Motor Drives for Oil and Gas Applications

- potential application areas and benefits of SiC devices

NIST High Megawatt Drives Workshop
September 2014

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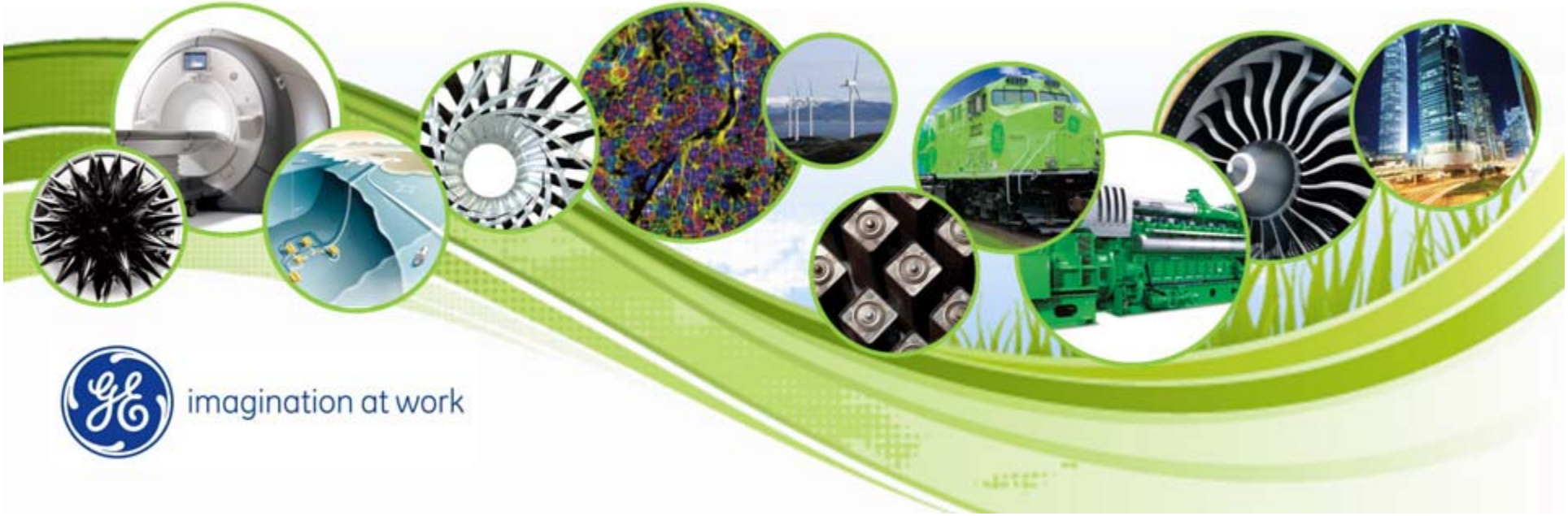
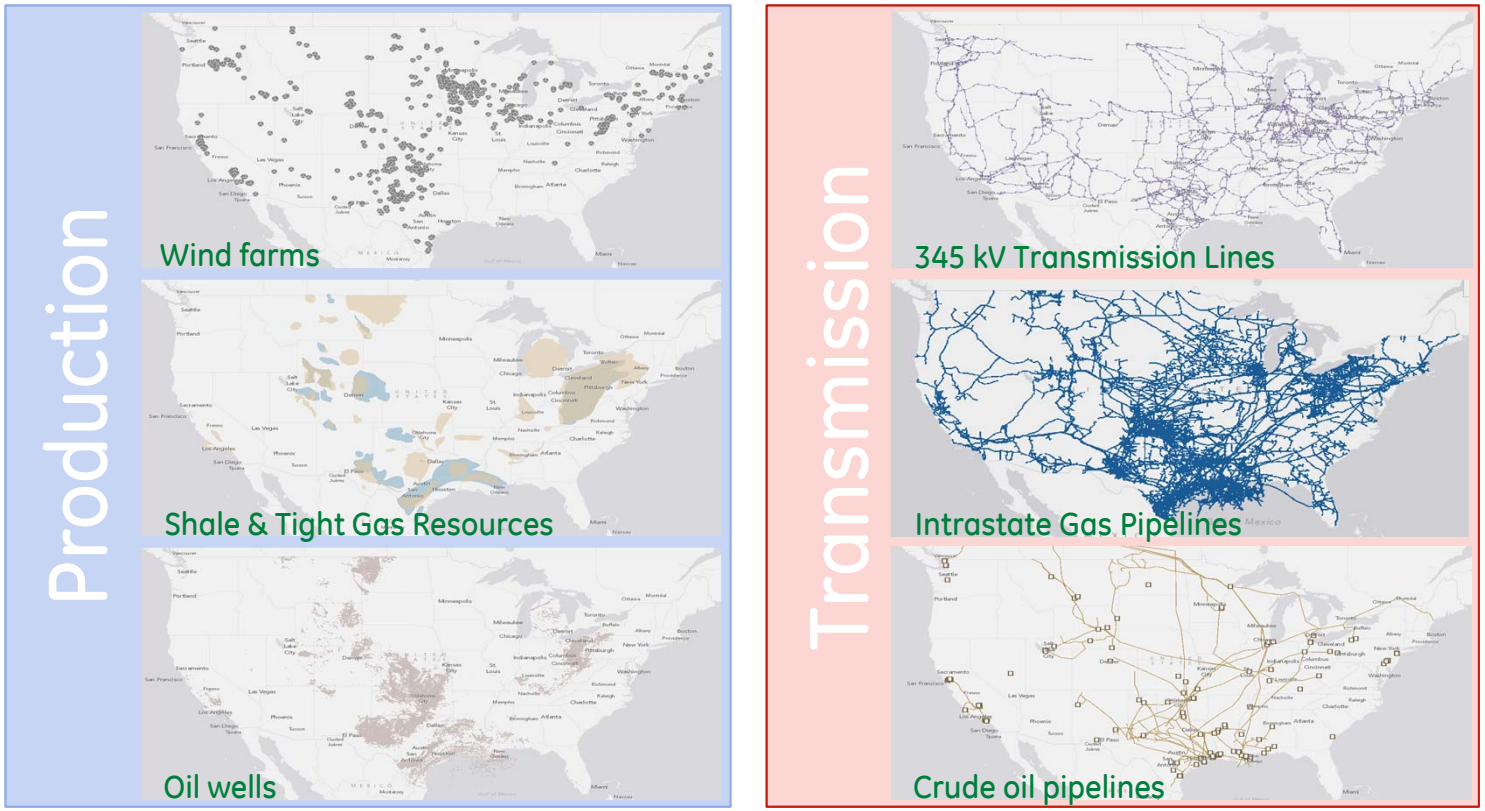


US Energy Map

Production and Distribution Infrastructure: Renewables, O& G

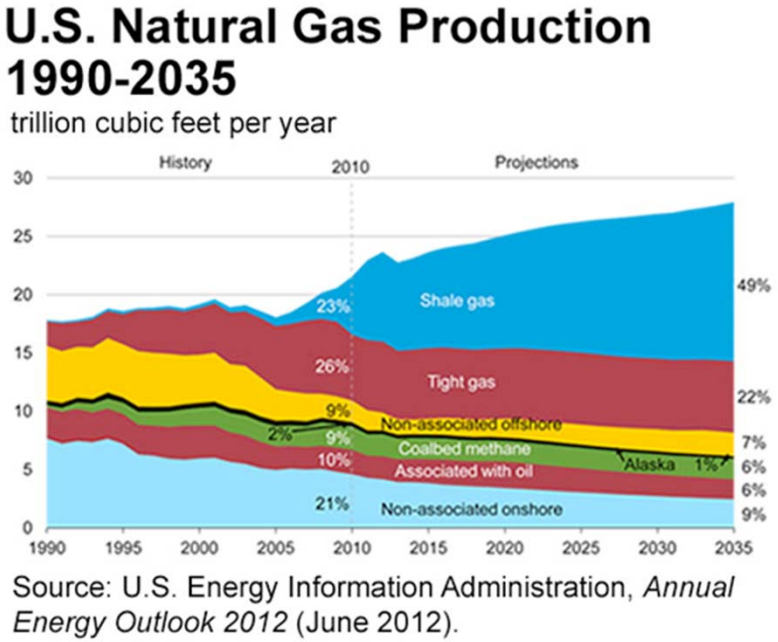


Source: US Energy Information Administration - US Energy Mapping System

Electric drives play a major role in the O&G production and distribution infrastructure

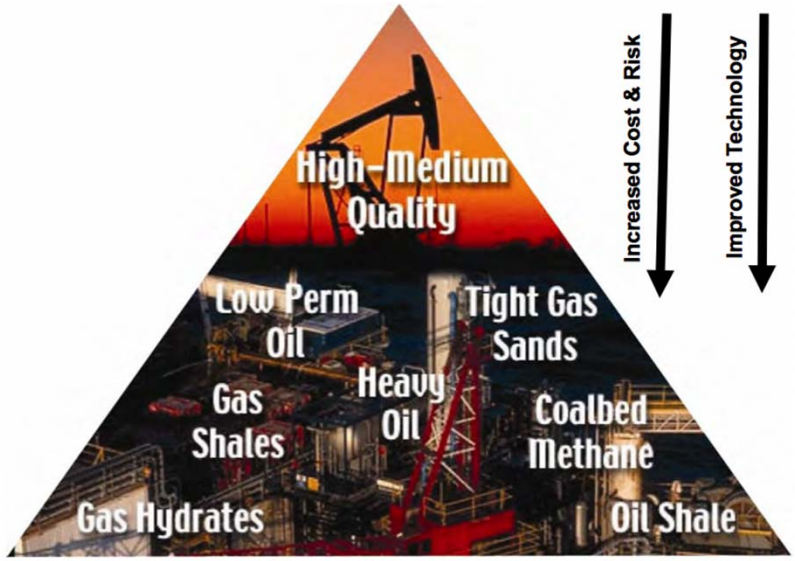
- pumping systems for oil; compression drive trains for gas infrastructure

US Shale Gas boom



Source: U.S. Energy Information Administration, *Annual Energy Outlook 2012* (June 2012).

Conventional Reservoirs
small volumes, easy to develop



Source: Steve Holditch, Texas A&M

Un-Conventional Reservoirs
Large volumes, difficult to develop

Technology as driver for US O&G production

Electrical Submersible Pumps
Challenges & Opportunities

Conventional Oil

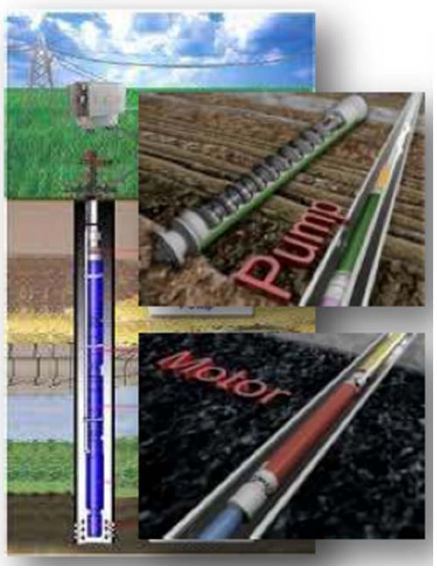
VFD-driven pump motors

Challenges:

- High-temperature harsh environment for down-hole motor
- High power quality for top-side drive

Opportunities:

- high temperature
- reliability
- size & power



Unconventional Oil

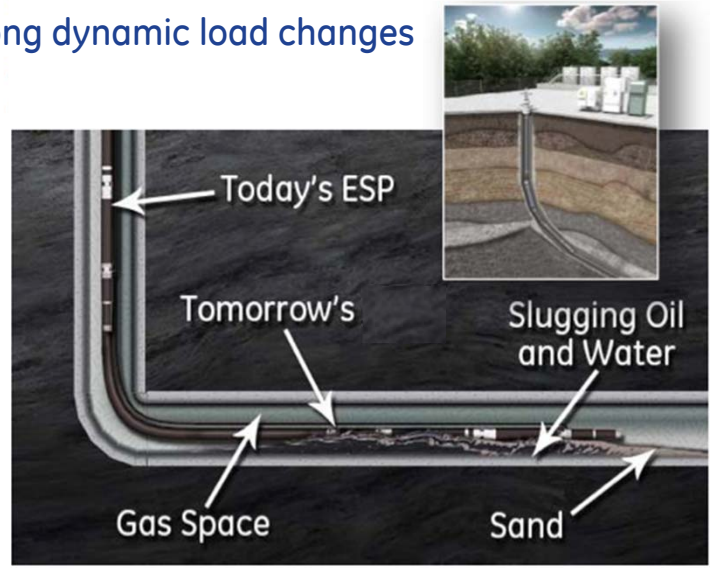
Enabler: horizontal drilling

Challenges:

- Tight angles
- multi-phase flow

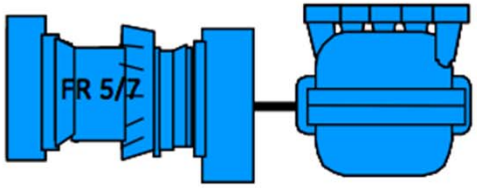
Opportunities:

- Power density
- Strong dynamic load changes



Mechanical & Electrical Compression Trains

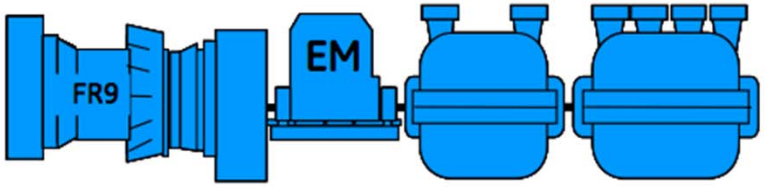
Mechanical Driven

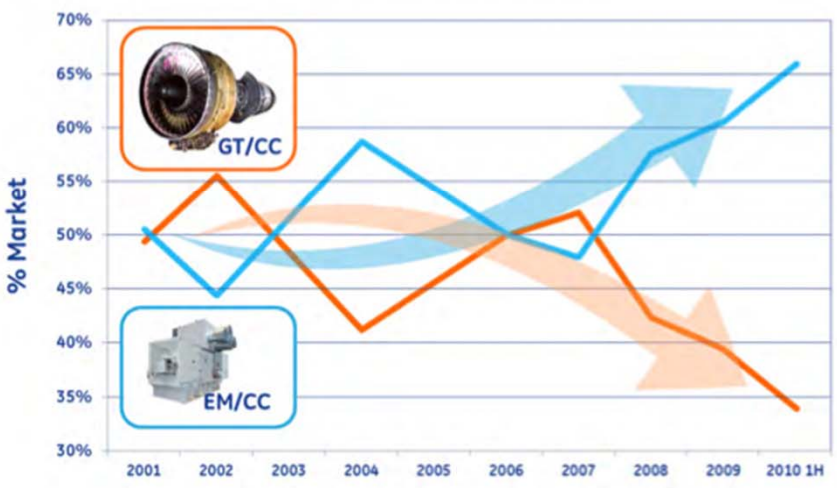


Gas: Gas Turbine Compressor
Oil: Recip Engine Pump

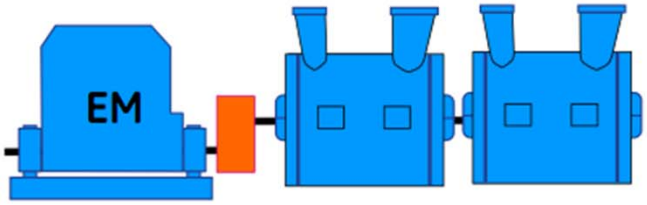
Electrical Driven

"Super Train" ... mechanical/electrical hybrid





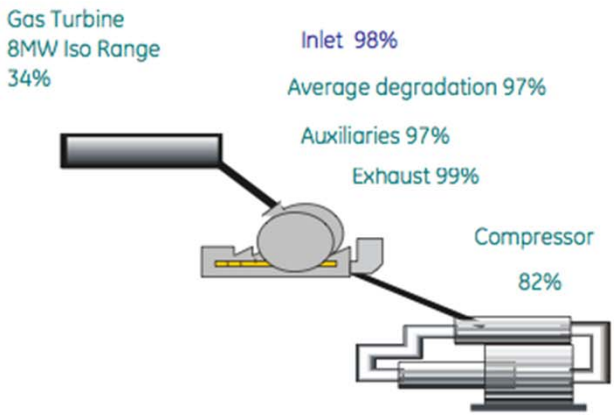
Full electric Trains



"more electric" trend

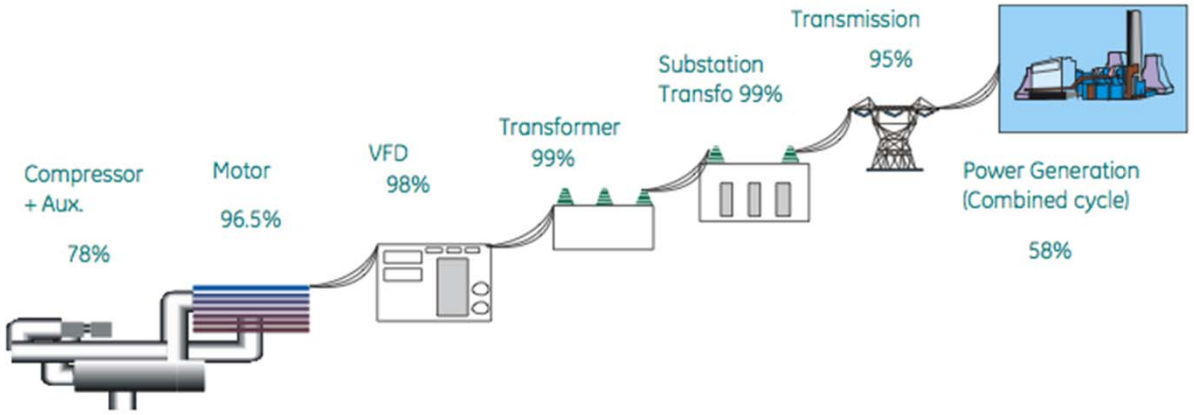
Why Electric ?

Mechanical Driven



Efficiency 25.4%

Electric Driven

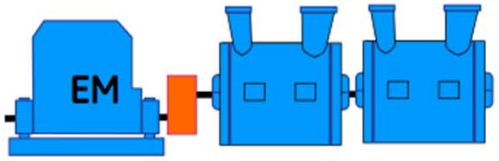


Efficiency 39.8%

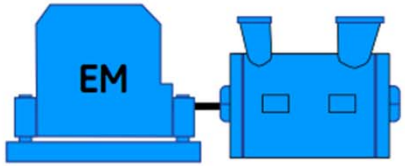
- Electrical solution +50% more energy efficient than gas fired solution
- 45% saving on CO2 emission

Integrated Electrical-Mechanical Systems

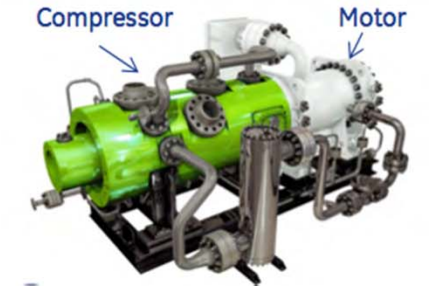
Full Electric Trains

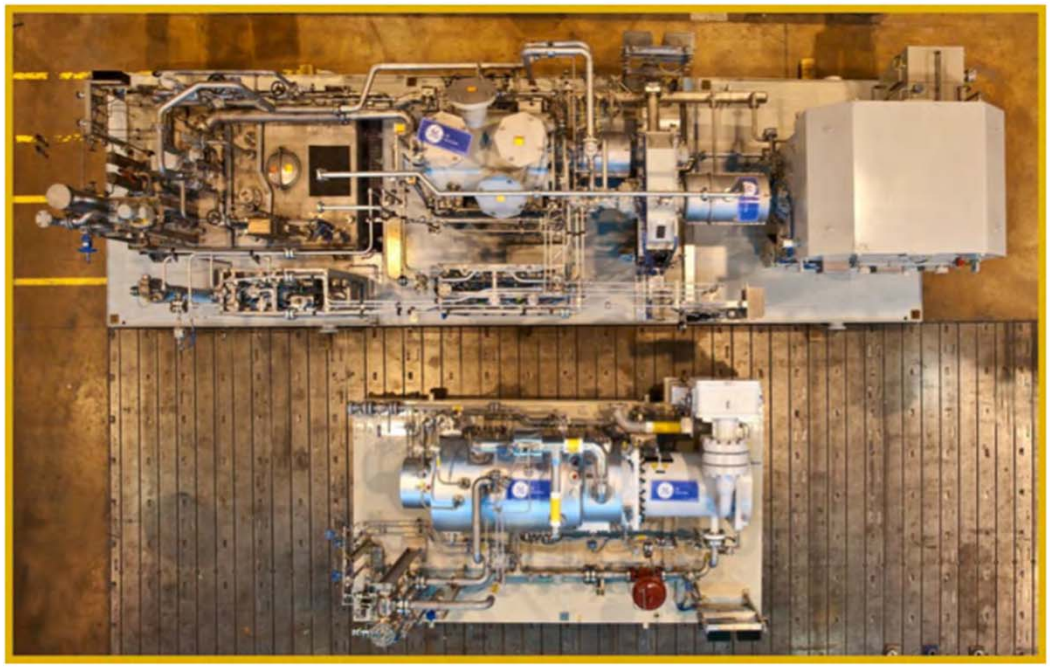


High Speed Direct Drive Trains



Integrated Compression Train





Power Density, Reliability, Efficiency

Technology progression:
Geared electric –> direct drive electric –> fully integrated electric compressor

Evolution of Subsea Production

Yesterday

Fixed

Today

Floating

Evolving

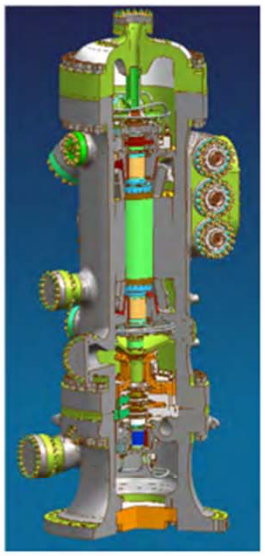
Subsea Pumps & Compressors

- Long Stepout … 100-600 km
- Deeper waters … 3 km depth
- Increased power … 100 MW class
- Multiple loads

Reliability … Availability

World's first motor-compressor & subsea VSDs

Blue-C Moto-Compressor



Compressor VFD

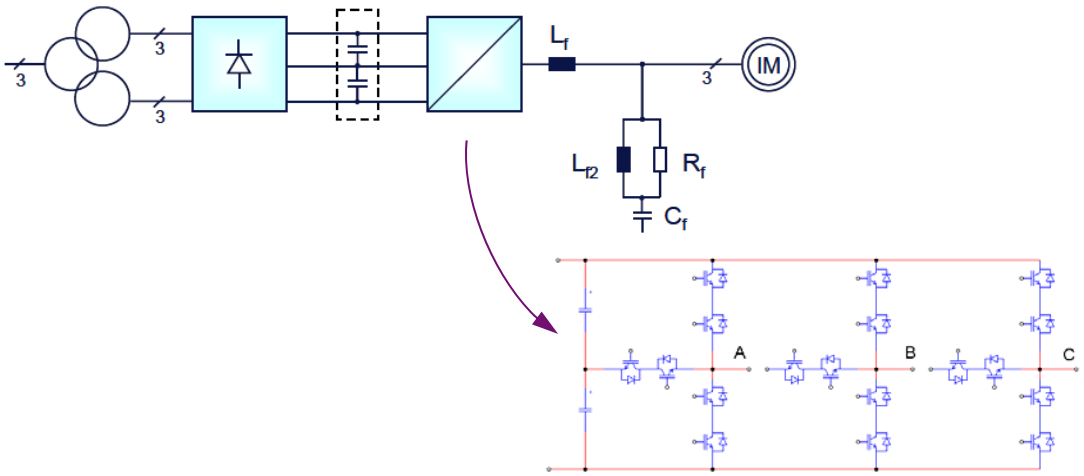
10.5 m (h) x 3 m (d)

Pump VFD

5.6 m (h) x 2 m (d)

- High frequency drive … 100 bar pressure, 10 yrs maintenance

Typical Drive for High Speed Motors



- Multi-level drive with series connected devices
- Selective harmonic elimination
  - optimized to reduce losses in drive plus motor
- Output filter to reduce dv/dt and harmonics

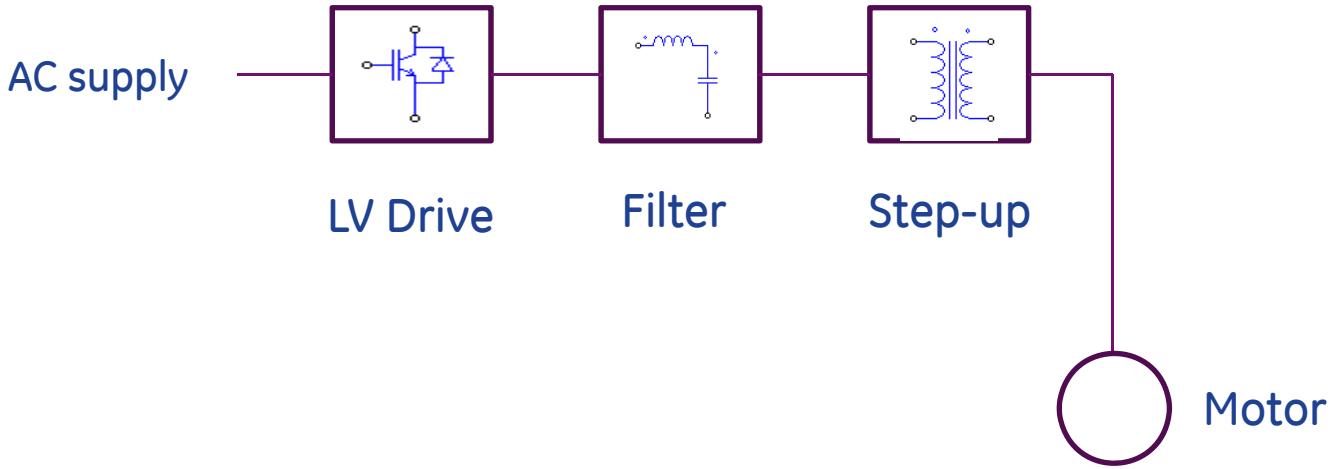
✓ 10kV+ SiC devices will allow compact, efficient two-level high speed drives

Typical high speed motor vs drive

Power Density challenge:

State-of-the-art Drives are 3-5x Motor size

Typical Drive for ESP



- LV drives are typically used instead of MV drives
  - lower cost
  - better waveform quality due to faster switching speeds
- Sine wave filter plus transformer for step-up

✓ SiC MV drive with high power quality can provide a compact alternative

Opportunities for Silicon Carbide

Wide range of demanding motor drive applications for O&G

Some high-power compressor motors are high speed

Most high-power motors are VFD-driven,

AND they will benefit from SiC advantages of

- compactness
- high-temperature capability
- fast switching (reduced filters, cleaner motor currents)
- high efficiency

Thank you