Solving the LV vs MV Dilemma When Optimizing Costs for Motor Management

A Guide to Large Pump Applications in Mining

schneider-electric.com/motor-management

Life Is On

Schneider Electric

5 reasons why you should read this document, and (re)consider motor management

1
Motors directly impact industrial electrical distribution and equipment

2
Motors are the foundation of all industrial processes

3
Motors are the largest consumer of energy (90%) in heavy industry

4
Motors are critical assets for predictive and preventive maintenance

5
Motors can be the opportunity to make a strategic choice between LV and MV

Summary

Introduction

The LV or MV Dilemma - A Lever for Optimizing the Cost of Motor Management

Motors consume more than 90% of the electrical energy in heavy industries and are the major loads defining the electrical distribution system and architecture design.

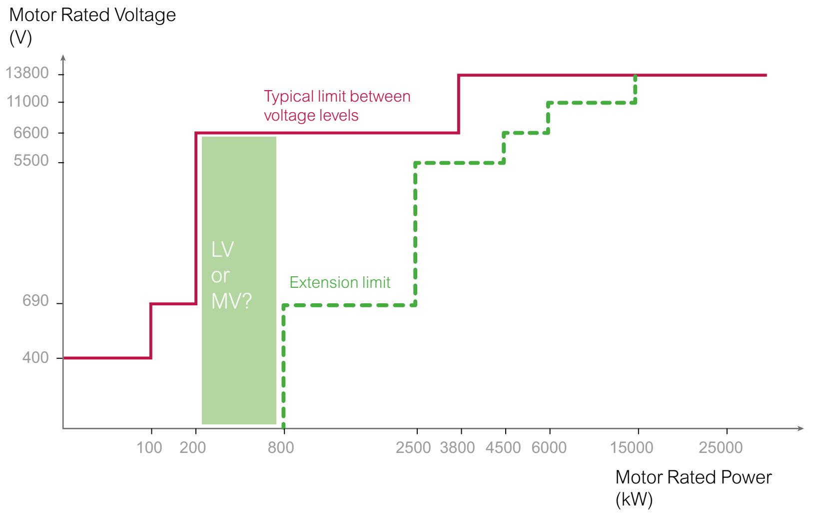
Depending on their rated power, motors can be connected to low voltage (LV) or medium voltage (MV) electrical distribution systems.
In the 100-800 kW range both connection levels are feasible and the decision is subject to technical, economic, and people-related criteria. Established practices and habits are just as important as the technical and economic arguments.

Motor technology and design are related to the voltage level. The choice of LV or MV can impact starting current, mechanical torque, inertia, and reactive power consumption. The voltage selection for large motors entails a different motor management design for the same application and motor power in LV and MV.

The following aspects need to be considered:

- Electrical distribution architecture
- Capital expenditure (CAPEX) related to the necessary investment in equipment, software, etc.
- Operation expenditure (OPEX) related to operational performance, maintenance costs, and energy efficiency
- Total cost of ownership (TCO) of the installation

This diagram compares generally established practices for voltage level selection and their reasonable limits. It shows that switching to MV often occurs much earlier than necessary while there might be a hidden cost minimizing optimization potential.



Practice and Limits of Electrical Equipment for Motor Feeders

What Are the Challenges When Optimizing Motor Management?

Electrical motors are an asset in electrical installations. Motor management optimization deals with the design of an adequate, yet simple solution, for integrating motors in industrial processes and electrical systems, while addressing several challenges:

- Optimizing investment
- Increasing uptime
- Reducing operating and maintenance costs
- Improving energy efficiency
- Minimizing the impact on the industrial process and the electrical system

Adequate voltage selection can achieve up to

20%

savings in CAPEX

Purpose of This Guide...

To explain the technological differences between LV and MV motor management and the impact on installation design, motor control and protection selection, power quality, etc.

To describe the Motor Management approach as a key to optimizing investment and operating costs.

To provide multiple guidelines and resources to help in decision making.

To allow end users to make the most of their installation by selecting the most suitable and consistent solutions for Motor Management.

Note: Although this guide focuses on pumping applications in mining, the guidance and conclusions presented are also valid for the Oil & Gas and Water & Wastewater industries.

Introduction

The Decision Triangle - End Users, Design Engineers, and Equipment Manufacturers

Choosing LV or MV connection voltage is a dilemma for end users and especially for design engineers. Often, for convenience or to minimize change and reduce risks, engineers prefer to repeat previous systems to avoid dealing with the fundamental questions around design.

At the same time, the optimal voltage selection could have an important impact on project profitability. This is where equipment manufacturers can play a significant role in overall optimization.

End users

Objectives:

- Optimize CAPEX, OPEX, and TCO

Expectations:

- Reliable and safe equipment
- Easy to maintain by personnel on site
- Lowest possible investment cost
- Lowest energy consumption
- Lowest footprint
- Large number of suppliers
- Simple in principle
- Fit for purpose
- ...

Equipment manufacturers

Objectives:

- Respond to the request
- Be selected as supplier

Values:

- In-depth knowledge of products and solutions
- Awareness on range effects
- Ability to help with overall optimization

Design engineers

Objectives:

- Minimize design process time
- Minimize CAPEX
- Meet application needs
- Cover eventual evolutions
- Guarantee performance
- Use approved solutions

Potential side effects of a conservative approach:

- Cumulative safety margins
- Range effects and unexpected costs
- Prioritization of manufacturer
- High-end solutions

Key points to remember

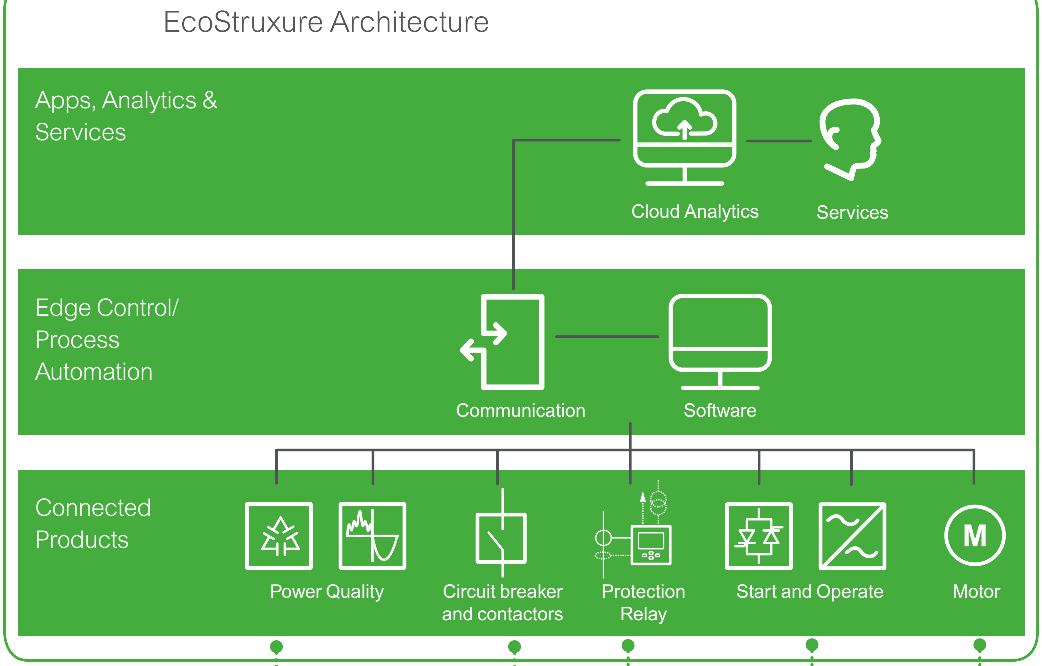
- Voltage level selection is a compromise between end users, design engineers and equipment manufacturers.
- It is part of the entire feeder design and requires a case-by-case approach.

Scope of the Motor Management Solution

Go to:
EcoStruxure for Mining
Scan or click on QR code

Motor management is part of a complete industrial installation with 3 levels:

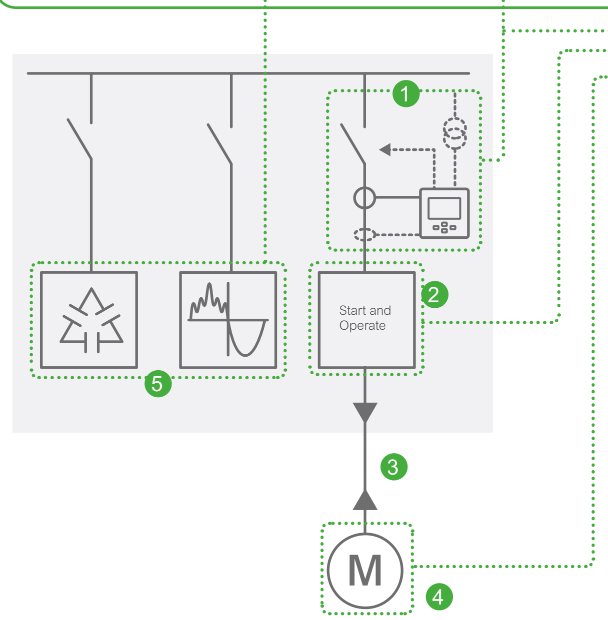
In Motor Applications



Predictive maintenance and services, based on cloud analytics, for proactive and preventive maintenance

Process automation and supervisory systems for local asset monitoring

Connected Products, to make data available for analysis



1. Circuit breakers and fused contactors associated with protection relays are typically used to connect, protect and start motors.
2. Soft starters or variable speed drives are used to start and operate motors by adapting the electrical and mechanical characteristics to the load and the network.
3. Cables are mainly sized according to installation requirements. Their conductive cross-section is defined by normal and fault currents. The control mode selection can influence cable sizing and bring optimization benefits.
4. Motors are essentially defined by application requirements. In high power ranges, their optimization can bring overall cost savings in terms of reactive power consumption, heat losses, upstream transformers and generator sizing.
5. Power quality concerns extra power consumption and financial penalties from utility or equipment malfunctioning. Motors act on power quality through their control mode.

Large Pump Applications in Mining

Large Pump Applications in Mining

Where are large pumps typically found in open pit mining operations?

Large pumps are used in multiple applications in the mining industry, including slurry pumping, dewatering, drainage, and jetting.

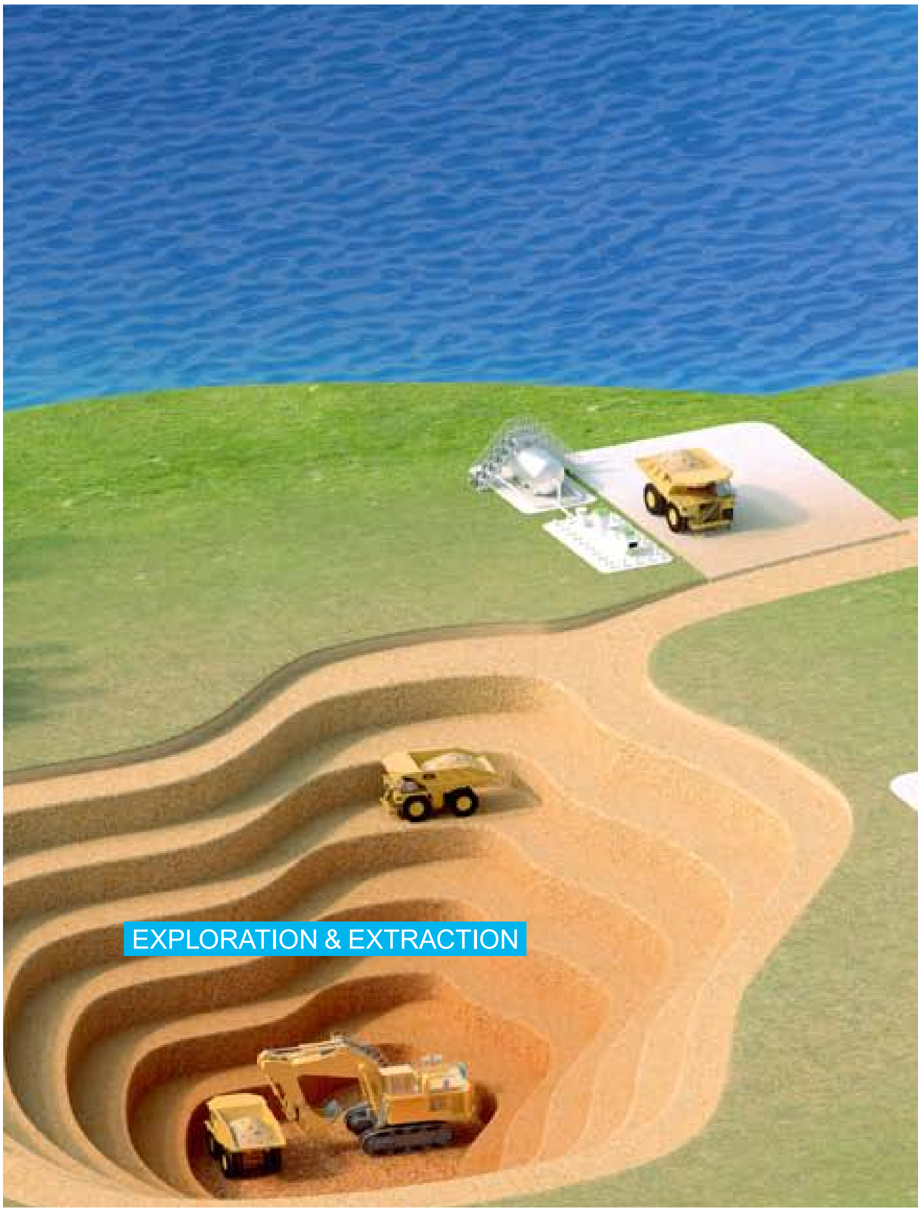
More than

70%

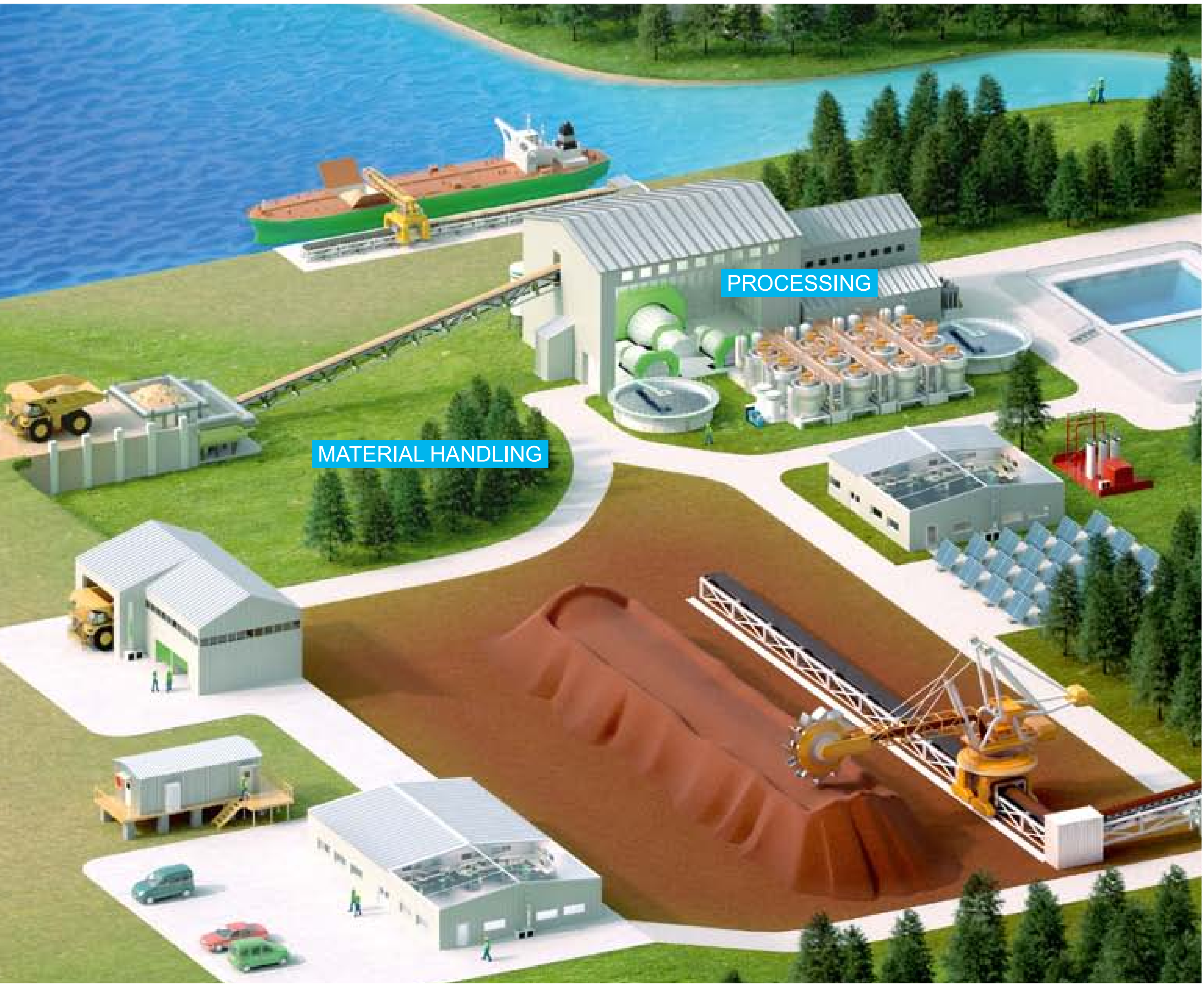
of them will be connected and controlled via contactors

30%

will use a variable speed drive



Process	Exploration & Extraction	Processing
Applications	Mine dewatering	Material grinding and classifying
Fluid	Water and non-settling slurry	Cyclone feed and fresh water
Pump technology	Centrifugal	Centrifugal
Motor power range	Up to 400 kW	Up to 1000 kW
Typical connection voltage	LV and MV	LV and MV
Flow	Constant	Constant
Operating mode	Intermittent	Intermittent



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				Material handing
	Comminution	Slurry pumping	Concentrating and refining	Transportation
	Process water	Settling slurry or tailings	Process water and leach acids	Settling slurry transportation
	Centrifugal	Positive displacement	Centrifugal	Positive displacement
	Up to 400 kW	Up to 1500 kW	110 – 300 kW	300 – 2500 kW
	LV and MV	LV and MV	LV	LV and MV
	Variable	Variable	Variable	Variable
	Continuous	Continuous	Continuous	Continuous

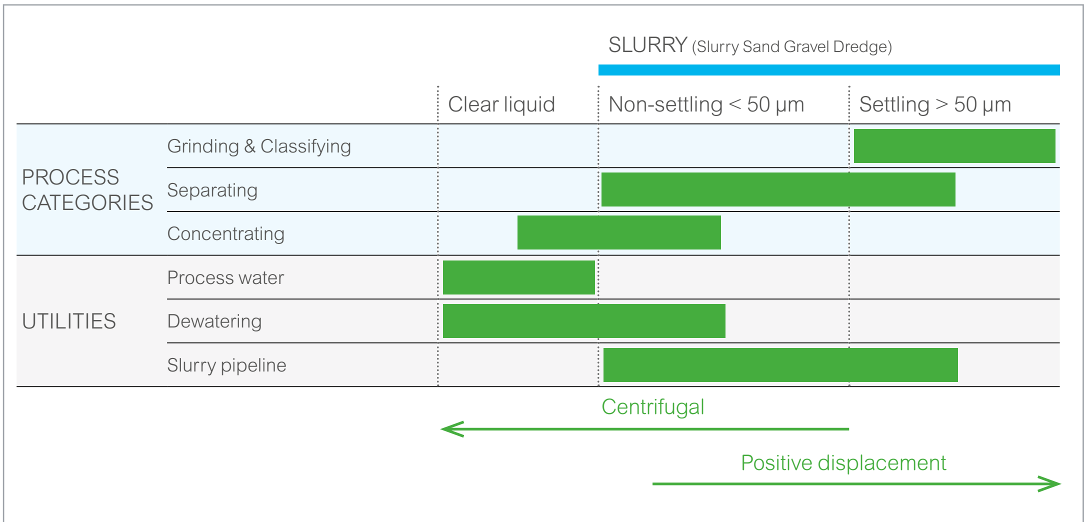
Large Pump Applications in Mining

Pump Characteristics

Pumped liquids can be divided into three main categories, depending on their viscosity and content:

- clear liquids: clear water
- non-settling slurry: usually in drainage, concentrating, and dewatering
- settling slurry: formed by raw material diluted with water for pipeline transportation

A global overview of this classification is illustrated below:



Mining Applications and Usual Liquid Categories

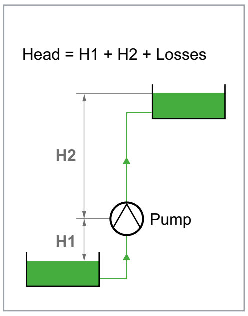
Definitions:

Head and flow are two of the main characteristics of a pump.

The head measures the vertical height that the pump can lift the liquid and is given in meters.

The flow measures the volume of liquid, usually in m^3/h. The flow varies with the head and vice-versa.

Best efficiency point, or BEP*, is defined as the head and flow combination giving the highest efficiency and lowest wear on the pump.

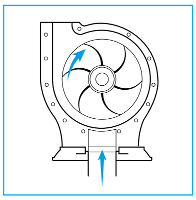


* Specific to centrifugal pumps.

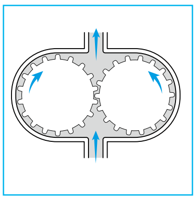
Key points to remember

- The type of liquid being pumped determines the kind of pump technology to be used.
- For financial reasons, most pumps in mining are centrifugal.
- Slurry pumping applications often use positive displacement pumps, typically rated up to 1500 kW.

Two Major Families of Pumps



Centrifugal pumps: More common



Positive displacement: More efficient

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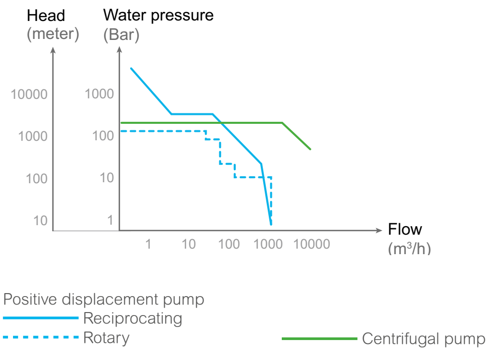
Centrifugal pumps are the more economical and widely used technology. These pumps are adapted for clear and non-settling liquids. They can be associated with variable speed drives for energy savings through variable loading.

Proper centrifugal pump operation is dependent on the pressure and viscosity of the liquid at the suction end and maintaining this is achieved through adequate upstream material processing.

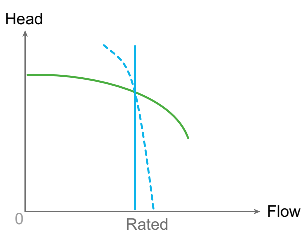
Positive displacement pumps are better adapted to the constraints of slurry pumping and slurry pipelines. These pumps operate at constant speed and can reach significant head. They are often driven with variable speed drives.

Positive displacement pumps are operated at constant flow and high efficiency, independent of the pressure or viscosity of the pumped material.

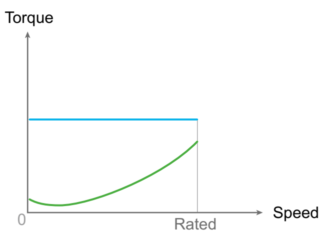
Head/Flow capacities*



Head/Flow comparison at fixed speed



Load torque comparison



* Reference: I. J. Karassik, J. P. Messina, P. Cooper, C. C. Heald, Pump Handbook Third edition, McGraw-Hill, 2001

Note: Slurry pumping implies dealing with variations in viscosity.
Centrifugal pumps often operate at less than best efficiency point. This increases pump wear and maintenance.
Centrifugal pumps are preferred to positive displacement pumps for higher flow levels and can have higher rated power.

Motor Management Equipment

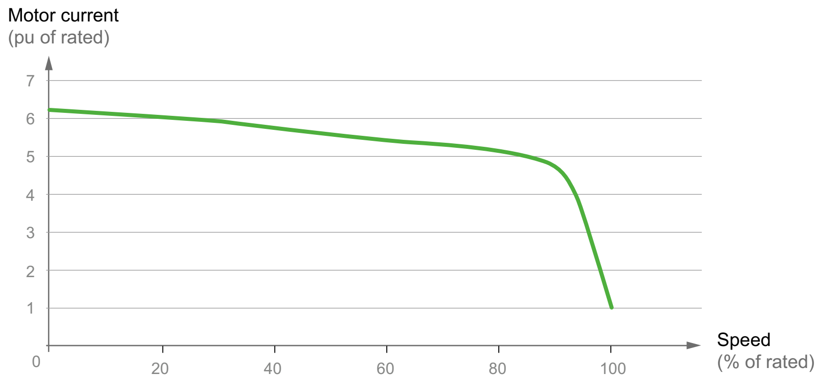
Motor Management Equipment

Electric Motors - The Interface Between the Application and the Electrical System

There are two major motor technologies: asynchronous and synchronous.

In pumping applications asynchronous motors prevail by far, hence our focus on this technology in this guide.

Asynchronous motors have a simple and robust construction and are much more **economical** than synchronous motors. They are designed for a high starting current because it is necessary to obtain sufficient torque and stability during operation. As a consequence, starting high-power motors is always an open question.



Typical Current of MV Asynchronous Motor

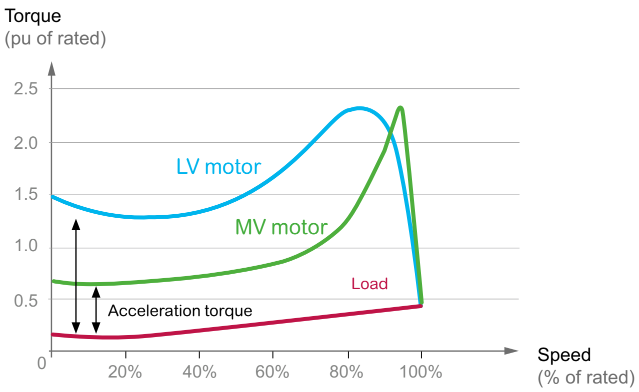
Asynchronous motors also have a non-unity power factor and require capacitor banks for reactive power compensation. They are frequently used with centrifugal pumps. Robustness and relative ease of maintenance are important decision factors for these motors. LV and MV motors are both standardized according to IEC 60034.

Key point to remember

Asynchronous motors are the predominant motor technology used for pumps in mining.

LV and MV - Relative Comparison of Asynchronous Motors

Comparison Characteristics	LV Motors	MV Motors
Economic benefit	●●●●	●●●
Footprint	●●●	●●●
Efficiency	●●●●●	●●●●
Power factor	●●●●	●●●●
Low starting current	●●●	●●●●
High starting torque	●●●●	●●
Repair	●●●	●●●●
Service life	●●●	●●●●●



Comparison of LV and MV Motor Torque With Respect to Pump Torque

Motors under 100 kW are usually LV whereas motors above 800 kW are usually MV.
It is the range between 100 kW and 800 kW that poses the dilemma of selecting LV or MV.

Key point to remember

The electromechanical behavior of LV and MV motors is different due to different motor design.

Motor Management Equipment

Motor Starting and Control - An Adequate Solution Leads to Optimized CAPEX and OPEX

Optimal motor starting and operational control are fundamental to the industrial process and electrical installation sustainability.
Options to consider:

Direct On Line

Direct On Line is a common starting method for its simplicity and low cost.

It may impose significant stress, however, on both the network and the mechanical load.

Advanced Starting Modes

Advanced starting modes modify motor behavior through voltage and/or frequency modulation and help to reduce:

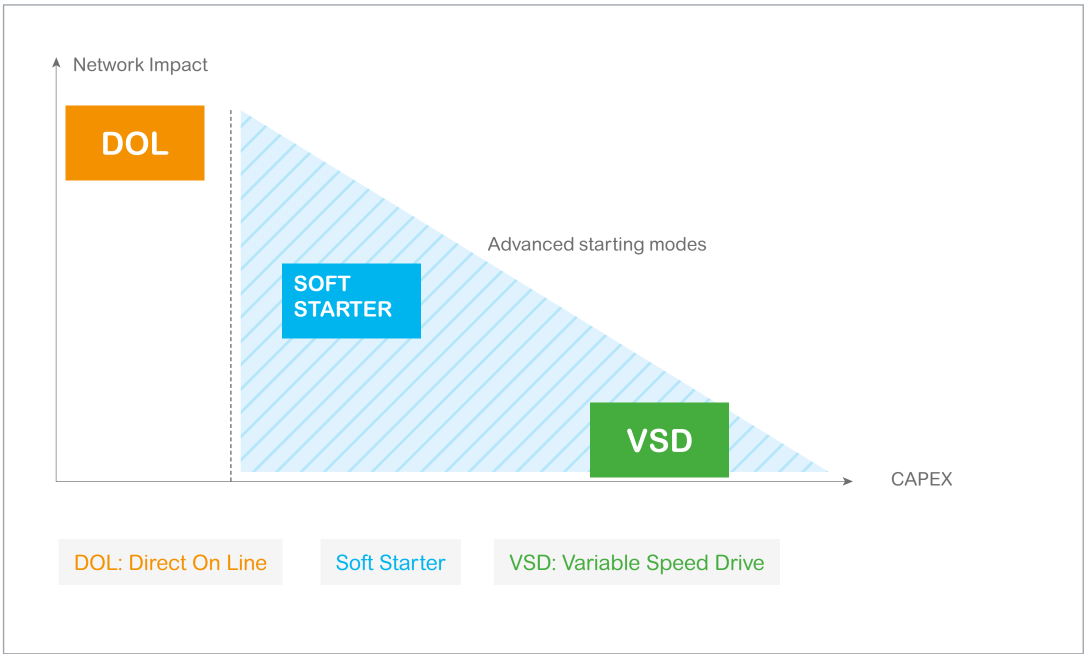
- starting current and voltage drop
- initial starting torque and mechanical stress, particularly water hammer effect with pumps
- sizing constraints on transformers or generators

Variable Speed Drives

Variable speed drives provide the following additional benefits:

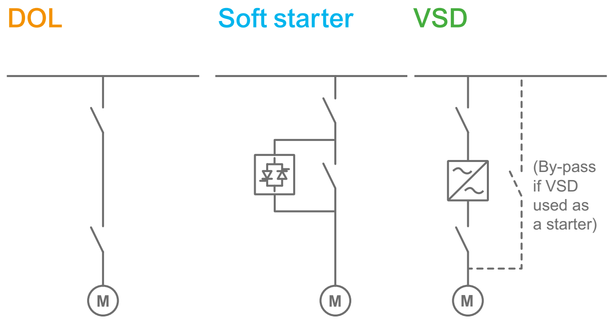
- starting with higher than rated torque required by positive displacement pumps
- minimized motor heating during starting
- increased number of starts per hour

Advanced starting modes are beneficial in the long term since they avoid oversizing and the need for frequent maintenance on the electrical and mechanical equipment.



WHAT ARE THE POTENTIAL IMPACTS OF UNSUITABLE MOTOR CONTROL?
Inadequate control can result in an increase in failures or premature wear of bearings and pump impellers.

Starting Method - Arrangements and Performance Comparison



	Starting Equipment	Standard DOL	Soft Starter	VSD
CAPEX	Initial cost benefit	●●●	●●	●
	Footprint saving	●●●	●●	●
	Weight reduction	●●●	●●	●
	Engineering simplicity	●●●	●●	●
OPEX	Ease of equipment maintenance	●●●	●●	●
	Pump energy and maintenance savings	●	●●	●●●
	Control flexibility	●	●●	●●●
Motor	Starting current control	●	●●	●●●
	Starting torque control	●	●●	●●●
Pump adequacy	Centrifugal	●	●●	●●●
	Positive displacement	●	●	●●●

C

Large Motor Starting 101: Discover the Constraints

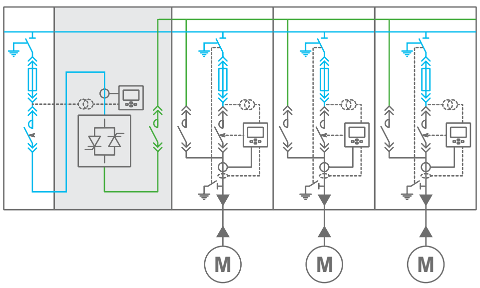
Click on the picture

Motor Management Equipment

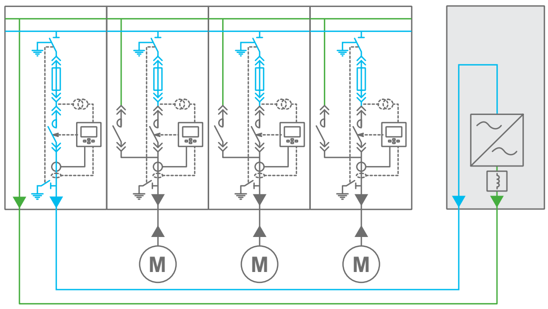
Motor Starter Sharing - An Economic Option for Multiple Pumps in Parallel

In MV applications, a single soft starter or drive is often used to start several pumps sequentially, saving on equipment cost and footprint. A redundant soft starter or drive can be added in order to increase availability. The cost of LV soft starters is lower and labor savings make preferable individual installations.

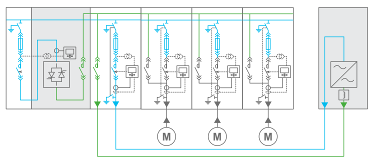
Mutualized soft starter



Mutualized drives as a starter



Redundancy is possible for critical applications:



Starting busbar one motor at a time
Feeding busbar after motor start

Key points to remember

The main criteria for selecting optimal motor control are:

- Process requirements: flow variation, pressure, dynamics. Slurry pumps do not have the same constraints in terms of torque, pressure, and viscosity as water pumps.
- Necessary torque for starting: Centrifugal pumps will have quadratic torque, increasing with speed, while positive displacement pumps will exhibit almost constant torque from zero to rated speed. Starting methods will differ for each.
- Frequency of starts: Intermittent starting will wear the motor bearings more rapidly, as well as the pump itself.
- Size of the pump: Higher power pumps will require starting methods that avoid voltage drops and parallel load disconnection.
- Motor voltage: Low voltage motors may need a soft starter to reduce their high starting torque. Medium voltage motors may need a VSD to increase their overall torque.

KEY SOLUTIONS FOR ADVANCED MOTOR CONTROL

Autotransformer starter
Motorpact RVAT

LV soft starter
ATS48

MV soft starter
Motorpact RVSS

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Variable Speed Drives - Operational Control and Energy Savings

Not only appropriate for starting, variable speed drives are also used during operation to:

Adapt the motor speed and torque to the application needs

Save energy in some applications such as pumping

Maintain operation at the best efficiency point

Energy costs represent 40% of the TCO of a typical pump operated at rated speed with flow control through mechanical valves. With VSDs, optimized motor control can bring up to 30% savings on energy consumption.

VSDs can easily operate the pump at their optimal efficiency point and reduce wear and maintenance.

The fault current contribution of any motor with VSD is significantly lower than when operated in direct on line. In some cases the reduced motor short-circuit current contribution can also optimize busbar sizing.

Selection of VSD voltage levels is highly impacted by cable technology and distance to the motor.

In LV applications, shielded cables will reduce the effect of EMC but will increase capacitances to earth and limit the length to several hundred meters. Adding a wave-smoothing sinus filter will increase maximum length, but will also increase the cost and footprint of the overall solution.

In MV applications, multi-level inverter technologies greatly improve the voltage waveform provided to the motor and allow operation over several kilometers without specific constraints on cables or the sinus filter.

Modern variable speed drives go far beyond motor speed and torque control. Embedded functions allow multiple advanced services to manage power, energy, process, and protection.

KEY SOLUTIONS FOR ADVANCED MOTOR CONTROL

LV drive
ATV600

MV drive
ATV6000

The services oriented drive: A new kind of energy management device

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Motor Management Equipment

Motor Protection and Control - Keeping the Process Up and Running

Motor and feeder protection is part of a global concern for safety, security, and process availability. It includes protection of:

- Personnel (operators and maintenance staff)
- The process
- The electrical network feeding the motor
- The motor

Protection is achieved by switchgear design and intelligent electronic devices.

Switchgear is an enclosure consisting of current switching equipment, measuring devices, intelligent electronic devices, etc. This is all housed in a protective cabinet that allows personnel to work safely on the electrical installation.

The design of LV and MV switchgear must be compliant with electrical standards that meet internal arc and compartmentalization requirements, etc. The main switchgear standard for LV equipment is IEC 61439-1/2 and for MV IEC 62271-200.

Switchgear can be a deciding factor regarding the footprint and weight of the overall solution.

In MV, circuit breakers and contactors are installed individually in cubicles, with typical footprints with fuse contactors around 0.35 - 0.6 m².

For higher power motors when only circuit breakers are used, this footprint is around 0.88 - 0.91 m².

In LV switchgear, several motor feeders are integrated in a panel. The number depends on the size of the motors and the diversity factor, related to the expected operation.

For 400 V, this can be up to 4 x 110 kW, or 3 x 160 kW, or 2 x 250 kW, which is a surface gain. For long distances, more cables will be required per phase. This cable-related constraint may impose the need for installation in more panels, thus canceling out the footprint advantage.

KEY SOLUTIONS FOR MOTOR PROTECTION AND CONTROL

LV power distribution and motor control
Blokset

MV motor control center
PIX MCC

MV primary distribution switchboard
MCset

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Motor Protection: 5 reasons to choose circuit breakers over fuses

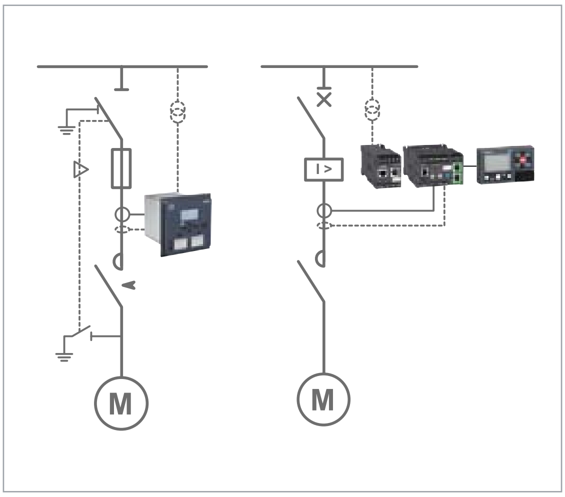
Click on the picture

Intelligent electronic devices (IED) are protection relays that are associated with circuit breakers or contactors. The difference between LV and MV relays can be in:

- Number of inputs
- Number of outputs
- HMI
- Communication protocols
- Number of integrated protection functions

Main protection functions common to LV and MV relays:

Protection type	Typical functions
Current-based	Earth fault and short-circuit
	Current unbalance
	Thermal overload
	Number of starts per hour
	Long start or excessive starting time
	Phase undercurrent
Voltage-based	Voltage unbalance
	Voltage phase loss
	Voltage phase reversal
	Undervoltage
	Overvoltage



In MV relays there are specific machine protection functions:

- Machine differential
- Stator windings and/or frame temperature
- Pole slip (for synchronous motors)

Consequences of motor failure

When a motor fails, it means the process itself is no longer available, and results in:

- loss of production
- Increased maintenance costs
- unacceptable risks in any critical process

Key points to remember

- Motor protection is adapted to the customer need and depends on how critical the motor is to the operation.
- MV or LV relays offer similar protection.
- MV installations will require more cabling and space as current transformers are not integrated in the relay.

KEY SOLUTIONS FOR MOTOR PROTECTION AND CONTROL

MV protection relay

Easergy P3

LV Intelligent Motor Management system

TeSys T

Contactor for high-power motors

TeSys F

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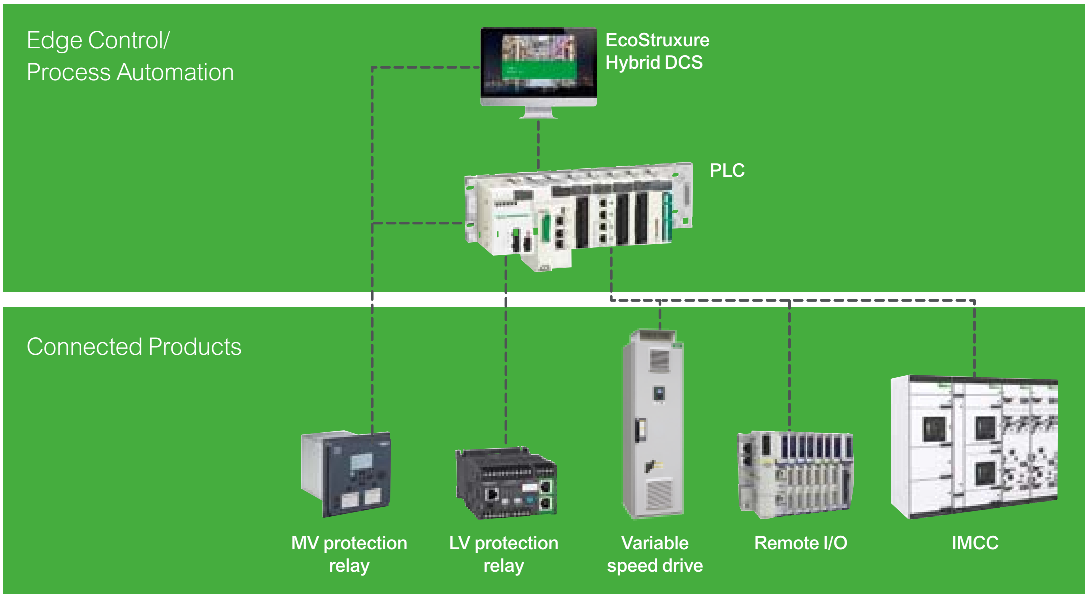
Motor Management Equipment

Process Control - For Consistent, Economical, and Safe Operation

Process control systems (PCS) enable automatic control, monitoring, and remote diagnostics of the mining process.

Process Control System



WHAT ARE THE BENEFITS OF A PROCESS CONTROL SYSTEM?

- Improved operational efficiency
- Lower total cost of ownership
- Lower energy costs
- Lower maintenance costs
- Lower labor costs
- Lower risk of error

Connected products consist of advanced motor protection and control products, sensors, and Intelligent Motor Control Centers (IMCC). These products also provide feedback and diagnostics for edge control and process automation, bringing intelligence and increased process availability.

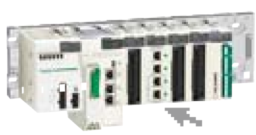
Edge control and process automation consists of a distributed control system (DCS) with integrated cyber security and:

- Programmable logic controller (PLC)
- Supervisory control and data acquisition (SCADA) system
- Remote I/O system.

To ensure good interoperability, featured data is transmitted via network protocols commonly used in industrial automation such as Modbus TCP/IP, Modbus Serial, EtherNet IP, or Profibus DP in LV applications and IEC 61850 in MV.

LV and MV installations will have similar features for process control. Except for a slightly higher amount of cabling of LV devices, there is no particular constraint for the selection of the motor connection voltage from this aspect.

KEY SOLUTIONS FOR PROCESS CONTROL SYSTEM



PLC Modicon M580

EcoStruxure Hybrid DCS

Remote I/O

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Power Quality - Making the System Sustainable

Capacitor banks, harmonic mitigation systems, and transformers ensure the correct operation of motors in the process with minimal impact on the power system.

As a rule of thumb, LV motors may have a slightly lower power factor and require a slightly higher reactive power compensation. The power factor difference depends on the motor manufacturer.

Capacitor banks are used for power factor correction (PFC). They are usually installed on the same busbar as the motors. In MV, there are also individual capacitors per motor.

3 safety measures for motors with individual power factor correction

Click on the picture

LV drive technology often has standard variable speed drives, generating high **harmonic currents. Active or passive harmonic filters** are generally suitable for installations where several LV drives are connected to the same busbar. Specific low harmonic LV drives for large motors are an efficient means of reducing harmonic levels without increasing the switchboard size.

MV drive technology - The most popular MV drives, such as multi-level inverters with embedded multi-pulse transformers, have the advantage of being almost a linear load with a high power factor. No harmonic reduction equipment is required.

Transformer power and short-circuit voltage define the voltage drop, especially during motor starting, and the impact of harmonic currents on busbar voltage. Large motor starting is a constraint for the system and requires careful analyses for the sizing of the transformer.
Up to 800 kW, DOL starting is generally not an issue in MV installations.

WHAT IS THE IMPACT OF POOR POWER QUALITY?
Inadequate power quality or equipment sizing may lead to overheating or vibration in the motors and accelerate their aging and replacement. It can also cause parallel load disconnection and production losses.

C

KEY SOLUTIONS FOR POWER QUALITY

Capacitor bank (power factor correction)
VarSet

Active harmonic filters
AccuSine PCS+

Low harmonic 3-level LV VSD
ATV680 drive systems

Transformers (outdoor and indoor)
Minera

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Motor Management Equipment

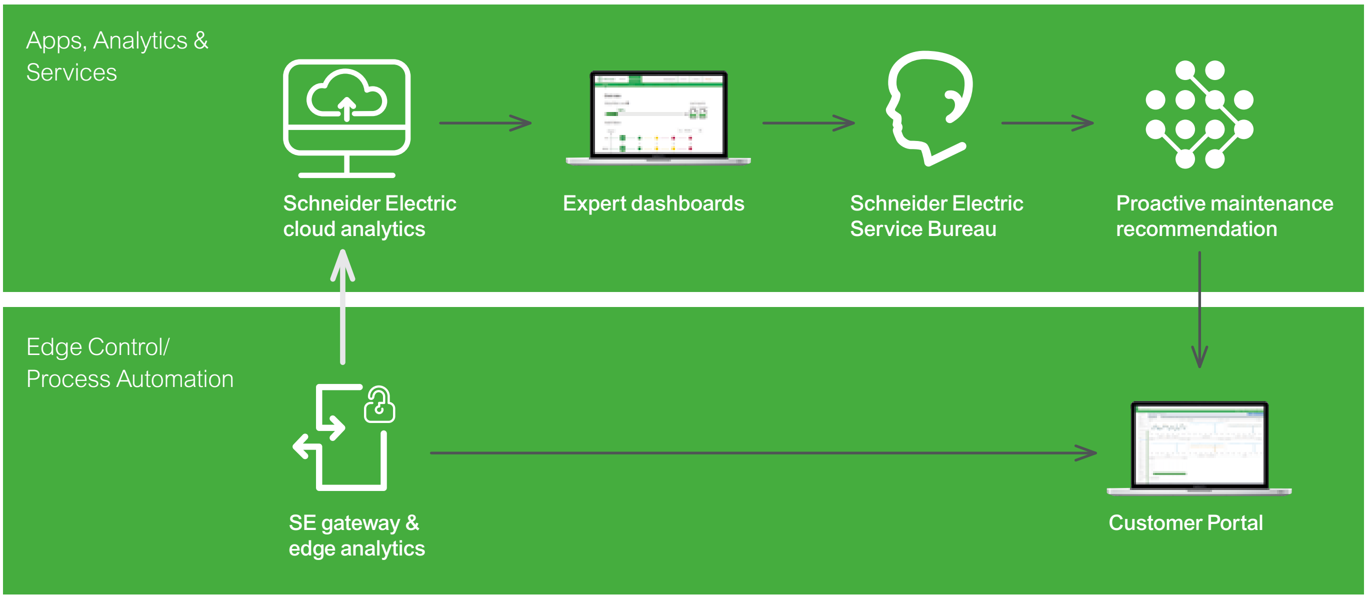
Motor Asset Management - Increasing Motor and Process Availability

Condition assessment and predictive technologies help to avoid motor and application failures in the early stages, with remote or local monitoring services.

Asset management services consist of the continuous monitoring of critical LV and MV motors and their related loads. A service bureau platform is used by experts on the premises of the equipment manufacturer. Experts use analytics to diagnose potential problems and they provide event reports and notifications of any necessary action that can help to:

- Prevent downtime, increase system continuity, ensure safety, and optimize asset lifetime
- Determine maintenance adjustments for cost optimization and risk mitigation.

Asset Management Services



Local monitoring of assets is achieved through the installation of dedicated monitoring devices, known as "edge analytics," and realized in the process control layer of the industrial installation. Asset management solutions are mostly defined by the criticality of the motor for the industrial process and do not influence voltage level selection.

KEY ASSESSMENTS

- Portfolio management
- Operational performance
- Motor condition
- Maintenance workspace

EcoStruxure Maintenance Advisor

EcoStruxure Asset Advisor

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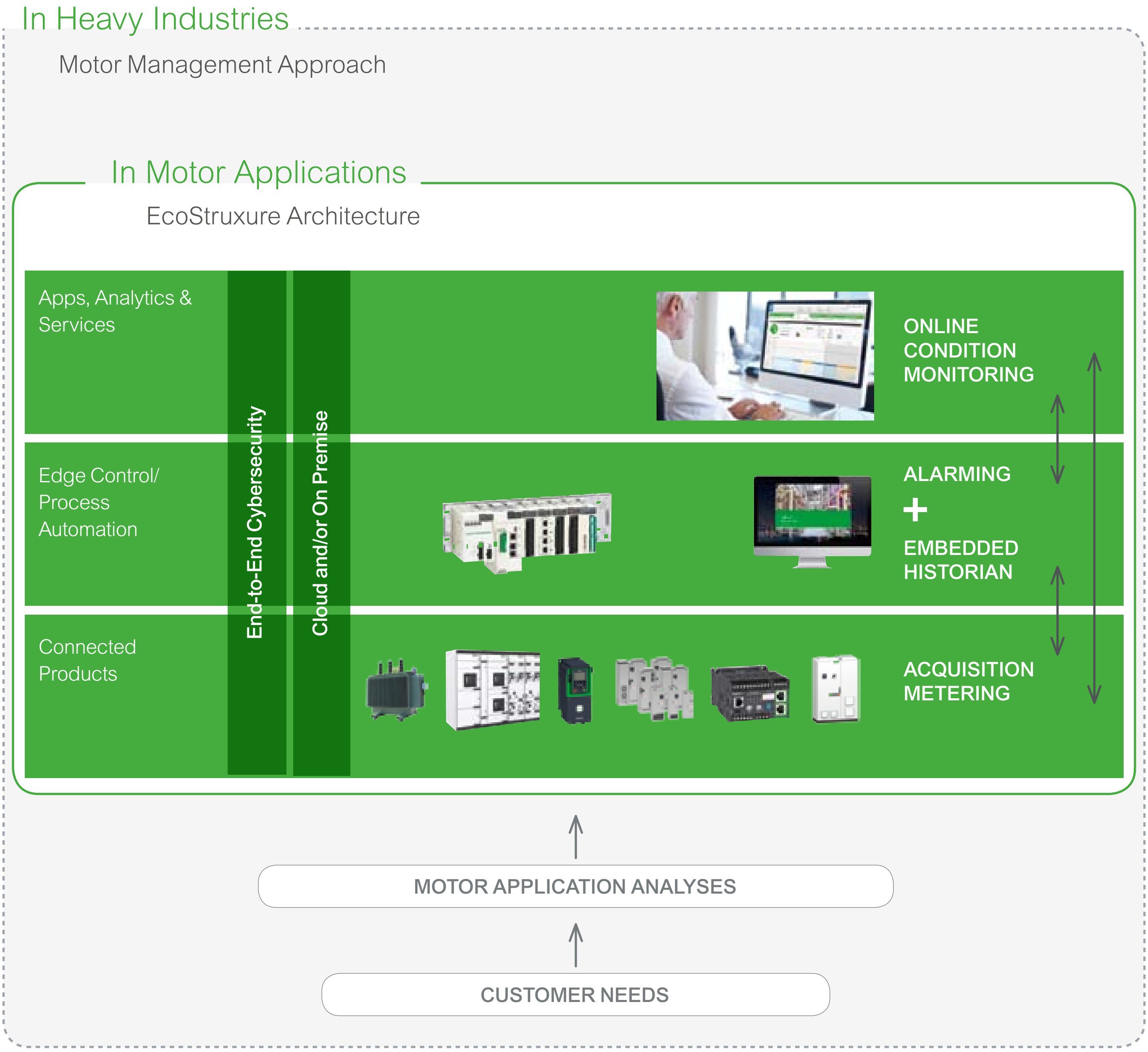
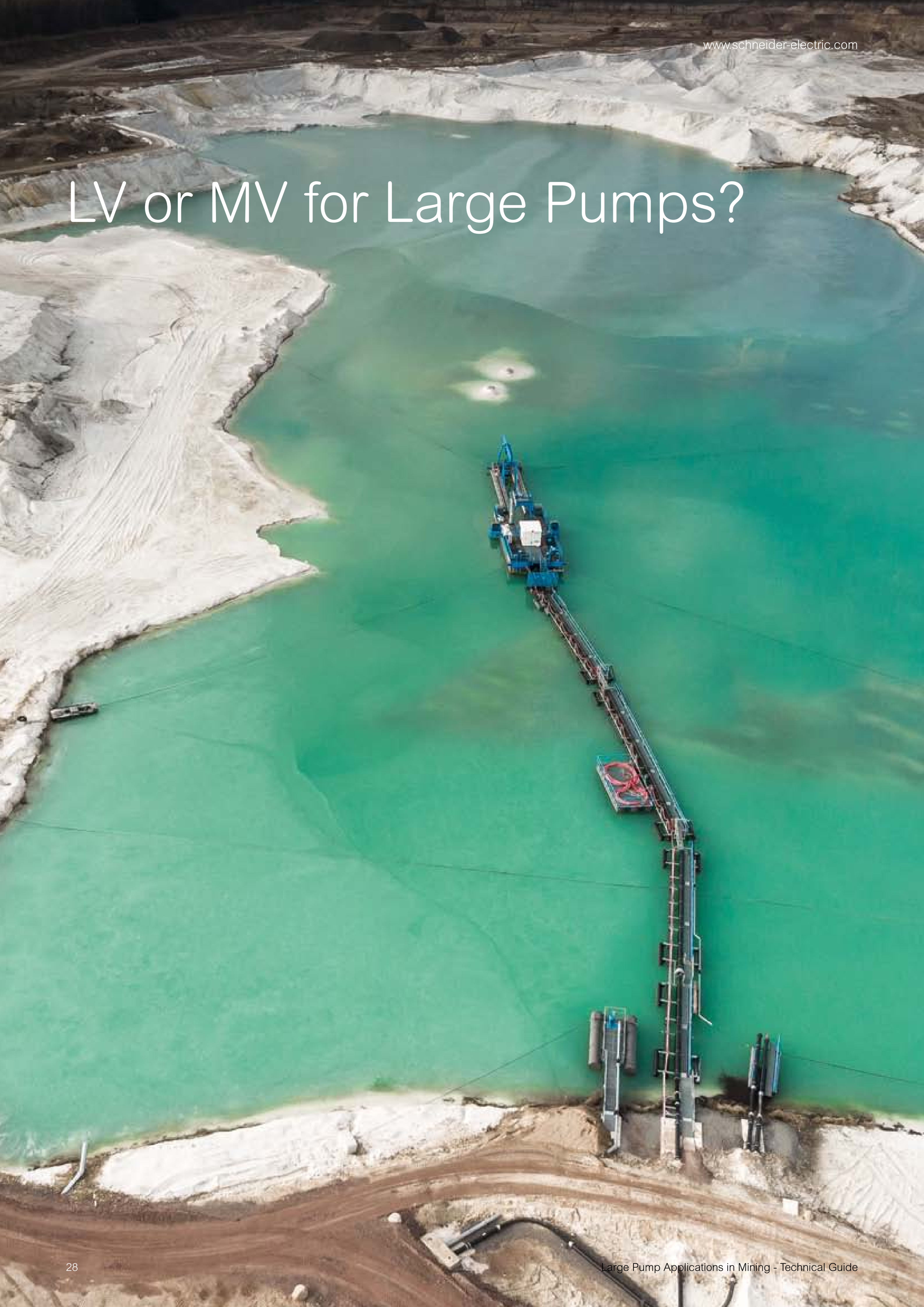
EcoStruxure - IoT-Enabled Architecture for Motor Control and Monitoring



LV or MV for Large Pumps?



LV or MV for Large Pumps?

A Holistic Motor Management Approach Will Help Make a Better Choice

The holistic Motor Management approach, developed by Schneider Electric, is based on our high level of expertise and proven solutions. It ensures that all decisions are made only after careful analysis of the application and the industrial power system.

DISCOVER HOW CAPEX DECISIONS DEPEND ON:
- Customer objectives, leading to starting mode selection
- Cable length, leading to LV or MV choice

MOTOR MANAGEMENT APPROACH

"ANALYZING" STEPS

CUSTOMER NEEDS

Key analyses
- Motor application
- Electrical installation
- Economical objectives
- Maintenance practices
- Operational requirements

EXPERT SERVICES FOR MOTOR APPLICATIONS

Key analyses
- Voltage level
- Power supply characteristics
- Short-circuit currents
- Mechanical and thermal stress
- Cable sizing
- Footprint optimization

"DEFINITION/PROPOSITION" STEPS

PRIORITY #1

ADVANCED MOTOR CONTROL

Key factors
- Process compliance
- Motor and load torque for starting
- Frequency of starting
- Voltage stability

PRIORITY #2

MOTOR PROTECTION & CONTROL

Key factors
- Power supply
- Motor control type
- Motor operating mode
- Motor criticality
- Communication requirements

PRIORITY #3

POWER QUALITY

Key assessments
- Power factor
- Harmonics
- Energy efficiency

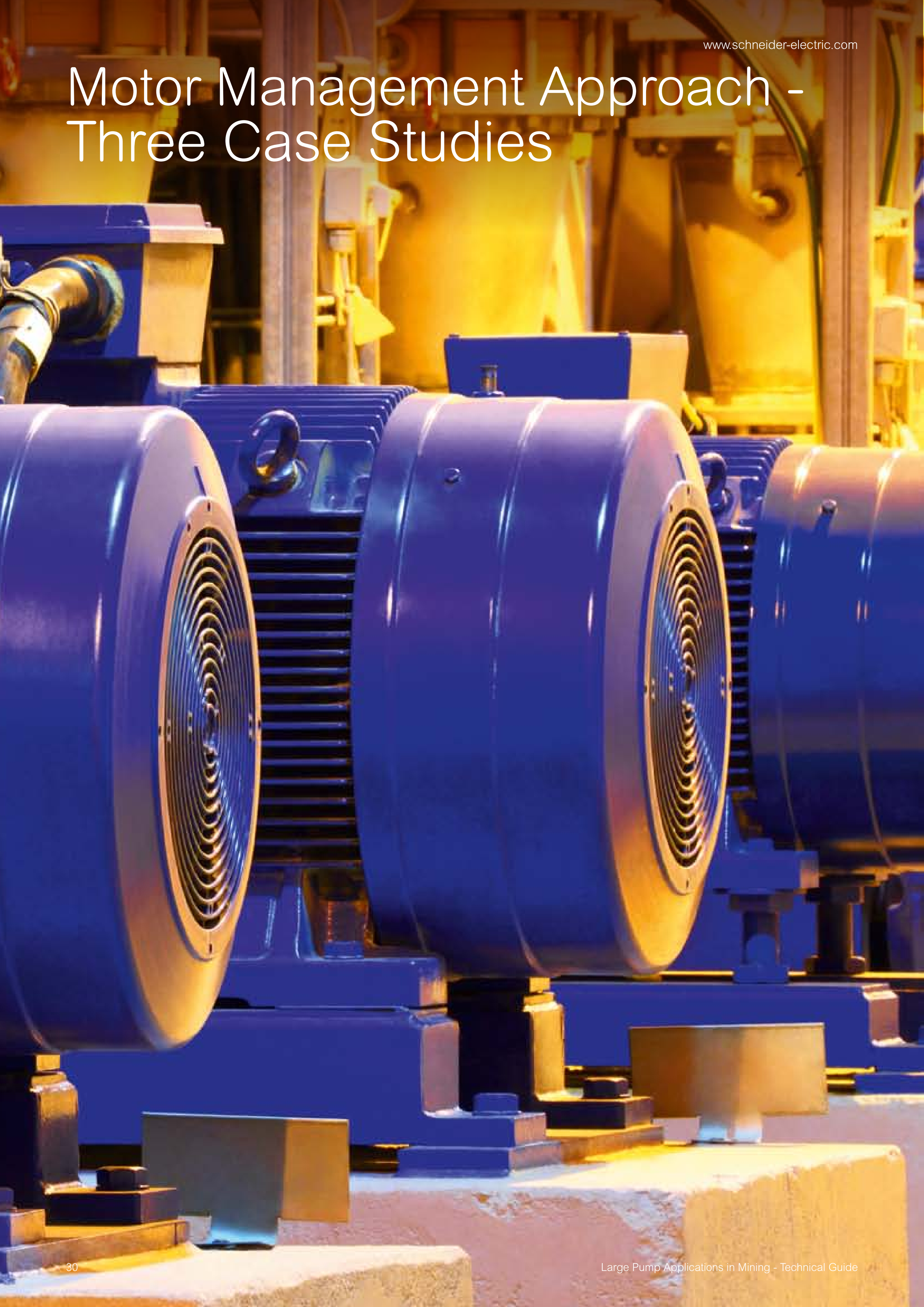
MOTOR ASSET MANAGEMENT

Key assessments
- Operational performance
- Motor condition monitoring
- Scalability of the application

D

Customer Objectives	Starting and Operation Method		
	DOL	Soft Starter	VSD
Solution simplicity	●	●	-
Frequent starting	-	●	●
High starting torque	●	-	●
Limited voltage drop	-	●	●
Reduced mechanical stress	-	●	●
Lower heating	●	-	●
Harsh environment	●	-	-
Variable speed	-	-	●
Energy saving	-	-	●
Footprint optimization	●	●	-

Motor Management Approach - Three Case Studies



Three Case Studies

Three typical mining applications illustrate how the motor management solution is developed for LV and MV connections and the related advantages and drawbacks of each.

The main factors to consider are:

- Application requirements
- Motor feeder main components
- LV/MV cost comparison
- Schneider Electric solution overview for each voltage level

1 3 typical applications

CUSTOMER NEEDS

2 Technical feasibility

EXPERT SERVICES FOR MOTOR APPLICATIONS

3 Decision key points

ADVANCED MOTOR CONTROL

MOTOR PROTECTION & CONTROL

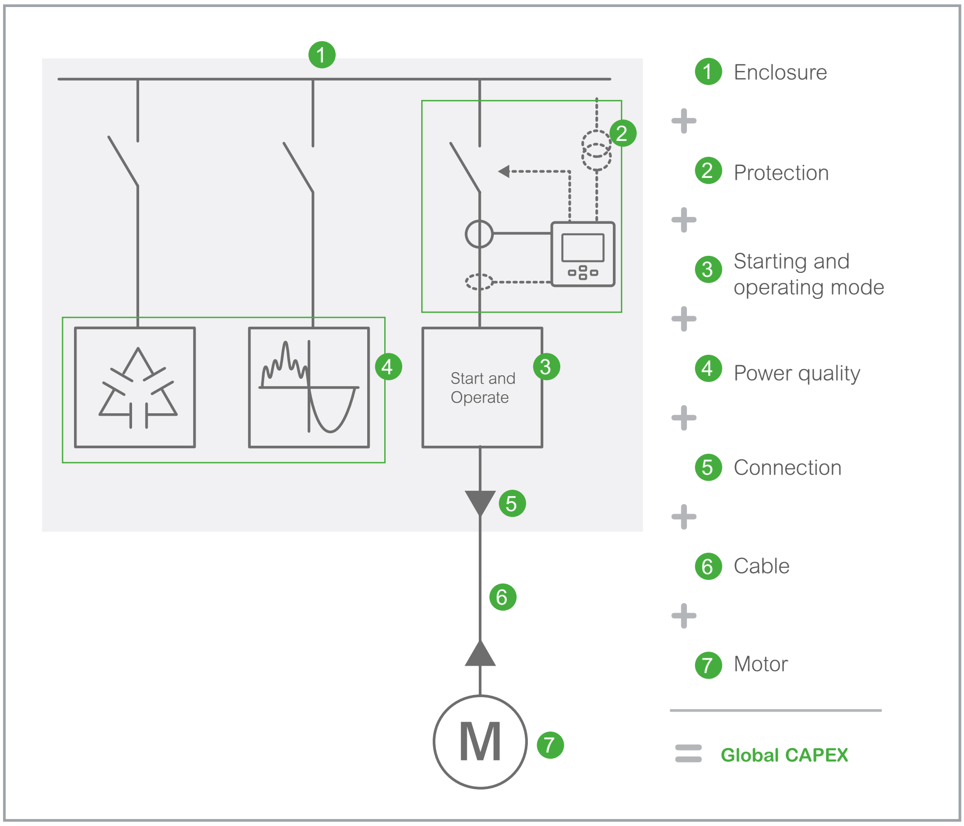
POWER QUALITY

MOTOR ASSET MANAGEMENT

Case Studies

LV/MV Cost Comparison

Typical Feeder Composition



Equipment costs are compared.

The costs of the LV and MV versions of a complete single feeder are compared for a given motor power.

All feeder elements are sized according to motor power and short-circuit current.

The result of the comparison is given as a LV to MV cost ratio. It limits the effect of option-related variation and allows the results to be generalized.

LV/MV ratio < 1 - Benefit is for LV solution

LV/MV ratio > 1 - Benefit is for MV solution

Non-technical factors such as habits, available voltage levels, and need for personnel competency improvement can influence the choice.
Even if a solution is more expensive, it may be preferred on the basis of such contextual reasons, but this may also be the case when the difference in equipment cost between the two voltage levels is negligible.

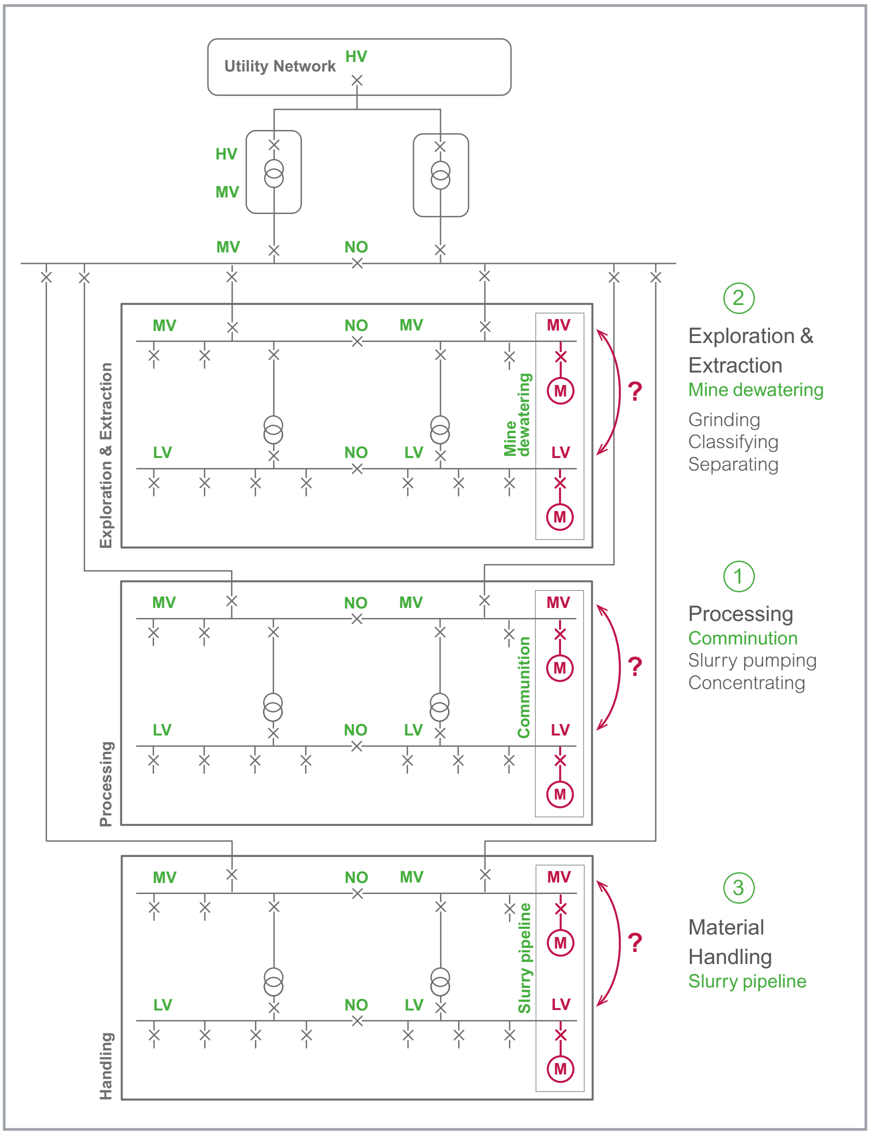
A margin, noted as context-dependent, is also considered to illustrate these variabilities.

Case Studies

Case Study Context - Open Pit Mine Electrical Distribution Overview

One of the most common electrical distribution architectures used for open pit mines is the double radial system. This consists of a main MV switchboard with two incomers and a normally open bus section.

Each half-busbar is supplied by a transformer loaded to 50% of its capacity but sized to supply the total load. If one transformer fails, the associated incomer circuit breaker trips and the bus section closes to transfer the total load to the other transformer. Double radial architectures offer a good compromise between energy availability, equipment redundancy, and overall cost.



The three examples concern:

- Clear water pump in communition
- Non-settling slurry pump in mine dewatering
- Slurry pump for material transportation

The pump feeders are sized in the following typical environment:

- Altitude < 1000 m
- Ambient temperature -5°C to 35°C
- Relative Humidity < 90%
- Ambient air not significantly poluted
- Protection IP31
- No seismic risk
- Insignificant vibrations

Motor power considered for each motor starting method:

Direct On Line	Soft Starter	Variable Speed Drive
200 kW	315 kW	400 kW

1 DIRECT ON LINE Application Case

Processing/Communition

Motor
- Motor power: 200 kW
- Frequency of starting: 2/week

Pump
- Type of pump: centrifugal
- Fluid: clear water

Electrical network
- Short-circuit power: high

Pumping clear water with a centrifugal pump can be achieved with Direct On Line starting when not frequent and not subject to water hammer.

MOTOR MANAGEMENT APPROACH

"ANALYZING" STEPS

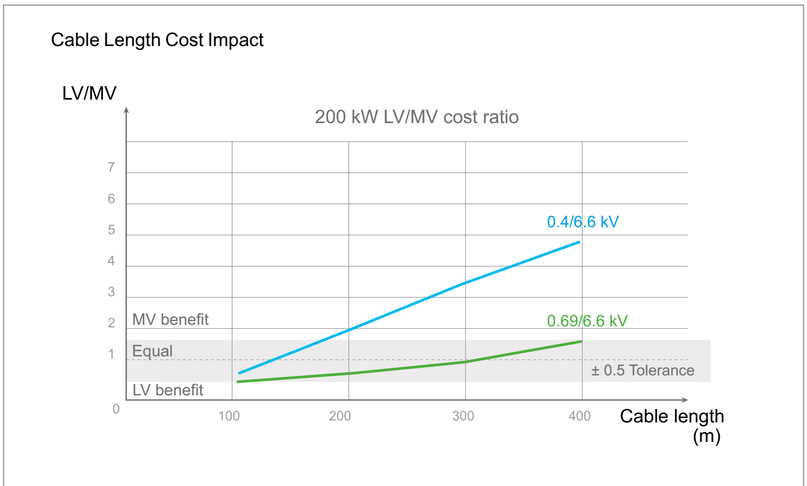
"DEFINITION/PROPOSITION" STEPS

CUSTOMER NEEDS > EXPERT SERVICES FOR MOTOR APPLICATIONS > PRIORITY #1 ADVANCED MOTOR CONTROL > PRIORITY #2 MOTOR PROTECTION & CONTROL > PRIORITY #3 POWER QUALITY > MOTOR ASSET MANAGEMENT

Analyze objectives
- **Simplicity**
- Frequent starting
- **High starting torque**
- Limited voltage drop
- Reduced mech. stress
- **Lower heating**
- **Harsh environment**
- Variable speed
- Energy saving
- **Footprint optimization**

Analyze results
- **DOL**
- RVAT
- RVSS
- VSD
- **PQ**
- **Protection**
- **Asset management**

	Control solution	Protection	Power quality	Asset management
LV	LV contactor	Circuit breaker + relay	Power factor correction bank	Asset Advisor
MV	MV contactor	Contactor + fuse + relay	Individual power factor correction	Asset Advisor

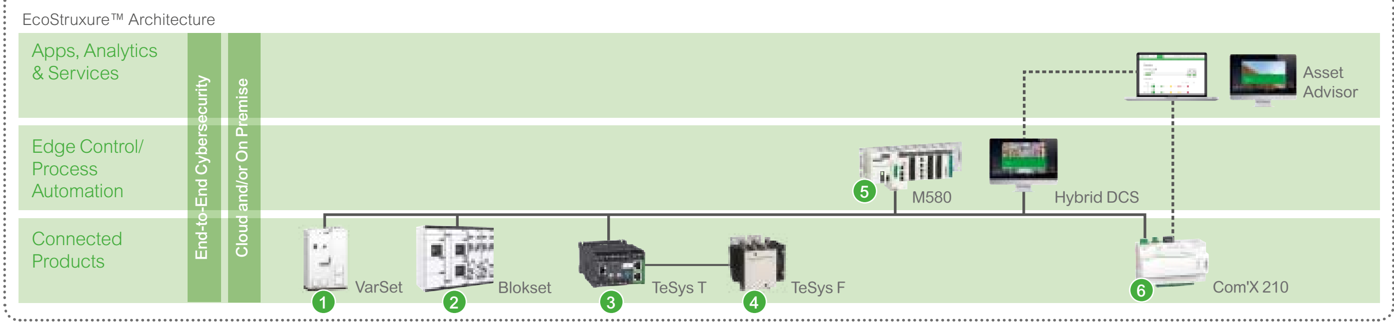


COMMENTS

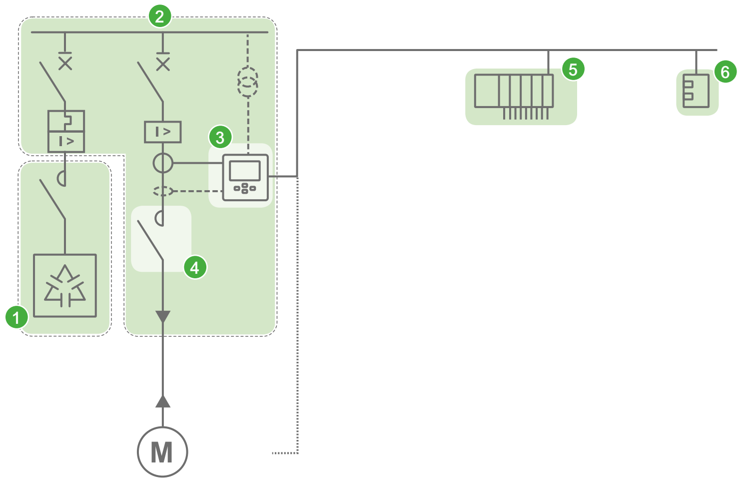
In the 400 V variant the economic benefit from the equipment cost is visible for a cable length around 100 m. Longer cables require changing to 690 V or switching to MV.

For 690 V the cable length has a much smaller impact. The LV or MV choice will be mainly defined by additional technical or personnel-related factors.

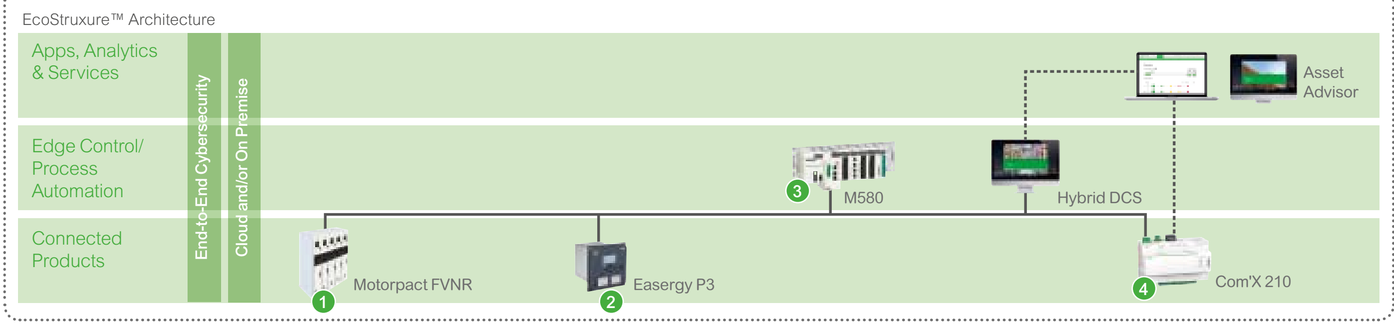
LV Reference Architecture



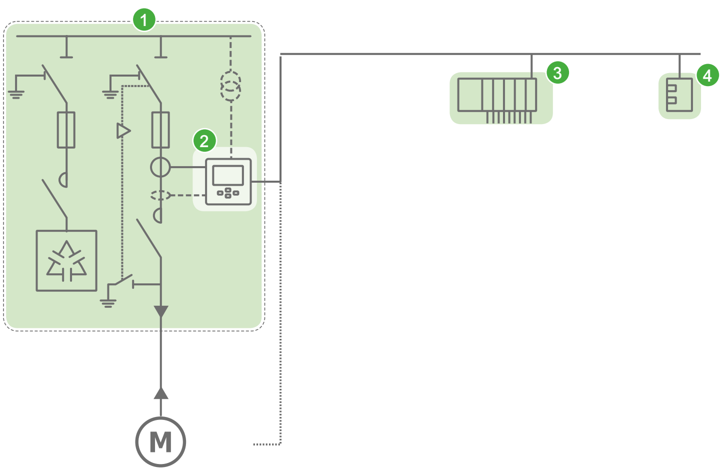
1 PCF bank
2 Motor Control Center
3 Protection relay
4 Contactor
5 PLC
6 Gateway



MV Reference Architecture



1 Motor control switchboard
2 Protection relay
3 PLC
4 Gateway



Direct on line is the basic and most frequent architecture for motor control. This is why the LV and MV variants are very similar.

In LV, the capacitor bank used for power factor improvement is separated from the motors on a dedicated feeder on the main busbar.

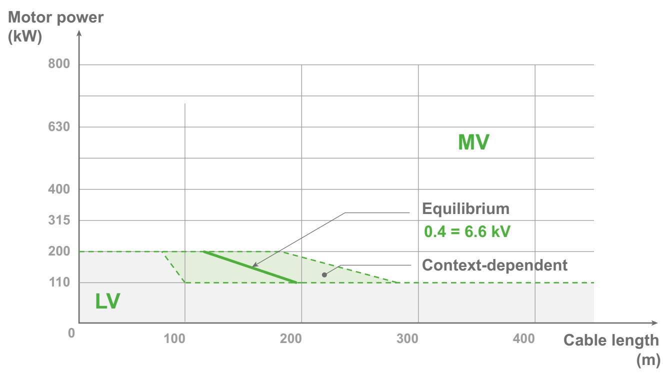
In MV, this solution exists but the capacitor bank can also be integrated in the cubicle containing the motor feeder. In this case, the capacitor is sized individually for the motor and operates only when the motor is connected.

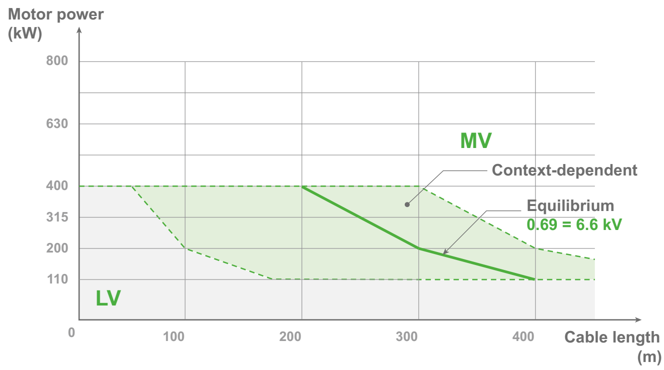
1 DIRECT ON LINE Application Case

General Recommendation

The case study analysis is extended in motor power. Context-dependent areas are defined around the LV/MV equivalence limits, based on the same tolerance as before.

The choice of MV or LV is recommended above and below these areas respectively.





Three zones are distinguished in the comparison graphs:

- "LV"
  where LV connection is recommended
- "MV"
  where MV connection is recommended
- "Context-dependent"
  where the connection is subject to the abovementioned cost variation factors

KEY TAKEAWAYS

The use of 400 V for large pumps is rapidly limited by cable length. This voltage level is suitable for lower power and numerous motors, where the supplying switchboard will be close to the pumps.

At 690 V, motors can reach much higher power. The context-dependent zone is larger as the decision to go to MV may impose the need to review the electrical distribution architecture. This is why this LV level is preferable for longer cable lengths.

2 SOFT STARTER Application Case

Exploration and Extraction/Mine Dewatering

Motor
- Motor power: 315 kW
- Frequency of starting: >1/day

Pump
- Type of pump: centrifugal
- Fluid: non-settling slurry

Electrical network
- Short-circuit power: low

High flow amplitude in dewatering is achieved by parallel pumping at rated speed. Risk of settling material requires progressive starting to avoid water hammer effect. soft starter also remains a robust solution as it operates only during starting.

MOTOR MANAGEMENT APPROACH

"ANALYZING" STEPS

CUSTOMER NEEDS > **EXPERT SERVICES FOR MOTOR APPLICATIONS**

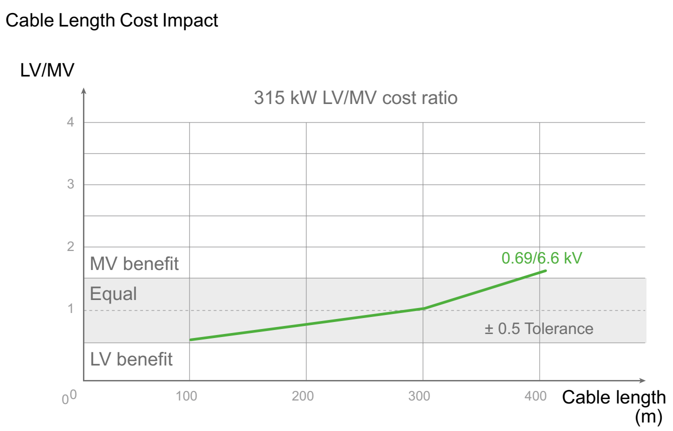
"DEFINITION/PROPOSITION" STEPS

PRIORITY #1 **ADVANCED MOTOR CONTROL** > PRIORITY #2 **MOTOR PROTECTION & CONTROL** > PRIORITY #3 **POWER QUALITY** > **MOTOR ASSET MANAGEMENT**

Analyze objectives
- Simplicity
- Frequent starting
- High starting torque
- Limited voltage drop
- Reduced mech. stress
- Lower heating
- Harsh environment
- Variable speed
- Energy saving
- Footprint optimization

Analyze results
- DOL
- RVAT
- RVSS
- VSD
- PQ
- Protection
- Asset management

	Control solution	Protection	Power quality	Asset management
LV	• LV Soft starter	Circuit Breaker + Relay	Power Factor Correction Bank	Asset Advisor
MV	• MV Soft starter	Contactor + Fuse + Relay	Individual Power Factor Correction	Asset Advisor



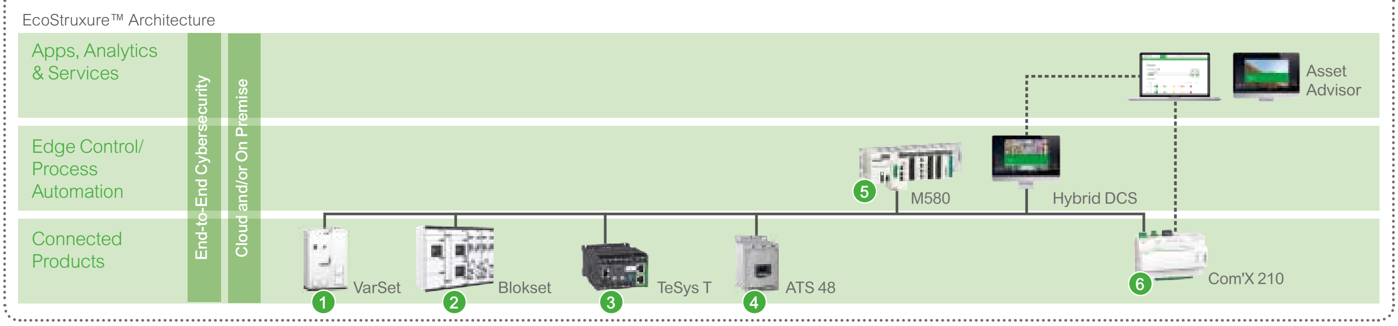
COMMENTS

The individual motor power to be connected in the system is increased with a soft starter due to the starting current reduction action.

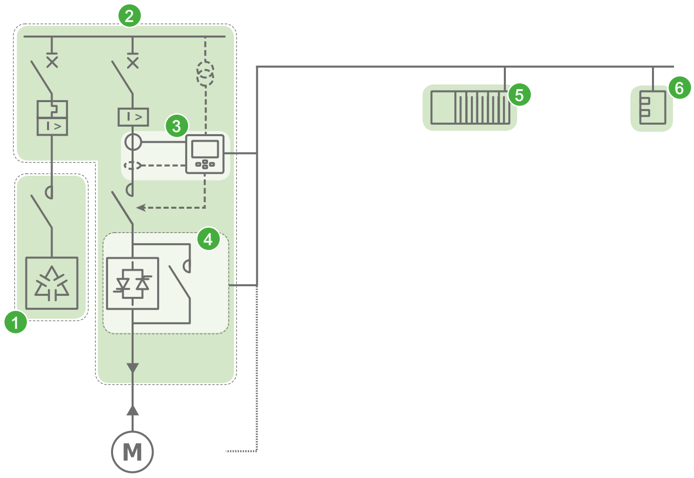
In the example, the motor power is compatible with a 690 V installation, but not at all common for 400 V, usually limited at 200 kW.

As in the case of direct on line starting, the decision for LV or MV is mostly dependent on non-economic factors, even for longer cable.

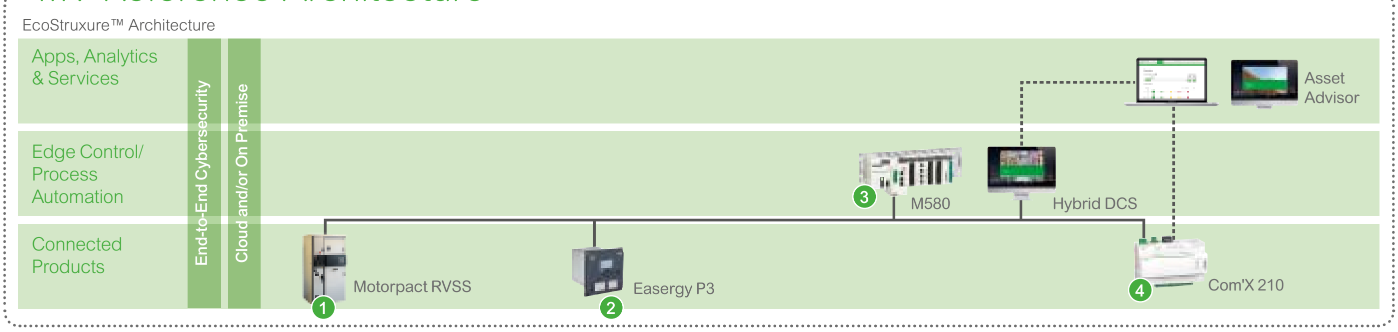
LV Reference Architecture



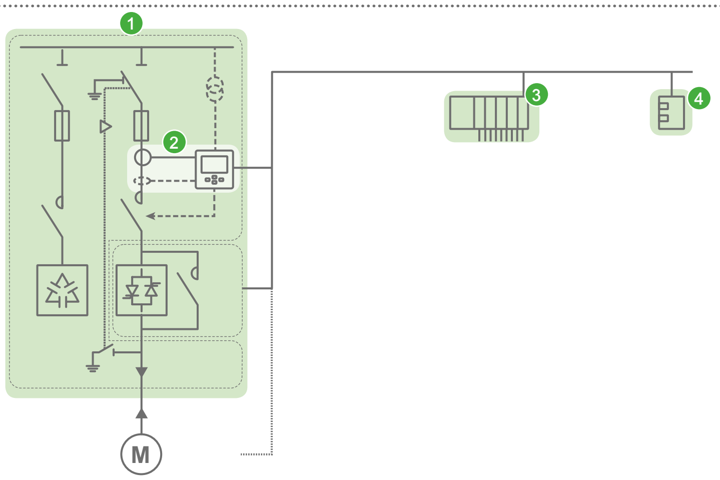
1 PFC bank
2 Switchboard
3 Protection relay
4 Soft starter
5 PLC
6 Gateway



MV Reference Architecture



1 Motor control switchboard with integrated soft starter and PFC capacitor
2 Protection relay
3 PLC
4 Gateway



The proposed architectures are very similar as they contain the same elements at the respective voltage levels. The motor protection can also be achieved in a simpler manner through the overcurrent and thermal protections integrated in the motor starter. The selection is dependent on the criticality of the motor and its power.

In MV, the motor protection relay contains a number of protections which are activated according to the project and application requirements.

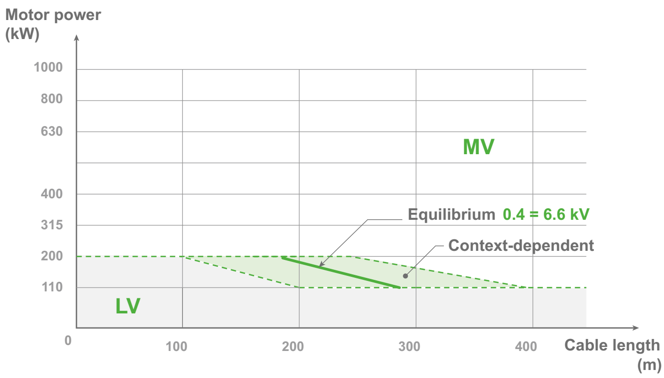
E

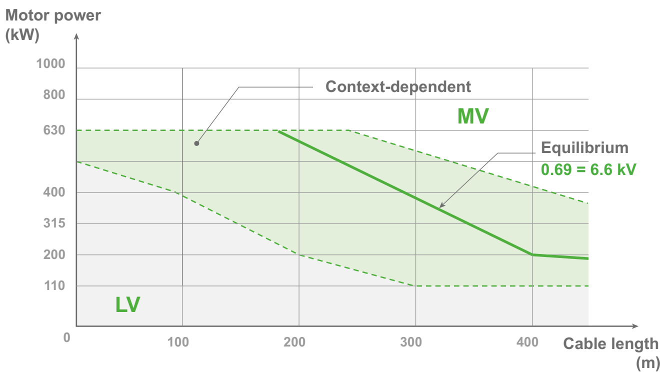
2 SOFT STARTER Application Case

General Recommendation

This case study analysis is extended in motor power. Context-dependent areas are defined around the LV/MV equivalence limits, based on the same tolerance as before.

The choice of MV or LV is recommended above and below these areas respectively.





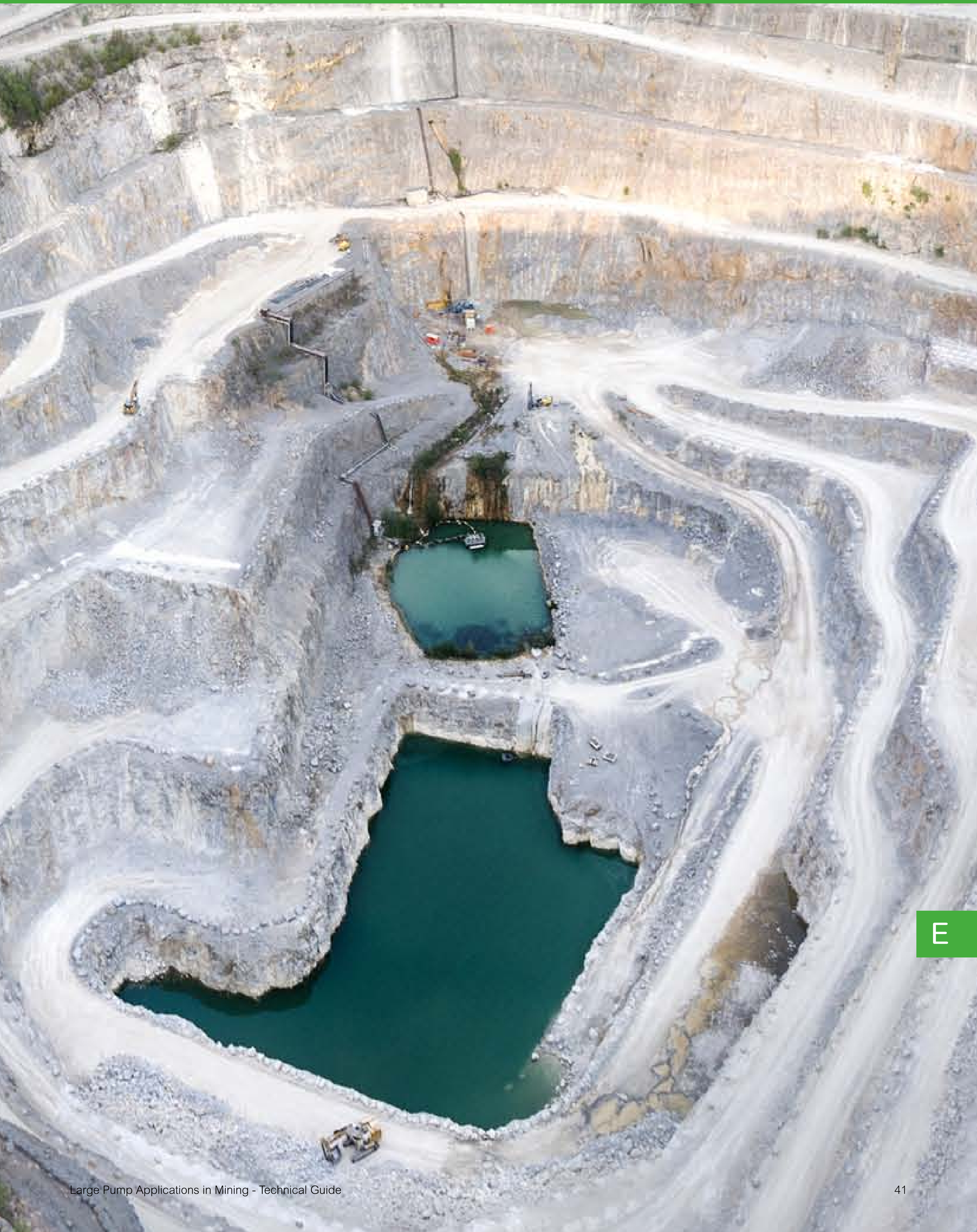
Three zones are distinguished in the comparison graphs:

- "LV"
  where LV connection is recommended
- "MV"
  where MV connection is recommended
- "Context-dependent"
  where the connection is subject to the abovementioned cost variation factors

KEY TAKEAWAYS:

Compared to the DOL architecture, the use of soft starters slightly increases the applicable cable length for 400 V application. This is mainly due to the MV soft starter cost, which remains high for the motor power range, compared to its LV equivalent.

In the 690 V variant, the soft starter use increases the maximum acceptable motor power compared to the DOL case. The equilibrium between LV and MV is obtained for longer cables. The MV solution becomes context-dependent from zero cable length between 400 and 630 kW. Compared to the DOL case, the context-dependent zone is larger, leaving room for the non-economic factors in the decision.



E

3 VARIABLE SPEED DRIVE Application Case

Material Handling/Slurry Pipeline

Motor
- Motor power: 400 kW
- Frequency of starting: 2/h

Pump
- Type of pump: positive displacement
- Fluid: slurry

Electrical network
- Short-circuit power: low to high

Dense material, subject to settling, needing higher torque to start. VSD is recommended, as it also minimizes voltage drop in more sensitive process environments.

MOTOR MANAGEMENT APPROACH

"ANALYZING" STEPS

CUSTOMER NEEDS › **EXPERT SERVICES FOR MOTOR APPLICATIONS**

"DEFINITION/PROPOSITION" STEPS

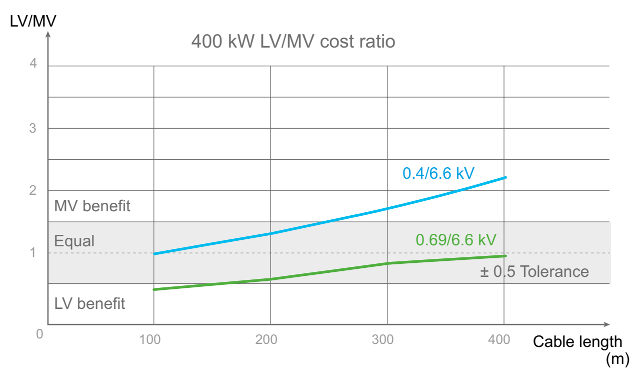
PRIORITY #1 **ADVANCED MOTOR CONTROL** › PRIORITY #2 **MOTOR PROTECTION & CONTROL** › PRIORITY #3 **POWER QUALITY** › **MOTOR ASSET MANAGEMENT**

Analyze objectives
- Simplicity
- Frequent starting
- High starting torque
- Limited voltage drop
- Reduced mech. stress
- Lower heating
- Harsh environment
- Variable speed
- Energy saving
- Footprint optimization

Analyze results
- DOL
- RVAT
- RVSS
- VSD
- PQ
- Protection
- Asset management

	Control solution	Protection	Power quality	Asset management
LV	• LV VSD	Circuit Breaker + Relay	AFE VSD option or active harmonic filter	Asset Advisor
MV	• MV VSD	Contactor + Fuse + Relay	(not necessary)	Asset Advisor

Cable Length Cost Impact



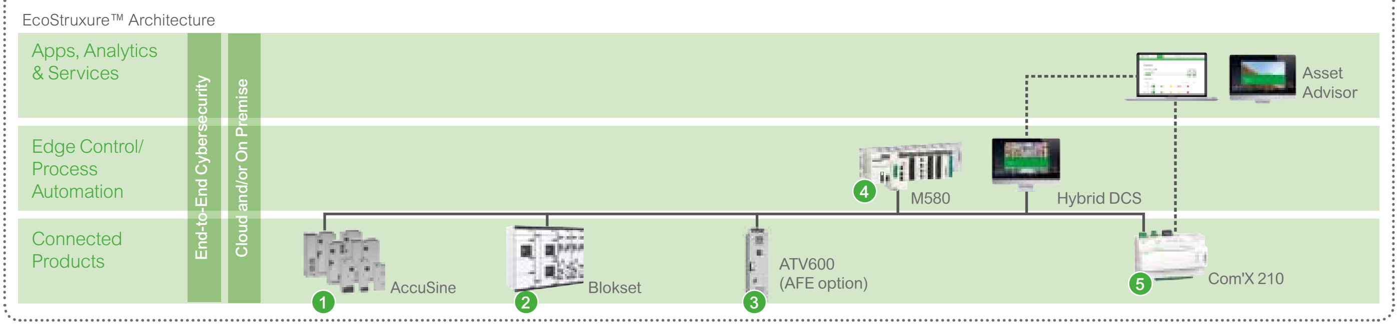
COMMENTS

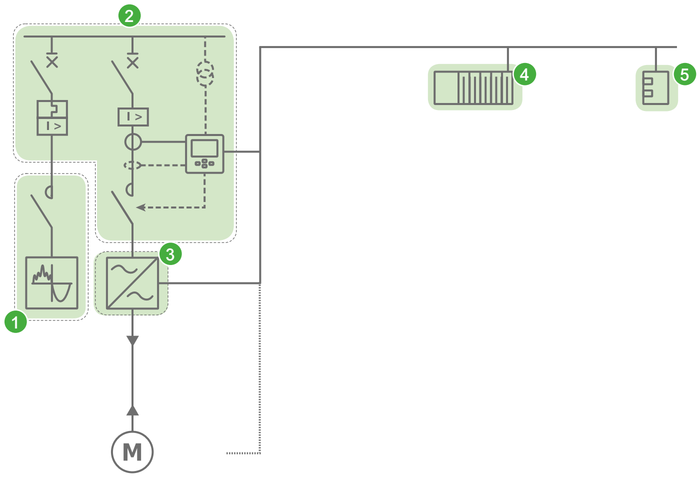
The use of VSD for motor control gives an important advantage to the 690 V solution.

The reason is mainly the cost advantage of LV equipment.

The 400 V variant also benefits from the VSD LV to MV cost difference and remains within the scope of consideration for cables up to 250 m.

LV Reference Architecture



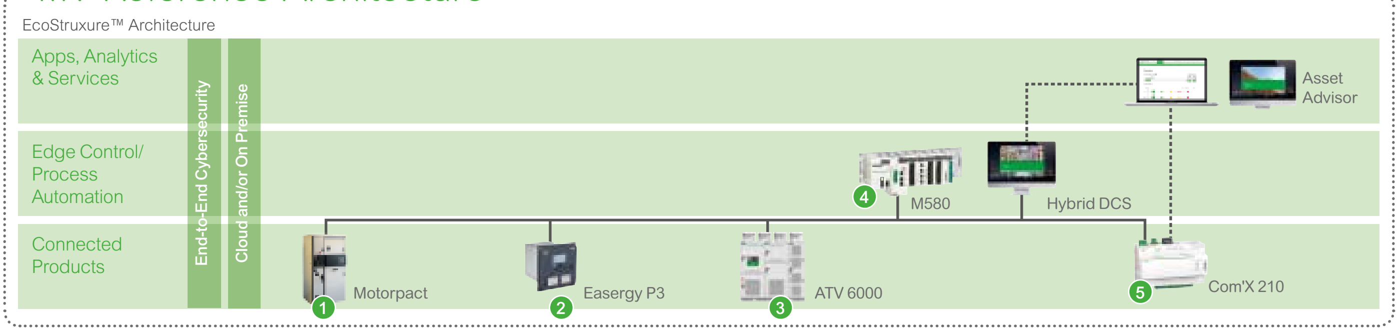


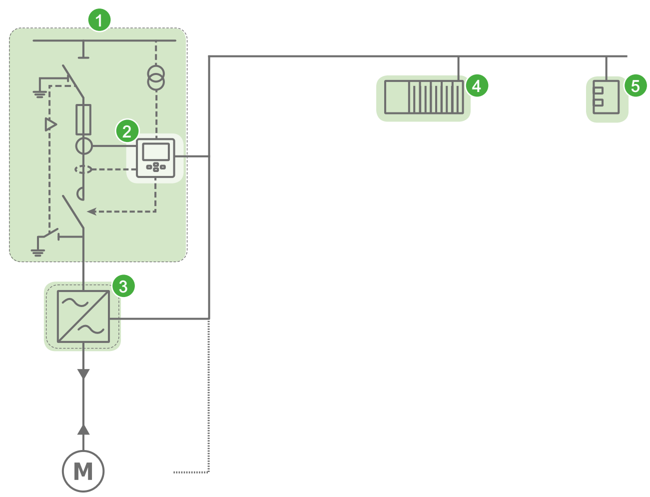
1. Active harmonic filter
2. Switchboard
3. Variable speed drive (low harmonic option)
4. PLC
5. Gateway

The proposed LV architecture comprises two feeders, one for the motor and another for the harmonic filter. This solution has been identified as more frequent and suitable for mixed power and multi-motor applications with VSD.

For single motor applications, the VSD should be of low harmonic type, shown as optional on the connected products layer. With a low harmonic VSD the second feeder is eliminated. This is also the solution that will be cost-compared with the MV equivalent.

MV Reference Architecture





1. Motor control switchboard
2. Protection relay
3. Variable speed drive
4. PLC
5. Gateway

The MV drive multi-level technology makes it naturally a low harmonic drive. In some cases the architecture may contain a grounding switch used for discharging the cables on the motor side.

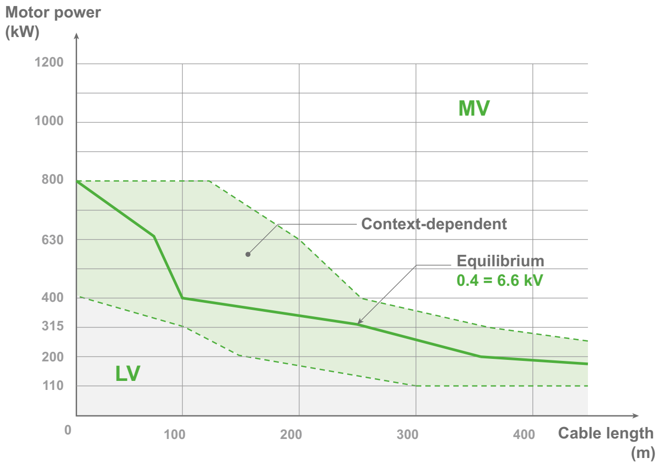
E

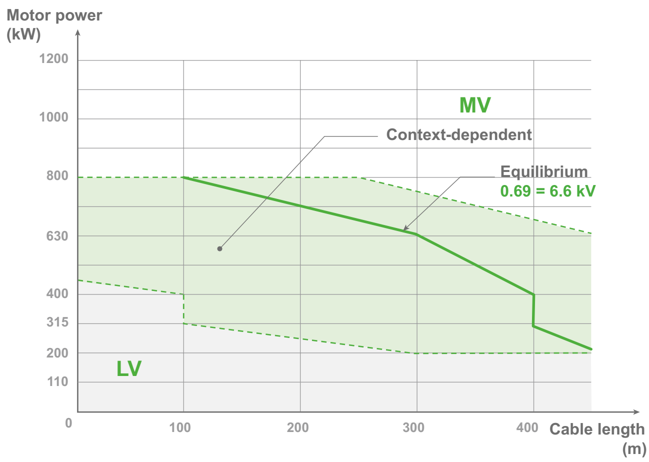
3 VARIABLE SPEED DRIVE Application Case

General Recommendation

This case study analysis is extended in motor power. Context-dependent areas are defined around the LV/MV equivalence limits, based on the same tolerance as before.

The choice of MV or LV is recommended above and below these areas respectively.





Three zones are distinguished in the comparison graphs:

- "LV"
  where LV connection is recommended
- "MV"
  where MV connection is recommended
- "Context-dependent"
  where the connection is subject to the above mentioned cost variation factors

KEY TAKEAWAYS:

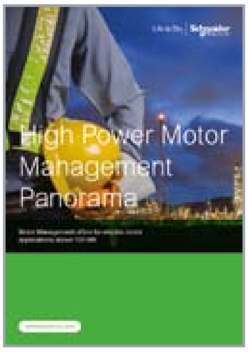
This variable speed drive LV to MV comparison is one of the most complex.

For both LV voltage levels the context-dependent zones are large and the applications remain interesting in LV even for longer cables. The origin of this extended LV application field is the higher cost of the VSD in MV for the considered power range.

E

More Information on Motor Management

Discover our high-power Motor Management offer panorama



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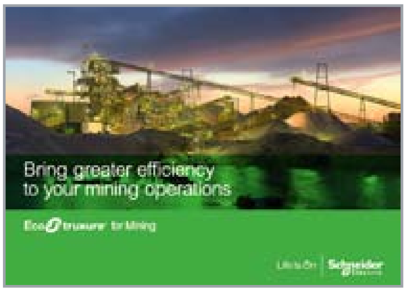

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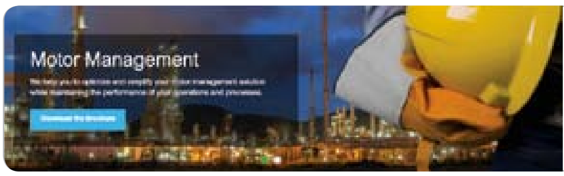

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