Powering Dredges – Session 7C
Thursday May 16, 2016

Legislation & Innovation in the Lifecycle Consideration of Dredging Industry Power Solutions

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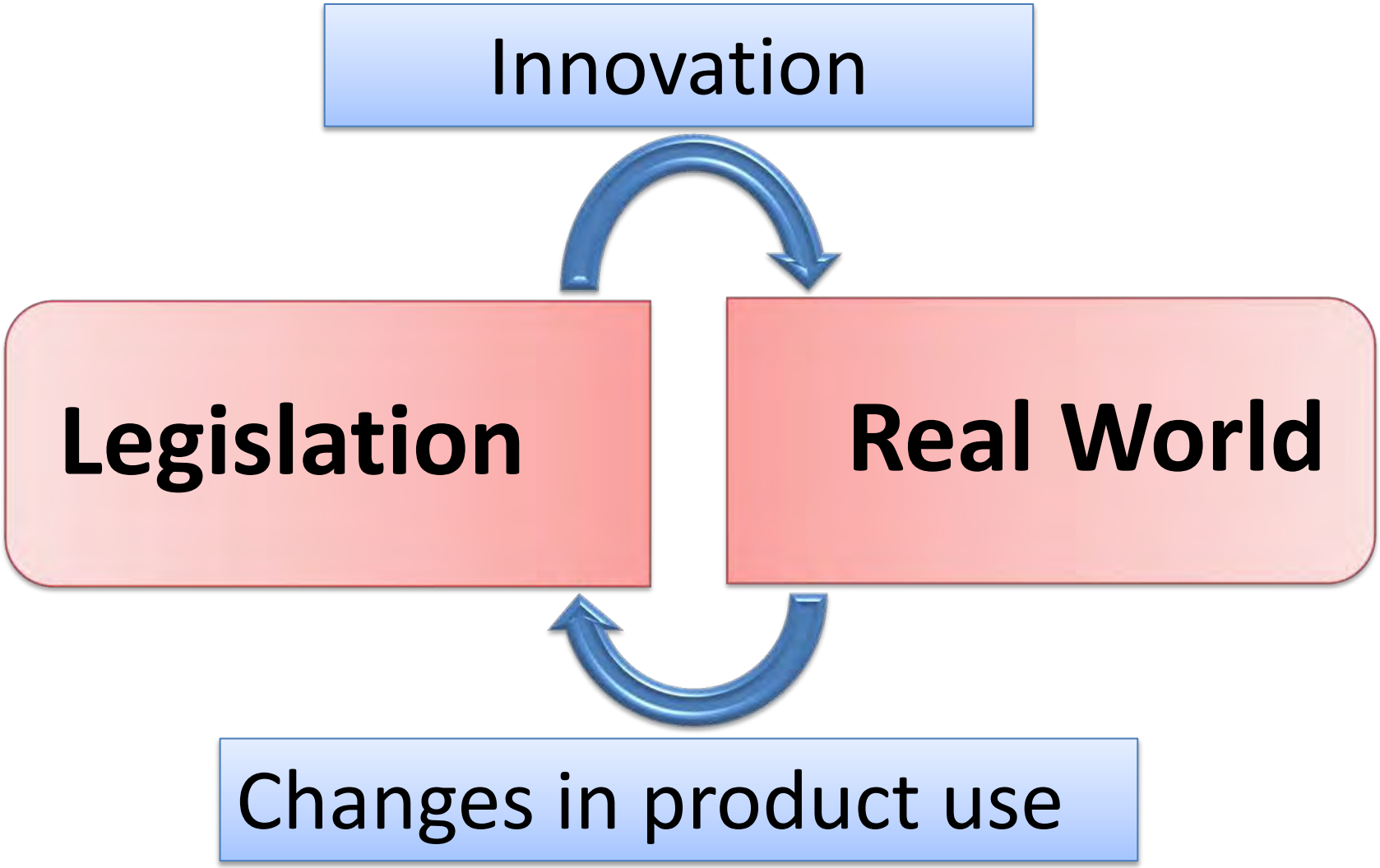
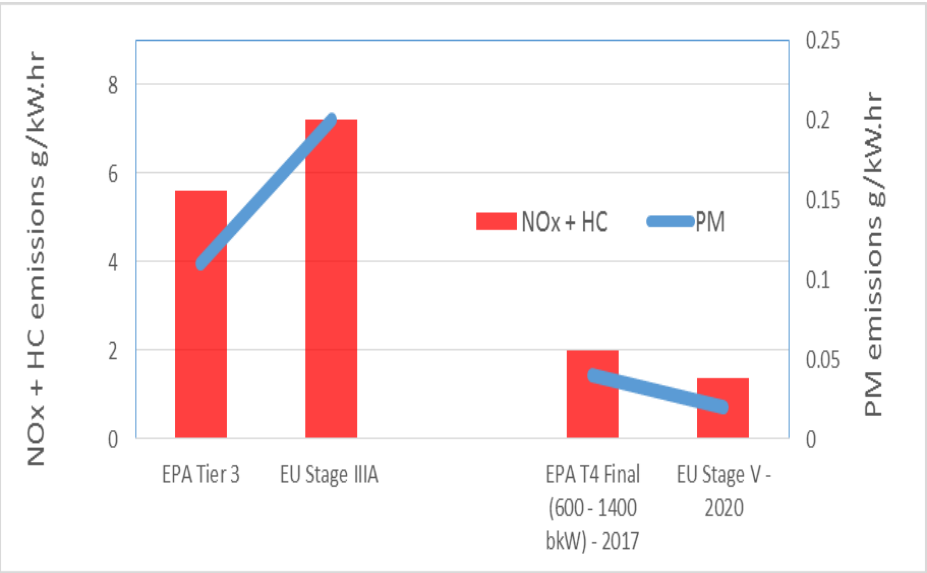
Introduction

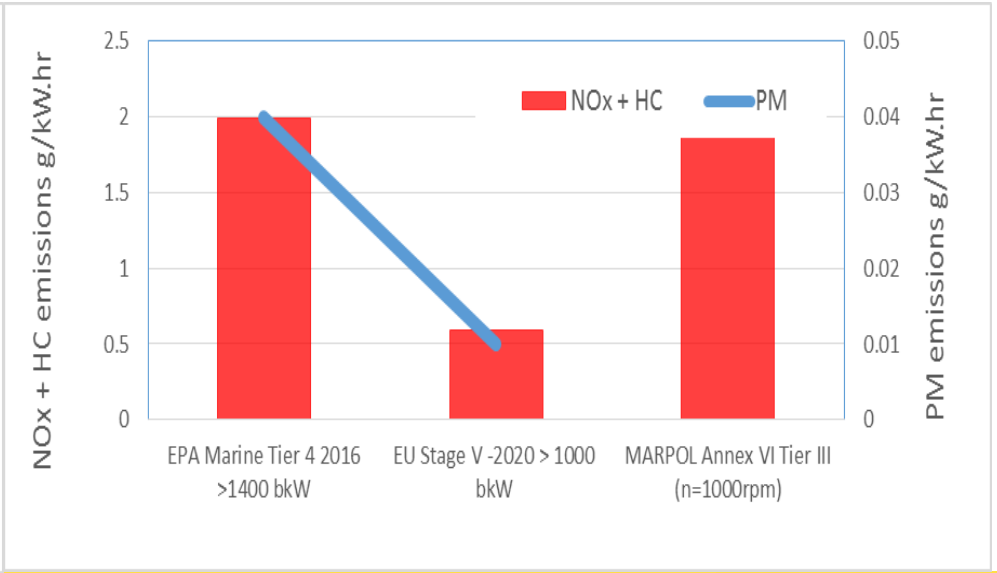


Legislation – Innovation cycle

- Policy Development
- Regulatory Development
- Product Development

Current and future regulations for 300 bkW and >1000 bkW diesel exhaust solutions

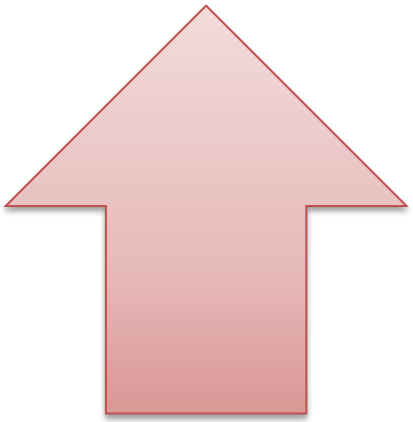




Engine Emissions from Diesel

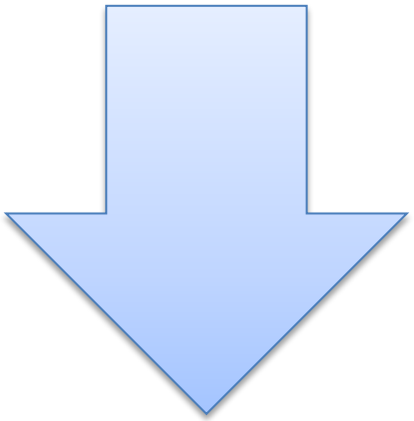
- NO_x

NO & NO_2



High Intensity

- PM
- HC
- CO

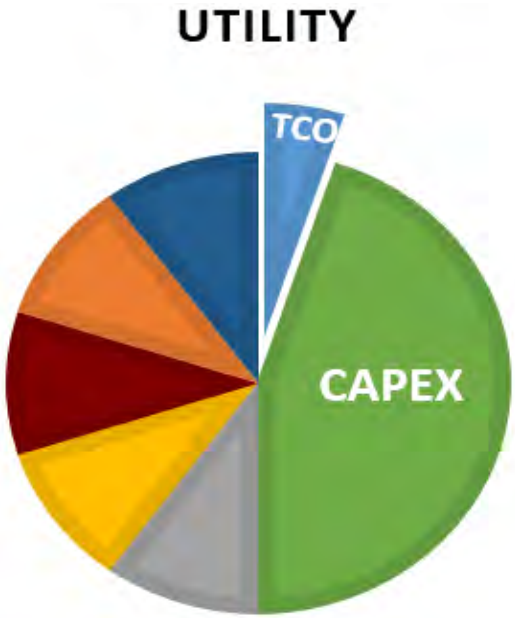


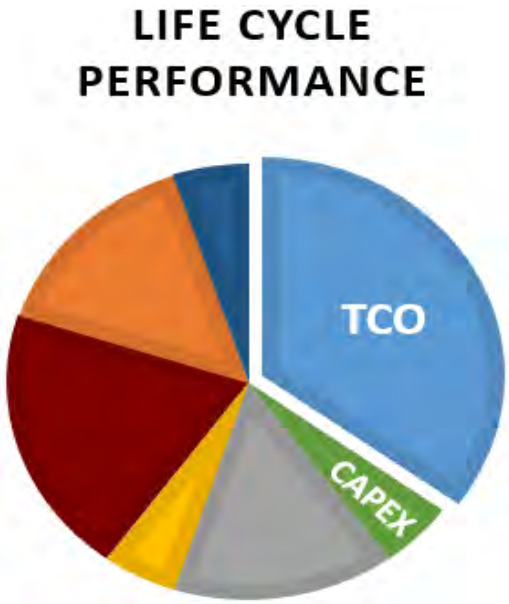
Low Intensity

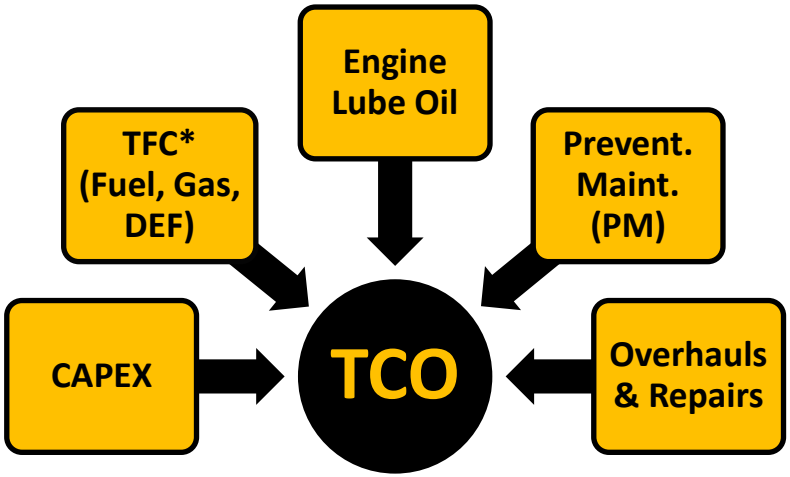
Diesel Engine Innovation

	Reduces	Increases	Benefits
HP Fuel injection	PM	NO_x	Economy
Turbocharging	PM	NO_x	Power
EGR	NO_x	PM	-
Particulate filter	PM	-	-
Oxidation catalyst	CO/HC	-	-
SCR	NO_x	-	Economy

Utility vs Lifecycle Value







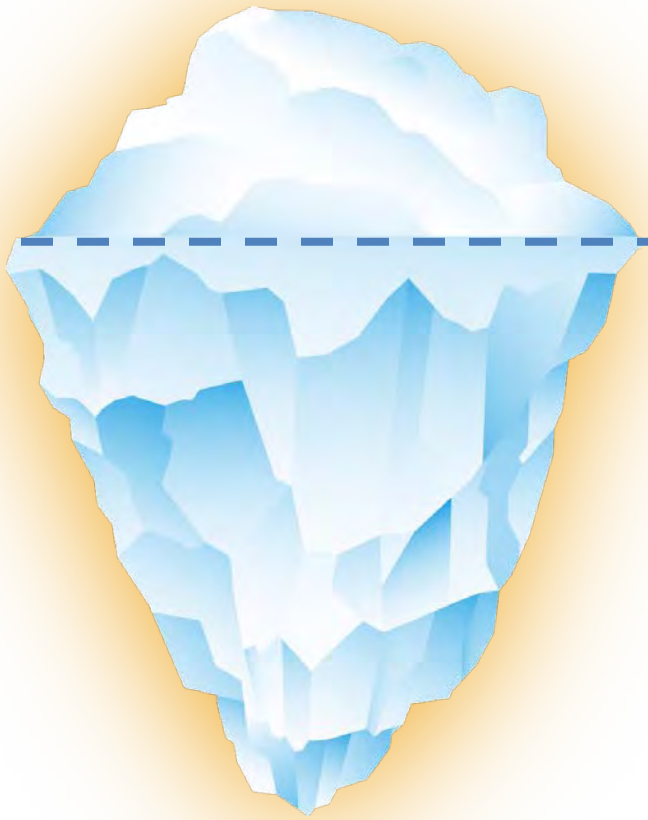
Costs ($)

- Owning Costs
- Operating Costs
- Downtime Costs

Benefits

- Performance
  - Productivity
  - Power
- Features

Upfront Costs - The Tip of the Iceberg



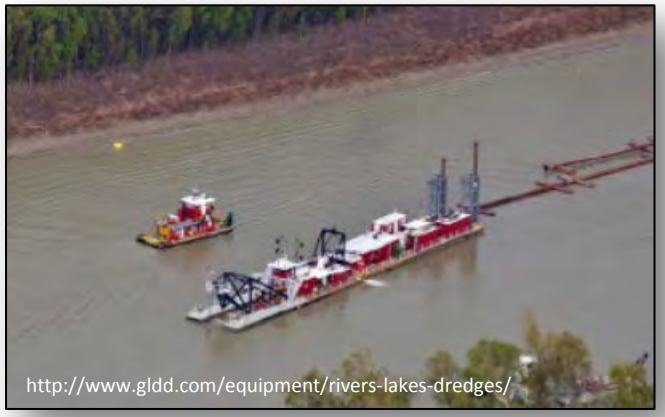
Owning / Capital Costs

- CAPEX (Total Installed Costs)
- RV at replacement (applicable to repower)

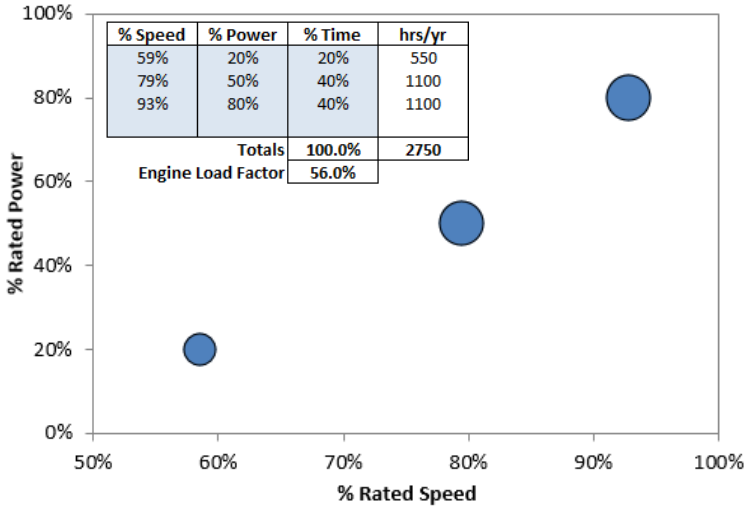
Operating Costs

- **Energy or Total Fluid Consumption - TFC (Diesel, DEF, LNG)**
- Lube Oil Consumption
- Preventative Maintenance (Coolant, filters, setting lash, parts & labor)
- Planned Overhauls & Repairs (parts & labor)

TCO Scenario 1: *Small Inland Suction Dredge*



- Vessel Type: 130ft long, ~50ft suction depth
- Engine Power: 310-340 bkW (1 high spd engine)



TCO Analysis Inputs & Assumptions

- Used Caterpillar engine TCO tool EVA™ (Engine Value Analysis) for comparison
- U.S. Based Repower Scenario: Tier 2 Marine or Tier 3 Non-Road to Tier 3 Marine or Tier 4F Non-Road
- 15-yr life cycle, 2750 hrs/yr
- 56% engine load factor
- $2.50/gallon diesel fuel
- $1.80/gallon DEF (diesel exhaust fluid)
- $10/gallon engine lube oil
- $100/hr labor rate for service/repairs
- 3% year over year escalation on diesel & lube oil, 1.5% on DEF, parts & labor

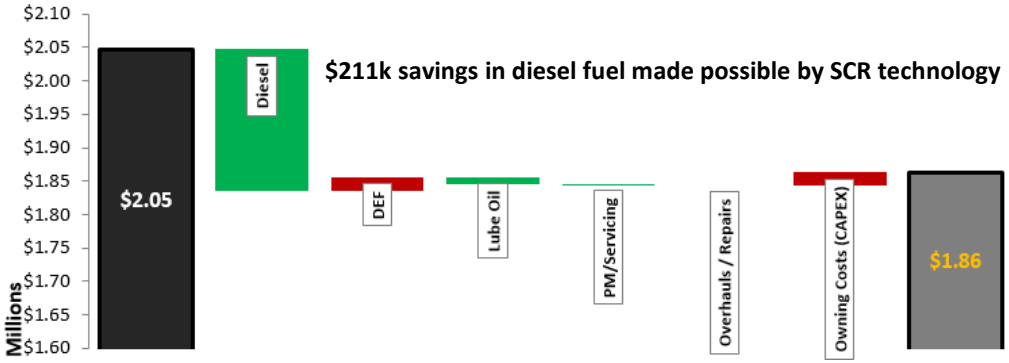
TCO Scenario 1: *Small Inland Suction Dredge*

Engine 1			Engine 2			Engine 3			Engine 4		
Emissions Compliance	EPA Tier 2		Emissions Compliance	EPA Tier 3		Emissions Compliance	EPA Tier 3		Emissions Compliance	EPA Tier 4F	
Engine Type	Diesel - High Spd.		Engine Type	Diesel - High Spd.		Engine Type	Diesel - High Spd.		Engine Type	Diesel - High Spd.	
Rating Type	Max. Continuous		Rating Type	Max. Continuous		Rating Type	Max. Continuous		Rating Type	Max. Continuous	
ENTER Engine Model	C12 Marine		ENTER Engine Model	C15 Industrial		ENTER Engine Model	C9.3 Marine		ENTER Engine Model	C13 Industrial	
ENTER Rated Power	339	*bkW*	ENTER Rated Power	328	*bkW*	ENTER Rated Power	310	*bkW*	ENTER Rated Power	328	*bkW*
ENTER Rated Speed	2,100	*rpm*	ENTER Rated Speed	2,100	*rpm*	ENTER Rated Speed	2,100	*rpm*	ENTER Rated Speed	1,800	*rpm*
Low Idle Speed	600	*rpm*	Low Idle Speed	900	*rpm*	Low Idle Speed	600	*rpm*	Low Idle Speed	900	*rpm*
Power Normalization	Yes		Power Normalization	Yes		Power Normalization	Yes		Power Normalization	Yes	
Data Tolerance Spec	SAE +/-3%		Data Tolerance Spec	SAE +/-3%		Data Tolerance Spec	SAE +/-3%		Data Tolerance Spec	SAE +/-3%	
Aftertreatment	No SCR		Aftertreatment	No SCR		Aftertreatment	No SCR		Aftertreatment	SCR	
									DEF Concentation	32.5%	

Select Baseline
C15 Industrial T3
328bkW 2100rpm

Total Cost of Ownership Comparison

Select Comparison
C13 Industrial T4F
328bkW 1800rpm



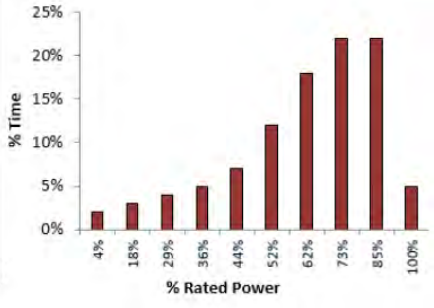
$211k savings in diesel fuel made possible by SCR technology

TCO Scenario 2: *Medium Trailing Suction Hopper Dredge*

http://www.20sim.com/images/stories/Factsheets/Factsheet%20Boskalis.pdf

- Vessel Type: 100m long, ~45m dredging depth
- 5000 m^3 capacity hopper volume
- Engine Power: 5420 bkW (2 medium spd engines)

% Speed	% Power	% Time	hrs/yr
35%	3.7%	2%	80
60%	18.4%	3%	120
70%	29.2%	4%	160
75%	35.9%	5%	200
80%	43.5%	7%	280
85%	52.2%	12%	480
90%	62.0%	18%	720
95%	72.9%	22%	880
100%	85.0%	22%	880
100%	100%	5%	200
	Totals	100.0%	4000
	Engine Load Factor	63.8%	



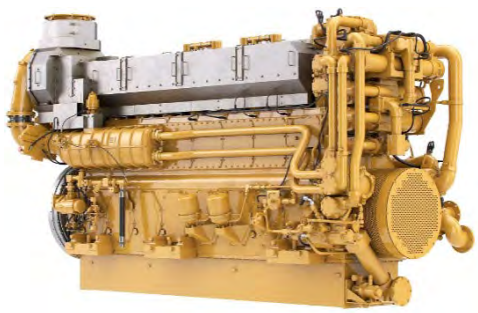
TCO Analysis Inputs & Assumptions

- Used Caterpillar engine TCO tool EVA™ (Engine Value Analysis) for comparison
- IMO Flagged Repower Scenario: IMO II to IMO III medium spd engines
- 20-yr life cycle, 4000 hrs/yr
- 64% engine load factor
- $2.25/gallon diesel fuel
- $1.10/gallon DEF (diesel exhaust fluid)
- $11/gallon engine lube oil
- $100/hr labor rate for service/repairs
- 3% year over year escalation on diesel & lube oil, 1.5% on DEF, parts & labor

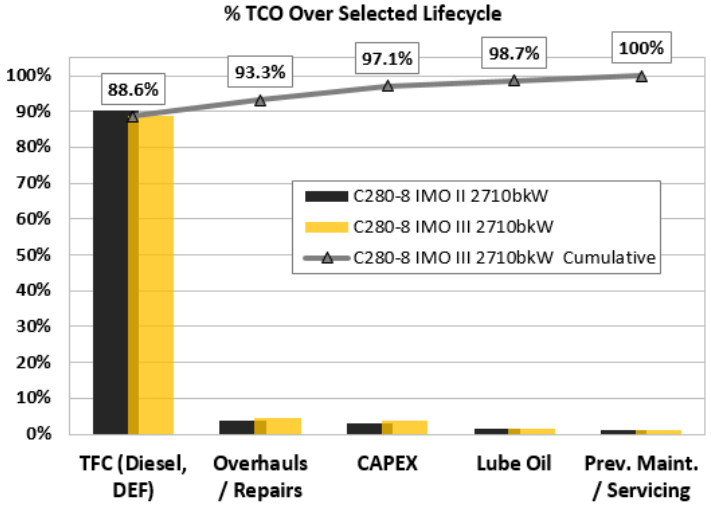
TCO Scenario 2: *Medium Trailing Suction Hopper Dredge*

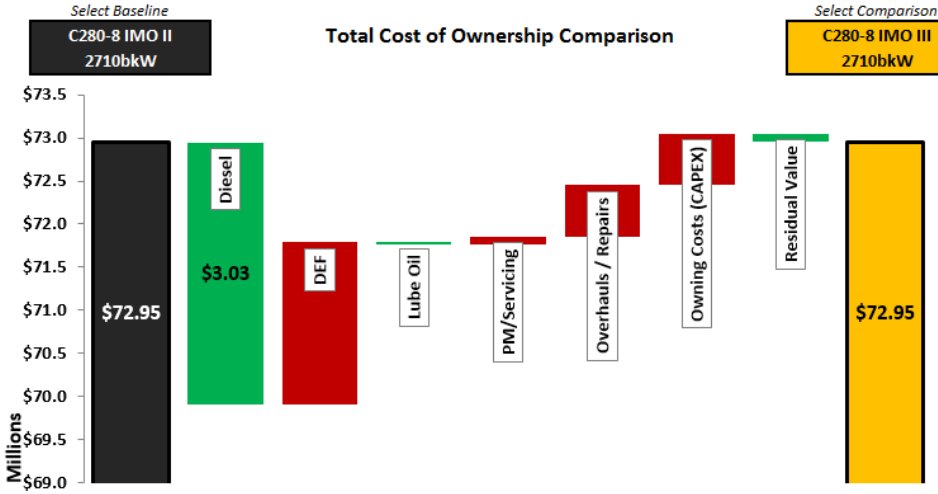
Engine 1		
Engine OEM	Cat®	
Emissions Compliance	IMO II	
Engine Type	Diesel - Med. Spd.	
Rating Type	MCR (Med. Spd.)	
ENTER Engine Model	C280-8	
ENTER Rated Power	2,710	bkW
ENTER Rated Speed	1,000	rpm
Low Idle Speed	350	rpm
Power Normalization	Yes	
Data Tolerance Spec	SAE +/-3%	
Aftertreatment	No SCR	
DEF Concentation	32.5%	

Engine 2		
Engine OEM	Cat®	
Emissions Compliance	IMO III	
Engine Type	Diesel - Med. Spd.	
Rating Type	MCR (Med. Spd.)	
ENTER Engine Model	C280-8	
ENTER Rated Power	2,710	bkW
ENTER Rated Speed	1,000	rpm
Low Idle Speed	350	rpm
Power Normalization	Yes	
Data Tolerance Spec	SAE +/-3%	
Aftertreatment	SCR	
DEF Concentation	32.5%	



- **30% increase in CAPEX for IMO III solution, added DEF costs, and incremental SCR maintenance & replacement costs all offset by savings in diesel fuel**





Closing Remarks

- Emissions legislation landscape for dredging industry power solutions can be complex and challenging to navigate
- Engine innovation also evolves with emissions legislation to avoid customer value erosion
- Important to precisely model lifecycle costs of engine solution alternatives against unique business and productivity demands
- Ultimate win-win scenario of cleaner running engines and decreased TCO is actually possible