



# Fueling the Future

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CMPS

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# Gerard Vittecoq, Group President Power system

## Changing world: Megatrends

- Developed to Developing Markets
- Diesel to Gas & renewable Fuels
- Mechanical to Electrical
- Hardware to Software
- Products to Solutions

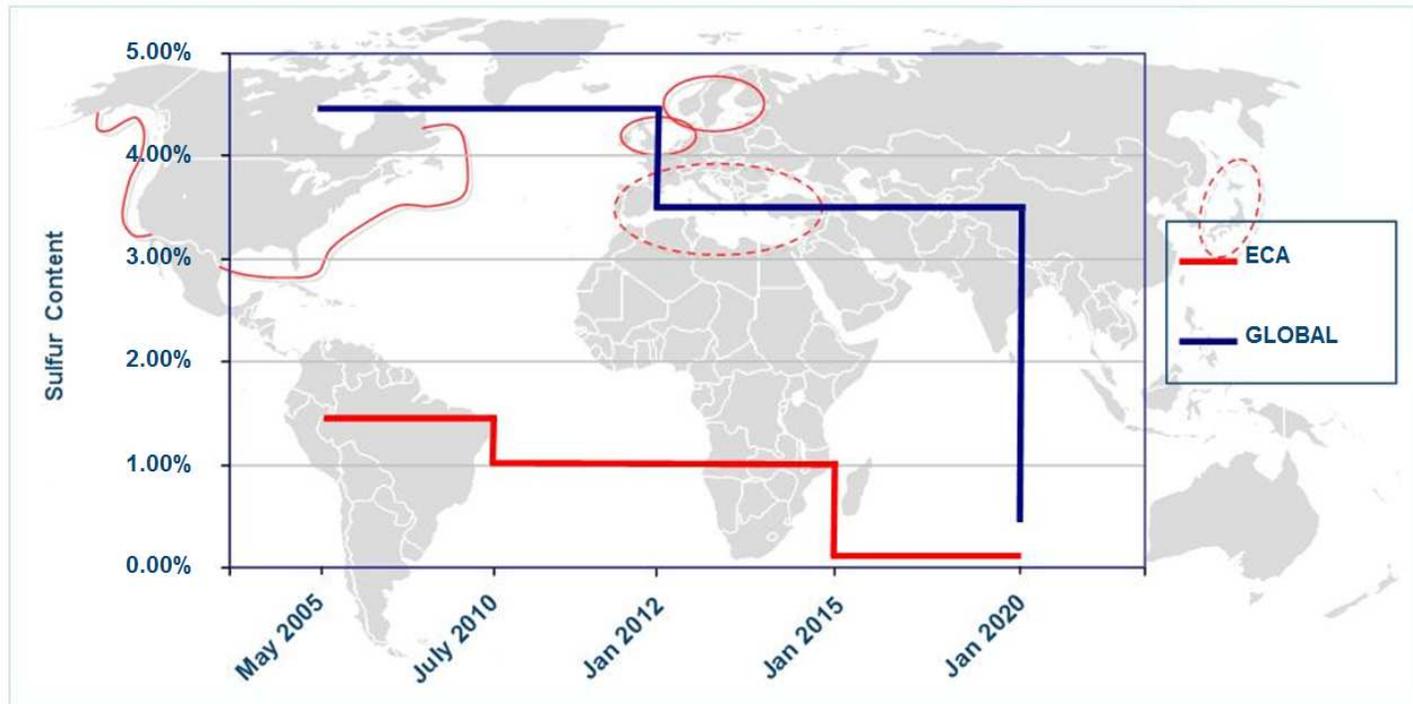
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# 0.1% Sulfur Limits in ECA effective 2015



— Emission Control Area  
 - - - Potential Future Emission Control Areas

## Key Drivers for Dual Fuel

- § Low Sulphur (0.1%) fuel regulations in ECA regions as of 2015
- § High fuel cost delta of MDO vs. LNG Amortization time of DF Retrofit by fuel cost savings ?
- § Increasing focus on "Green Image" ?

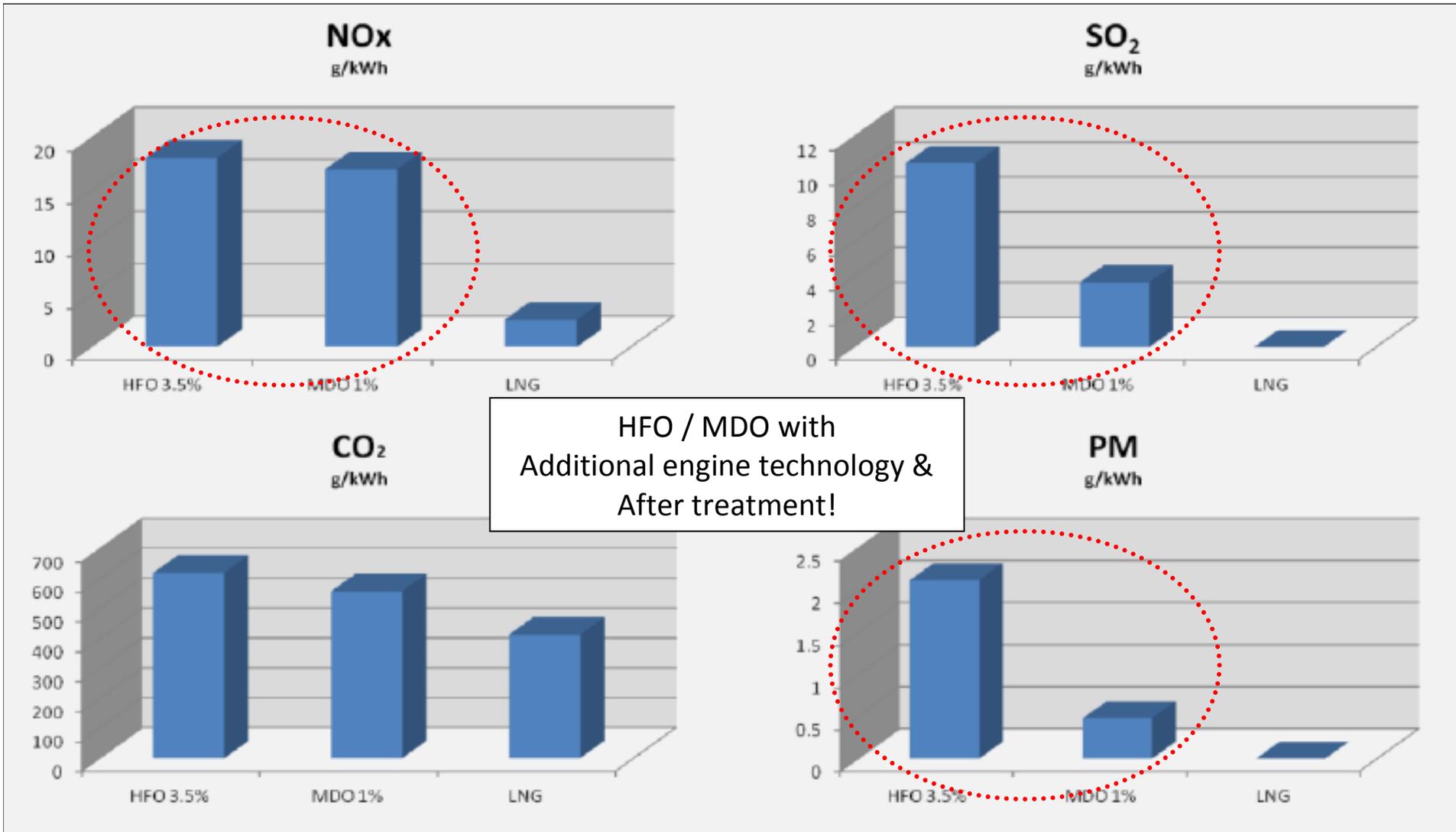
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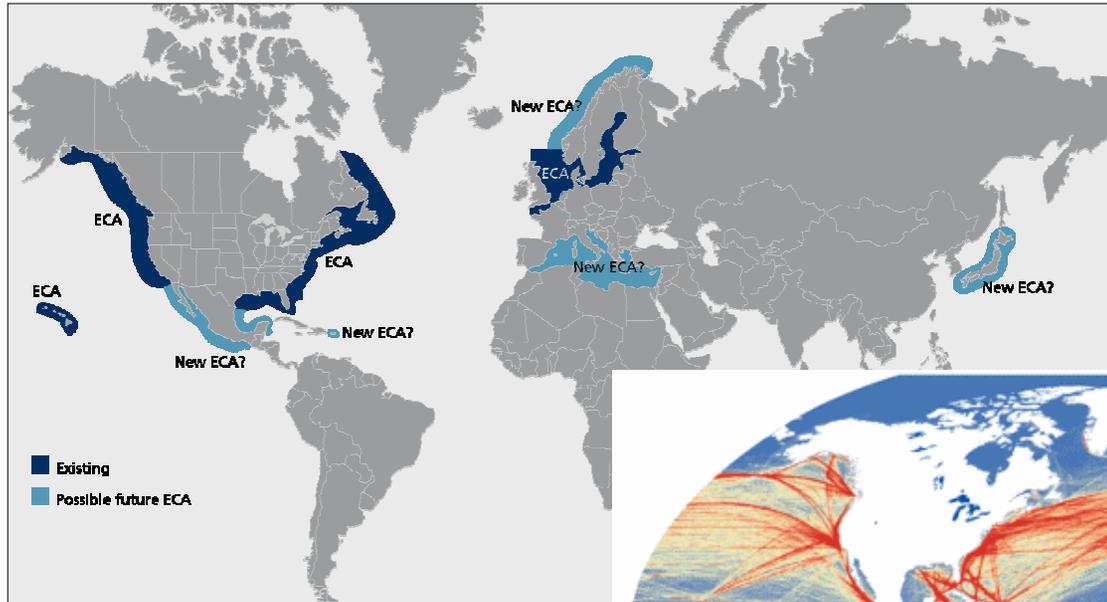
# Emissions – Differ with the fuel used



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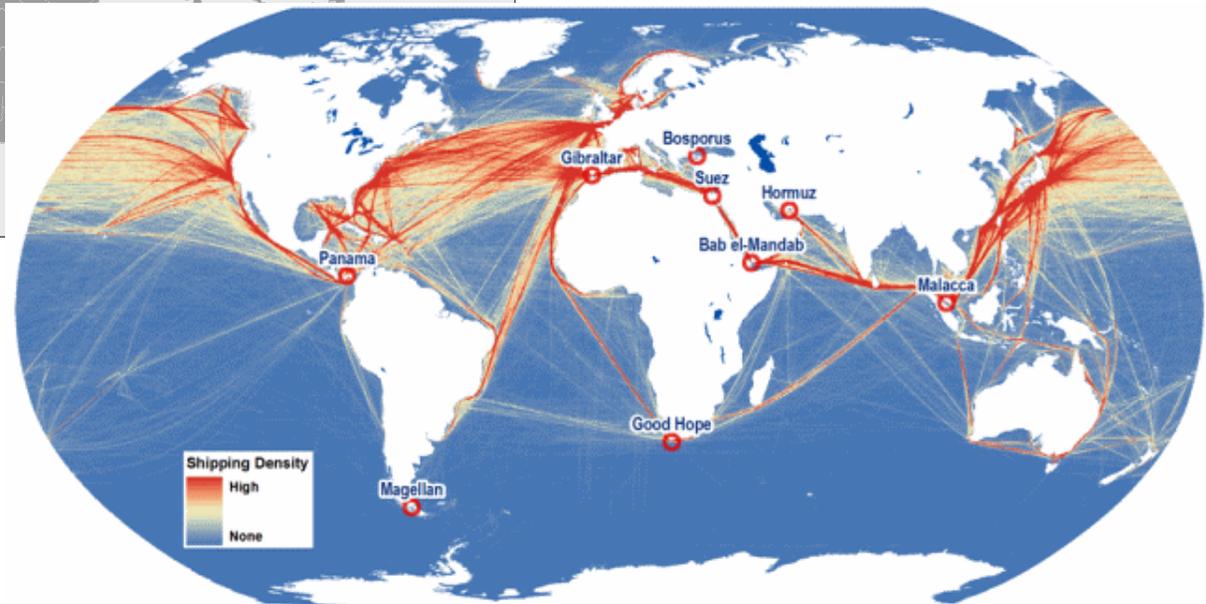
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# ECA Zones - Area of Operation



## Logistics

Area of Operation  
- Percentage, Routing & Distance  
LNG infrastructure  
Refuel cycle  
Vessel charter time  
Retail



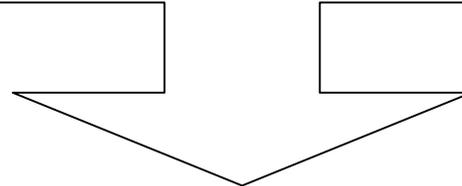
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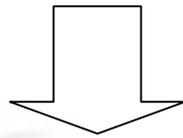
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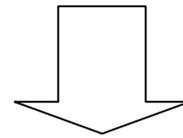
# Meeting the Emissions regulations With Operational Efficiency



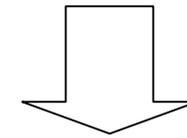
## Technical Requirements Emissions Solutions



**Low sulfur Fuel**  
Operating cost+



**Heavy fuel**  
Engine Complexity+  
After treatment



**LNG**  
Engine Design?  
Cargo space?  
Availability?

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# Operational cost – Choice of solution



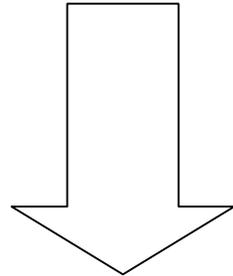
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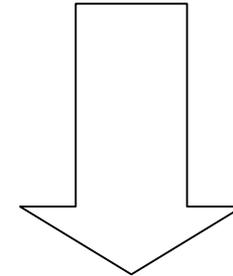
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**LNG – Running on GAS**

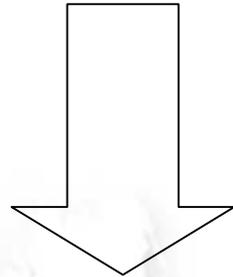


**Dual Fuel**

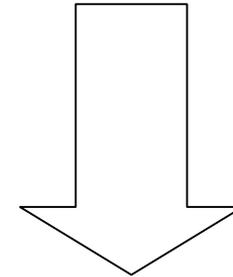


**Spark Ignited**

**If Yes Then ?**



**Mechanical**



**Diesel Electric**

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# Where is Caterpillar in all of this?

**Dual Fuel?**

**Spark Ignited?**

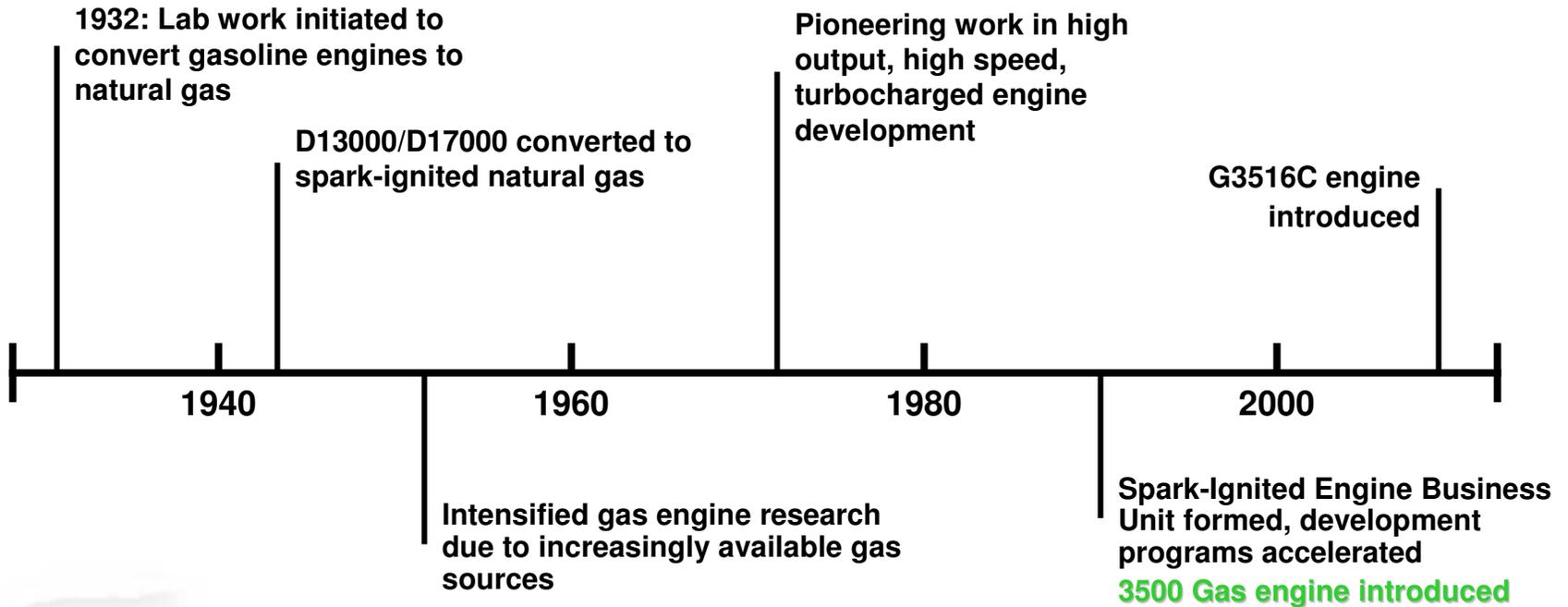
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# Marine Gas Genset – Caterpillar Gas History



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# Caterpillar Gas Engine Product Range

- Current Gas Engine Range
  - G3300, G3400, G3500, G3600, & GCM34 platforms
  - MWM brand
  - 67 – 6100kW
- First 3500 Gas engine produced late 80's
- Markets
  - Electric power & gas compression
  - Future Marine & Petroleum
- Engines Shipped
  - 18'000+ G3500 Sold
  - 4'000+ G3600 Sold

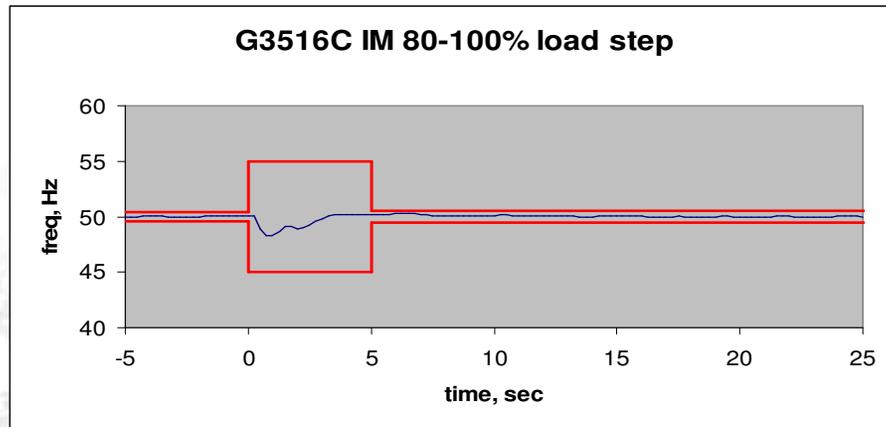


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# 3500 Marine Gas Genset

- Marinization of an existing Gas Generator Set
- Technical feasibility study completed
- Technical review conducted with multiple Marine Classification Societies
- Gas Technology Demonstration Project ready for technology validation



Capable to meet MCS requirements at 20% block load



**G3516C**  
**Technology Demonstrator**  
1555ekW @ 1500 rpm

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# Dual Fuel vs. Spark Ignited - Considerations

## Gas Only (Spark Ignited):

- æ Expected to Meet IMO III / EPA Tier 4 without After-treatment
  - æ Biggest Fuel Cost Savings
  - æ Simple and well proven Engine / Control System
  - æ Durability Better Than Diesel
- Slower Response than Diesel  
Requires Regular Access to Gas Supply



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# Dual Fuel MaK M46DF

- Shares engine platform with M43C
- 460mm bore
- Conventional diesel system
- Common rail pilot injection system
- HFO / MDO / LNG capable
- Running in test bed since Q3 2011



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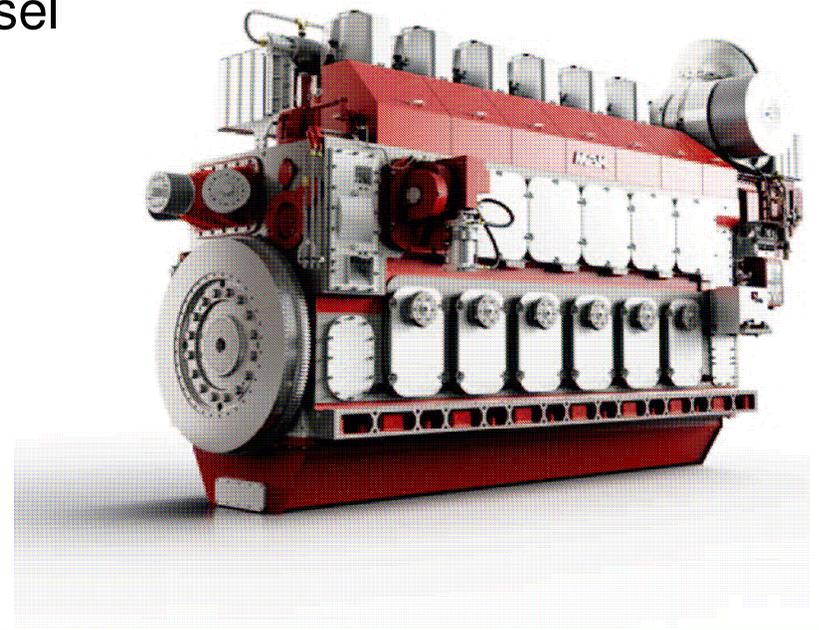
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# Dual Fuel vs. Spark Ignited - Considerations

## Dual Fuel:

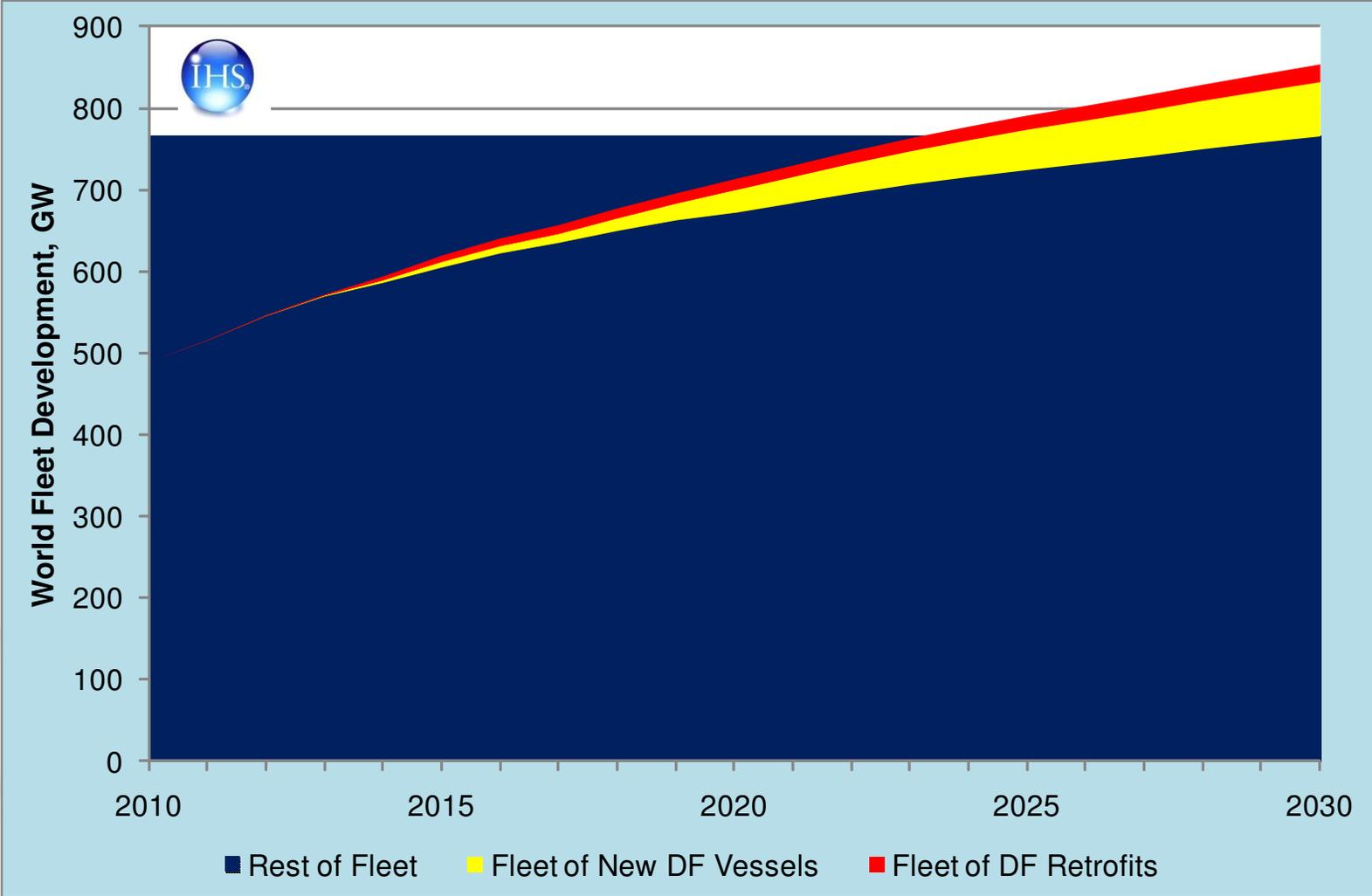
- æ Transient Response & Acceleration Similar to Diesel
- æ Fuel Flexibility – Diesel, Gas, HFO or Mix
- Requires more Sophisticated Controls
- Fuel Cost Savings Limited by Need for Diesel Pilot
- Durability expected to be similar to Diesel



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# Future of Dual Fuel

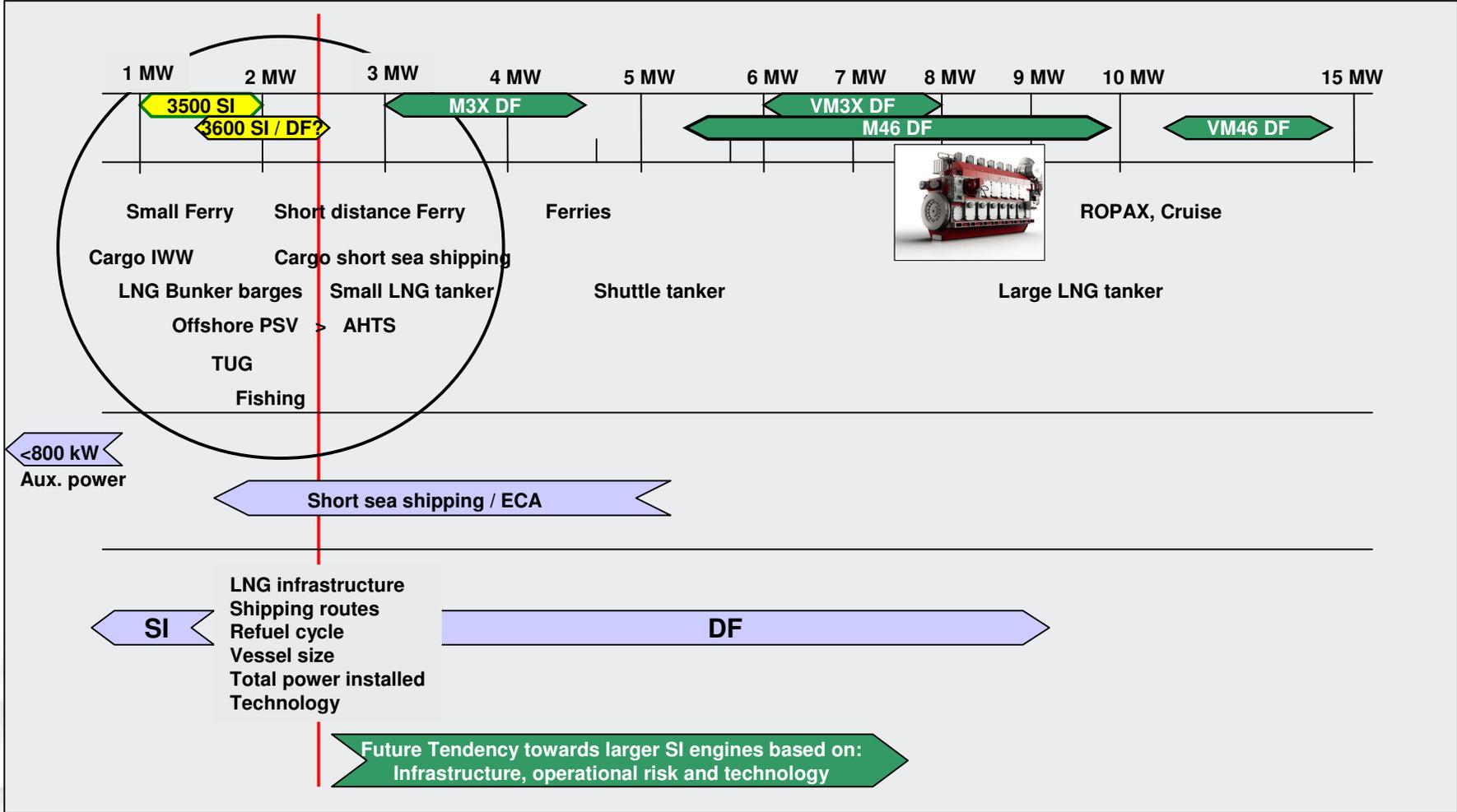


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# LNG engine strategy



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# Summary

- New emission regulations are coming!
- Future fuel price/availability is an uncertain factor
- LNG is a good option, but not the only one

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# Thank you!

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