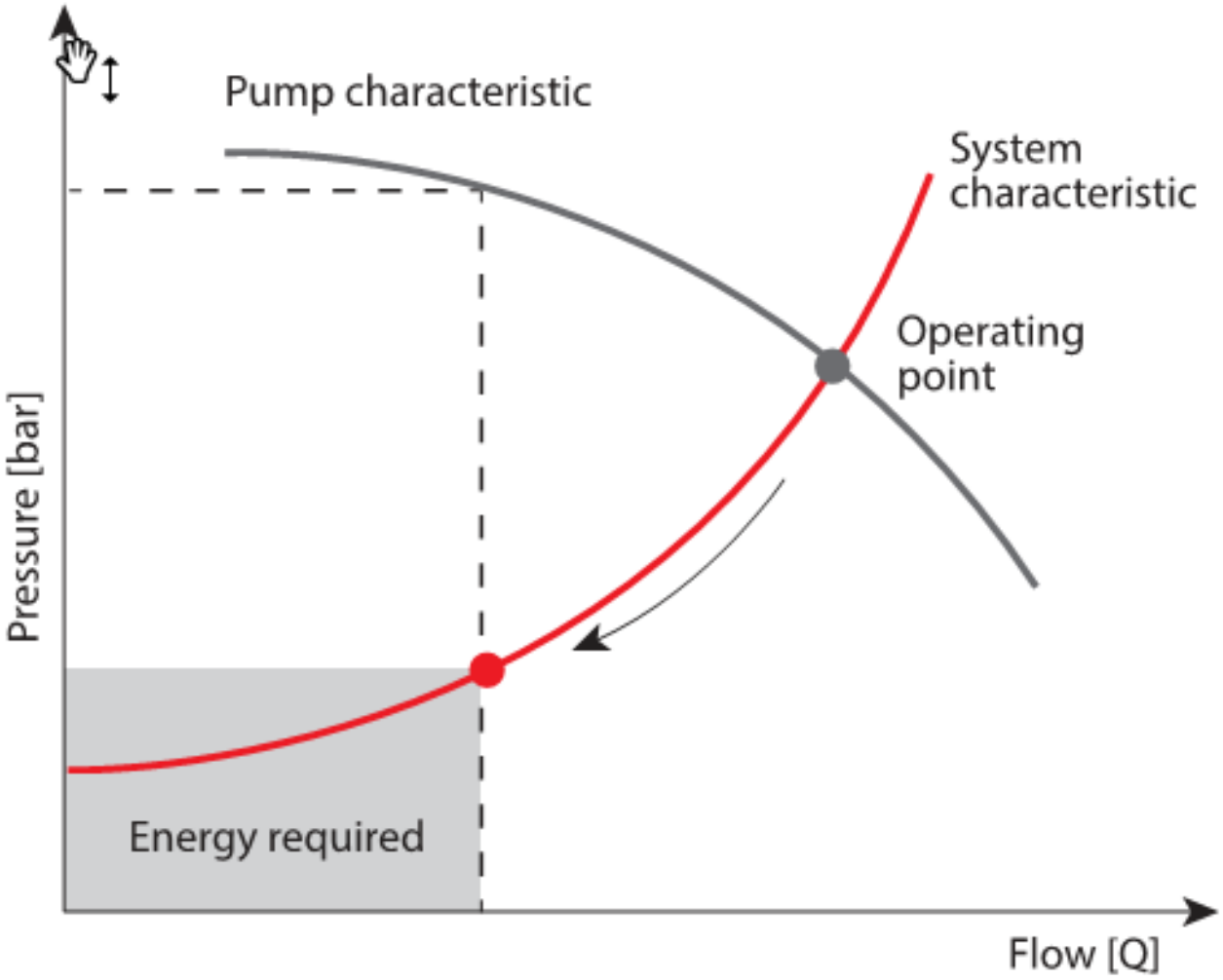


Energy efficiency benefits



Energy required in a variable torque pump application for throttle control

Energy efficiency benefits

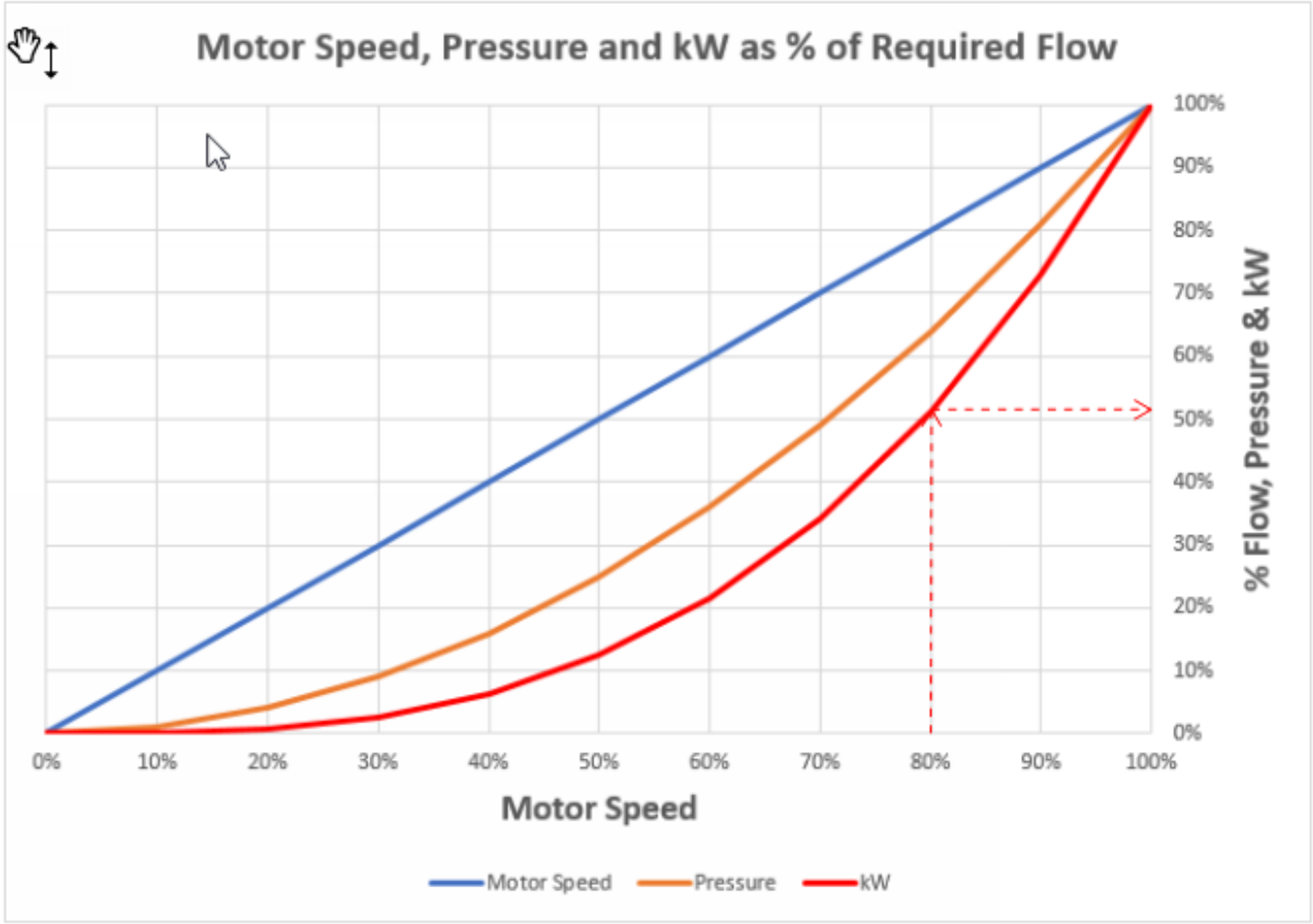


Energy required in a variable torque pump application for speed control

Energy efficiency benefits

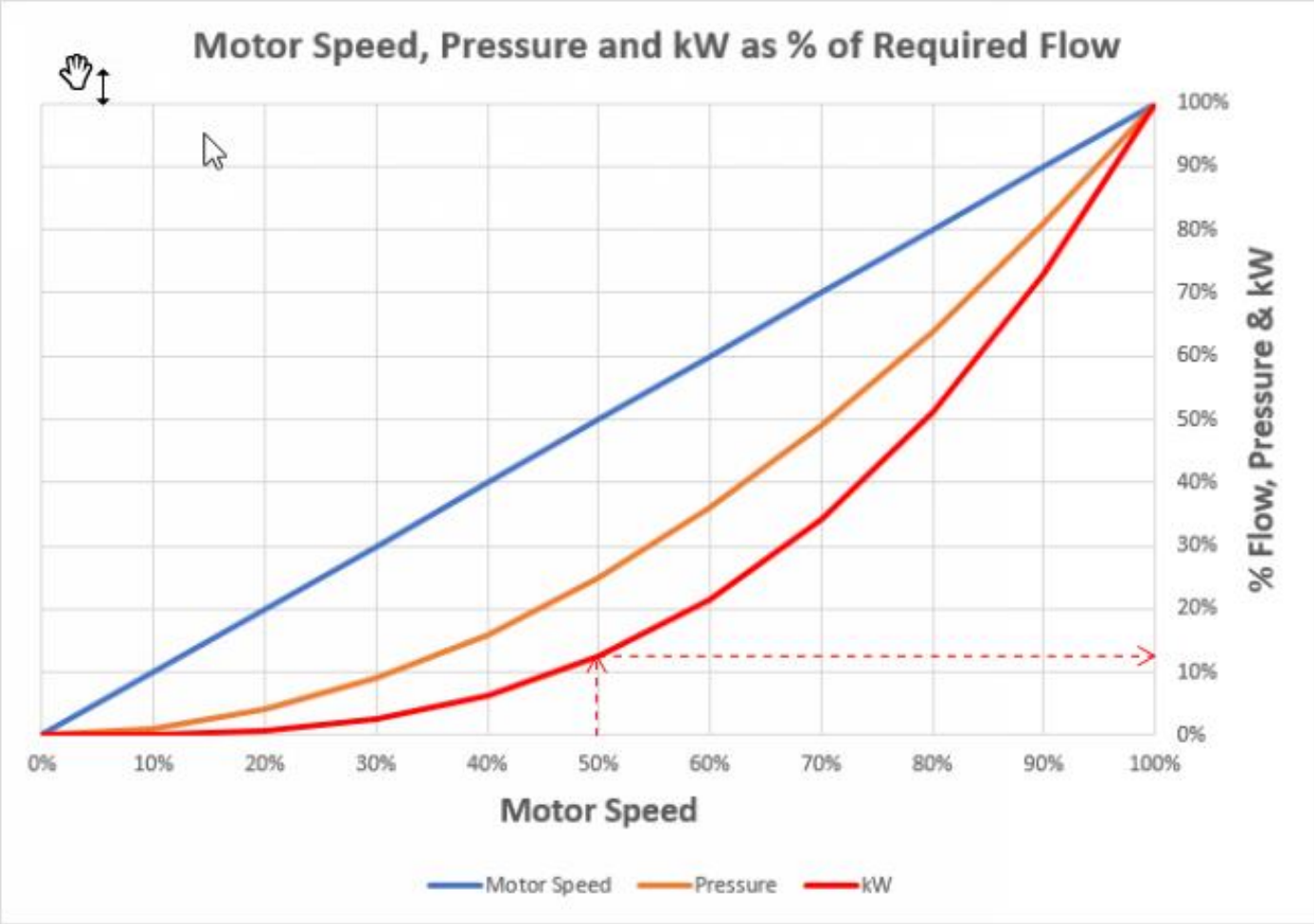
- In theory a reduction in speed of 20% results in an energy reduction of 50%.

% of Flow	80%
% of Speed	64.0%
% of kW	51.2%



Energy efficiency benefits

% of Flow	50%
% of Speed	25.0%
% of kW	12.5%



Energy efficiency benefits

- We know that air conditioning systems spend little time at their full cooling or full heating duty point, spending the majority of their lifetime at somewhere in between
- Therefor there is significant opportunity therefore for system speed modulation at part load conditions and which in turn allows energy savings to be achieved.

Benefits of VSDs in commissioning and system tuning

Commissioning

How do we adjust or control a VSD?

- VSD (motor) speed can be controlled locally (manually), remotely or automatically using internal or external controls.
- At the drive touchpad/keypad for manual adjustment to operate at a static duty - Most basic use
- By electronic controls system or BMS system interface to operate at a static duty
- Modulation by electronic controls system or BMS system, to achieve dynamic control

Benefits of VSDs in commissioning and system tuning

Why do we adjust or control VSD driven kit?

- Adjust system duty point due to variances in calculated system operating duties to as built duties (mainly pressure)
- To match changes in what is actually required to satisfy the installation as compared to what was calculated?
- Realise time savings by readily and accurately adjusting system parameters rather than using a multitude of throttling devices to impose unnecessary pressure losses to achieve acceptable duty points
- Changes in client/project needs that may occur between when originally designed and when built

Benefits of VSDs in commissioning and system tuning

System tuning

- Optimise performance at maximum and minimum design conditions
- Optimise performance for different seasons and times-of-use by utilising smart logic and control strategies
- Realise energy efficiency levels that everyone dreams of but rarely achieves
- Utilise advanced and adaptive BMS tuning algorithms
- Lower operating duties mean less wear and tear, reduced maintenance costs and longer service life
- Better comfort control (accurate temperate control, and humidity control where applicable)
- Lower audible noise levels of fans and pumps

Benefits of VSDs in commissioning and system tuning

System tuning

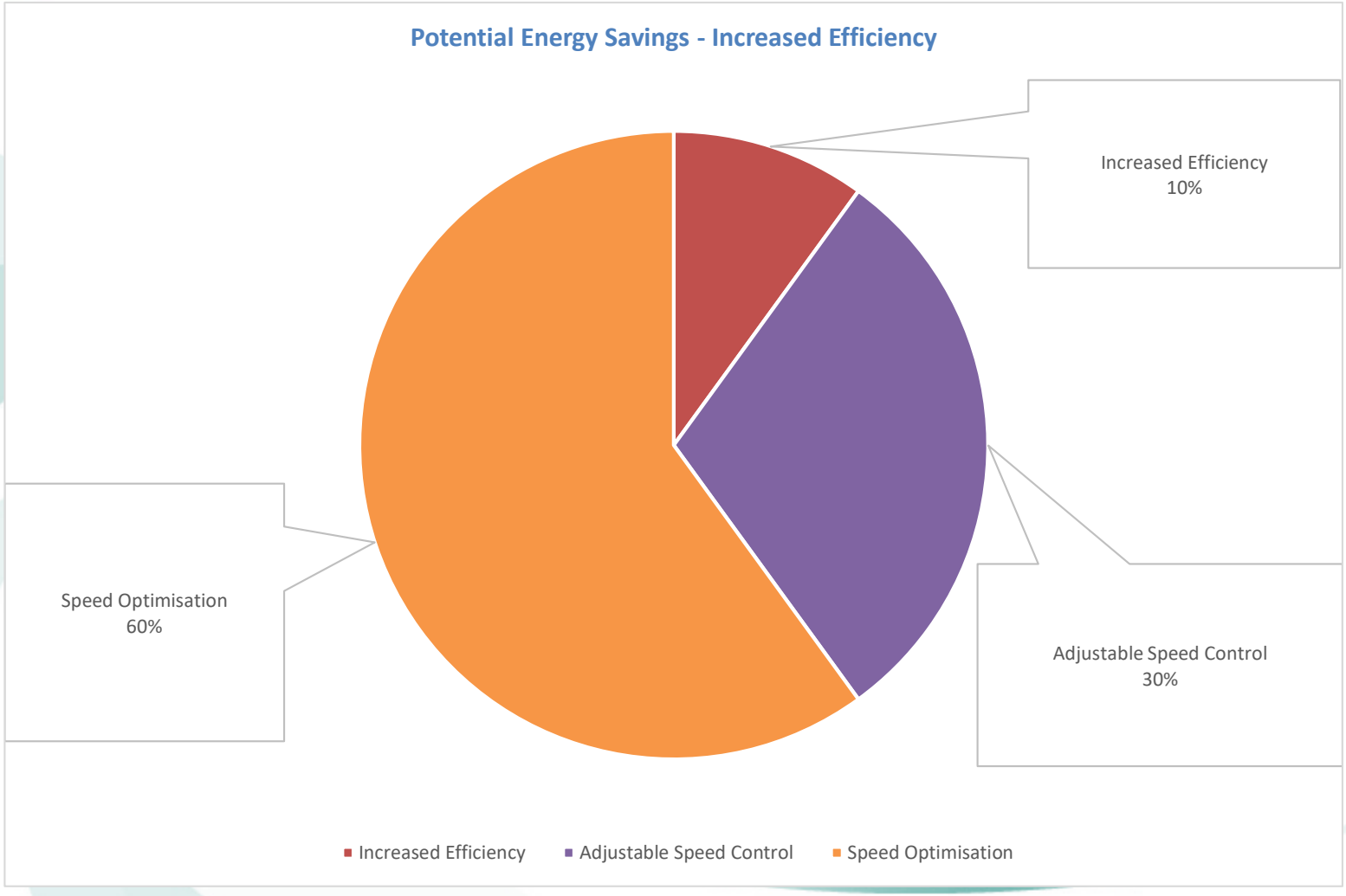
- Extract from the "***Facts Worth Knowing about Frequency Converters Handbook - VLT Frequency Converters***" publication by DANFOSS states:

  When total potential savings that could be made in a system are defined as 100%, roughly 10% of that potential could be obtained through the use of more efficient components, such as motors.

  Operation with adjustable speed control offers potential energy savings of approx. 30%.

  However, the greatest savings (approx. 60%) are to be made by optimising the entire system

Benefits of VSDs in commissioning and system tuning



Application of VSDs in staged installations

- Staged handover may require part load performance through various stages of a new development or staffed refurbishment
- Can pretty much dial up any operating duty for each piece of kit between nothing and flat out ☺
- Fixed or dynamic control both provide benefits

Design and installation flexibility and futureproofing

- Changed use of installation over life of building
- Future upgrade
  - Fit out of shell space
  - Additional floors to a building
- Additional buildings or load in secondary chilled water legs
- Additional condenser water load to serve additional cooling towers in staged chilled water plant upgrade

Upgrade and retrofit opportunities and applications

- Energy efficiency improvements
- Support other intelligent and efficient kit upgrades
- Improved comfort control
- Enhanced service life
- Ease of upgrade works – staging mainly
- Opex reduction (operating costs)

Control options

- Standalone fixed (static) control through drive settings
- Automatic control utilising on board drive control functionality
- Electronic control systems – low level control
- BMS control - low level control
- BMS control and interfacing - HLI (High Level Interface)
- Modbus, LonWorks, BACNET, and other open protocols

Control options

- There are many drives now dedicated to the HVAC industry for optimisation of fans and pumps.
- Commonly include interfaces and logic to deal with fire mode, dampers interface, ramp times, on board flow compensating via PID control loops, energy monitoring functions etc.

Additional benefits of using drives

- Phase protection (reversal and loss)
- Voltage imbalance protection
- Smooth start and significantly reduced starting currents (electrical system implications)
- Less demand on electrical supply infrastructure

Fire mode applications and considerations

- Stairwell pressurisation system and associated relief air systems (e.g. lobby relief systems)
- Zone pressurisation systems, variable supply air, return air and exhaust air control
- Be aware of particular electrical installation and fire rated installation requirements
- Understand what the basis of the control is. As good as VSD are, you must still have a clear control methodology and sensing arrangement for a system to work properly
- KISS

VSD Do's and Don'ts

- Supply air distribution:
  - Dumping in diffusers if not properly selected
  - Swirl diffusers can assist a lot here
- Can maximise system performance by parallel operation of units rather than full duty of individual units, especially cooling towers and common condenser water system.

VSD Do's and Don'ts

- Correct control
  - where you measure the parameter on which you want to control.
  - Think through your control strategy, Just throwing VSD's and "SMART" controls at in installation will not alone give you a good result,. Effective control strategy makes systems work and allows you (your client) to get true value for money in kit like VSDs.
- Be mindful of:
  - VSD installations regarding Noise protection: EMC C1, C2, C3
  - installation regarding Harmonic introduction and what mitigation features various manaufacturers and drives provide
  - Audible noise may impact your installation

Thank you for your attendance

Please join us for refreshments