



# Emissions of Handheld- and Small Machines HaSMa <19kW

contribution to the occupational health protection



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12th VERT Forum, EMPA/Web, March 24th 2022



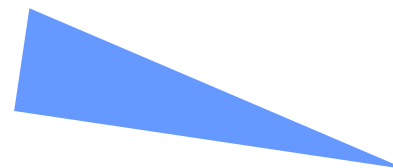
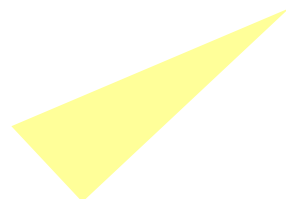
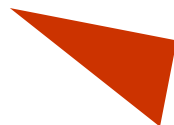
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- Handheld Machines (HaMa) – 2-S engines
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# General Situation





# **NRMM Directive is insufficient for NRS**

**→ Meeting VERT with EU-  
Commission 13.June 2017**



**2022 !!!**







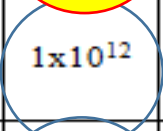
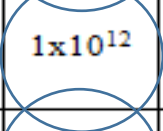
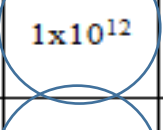
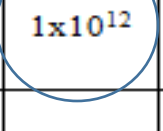
# Limit Values for handheld Petrol NRSh

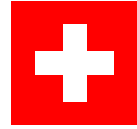
Emissionsstufe	Motorenunterklasse	Leistungsbereich	Art der Motorzündung	CO	HC + NO <sub>x</sub>
		kW		g/kWh	g/kWh
Stufe V	NRSh-v-1a	0 < P < 19	FZ	805	50
Stufe V	NRSh-v-1b			603	72

***PM/PN and PAH not even mentioned***

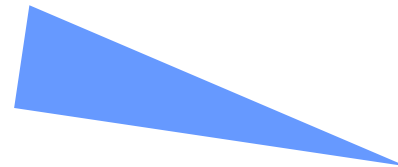
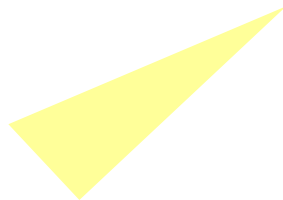
***Meanwhile we are used to milligramms/kWh but here we are in the order of magnitude of (Kilo)gramms***

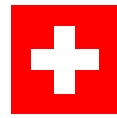
# NRMM-Limits – NRE → PN introduced !?

Emissionsstufe	Motorenunterklasse	Leistungsreich	Art der Motorzündung	CO	HC	NO <sub>x</sub>	Partikelmasse	PZ	A
		kW		g/kWh	g/kWh	g/kWh	g/kWh	#/kWh	
Stufe V	NRE-v-1 NRE-c-1	0<P<8	SZ	8,00	(HC+NO <sub>x</sub> ≤7,50)		0,40 <sup>1)</sup>		1,10
Stufe V	NRE-v-2 NRE-c-2	8≤P<19	SZ	6,60	(HC+NO <sub>x</sub> ≤7,50)		0,40		1,10
Stufe V	NRE-v-3 NRE-c-3	19≤P<37	SZ	5,00	(HC+NO <sub>x</sub> ≤4,70)		0,015	 1x10 <sup>12</sup>	1,10
Stufe V	NRE-v-4 NRE-c-4	37≤P<56	SZ	5,00	(HC+NO <sub>x</sub> ≤4,70)		0,015	 1x10 <sup>12</sup>	1,10
Stufe V	NRE-v-5 NRE-c-5	56≤P<130	alle	5,00	0,19	0,40	0,015	 1x10 <sup>12</sup>	1,10
Stufe V	NRE-v-6 NRE-c-6	130≤P≤560	alle	3,50	0,19	0,40	0,015	 1x10 <sup>12</sup>	1,10
Stufe V	NRE-v-7 NRE-c-7	P>560	alle	3,50	0,19	3,50	0,045	-	6,00



# Handheld Machines (HaMa) – 2-S Engines





# HaMaNet

Organized by AFHB Oct. 2011 until May 2018, 9 Meetings

Hanheld

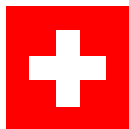
Machines

Network

NRSh

JRC/VELA; FOEN; UBA; Swiss Lubes; AECC;  
MOTOREX; Aspen; Emak; STIHL; MOT;  
Dolmar, Husquarna, KIT/MOT, Lubrizol, DUH, ENI,  
Heraeus, VSS, VSI, TTM, AFHB





Research and screening test  
programs inspired by MaMaNet

**JRC**  
**MAY 2016 TO FEBRUARY 2018**

**22 MACHINES**

**ISM AND COP**

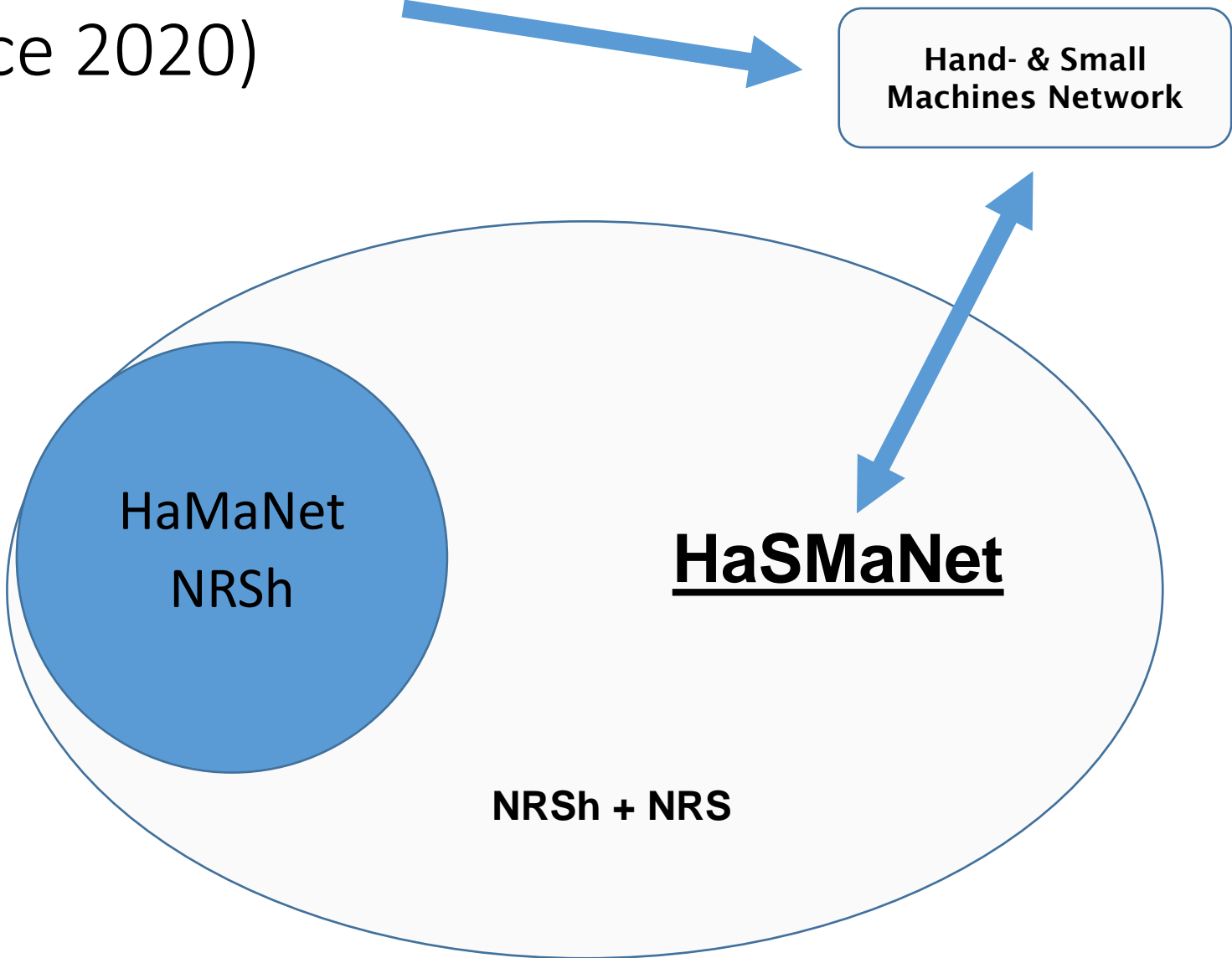
- STIHL
- KIT / MOT
- SWRI / Lubrizol
- JRC
- FOEN / AFHB
- Motorex

# Technical conclusions (2-S)



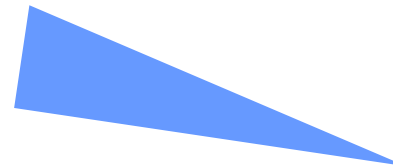
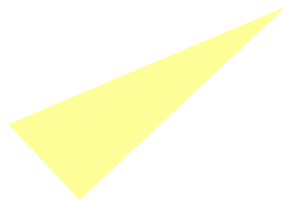
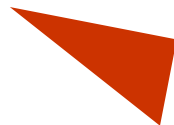
- small 2-S aerosol (PN) → lube oil
- condensation effects, HC-matrix → important for PN
- influence of lube oil ash-content → moderate
- ox. cat. → significant reduction of PM & PN
- BAT → lube oil + Alkylate fuel + ox. cat.

Consider NRS  
(since 2020)





# **Small Machines (SMa) – 4-S Engines**



# Some examples



vibration  
pounder



small  
dumper



plate  
compactor

Simple SI 4S-engines

# Yoke-mower

Simple SI 4S-engine



# Lawn-mower



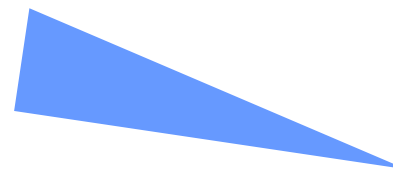
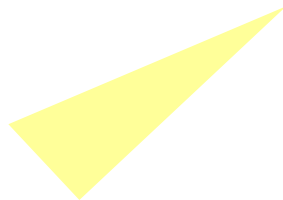
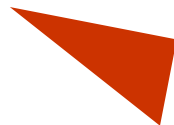
# Technical conclusions (4-S)



- **Excursion on internet:** there are small engines both SI and Diesel; no information about exhaust aftertreatment (EAT)
- For the manufacturers no necessities for BAT because of not sufficient legal stimulation (most of the manufacturers have the actual EAT-technology for bigger engines in house)
- With the actual EAT considerable reduction of emissions similarly, like in the on-road sector, are possible. For SI – Ox.Cat.+sec.air, 3WC, or 4WC; for Diesel – Ox.Cat, Ox.Cat.+DPF, or Ox.Cat.+DPF+deNOx



# HaSMaNet Web- Meeting, Dec.'20





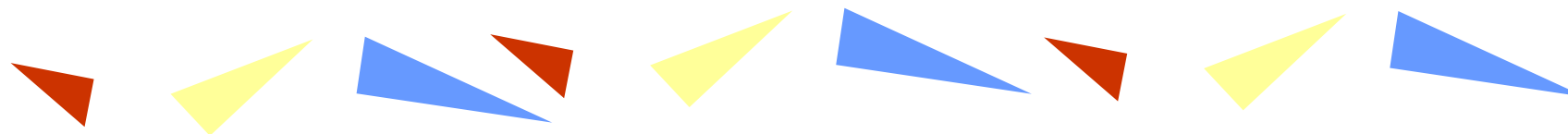
# Most important statements (HaSMaNet Web-Meeting Dec.'20)



- STIHL: **powertrain electrification** progress approx. 25%/a, in hobby-sector almost exclusively, partly also in the professional sector (with the requirements of higher power density and longer operation time the ICE-propulsion is needed)
- DUH: performed three big market screenings of handheld machines 2013, 2015 and 2017. High rate (mostly above 50%) of exceedances of legal limit values were registered. A consequent, coordinated and centralized **market surveillance** with well established legal procedures and penalties is necessary.
- AFHB: shows potentials of **lowering CO and HC** of a small 4-S engine with oxidation catalyst and puls-air-valve.
- All: further legal steps for improving the occupational protection are necessary – **lowering of limit values, provisions for CoP, ISC, PTI.**



# Conclusions for VERT





# ***VERT extends the work for emission reduction to all engines < 56 kW***

- introduce Alkylate Fuel worldwide to eliminate cancer and accident risks*
- introduce Oxidation Catalyst with Sec.Air, as the first step to oxidize CO and HC*
- demonstrate feasibility of EAC for < 56 kW*
- Standardization for Alkylat Fuels and Lube Oils*
- increase awareness of lube oil toxicity*
- increase awareness for PTI for small engines*
- Inspection and Maintenance (I&M) rules*

With common efforts: legislation, testing, market control & occupational protection – significant improvements are possible.

**Thank you for  
your attention!**

