BAKER HUGHES
a GE company

SPE International
Aberdeen Section

Downhole ESP Gauge with Motor Diagnostics

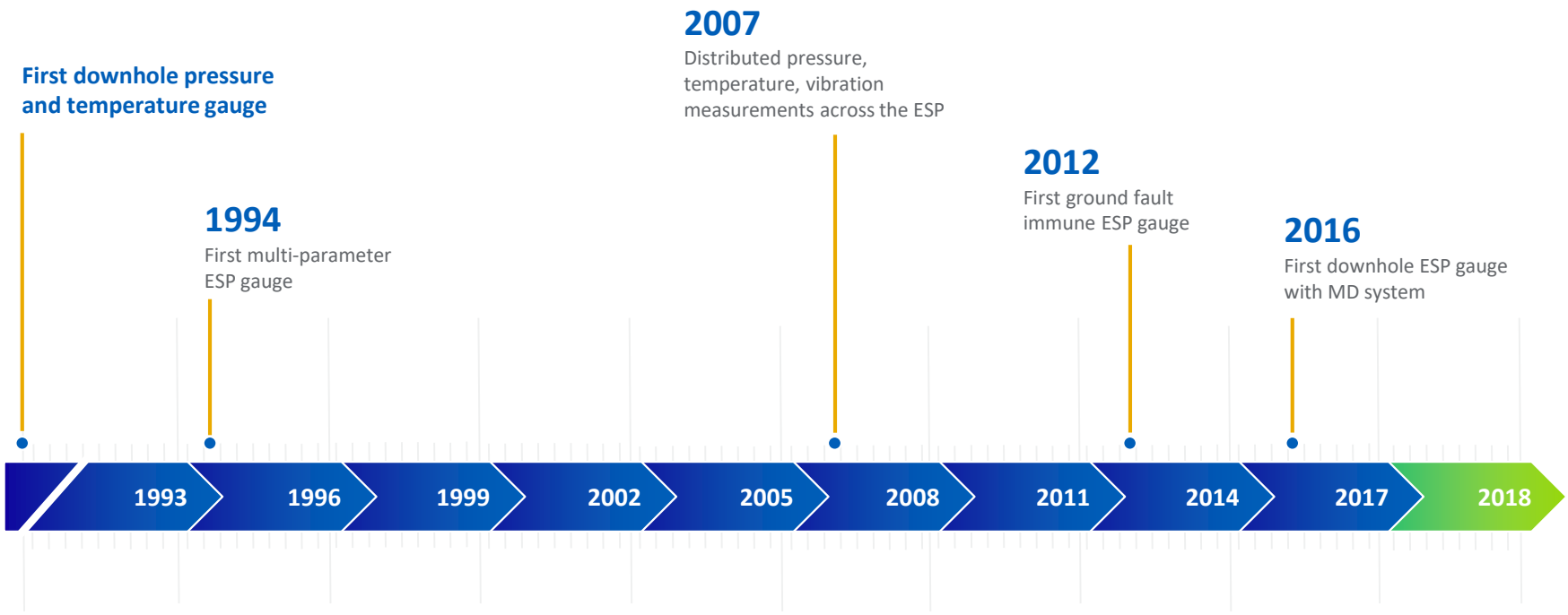
New Downhole electrical measurements optimising efficiency & output

EuALF 2018 European Artificial Lift Forum
13-14 June 2018, AECC, Aberdeen, UK

June 27, 2018

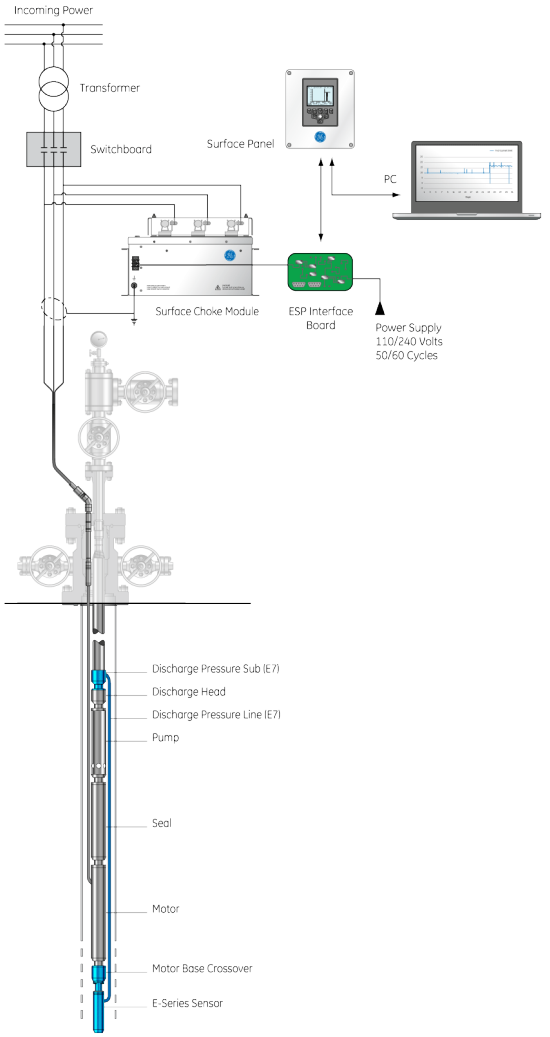
Gauge history

DOWNHOLE GAUGE DEVELOPMENT



ESP gauges are typically “Comms on Power”

- Gauge connected to the motor WYE point
- Gauge power and data superimposed onto the 3phase ESP electrical circuit
- Extracted at surface via a electrical choke
- No separate TEC lines to surface



The latest ESP gauge parameters

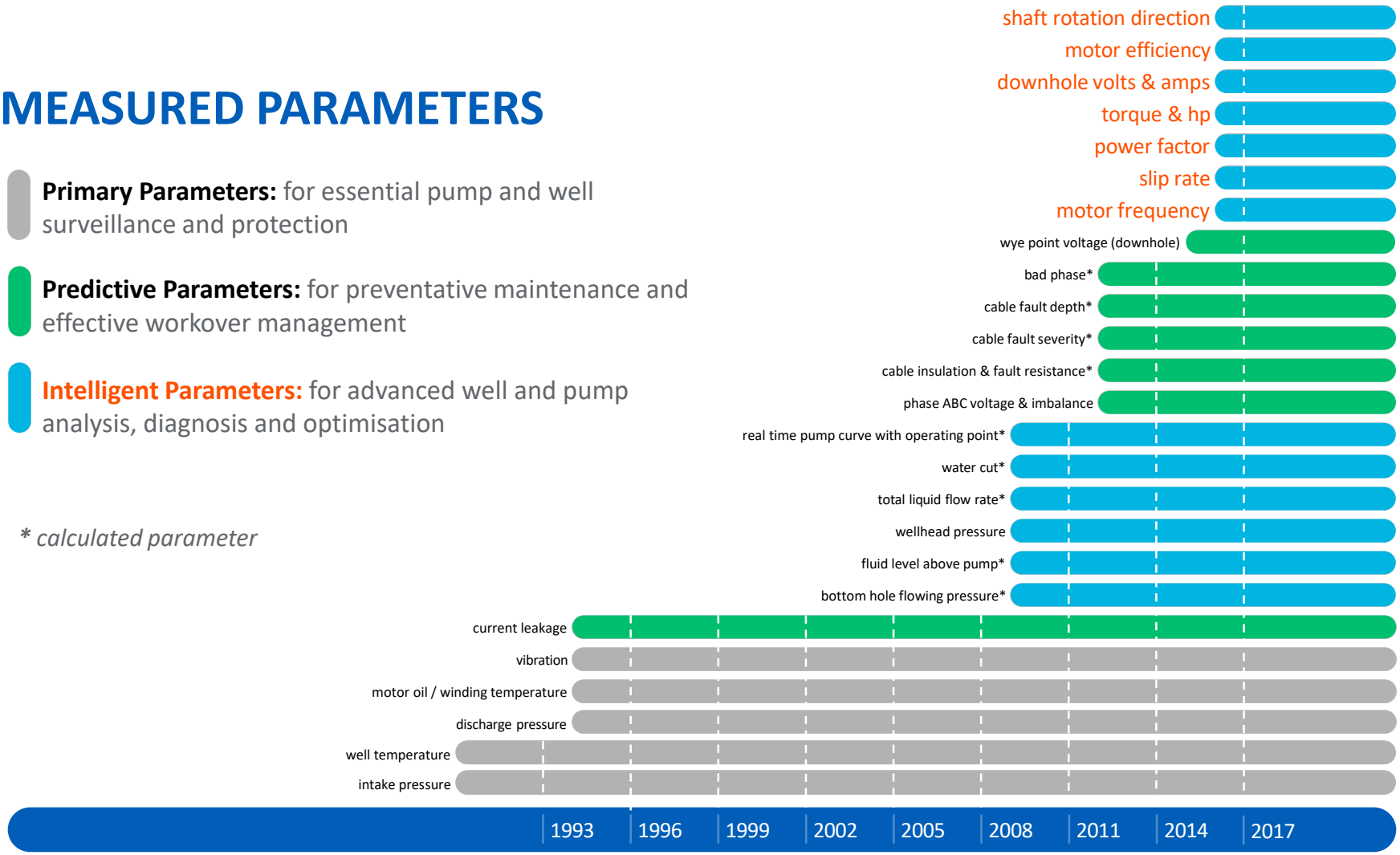
MEASURED PARAMETERS

Primary Parameters: for essential pump and well surveillance and protection

Predictive Parameters: for preventative maintenance and effective workover management

Intelligent Parameters: for advanced well and pump analysis, diagnosis and optimisation

** calculated parameter*



ESP gauge with motor diagnostics

PACKAGING

Looks like a regular ESP comms on power gauge

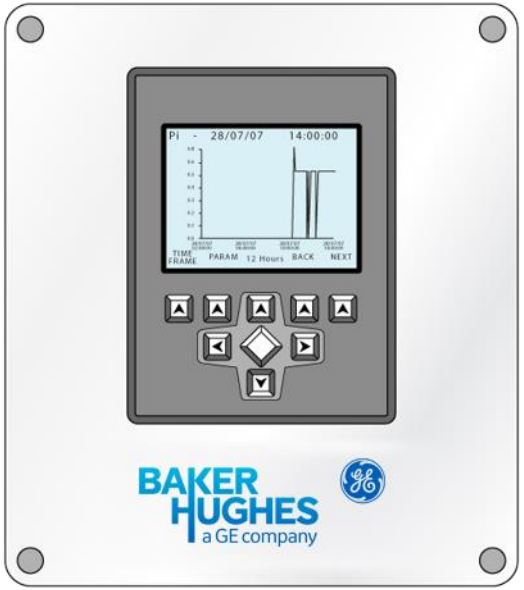
- Connects to the motor windings in the same way as a conventional ESP gauge
- New electrical measurements added to the standard pressure, temperature and vibration parameters
- All data transferred via ESP cable to surface
- Conventional surface logger displays/logs parameters

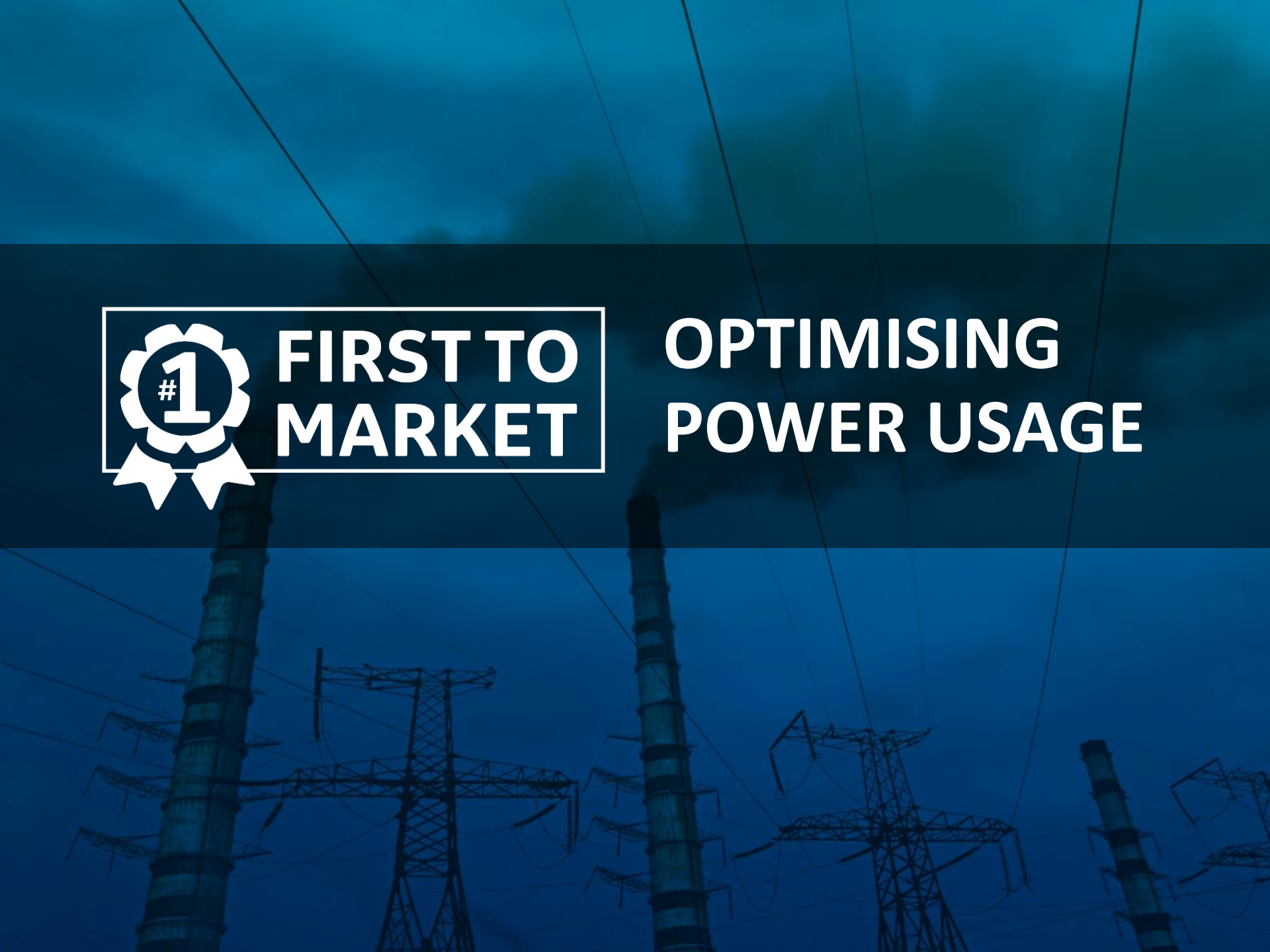
Zenith E-Series ESP gauge with motor diagnostics

MEASURED PARAMETERS

Along with Pi, Pd, Ti, Tm, Vx and Vz, the gauge provides:

Measurement	Impact
Shaft RPM	Lift Performance / power / production
Slip rate	Lift Performance / power / production
True power factor	Power
Torque	Lift Performance
Motor HP	Power
Real-time cable insulation	Lift Diagnostics
Imbalance indicator	Lift Diagnostics
Motor efficiency	Lift Performance / power
Shaft rotation direction	Lift Diagnostics / production




#1
FIRST TO MARKET
OPTIMISING POWER USAGE

Power optimisation

TRADITIONAL PARAMETERS

- Pressures
- Temperatures
- Vibration

NEW ELECTRICAL DATA

- Downhole wye-point
- Waveform analysis
- Surface wye-point
- Waveform analysis
- Volts, Amps, Hz

OUTPUT PARAMETERS

- Slip rate
- Power factor
- True motor horse power
- Efficiency
- Torque
- Imbalance
- Rotation direction

Replaces calculated parameters with real time measured data

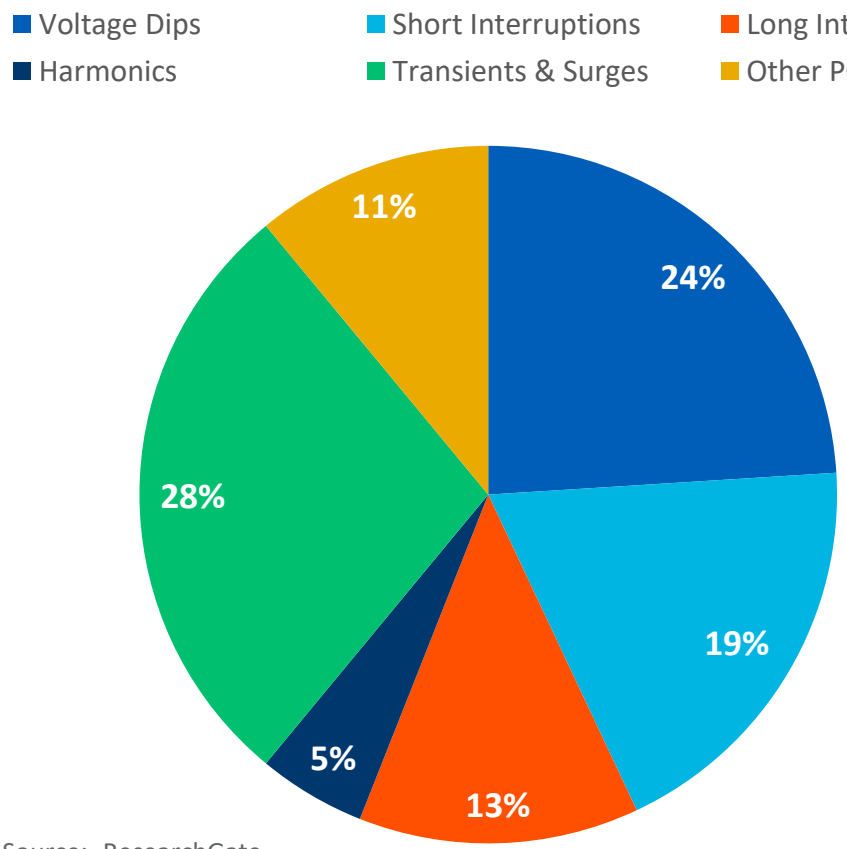
➔ allowing more accurate and confident ESP optimisation

Fully compatible with intelligent well and field optimisation software

➔ optimise power vs barrels produced considering both production and ESP power usage

Customer power quality challenges

SOURCES OF POWER QUALITY ISSUES



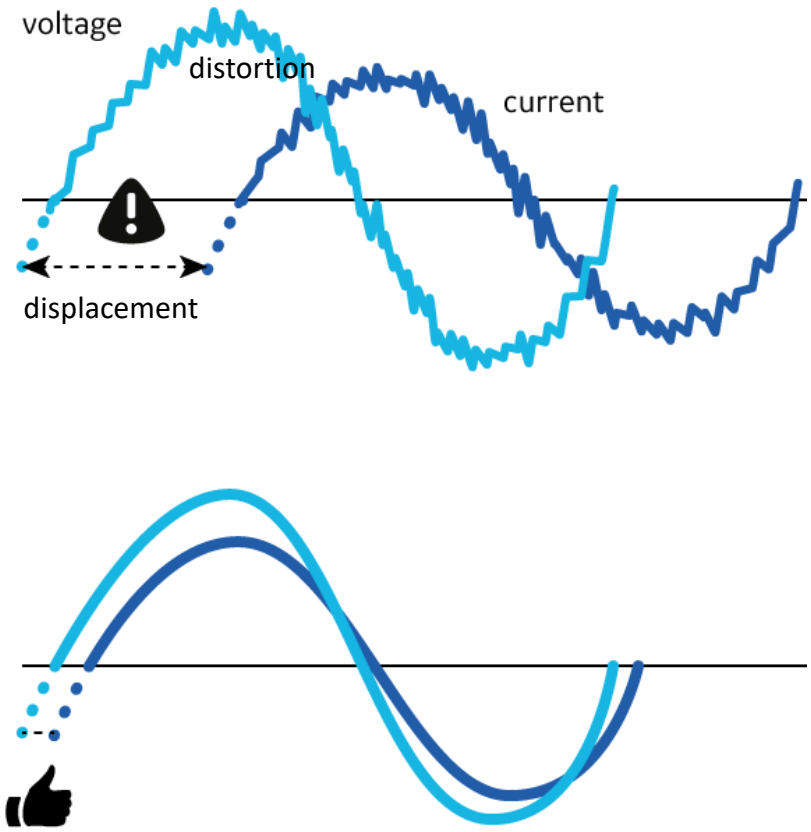
Source:- ResearchGate

Effect of power quality on ESP operations:

- Operating Expense
- Downtime
- Equipment Run Life

The impact of insight into true power factor

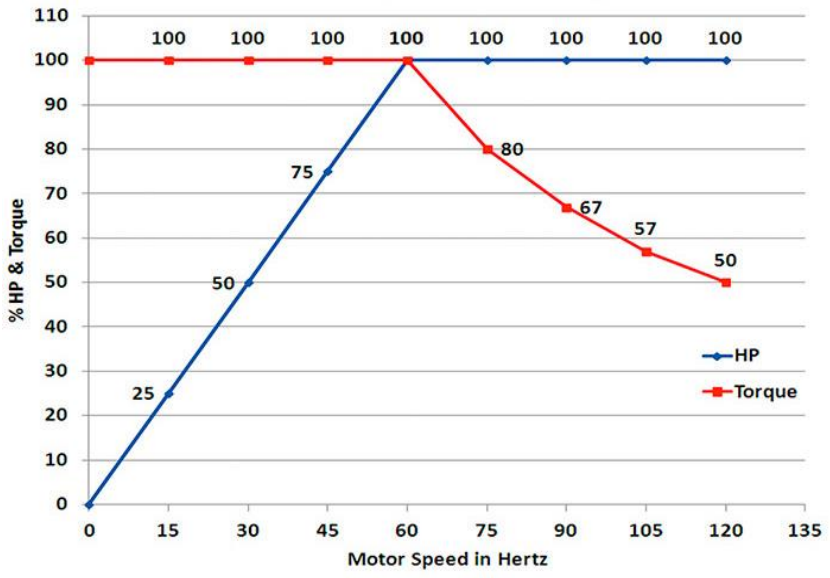
BENEFITS OF KNOWING YOUR TRUE SURFACE AND DOWNHOLE POWER FACTOR



- Reduction of electricity bills
- Extra KVA available from existing supply
- Reduction of losses and voltage drops
- Extended equipment life
- Environmental
  - Reduced consumption / improved efficiency
  - Less emissions / fossil fuel depletion

Motor load – why is measured torque and horsepower useful?

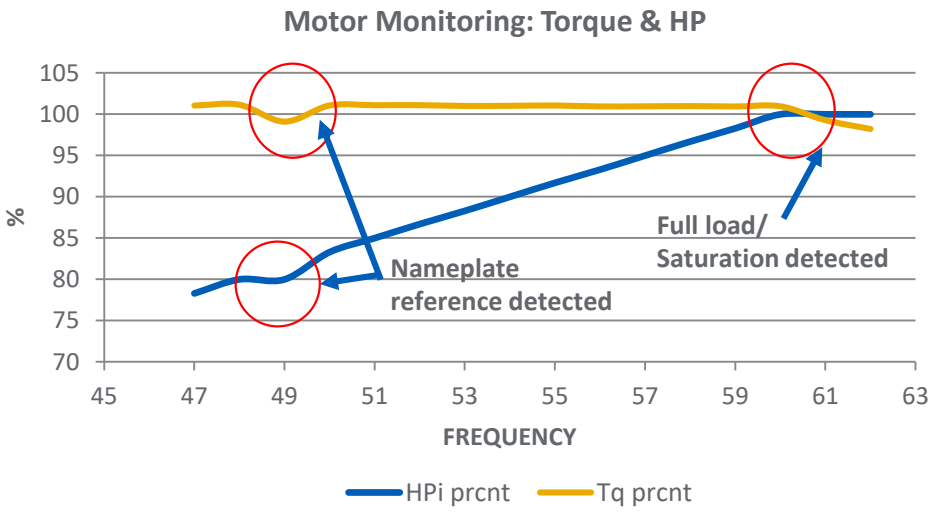
THE RELATION BETWEEN FULL LOAD AND TORQUE / HP

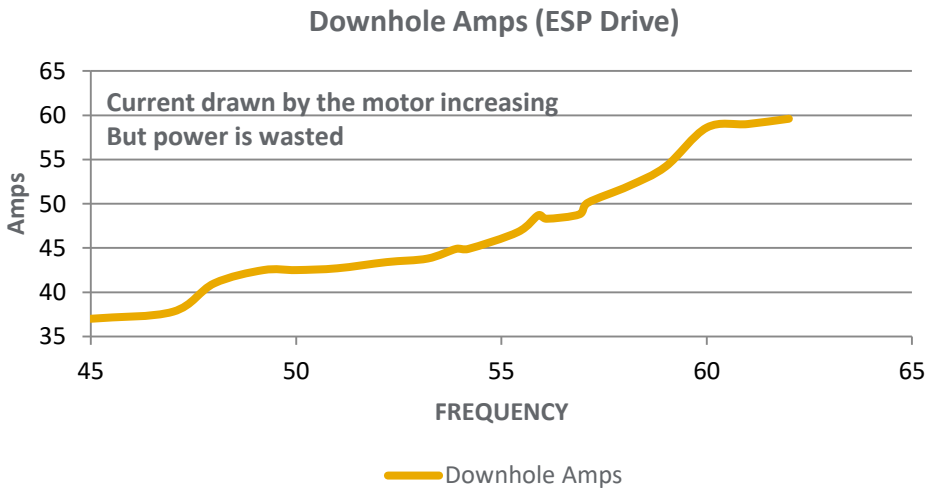


- Ideally you can vary motor load from 0 – 100% by changing the frequency from 0 – 60Hz, this is in an ideal motor and ideal design.
- To run a motor efficiently it is beneficial to know torque,
  HP and load.
- A VSD does not have a direct measurement of downhole torque, HP or load at the motor (a VSD calculates these parameters based on correct input of motor vs surface electrical data)
- The motor diagnostics gauge is agnostic of input data and highlights when 100% load is achieved in real time
- **Load and torque can be used to protect the motor and run at optimum power consumption**

CASE STUDY: Motor load optimization

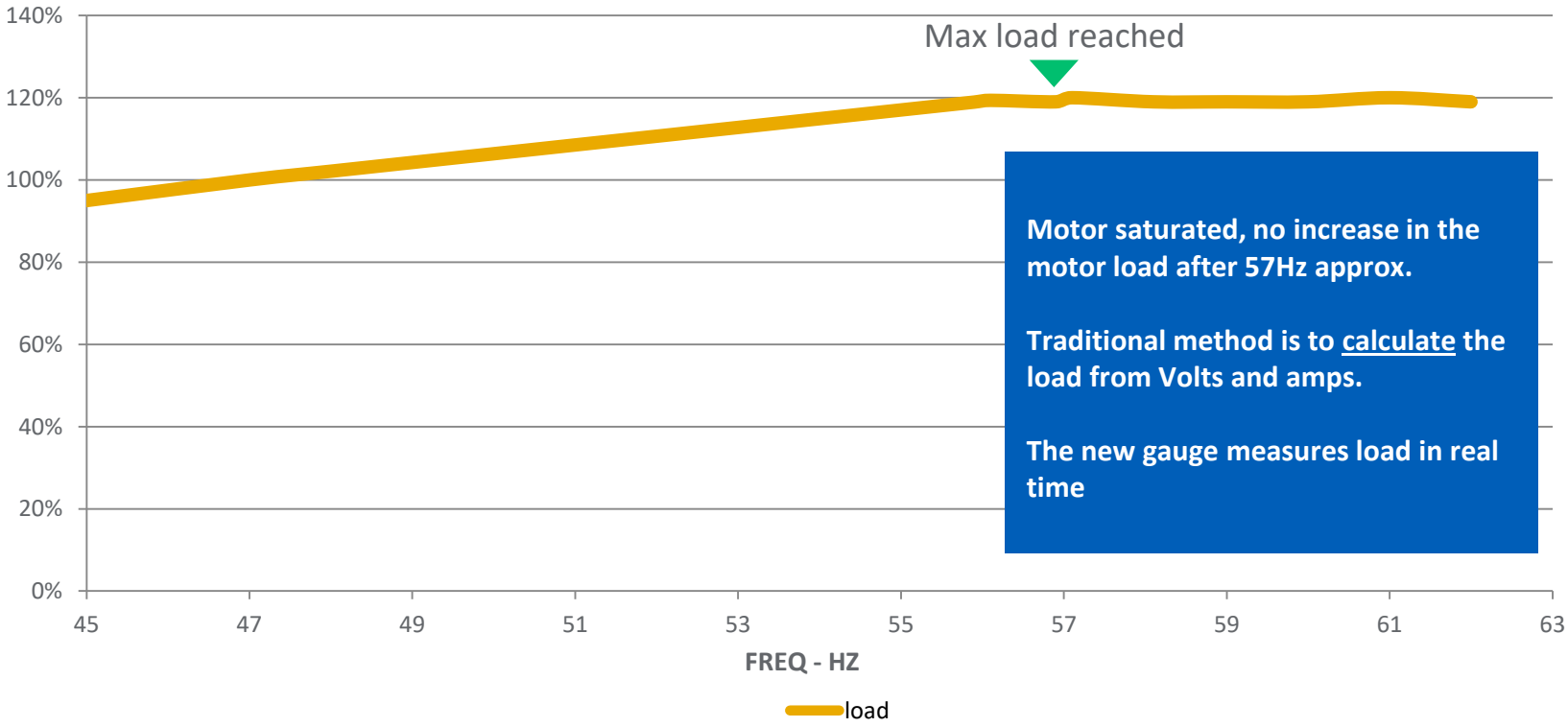
- The ESP was designed to reach 100% load and 100% HP at 60Hz.
- However the gauge identified that the motor reached 100% load at around 48Hz.
- It was (later) advised that at this point the motor was re-rated to 150% by adjusting tappings and “adjusting” VSD nameplate value settings
- Full load was detected again by the gauge at ~57Hz.
- **The motor diagnostics gauge advises exactly when 100% HP is achieved so user can correct tappings to operate at best motor efficiency vs load**





June 27, 2018

CASE STUDY: Motor load

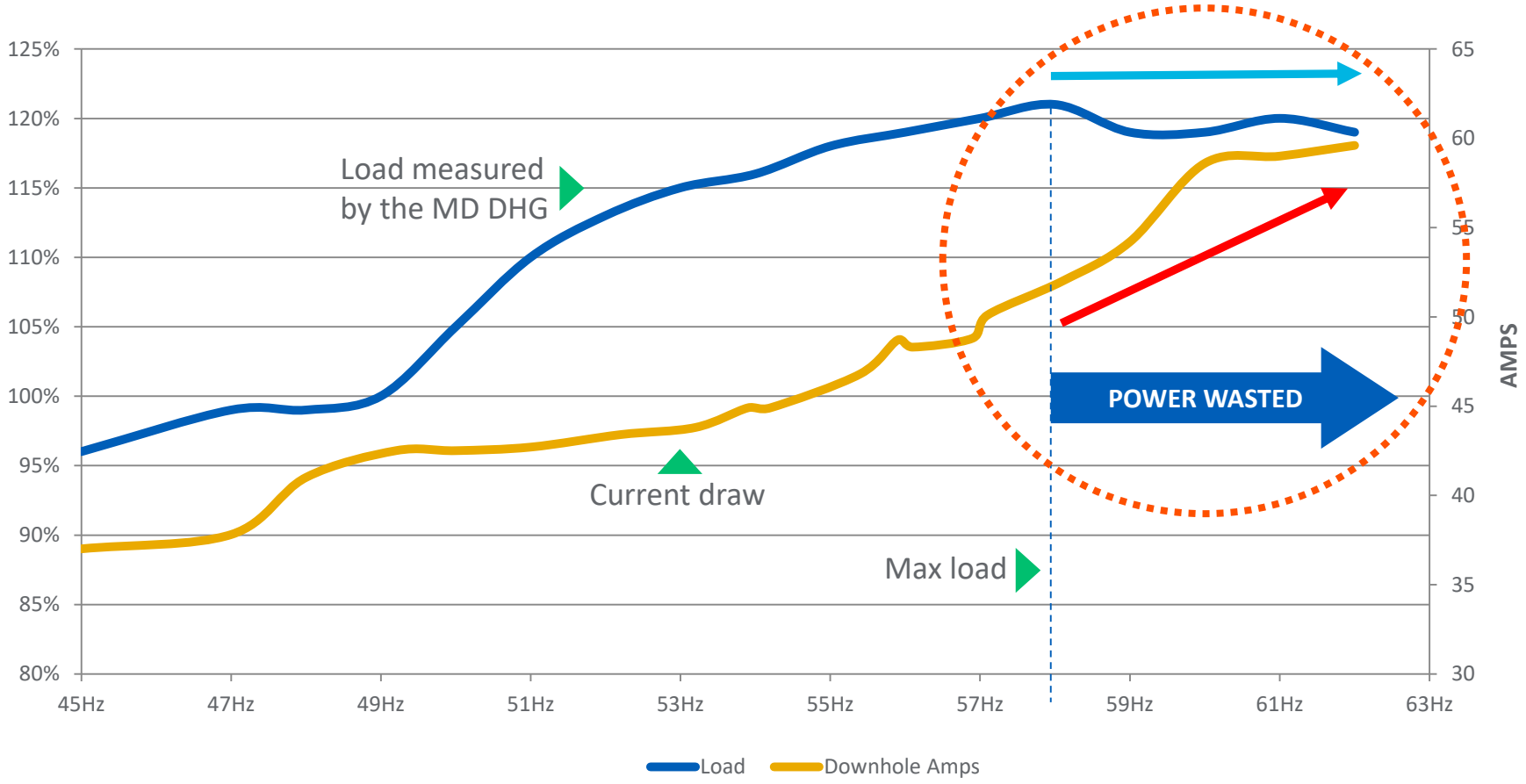


At ~120% of motor rated load (~120% of original nameplate)
extra power supplied from increasing frequency is wasted

SAME PRODUCTION @ LESS POWER COST

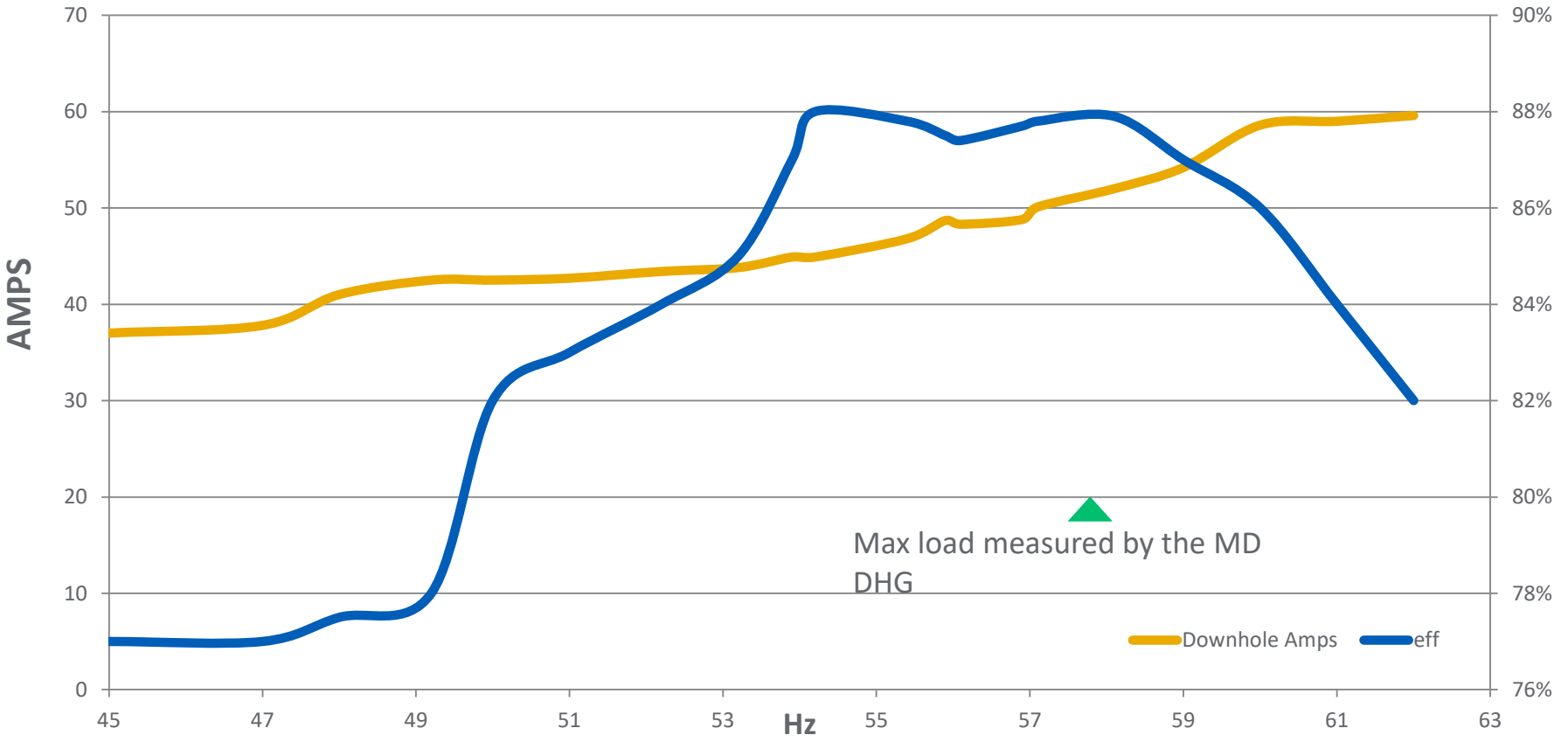
CASE STUDY: Motor load

MEASURED MOTOR LOAD (GAUGE) VS. CALCULATED MOTOR AMPS (VSD)



CASE STUDY: Motor load

MOTOR EFFICIENCY VS VSD CALCULATED DOWNHOLE AMPS



CASE STUDY: Available power saving

- Motor data suggests that by changing Volt/Hz ratio from current settings to 60 Hz (e.g. volts which are supplied at 63Hz now to be supplied at 58 – 60Hz) should deliver

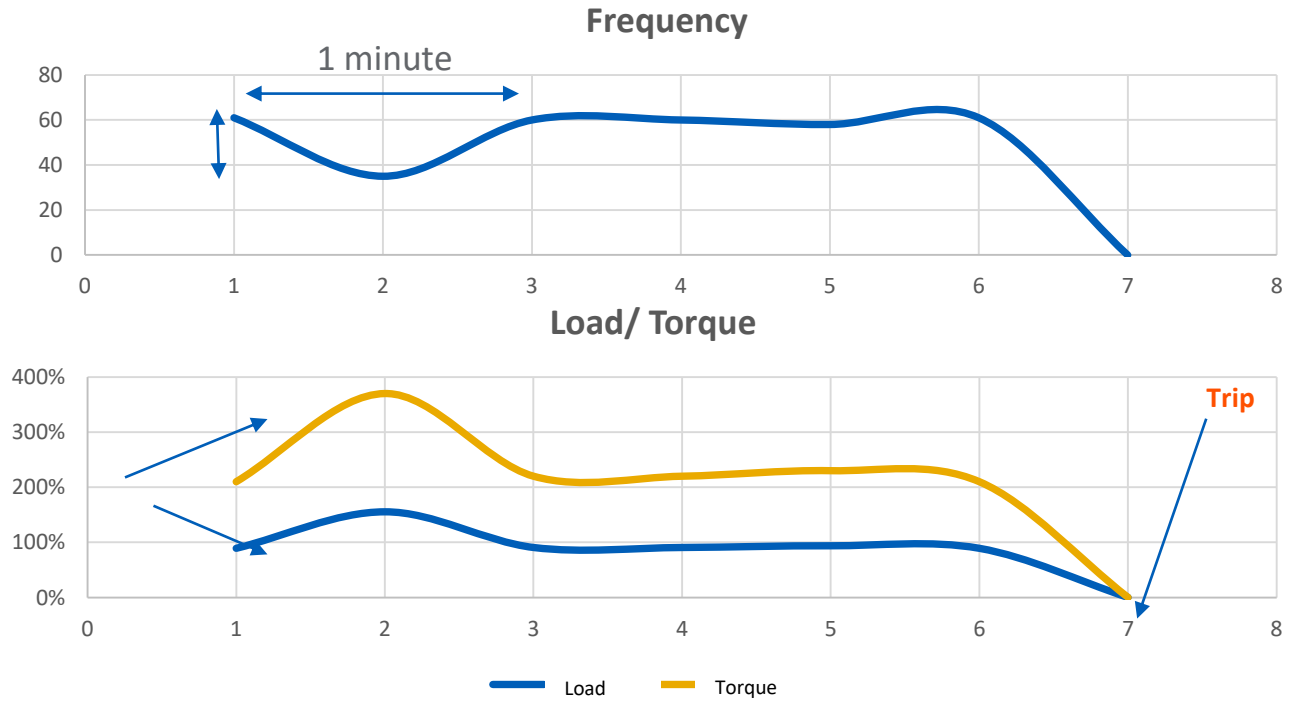
Potential saving of 9% - 13% on power cost with the same production

- In this case the VSD tripped many times after exceeding the suggested maximum operating point of 57Hz .
- Due to long log rate of VSD data — poor user input — trips were not always detected in VSD amperage log leading to extended downtime

CASE STUDY: Motor performance diagnostics

~150% SUDDEN INCREASE IN LOAD DETECTED

Exceeding **maximum motor torque**, in this case 350%, may shear the shaft or cause permanent damage – if not controlled or rectified.



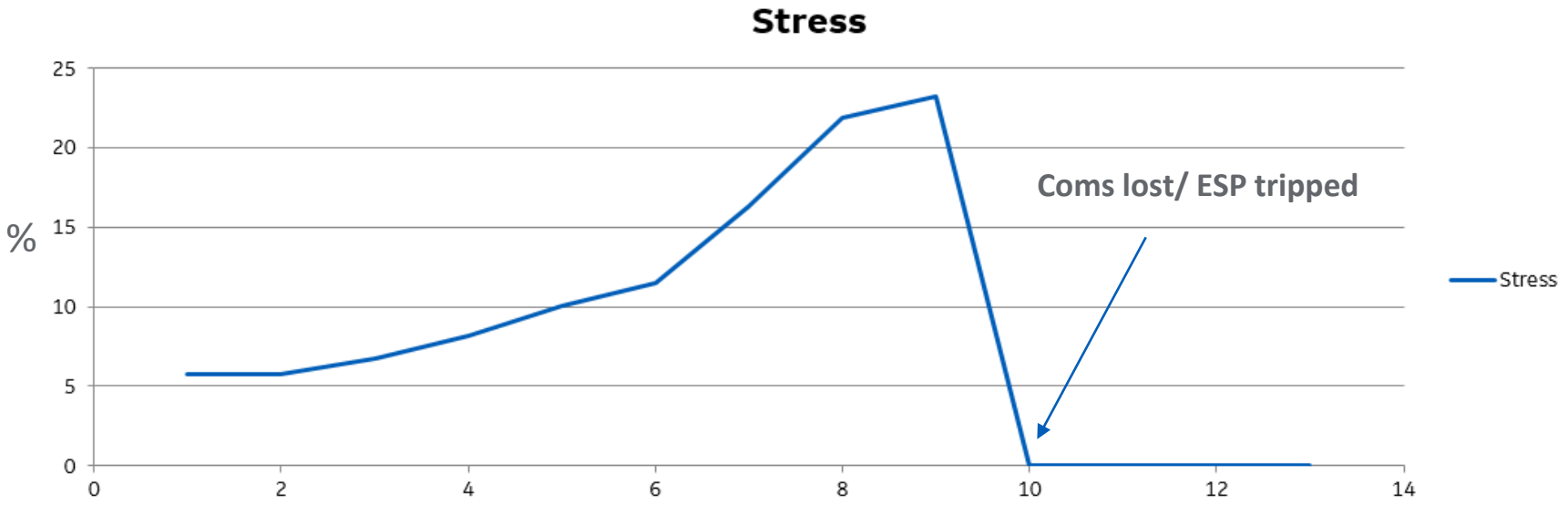
Within 1 minute, frequency drops from 60Hz to 35Hz & returns to 60

Caused huge steps of motor load and torque

CASE STUDY: Motor failure prediction

Increased **stress indicated by the DHG**, while ΔP and DH amps did not change.

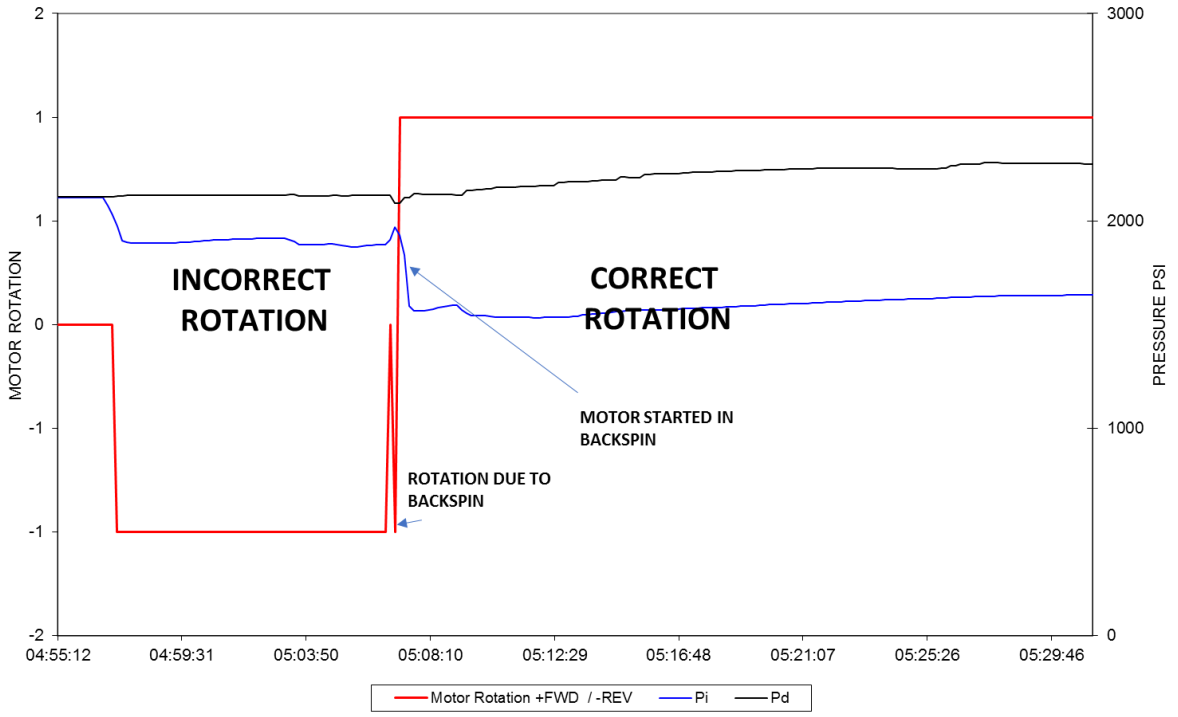
The ESP tripped for electrical motor failure.



# of point – over 13 hours

Optimising production

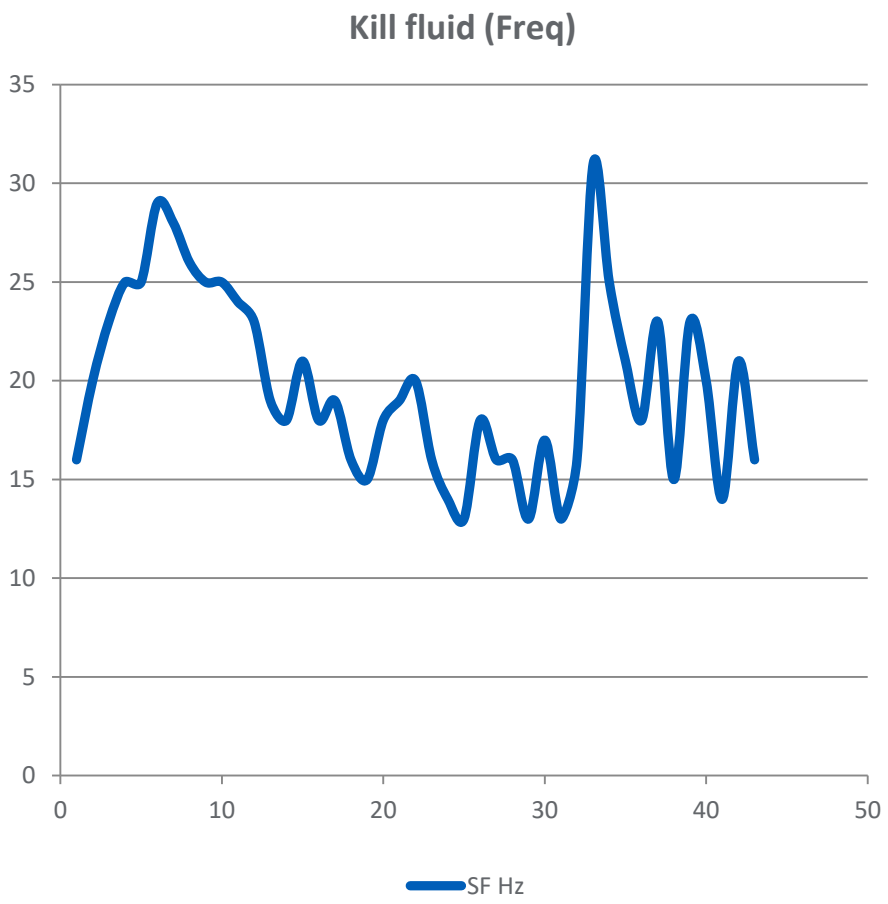
- Motor diagnostics gauge immediately shows motor direction without having to wait for fluid to surface
- Detects stuck pumps
- Forward/reverse configurable for pump manufacturer



Case study data: Backspin

MEASURING TRUE BACKSPIN DOWNHOLE

- Zenith gauge is capable of detecting backspin, **ruling out risk** involved in measuring voltage manually & perhaps eliminating need for a backspin relay.
- Backspin info can be vital during RIH ensuring kill fluid rate is within safe range to the ESP stages.
- Pi, Pd readings will not necessarily indicate backspin in all cases.
- Graph is an example of backspin logs taken at intervals during RIH.



Conclusion

Zenith E-Series ESP gauge with motor diagnostics

BENEFITS

Motor Shaft RPM | Slip Rate | Power Factor | Torque & HP | Imbalance Indicator | Shaft Direction | Motor Efficiency

- Replaces inaccurate surface calculations
- Enables accurate electrical performance monitoring
- Run equipment at actual optimum points against load

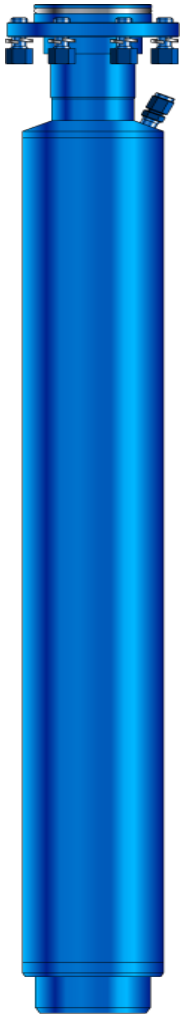
System adjustments are made based on measured not estimated values
ensuring truly efficient, safeguarded ESP operations.

Zenith E-Series ESP gauge with motor diagnostics

CONCLUSION

The Zenith E-Series Gauge with Motor Diagnostics provides **real-time power analysis** enabling operator to:

- Monitor motor performance for informed decision-making
- Operate ESP at the best efficiency and lowest cost
- Place less strain on equipment to enhance runlife
- Quickly know pump is spinning the correct way at start up
- Optimize production vs power consumption

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