

# Challenges to achieve existing and upcoming environmental regulation



## Natural gas for inland shipping

Challenges and options the use of Liquefied Natural Gas (LNG)  
and Compressed Natural GAS (CNG)

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Khalid Tachi  
EICB/EIBIP

# IWT Emission Regulations: CCR and NRMM



$P_N$ [kW]	CO [g/kWh]	HC [g/kWh]	NO <sub>x</sub> [g/kWh]	PM [g/kWh]
$18 \leq P_N < 37$	5,5	1,5	8	0,8
$37 \leq P_N < 75$	5,0	1,3	7	0,4
$75 \leq P_N < 130$	5,0	1,0	6	0,3
$130 \leq P_N < 560$	3,5	1,0	6	0,2
$P_N \geq 560$	3,5	1,0	6 (n ≥ 3150)	0,2
			45 * n <sup>(-0.2)</sup> - 3 (343 ≤ n < 3150)	
			11 (n < 343)	



Europese Unie

Categorie	Verplaatsing (D)	CO	HC+NO <sub>x</sub>	PM
	dm <sup>3</sup> per cylinder			
V1:1	D ≤ 0.9, P > 37 kW	5.0	7.5	0.40
V1:2	0.9 < D ≤ 1.2	5.0	7.2	0.30
V1:3	1.2 < D ≤ 2.5	5.0	7.2	0.20
V1:4	2.5 < D ≤ 5	5.0	7.2	0.20
V2:1	5 < D ≤ 15	5.0	7.8	0.27
V2:2	15 < D ≤ 20, P ≤ 3300 kW	5.0	8.7	0.50
V2:3	15 < D ≤ 20, P > 3300 kW	5.0	9.8	0.50
V2:4	20 < D ≤ 25	5.0	9.8	0.50
V2:5	25 < D ≤ 30	5.0	11.0	0.50

# NRMM Stage V: General Overview



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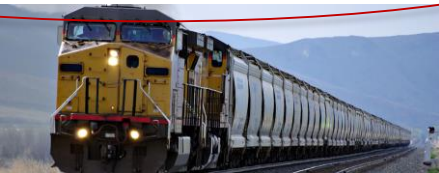
19-37kW

37-56kW

56-130kW

130-560kW

>560kW



Engines for IWT

- IWP en IWA
- NRE
- Equivalent engines like road EURO-VI

0-130kW

>130kW



19-75kW

75-130kW

130-300kW

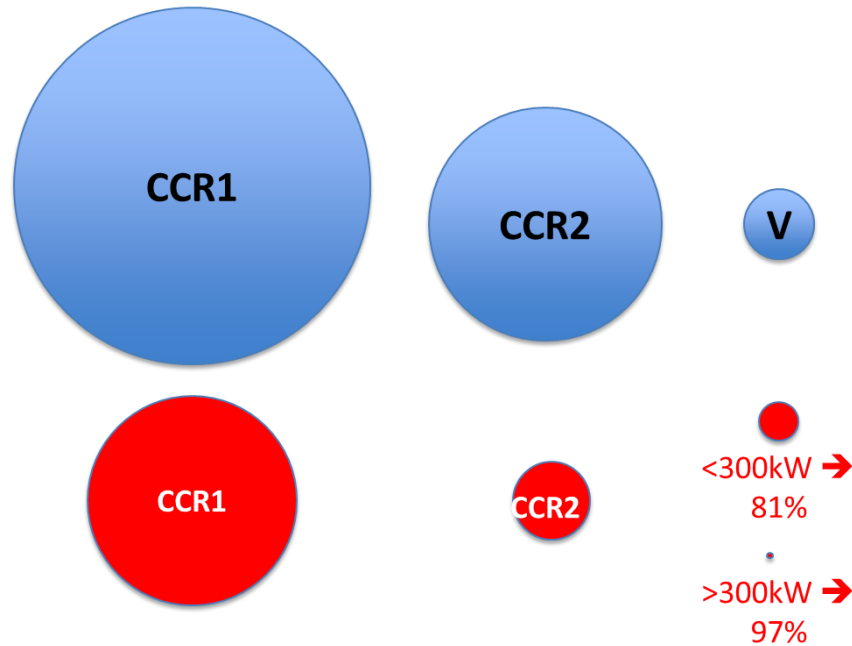
>300kW

IWP, IWA engines emissions in g/kWh	Reg (EU) 2016/1628					
	CO	NOx	HC	PM	PN	A
19-75 kW	5,0	Σ: 4,7	0,3	-	-	6,0
75-130 kW	5,0	Σ: 5,4	0,14	-	-	6,0
130-300 kW	3,5	2,1	1,00	0,1	-	6,0
>300 kW	3,5	1,8	0,19	0,015	1x10 <sup>12</sup>	6,0

in line met EPA (VS)

strenger dan EPA (VS)

# NRMM Stage V: Emission Limits



# NRMM STAGE V: REGULATION (EU) 2016/1628

## Engine Categories:

### 'category IWP':

- (a) engines exclusively for use in inland waterway vessels, for their direct or indirect propulsion, or intended for their direct or indirect propulsion, having a reference power that is greater than or equal to 19 kW;
- (b) engines used in place of engines of category IWA.

### 'category IWA':

auxiliary engines exclusively for use in inland waterway vessels and having a reference power that is greater than or equal to 19 kW;

### 'category NRE':

- (a) engines for non-road mobile machinery .....
- (b) engines having a reference power of less than 560 kW used in the place of Stage V engines of categories **IWP**, **IWA**, **RLL** or **RLR**;

# NRMM STAGE V: REGULATION (EU) 2016/1628

## Whereas:

(19) It is necessary to encourage the introduction of alternative fuel engines which can have low NOx and particulate pollutant emissions. Therefore, limit values for total hydrocarbons should be adapted in order to take into account non-methane hydrocarbons and methane emissions.

## Definitions:

(18) **‘dual-fuel engine’** means an engine that is designed to simultaneously operate with a liquid fuel and a gaseous fuel, both fuels being metered separately, the consumed amount of one of the fuels relative to the other one being able to vary depending on the operation;

(19) **‘single-fuel engine’** means an engine that is not a dual-fuel engine;

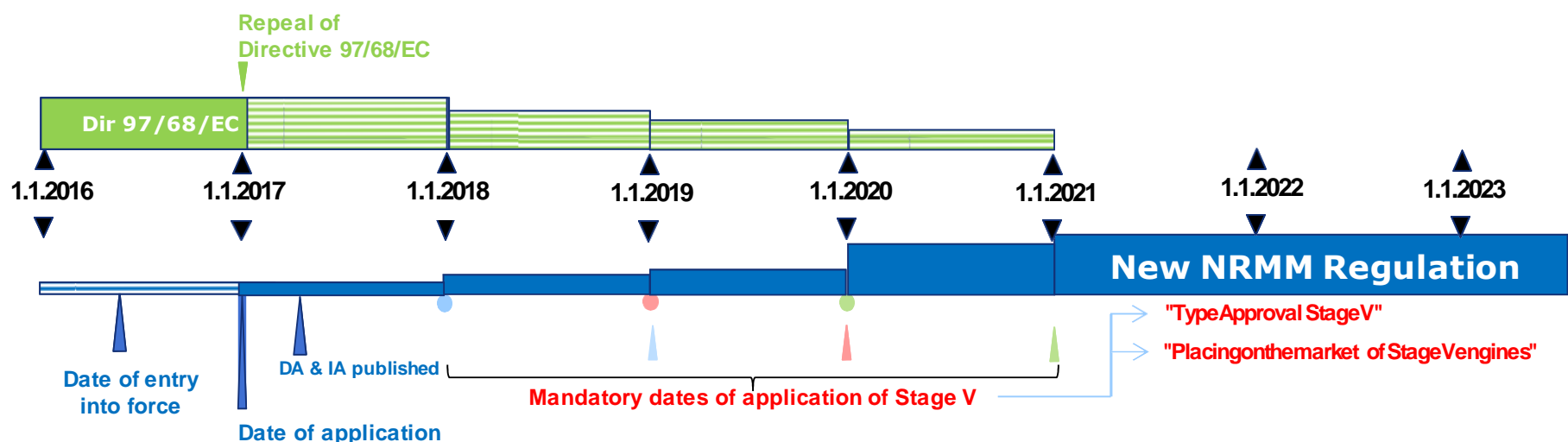
(20) **‘GER’ (Gas Energy Ratio)** means, in the case of a dual-fuel engine, the ratio of the energy content of the gaseous fuel over the energy content of both fuels; in the case of a single-fuel engine, GER is defined as being either 1 or 0 according to the type of fuel;

(34) **‘inland waterway vessel’** means a craft falling within the scope of Directive (EU) 2016/1629;

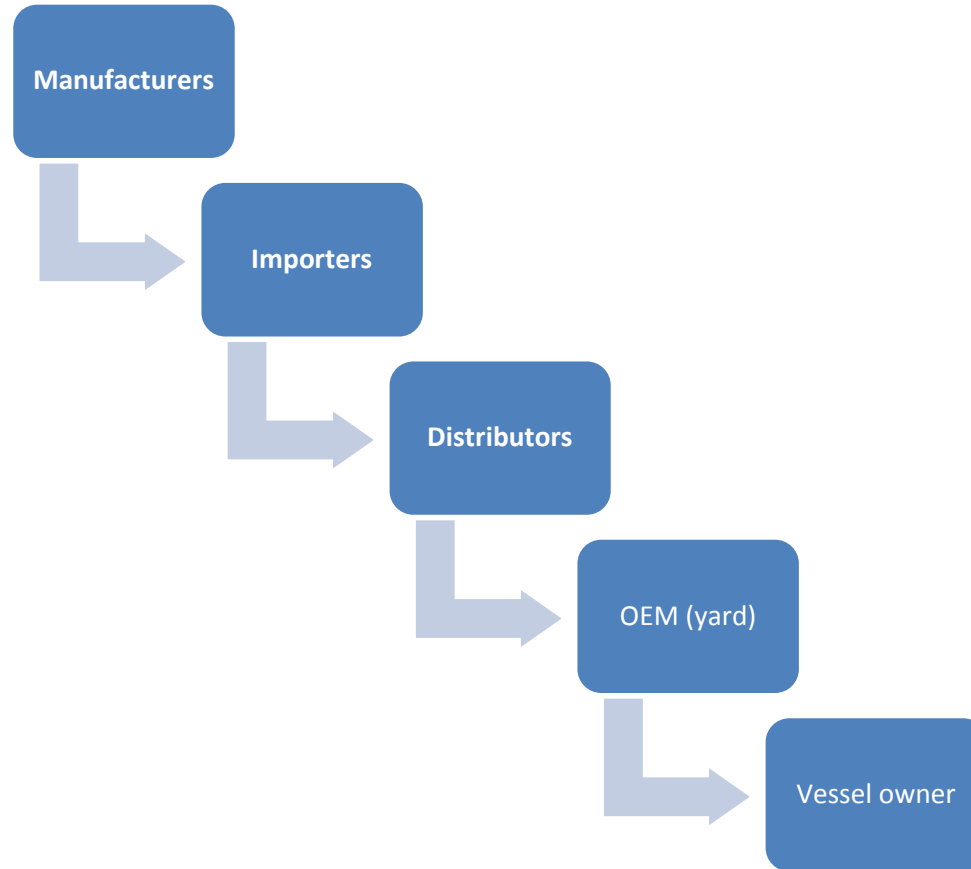
(73) **‘emission durability period’ or ‘EDP’** means the number of hours or, where applicable, the distance used to determine the deterioration factors;

(74) **‘deterioration factors’** means the set of factors that indicate the relationship between emissions at the start and end of the emission durability period;

# NRMM Stage V: Transitional provisions



# Emission requirements for inland waterways: Obligations





# NRMM Stage V: additional requirement

- ANNEX I: Requirements for any other specified fuels, fuel mixtures or fuel emulsions
- Approval process for natural gas and LPG fuelled engines including dual fuel engines

# Installation requirements for IWT

- **European Standard** laying down **Technical Requirements** for **Inland Navigation** vessels (**ES-TRIN**).
- By the **European Committee** for drawing up **Standards** in the field of **Inland Navigation** (**CESNI**)
  - ANNEX 8 :SUPPLEMENTARY PROVISIONS APPLICABLE TO CRAFT OPERATING ON FUELS WITH A FLASHPOINT EQUAL TO OR LOWER THAN 55 °C
    - Vessel Arrangements and System Design
    - Fire Safety
    - Electrical Systems
    - Control, Monitoring and Safety Systems

# NRMM Stage V: What is important?

- Effect on fuel consumption(CO2 en opax) and emissions (NOx, PM)
- Sailing profile
- Technical applicability
- Economic feasibility

Technology	Emission reduction (TTW)						Feasibility			
	CO2		NOx		PM	Comply with EURO VI	Operational feasibility	Technical feasibility	Economic feasibility	Overall
EURO VI truck engines (diesel)	0%		95%		99%		!	!	×	!
EURO VI (L)NG truck engines with spark ignition	0%		95%		99%		!	!	×	!
Selective catalytic reduction + Diesel particulate filter	0%		95%		99%		✓	✓	!	✓
CNG/LNG Industrial engines	0%		70%		85%		!	!	!	!
GTL fuel	0%		13%		49%		✓	✓	!	✓
Hybrid propulsion	10%		10%		10%		✓	✓	!	!
Full Electric	100%		100%		100%		×	×	!	×
Fuel-water emulsion	2%		30%		50%		!	!	!	!
Bio fuels	10%		10%		0%		✓	✓	!	!
Methanol	0%		67%		90%		×	×	!	×
Hydrogen / fuel cells	100%		100%		100%		×	×	!	×
Hydrogen injection	10%		25%		40%		!	×	×	×

# NRMM Stage V: Technical Solutions

- I. EURO-VI engines*
- II. EURO VI LNG/CNG engines*
- III. After treatment Selective Catalytic Reduction (SCR) + Diesel Particulate Filter (DPF)*
- IV. CNG / LNG Marine or Industry engines*
- V. Batteries*
- VI. Hydrogen / fuel cells*

*Addition technology is required:*

- I. GTL,*
- II. Methanol,*
- III. Fuel-water emulsion,*
- IV. Bio fuels*



Thank you for your attention