

# SOGIC 2018

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# DEPLOYMENT OF MV DRIVES: ESP - SAGD APPLICATIONS

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# Introduction



- Upstream customers seek:
- Improved processes;
- Reduce life cycle costs
- Increase profit and reliability

Siemens studied the installation of Medium Voltage Drives in Electrical Submersible Pumps and they found OPEX savings and reduced installation and floorplan costs



# Introduction

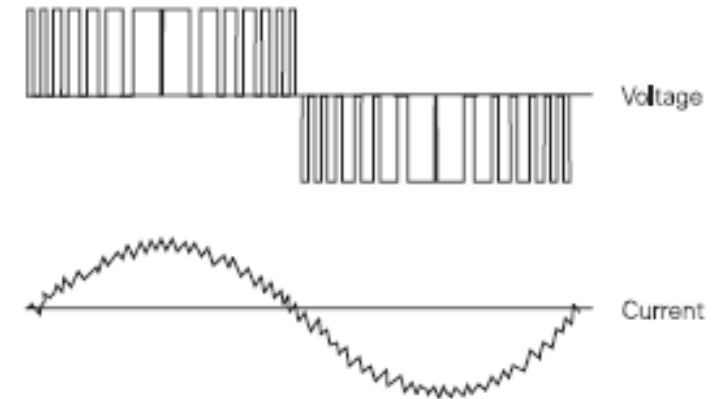


- Cost savings between LV and MV drives (last 20 years)
- Technical advantages and increased reliability
- Decreased total cost of ownership
- ESP applications demand increased reliability
  - high cost of downtime
  - significant replacement costs of downhole equipment
- This paper contrasts significant benefits
  - reduced total installation footprint
  - greatest reliability of down-hole/subsea pumping equipment



# Contemporary Alternatives: LV Drive

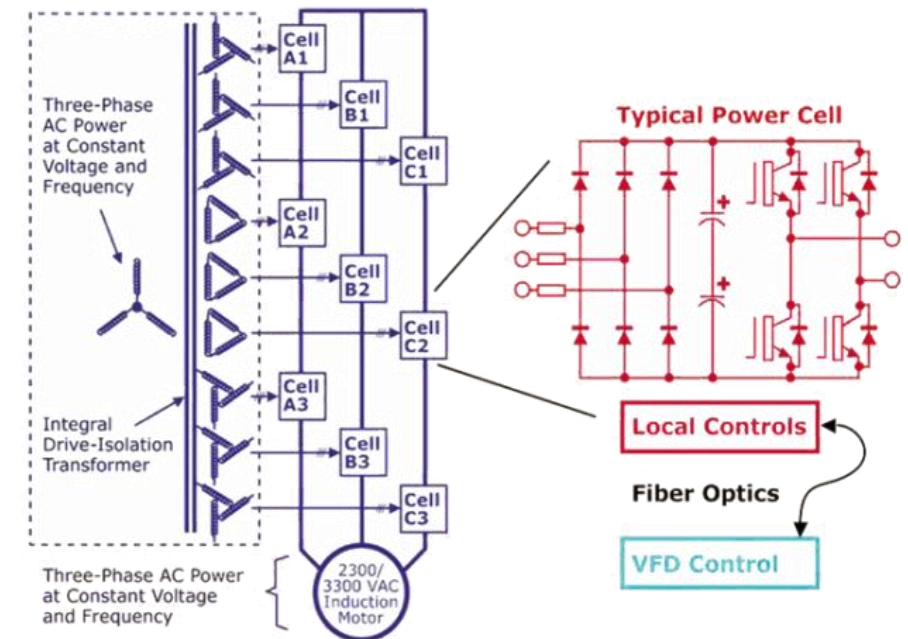
- DC Link Voltage ~ 750 – 900V (input @ 480-600V)
- Step voltage up to 1800 volt peaks
- Multi-Tap output SUT: Step up Transformer
- Filter required to protect cable + ESP motor
  - Technical challenges are:
- Low speed torque control, up to 15Hz(+) jump starting
- Capacitive charging / reflected wave output filter
- Input system voltage sensitivity, up to 90 minutes lost production



# Contemporary Alternatives: MV Class Drive

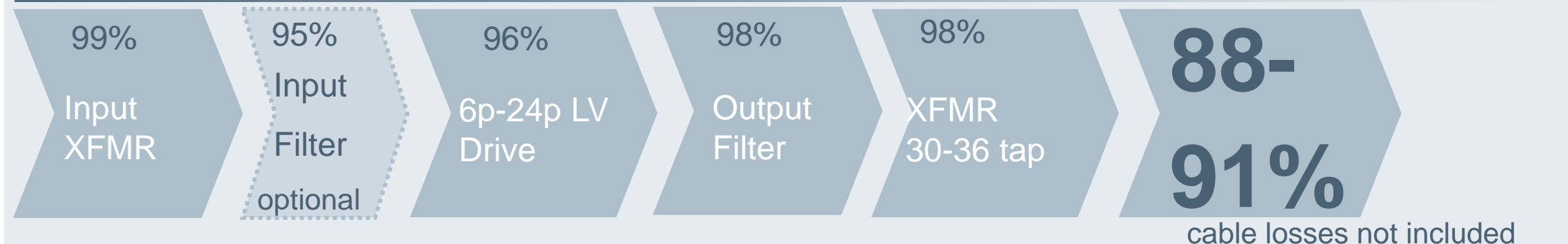


- Input Transformer accepts LV or MV input
- Cascaded H-Bridge, PWM
- Motor friendly output voltage
- Ramp from zero Hz, soft starting
- Supports long cable up to 2.2 km
- Input System V drop ride through
- Reduced operating losses
- Higher uptime = more production

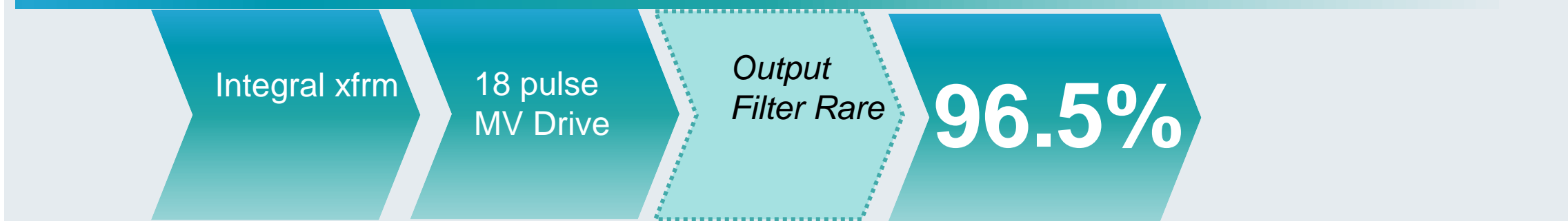


# System Efficiency Comparison

## LV AFD system



## NEW: MV AFD system



# Essentials of Thermal ESPs

- High steady state heat environment ( $> 220^{\circ}\text{C}$ )
- High water content in produced fluids
- Sour composition ( $\text{H}_2\text{S}$  and  $\text{CO}_2$  ~ harmful acids)
- Sand in the fluids ( $\geq 1\%$ , contributes to erosion)
- Multiphase production of fluids, gas and steam can lead to cavitation
- Viscosity variations require tight torque and speed control
- Steam break-through vaporizes produced fluids



# ESP Application Design Challenges

- ESP design target operating life typically 36 months
- Motor rating differs for various applications
- Harsh ambient conditions vary widely
- Multiphase production (fluids and gas) can lead to cavitation
- Product viscosity variations
- Steam break-through vaporizes produced fluids
- Long cable runs
- Typically installed in remote locations



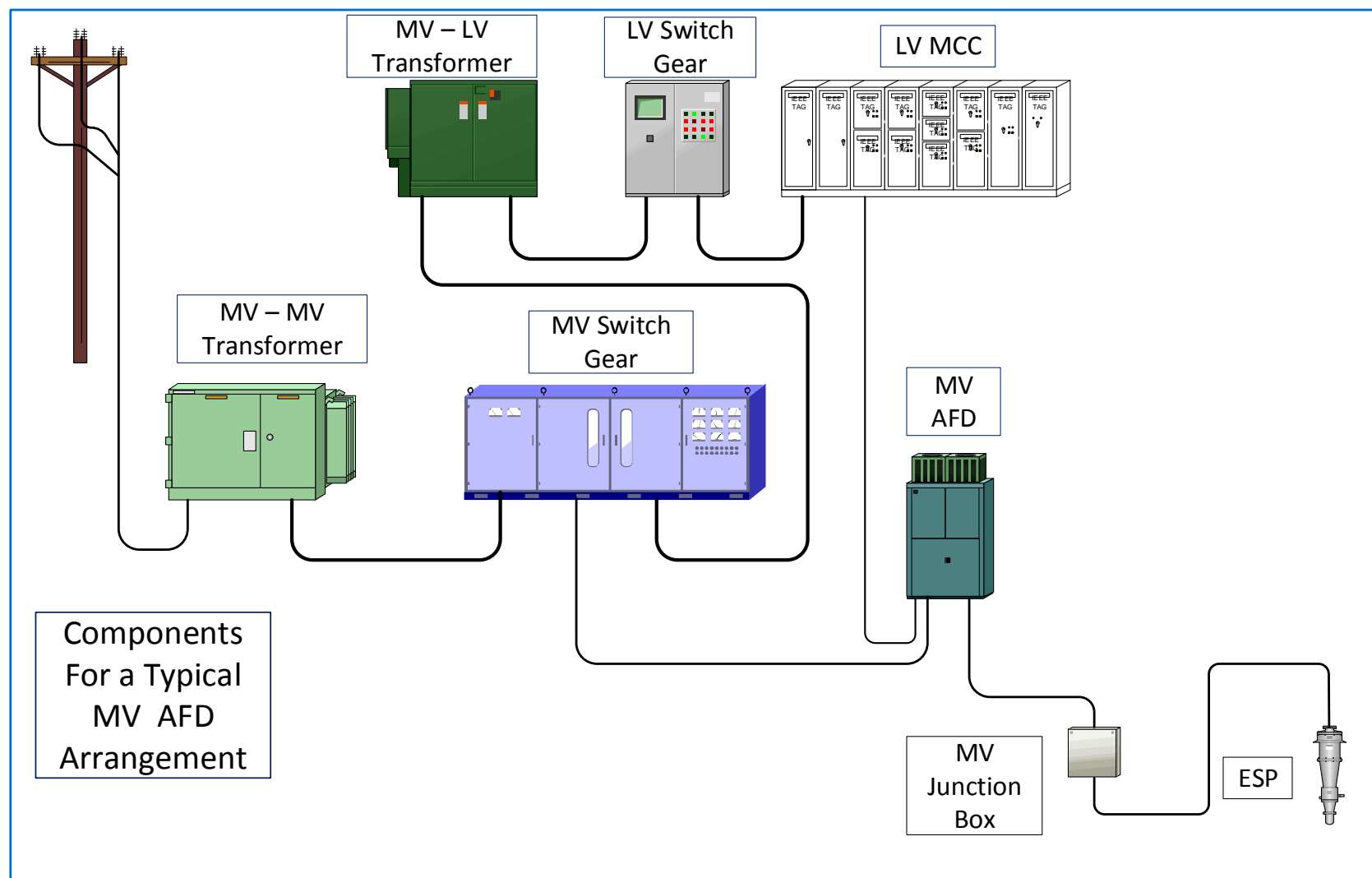
# AFD Application Challenges

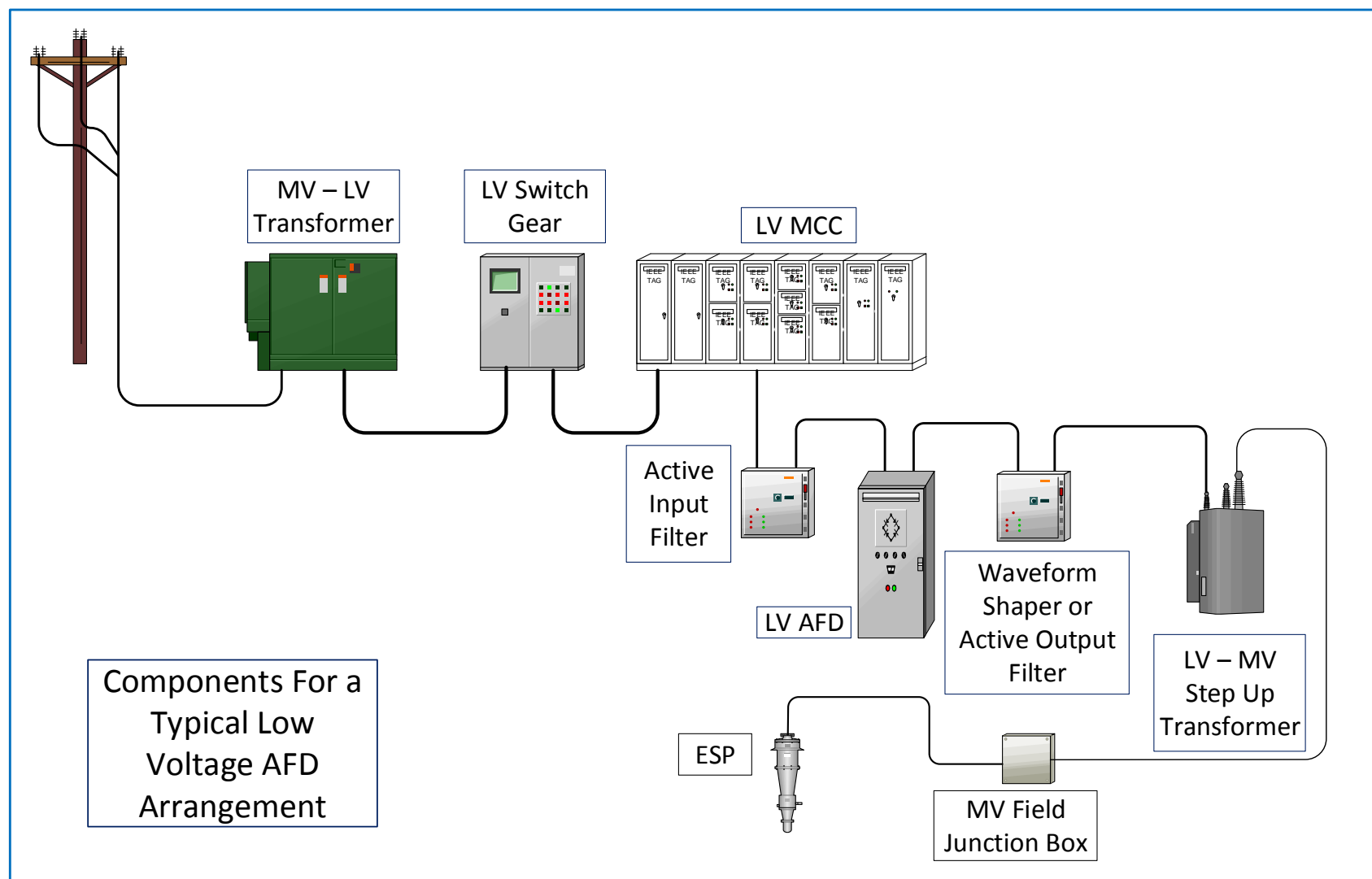
- Client standardized on ESP motor size (150 HP)

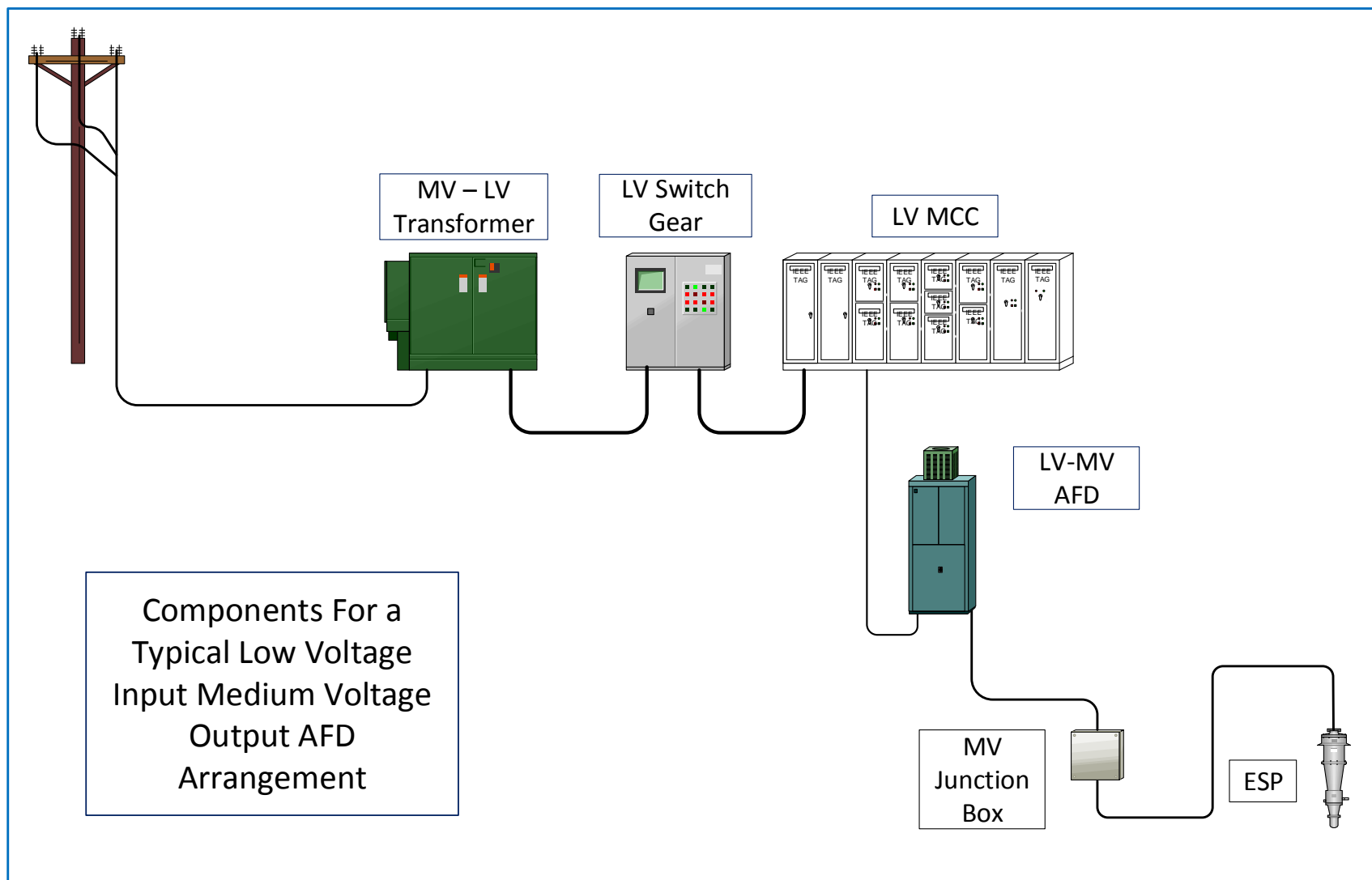
When considering modularization of electrical, found:

- MV Input / MV Output Drives = High CAPEX and Medium TIC
- LV Input / LV Output AFD = Low CAPEX and High TIC
- LV Input / MV Output AFD = Medium CAPEX and Low TIC
- each in analysis









# Break Even - LV/LV vs LV/MV AFD

- Industry assumption is that LV / LV AFD present a lower CAPEX on smaller ESP even with filtering and additional field costs
- Each application unique = TIC should be fully reviewed
- Early studies indicate ~150+ HP = lower TIC using LV / MV drives solutions for ESP
- The first units delivered in November 2017, since then installed and currently undergoing commissioning



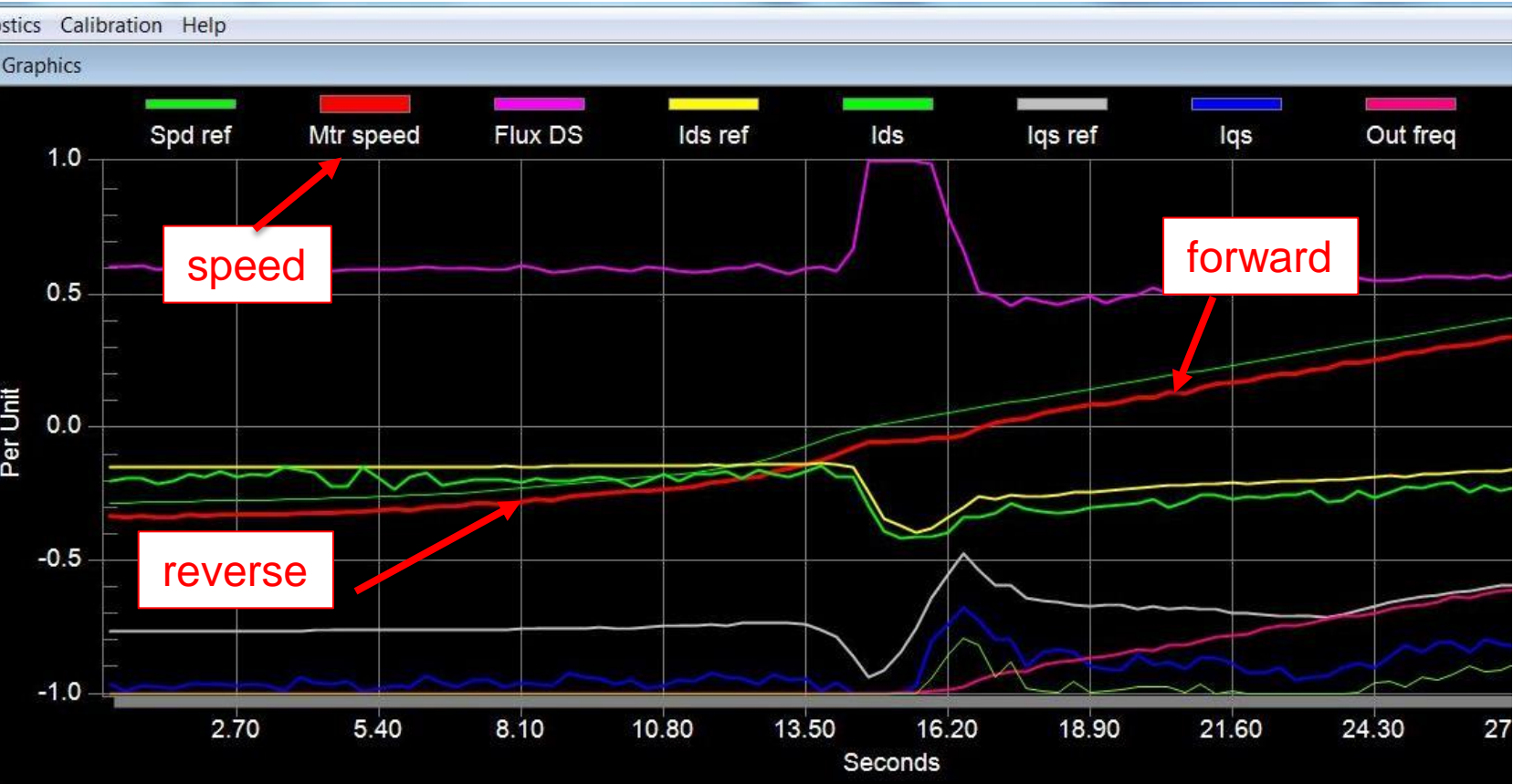
# Direct AFD-Motor Connection Advantages



- Allows easier catching of back-spinning load
- Reduced mechanical impact, no boost start required
- Vector control, enabling virtual metering
- Increased efficiency
- Allows AFD to detect  $V_{gnd}$ : Predicts and avoids fail to ground



# Benefits: MV class AFD, Load Back-spin



Catching a back-spinning load minimizes loss of production

# Removing SUT - Precise Vector Control



STARTING;

SUT requires >0 frequency

DC not allowed

7-15+ Hz boost causes motor inrush

MV class AFD ramps from 0 Hz

Linear ramp-up

No mech transient introduced

Lower amps per unit of torque

Unit	Approximate	MV	LV step-up
Hz	Start f	0.2 Hz	7-15 Hz
PU A	Starting Torque	1 PU	0.2 PU
PU	Torque Oscillations	None	0.5 PU
	Starting Shock (Mech)	Low	High
	Voltage Spikes	Low- Med	Med-High
	Starting Stator Saturation Transformer Saturation	None None	Likely Likely

# Removing SUT – Virtual Flow Meter

- Wellpads use mechanical flowmeter, \$
- Precise vector control - manages motor torque
- Obtaining motor speed and torque value, flow can be measured/calculated from pump curves
- Elimination of mechanical metering skid = save \$\$\$
- Currently under field validation

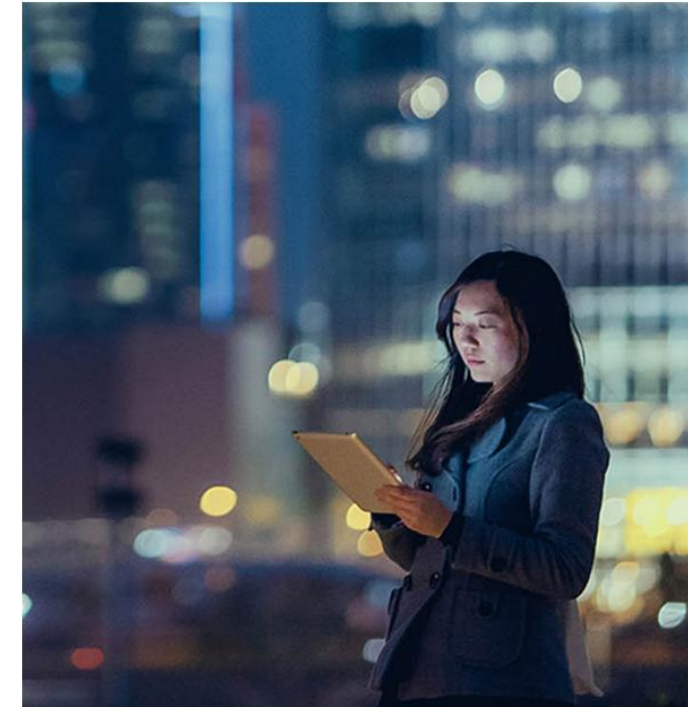


## V/HZ to Vector Control

Initial site measurements indicate increased system efficiency of 4-7%

Reduction of motor current for comparable production

This is on top of overall system efficiency gains on the MV class AFD vs LV system

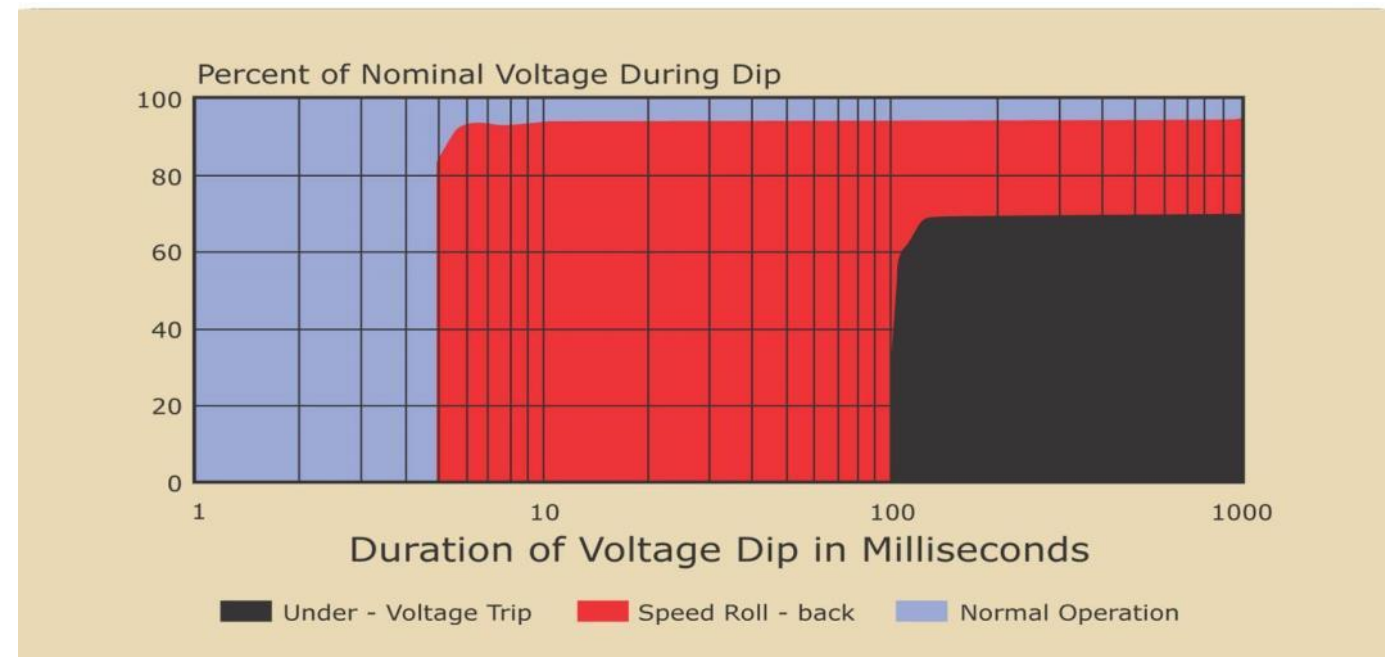


# MV Class AFD – Undervoltage Ride-through

Tripping = production loss

Improved ride-through equates to reduced loss of production compared to LV AFD

AFD still active down to 55% input volts



# Next Steps

- Deployment of Outdoor/NEMA 4 model
- Continuing testing and data collection at site
- Adjusting existing installed base of drives (scalar to vector) to record and review operational improvement
- Testing “Virtual Flow Meter” - accurate torque and speed signal from drives
- Data collected reveals increased efficiency with lower motor current
  - normally reflects longer motor life



# Future Developments

- Seek to continually decrease equipment cost
  - Size, footprint, economies of scale
- Continue collection of operational data
- Confirming design target downhole component life
- Productization of virtual flow meter (digitalization)



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**Thank you.**

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