IMO TIER III COMPLIANCE USER PERSPECTIVE

MARPOL 2020 & STAKEHOLDER READINESS

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IMO TIER III

BACKGROUND

- **MARPOL 73/78** – " International Convention on the Prevention of Pollution from Ships" – Contains IMO Ship Pollution Rules
- 27th September 1997 – Inclusion of Annex VI to the MARPOL Convention by "1997 Protocol"
- **Annex VI – "Regulations for the Prevention of Air Pollution from Ships"**
- Sets limits for **NOx** and **SOx** emissions from Ship Exhausts **(Regulations 13,14)**
- Prohibits deliberate emissions of Ozone depleting substances from ships of 400GT & above
- Emission Standards **FOR NOX** are commonly referred to as **Tier I, Tier II, Tier III standards**

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AMENDMENTS

- **1997 Protocol – Tier I** – Applicable to New Engines > 130 kW
  - Installed on vessels constructed on or after 1st January 2000
  - or which undergo a major conversion after that date
  - Also applicable to Fixed & floating rigs and to Drilling platforms

- **2008 Amendments – Tier II , Tier III** – Adopted in October 2008
  - Tier II and Tier III NOx emission Standards for New Engine
  - Tier I NOx requirements for Pre-2000 Engines

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EMISSION CONTROL AREAS

Emission Control & Fuel Quality Requirements are broadly divided into –

1. **Global Requirements**

2. More Stringent requirements applicable to ships in **Emission Control Areas (ECA)**

Emission Control Area designated for

- SOx (Sulfur Oxides) and
- PM (Particulate Matter) or
- NOx (Nitrogen Oxides) or
- All Three Types

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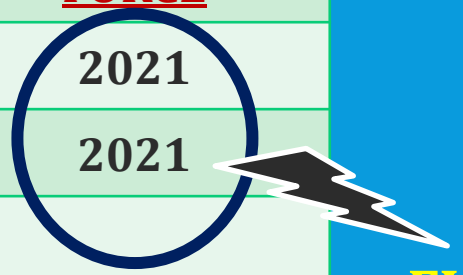
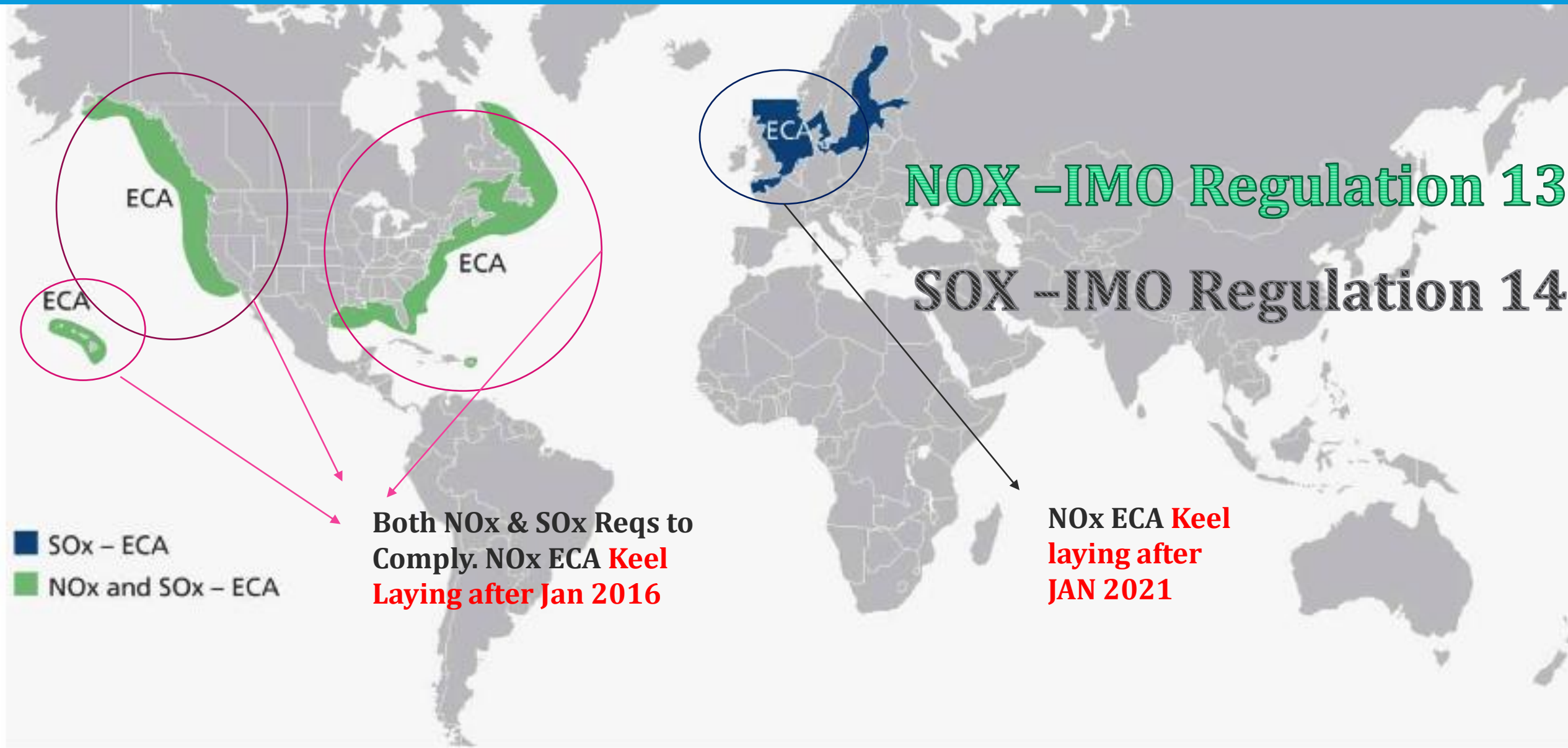
EMISSION CONTROL AREAS

- Existing Emission Control Areas Include:

LOCATION	SOX		NOX	
	ADOPTED	ENTRY INTO FORCE	ADOPTED	ENTRY INTO FORCE
1. BALTIC SEA	1997	2005	2016	**2021**
2. NORTH SEA	2005	2006	2016	**2021**
3. NORTH AMERICAN ECA (incl most of US & Canada coast)	2010	2012	2010	2012
4. US Caribbean ECA, incl Puerto Rico & US Virgin Islands)	2011	2014	2011	2014



FUTURE AREA



NOX –IMO Regulation 13

SOX –IMO Regulation 14

Both NOx & SOx Reqs to Comply. NOx ECA Keel Laying after Jan 2016

NOx ECA Keel laying after JAN 2021

What Future Looks Like

IMO TIER III

NOx EMISSION **STANDARDS**

- Emission Limits of MARPOL Annex VI applicable to each Marine Diesel Engine with a **Power output > 130 kW** installed on a Ship

- Marine Diesel Engine – Any Reciprocating internal combustion engine operating on Liquid or Dual Fuel

- **Not Applicable to** –
  1. Engines used solely for Emergencies
  2. Engines on ships operating solely within waters of the state in which they're flagged**

  **Subject to alternative NOx Control measure

IMO TIER III

NOx EMISSION **LIMITS**

- Limits are dependent on **Engine maximum operating speed (n / rpm)**

- **Tier** of the engine is **dependent** on the **Date of Construction of the Vessel**.

  Date of Construction means **KEEL LAID**

- In case of Major modifications, with a non-identical or an additional engine, Standards of the Regulation at the Time of Modification will be applicable

Tier I & II limits are global.

Tier III Standards applicable in NOx ECA areas designated by IMO Regulations

MAJOR CONVERSION

A MODIFICATION on or after 1 JAN 2000 of a Marine diesel engine that has not already been certified to the standards of Tier I, II or III –

1) **2.1.1** The Engine is **Replaced** by Marine Diesel Engine or an **Additional** Marine Diesel Engine is Installed (or)
2) **2.1.2** Any Substantial Modification as defined in the revised NOx Technical Code 2008, is made to the engine (or)
3) **2.1.3** The **MCR** of the engine **is increased** by **more than 10%** compared to the MCR of the original certification of engine.

For a major conversion – Replacement / Addition – Standards in force at the time of Replacement / Addition shall Apply

MAJOR CONVERSION – ON/AFTER 01.01.16

- On or After 1st JAN 2016 – In case of REPLACEMENT ENGINES – if it is not possible for such a replacement engine to meet standards of IMO Tier III regulations, then that replacement engine shall meet standards of Tier II regulations. *<<Discussed in Slides 23, 24>>*
- Guidelines are to be developed by the Organization to set forth the criteria when it is not possible to meet the Tier III standards. *<< Discussed in 23, 24>>*
- IN CASE OF **2.1.2 & 2.1.3** <<**Refer Previous Slide**>>
- For Ships Constructed Prior 1 Jan 2000 – **Tier I** Standards shall Apply
- For Ships Constructed After 1 Jan 2000 – Standards in Force at the **Time Ship was constructed** will apply

IMO TIER III

STANDARDS

Tier	Ship construction date on or after	Total weighted cycle emission limit (g/kWh) n = engine's rated speed (rpm)		
		n < 130	n = 130 - 1999	n ≥ 2000
I	1 January 2000	17.0	$45 \cdot n^{(-0.2)}$ e.g., 720 rpm – 12.1	9.8
II	1 January 2011	14.4	$44 \cdot n^{(-0.23)}$ e.g., 720 rpm – 9.7	7.7
III	1 January 2016	3.4	$9 \cdot n^{(-0.2)}$ e.g., 720 rpm – 2.4	2.0

HOW TO MEET – IMO **TIER II** STANDARDS

- Tier II Standards are expected to be met by Combustion process Optimization

- The Parameters examined by Engine manufacturers include
  1. Fuel injection timing
  2. Pressure & Rate/ Rate shaping
  3. Fuel nozzle flow area
  4. Exhaust valve timing
  5. Cylinder compression volume

HOW TO MEET – IMO **TIER III** STANDARDS

- Achieving NOx Criteria in many cases is Beyond well known adjustments to Combustion process in 2 Stroke Diesel. They Require Add on Tech.

- Tier III Standards are expected to require following technologies

1. Water induction into the combustion process (via – Fuel, Scavenging air or In-Cylinder)
2. **Exhaust gas recirculation (EGR)**
3. **Selective Catalytic reduction (SCR)**

Other Technologies

Low pressure Gas Engines, Duel Fuel Engines with LNG as a Fuel, Two Stage Turbocharging (Using Miller Cycle), etc.

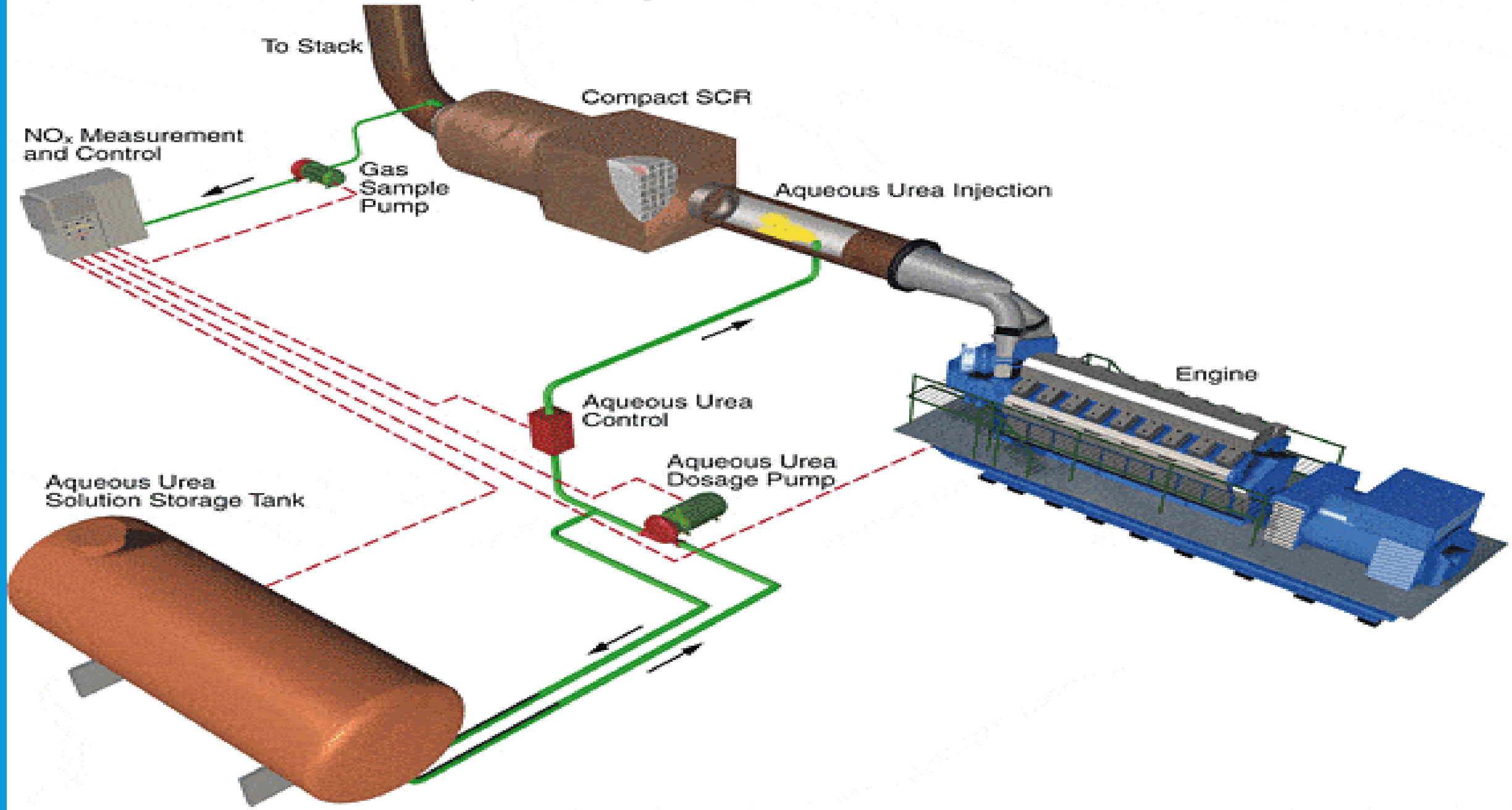
SCAVENGER AIR MOISTURIZING

- Air from the turbocharger, after passing through the compressor, has high temperature.
- Seawater is injected to this high temperature air for cooling and making it saturated. Distillation process makes it possible to use sea water instead of fresh water.
- Humidification of air is controlled by maintaining scavenge air temperature between 60-70 Deg C. Water in saturated air reduces the peak temperature as water has higher heat carrying capacity than air.
- Around 60% NOx reduction is achieved by this method. By using combination of other technologies such as EGR with Scavenge Air Moisturizing, NOx Tier III standards can be achieved.

SELECTIVE CATALYTIC REDUCTION (SCR)

- In this system, **urea or ammonia** is injected in the exhaust gas before passing it through a unit, which consists of special catalyst layer, at a temperature between 300 and 400 Deg C.
- Chemical reaction between Urea/ammonia and NOx in exhaust gases reduces NOx (NO and NO2) to N2.
- SCR unit is installed between the exhaust manifold/receiver and the turbocharger.
- High efficiency turbocharger is required for this system as there is pressure drop across SCR Reactor.
- Engine load should be 40% and above, as NOx is reduced to N2 within specific temperature window (300-400 Deg C).

NO_x Reduction Typically: 85 - 95%

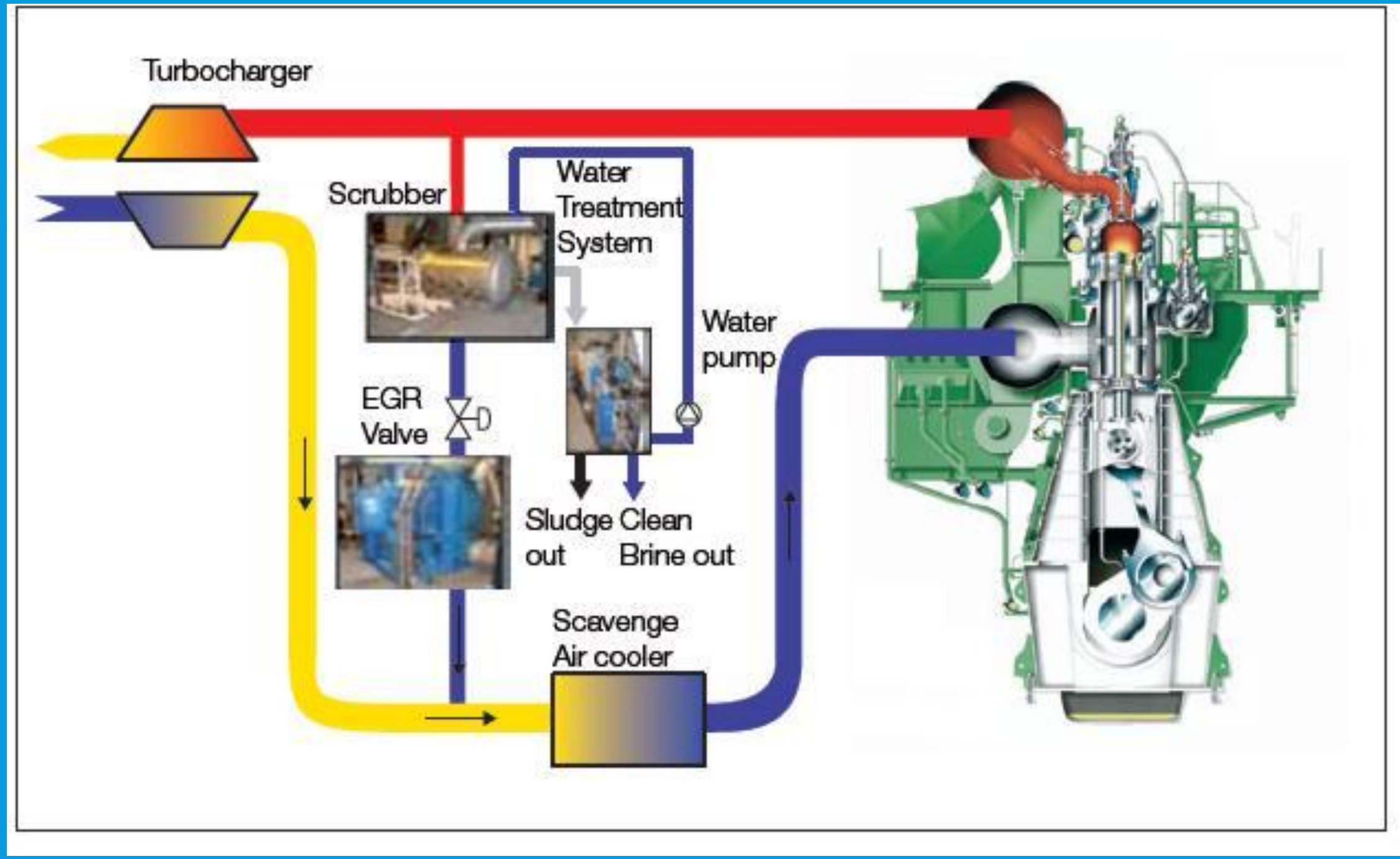


SCR CHALLENGES

- Availability of UREA & Replenishment of UREA Solution
- Space for UREA tanks and Components of SCR
- Engine load has to be maintained above 40% as the chemical reaction of NOx to N2 happens in the window of 300~400`C

EXHAUST GAS RECIRCULATION

- In this technology, part of the exhaust gas after turbocharger is recirculated to scavenge receiver after passing it through the scrubber (exhaust gas washing) unit. Around 50-60% NOx reduction from Tier I is claimed by making use of EGR.
- However discharge of cleaning water requires treatment like purification and separating exhaust gas cleaning sludge. As some countries are against discharge of this water, re-using this water poses corrosion problem.
- NOx reduction takes place due to reduction in excess air (oxygen content) used for combustion, addition of CO_2 and water vapour reduces peak temperatures as both have higher specific heat than air.
- EGR system along with combination of one of the technologies such as altered (delayed) injection method, new design fuel valve, common rail injection principle, electronic engines , Scavenge Air Moisturizing, can be used to comply with Tier III standards.


Turbocharger
Scrubber
Water
Treatment
System
Water
pump
EGR
Valve
Sludge
out
Clean
Brine out
Scavenge
Air cooler

EGR CHALLENGES

- Protection of Components from Highly corrosive Sulfuric Acid which is a byproduct
- Water Carry over from EGR scrubber should be avoided due to risk of contamination by Na2SO4 from Scrubber water
- Corrosion of Non Stainless Steel components such as EGR cooler housing, Cooler elements, Blower wheel, Pipe etc. Components have to be Non corrosive Stainless Steel.
- Installation of NAOH & EGR Sludge tanks
- Difficulties in controlling dousing amount of NaOH
- Installation of a Water Treatment System

WHERE DO WE STAND?

- **VESSEL BUILT *BEFORE 2016***

1. If Vessel Built 2000 – 2011 – For World wide trade including ECA – **TIER I** Standards
2. If Vessel Built 2011 – 2016 For World wide trade including ECA – **TIER II** Standards
3. If Major modification (Replacement/ Addition) after 2016 – To trade in ECA areas – **Tier III** Standards else TIER II

- **VESSEL BUILT *AFTER 2016***

1. Vessel Built after 2016 –To trade in North American ECA Or US Caribbean ECA area – **TIER III**
2. Vessel Built after 2021 – To Trade in Baltic Sea ECA & North Sea ECA area – **TIER III**

EXEMPTION CRITERIA GUIDELINES MEPC 230(65)

- **<u>Non Identical Replacement Engines not required to meet Tier III Standards : Following Criteria will be Considered for Exemption:</u>**

1. Not Commercially Available
2. NOx Reduction Device
    1. Availability of Space
    2. Extensive Heat release could have an adverse impact
3. Non Feasibility of replacement due to other pertinent ship characteristics
    1. Drive Shafts, Reduction gears, Cooling Sys, Exhaust & Ventilation sys, Propeller Shafts
    2. Electrical Sys for Diesel Generators (Indirect Drive engines)
    3. Other Ancillary systems & equipment that would affect choice of Engine
4. Engine adjustment/ matching needed to meet boundary conditions & performance data necessary for SCR operation at all relevant mode points

EXEMPTION CRITERIA GUIDELINES MEPC 230(65)

5. In case of Multi engine arrangement – Need to match a replacement engine within multi-engine arrangement. <<This is for Propulsion Engines >>

6. Structural Integrity shouldn't be compromised because of replacement

CRITERIA NOT CONSIDERED

1. Warranty Period/ Life Expectancy
2. Cost
3. Production Lead time

SHIPOWNER to provide Evidence to ADMINISTRATION that a TIER III engine cannot be installed – Taking the provisions of these Guidelines

SHIPOWNER Should document search for Compliant Tier III engine & explain why closest available engine not appropriate w.r.to Size / Performance

Duly endorsed Document to be kept with replacement engine's EIAPP Certificate

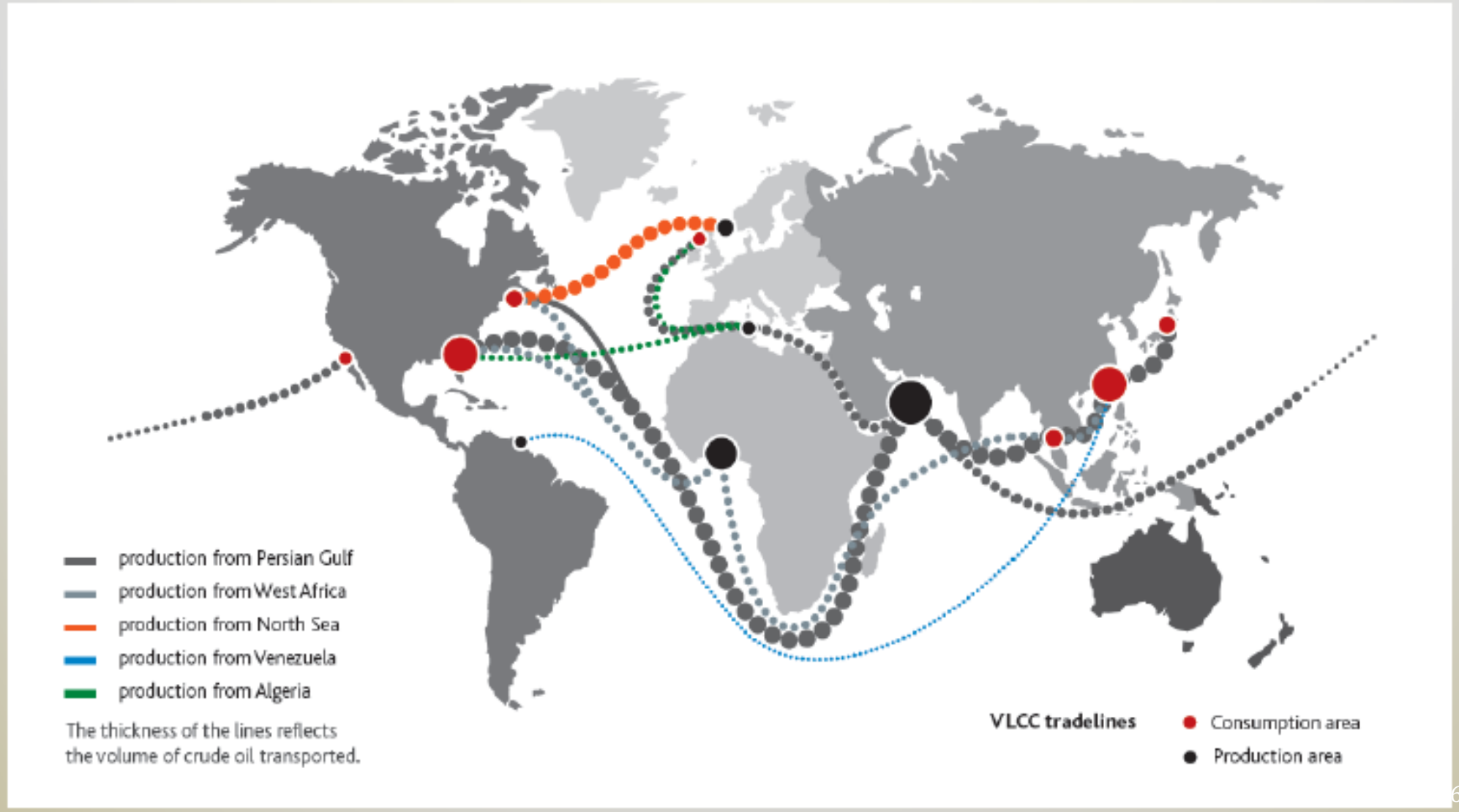
HOW TO MOVE FORWARD?

- Based on the Regulatory requirements, following factors will affect the Owners in their choice of TIER Engines

1. Date of Construction of Ship
2. Date of Major Modification w.r.to Engines & Aux Engines > 130 kW
3. Trading Patterns.
4. CAPEX & Economic Life of the Vessel.

Some MAJOR Trade Routes for Different types of Vessels are illustrated here after for the Owners to make an informed decision for Engine Choice.

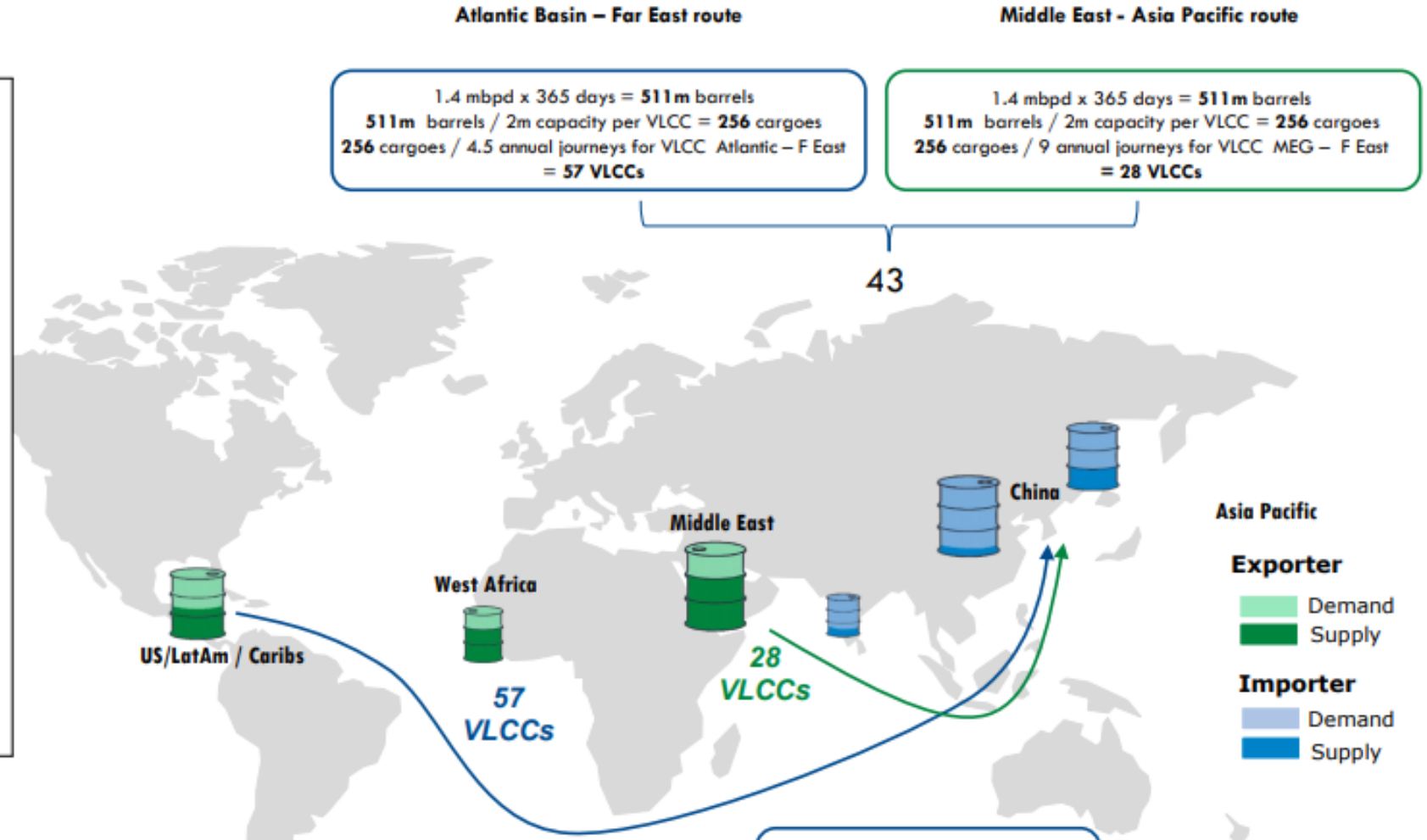
VLCC TRADING ROUTES



TON MILES - INCREASING

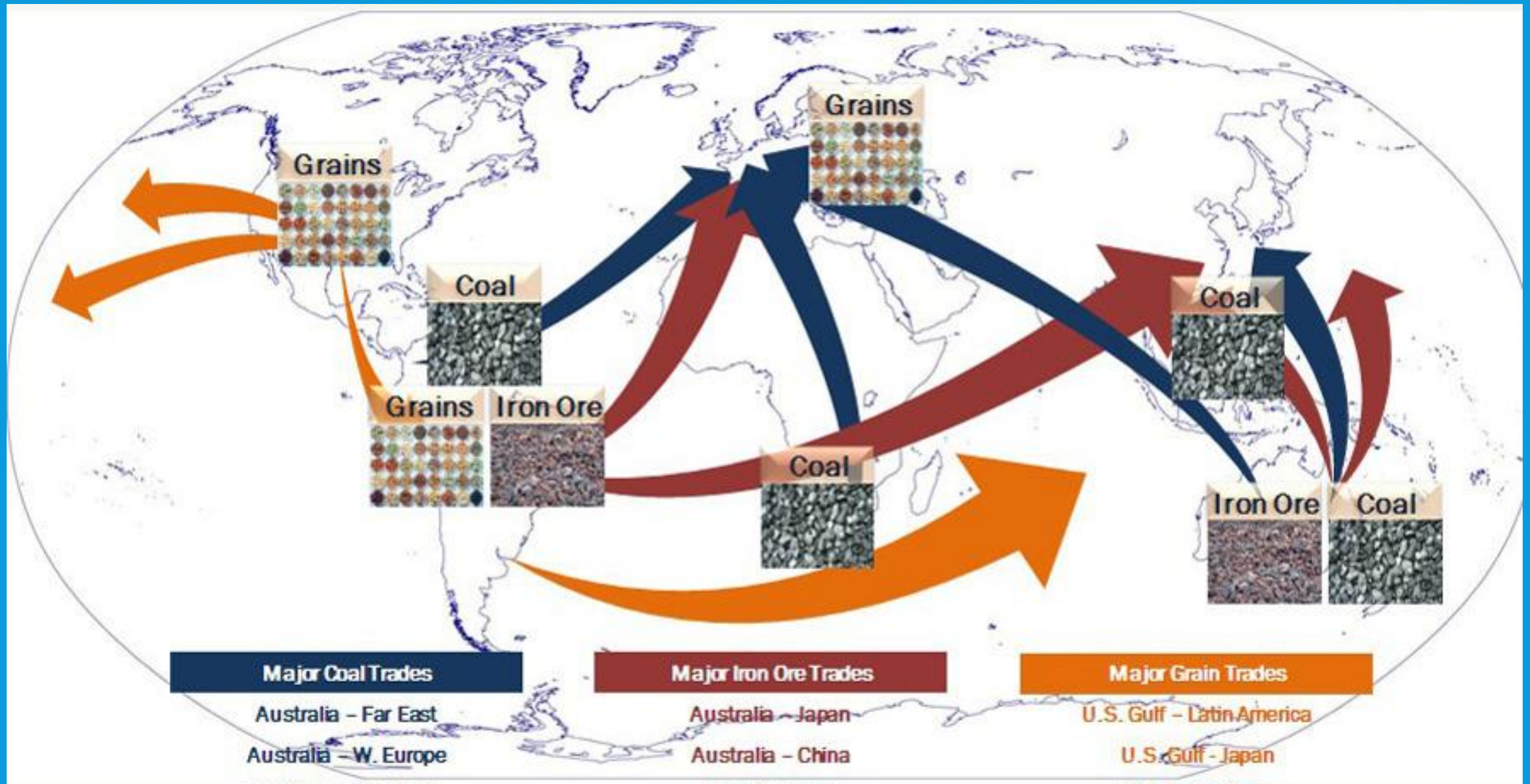
Demand growth all from Far East – key for tankers is where supply is sourced from

Annual demand growth (mbpd)	VLCC equivalents
1.6	49
1.5	46
1.4	**43**
1.3	40
1.2	37
1.1	33
1	30
0.9	27
0.8	24
0.7	21

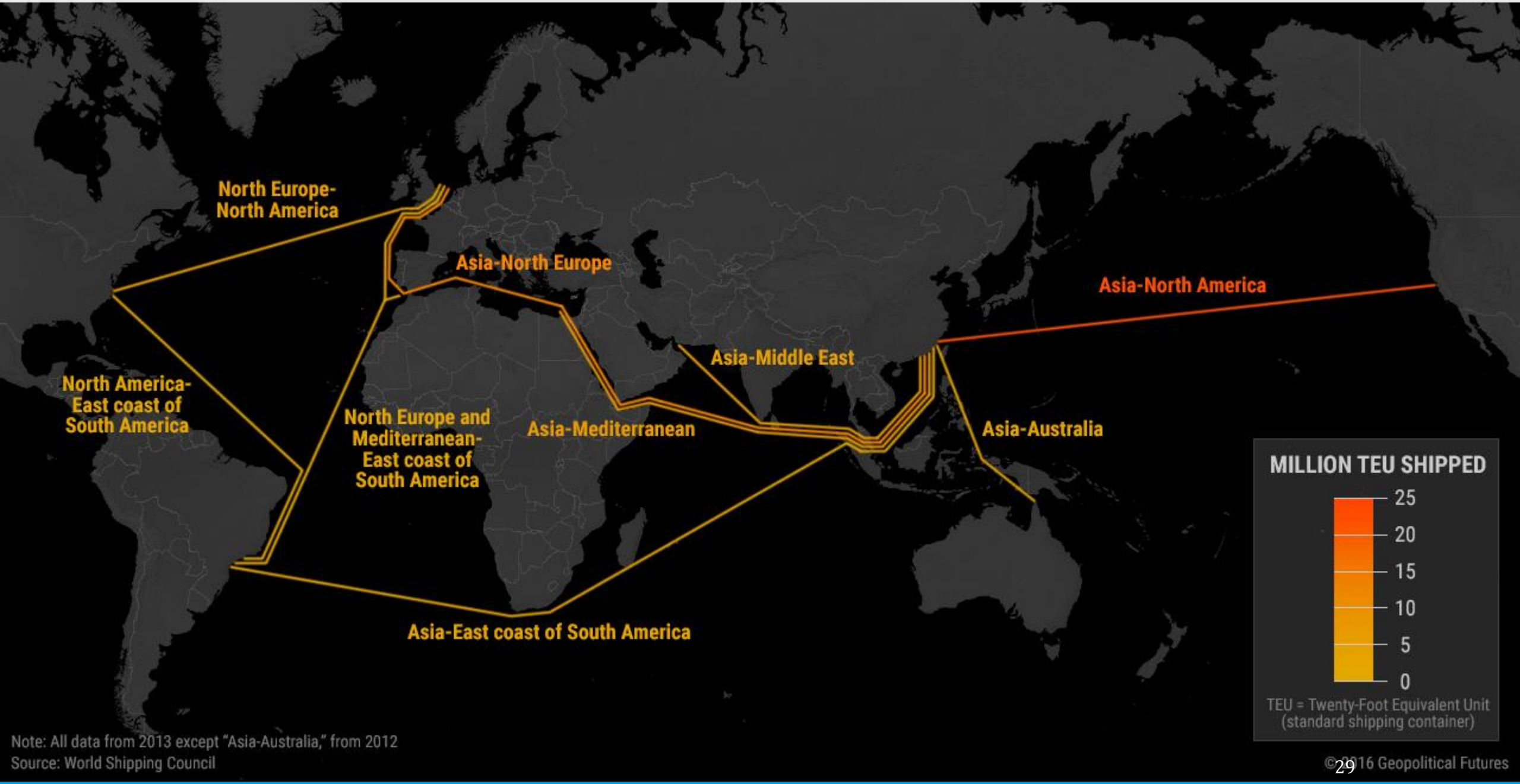


Source Euronav, Morgan Stanley, Fearnley

BULK CARRIER TRADING PATTERNS



TOP CONTAINER SHIP TRADE ROUTES



CHOOSE WISELY & JUDICIOUSLY

THANK YOU