Preliminary Emission Inventory for Agricultural and Road Machines

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Technical Collaboration: IMT – Mauá Institute of Technology
ATC – IBAMA Accredited Technical Agent

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Introduction

Afeevas ASSOCIAÇÃO DOS FABRICANTES DE EQUIPAMENTOS PARA CONTROLE DE EMISSÕES VEICULARES DA AMÉRICA DO SUL

- **Emission Source Inventory is a tool that uses statistical data from machine utilization and its average emission factors to estimate environmental impacts.**
- **Inventories are not absolute truths, but exploratory estimates compared under similar criteria to verify the need for emissions control and estimate the required intensity of the proposed actions.**
- **1st phase preliminary → inventory, with conservative data:**
  - **assess the need for emission control intensification, without the risk of overestimating;**
  - **categorize sources comparatively, setting control priorities;**
  - **estimate the order of magnitude of the required reductions**
- **Phase 2 → discuss what will be possible to do in light of the needs pointed out by the preliminary inventory**
  - **Define technically and economically feasible emission limits**
  - **Create threshold deployment scenarios by category**
  - **Re-inventory each idealized scenario with more realistic data so that the control program is not defined from very optimistic expectations and results ineffective.**

This work corresponds to the 1st phase and was developed by EnvironMentality at the request of AFEEVAS and discussed with the interested parties in the Technical Off-Road Commission and Generators of the AEA, having received numerous adjustments in its primary data from the participating entities, especially the emission factors that were gently compiled and provided by the Mauá Institute of Technology.

Introduction

- There is a lot of data on the circulating fleet of automotive vehicles in Brazil;
- There is also data with the number of Machines sold in the Brazilian Market;

Syndipes Data
Circulating Fleet

ANFAVEA
Directory

- However, there is no data that determines the size of the circulating fleet of Agricultural and Construction Machines in Brazil.

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In light of this scenario, AFEEVAS took the initiative to create an inventory that was not as complex and expensive, but with the level of accuracy necessary to show the relevance of emissions from Off-Road Machines.

KEY AXES OF WORK

- Consolidation of machine sales data from Anfavea Directory and Syndipeças Current Fleet Report (public data)
- Extrapolation of machine sales for 2023 and 2030
- Definition of scrapping curves and adjustment for wheel tractors, harvesters and construction machines, based on industry data
- Determination of circulating fleet size in 2020 and projections 2023 and 2030
- Exhaust Gas Emissions Calculations
- Inclusion of data shared by the Mauá Mauá Institute
- Interpretation of data and conclusions

Machine Selling - History

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Internal Sales of National and Imported Machines

Year	Motorized Growers	Wheel Tractors	Treadmill Tractors	Grain Harvester	Cane Harvester	Retro-excavators	Blades Loaders	Hydraulic Excavators	Motor Graders	Compactor rollers	Mini loader	Telescopic Handlerv	Total
1960		37											37
1961	751	1.679											2.430
1962	1.240	7.586											8.826
1963	1.110	9.908											11.018
1964	1.765	11.535											13.300
1965	2.403	8.401											10.804
1966	3.120	9.543											12.663
1967	1.971	6.506	72										8.549
1968	2.535	9.376	104										12.015
1969	2.081	9.977	54			5							12.117
1970	2.241	14.586	24			154							17.005
...	...	...	...	...	...	...	...	...	...	...	...	...	...
2000	722	24.591	592	3.780		1.377							31.062
2001	856	28.203	496	4.098		1.870	1.538	834	574	304	137		38.910
2002	1.050	33.217	526	5.648		2.102	1.639	979	673	364	118		46.316
2003	1.585	29.476	450	5.440		1.196	1.502	654	312	186	90		40.891
2004	1.682	28.803	530	5.605		1.320	1.944	904	383	247	81		41.499
2005	2.141	17.729	409	1.534		1.672	1.905	1.360	583	325	170		27.828
2006	1.857	20.435	309	1.030		2.398	1.831	1.504	743	410	306		30.823
2007	1.548	31.300	439	2.377		3.396	2.753	2.091	1.000	477	643		46.024
2008	1.852	43.414	664	4.458		5.199	3.008	2.837	1.245	1.227	1.171		65.075
2009	1.759	45.437	612	3.817		5.119	2.252	2.522	1.245	1.432	583		64.778
2010	1.807	56.420	870	4.549		7.661	3.783	4.068	2.094	2.548	1.030		84.830
2011	1.307	52.296	1.022	5.343		8.239	3.986	4.284	1.922	2.177	2.947		83.523
2012	1.348	55.819	1.071	6.278		8.701	3.884	4.050	1.378	1.670	1.190		85.389
2013	1.618	65.089	927	8.539	1.406	11.295	4.467	3.899	4.132	1.774	2.646		105.792
2014	1.553	55.612	815	6.448	982	6.634	4.867	6.050	3.473	2.083	2.100	181	90.798
2015	1.059	37.381	408	3.917	713	6.273	2.614	3.728	399	798	806	87	58.183
2016	747	35.956	302	4.498	910	2.143	1.920	2.394	245	288	475	55	49.933
2017		35.622	295	4.537	721	2.016	1.905	2.325	372	290	489	56	48.628
2018		38.803	473	5.759	643	3.909	3.033	3.707	754	407	543	101	58.132
2019		33.148	547	5.580	645	5.772	3.661	5.435	928	649	790	150	57.305
2020		35.369	939	5.614	772	6.625	4.906	7.324	1.126	1.131	698	139	64.643

Source: ANFAVEA and Abimaq Directory (in blue)

Total	2,531,321

- **Data considered from 1960 to 2020**
- **Abimaq data (in blue) as of 2001**
- **Sum > 2.5M equipment sold**

Machine Selling – Update and Projection

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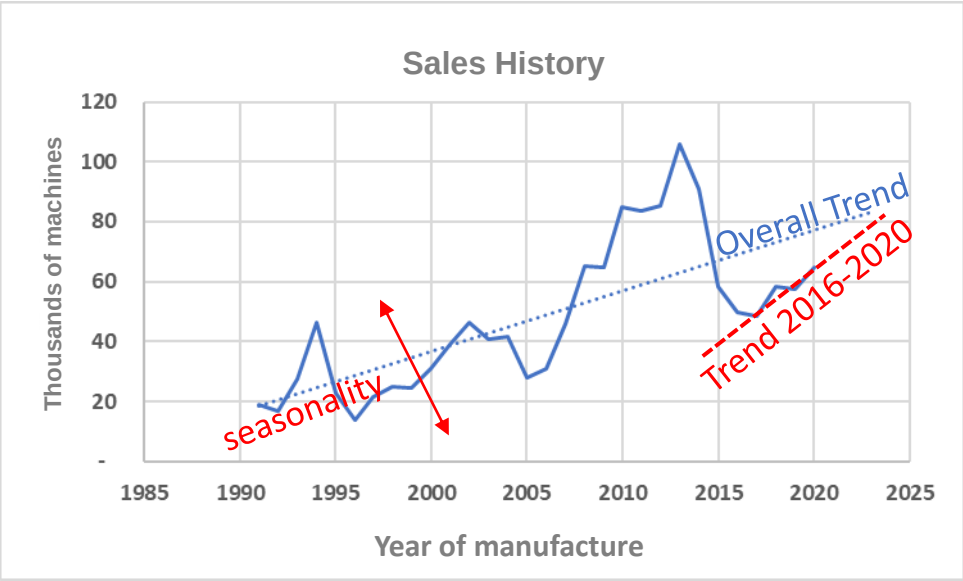

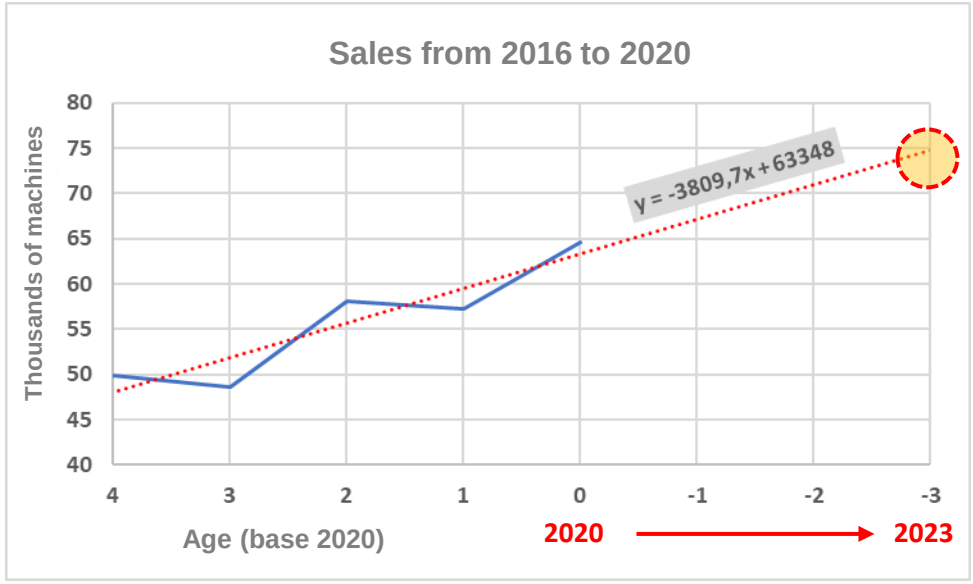

1) Evaluation of historical sales data for the past 30 years

2) Estimate of the trend of the last 5 years → extrapolation

Estimated engine sales
Manufacturers

Year	Volume	mkt share	Vol. Est.
2023	42.000	56%	74.777
2024	49.000	÷	87.240
2025	51.000		90.801
2026	56.000		99.703
2027	57.000		101.483
2028	58.000		103.264
2029	59.000		105.044
2030	59.000		105.044

Year	Motorized Growers	Wheel Tractors	Treadmill Tractors	Grain Harvester	Cane Harvester	Retro Excavators	Blades Loaders	Hydraulic Excavators	Motor Graders	Compactor Rollers	Mini loader	Telescopic Handler	Total
2011	1.307	52.296	1.022	5.343		8.239	3.986	4.284	1.922	2.177	2.947		83.523
2012	1.348	55.819	1.071	6.278		8.701	3.884	4.050	1.378	1.670	1.190		85.389
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2020		35.369	939	5.614	772	6.625	4.906	7.324	1.126	1.131	698	139	64.643
2021		41.973	662	6.310	817	5.380	3.966	5.518	934	727	740	131	67.158
2022		44.354	699	6.668	863	5.685	4.191	5.831	987	769	782	138	70.967
2023		46.736	737	7.026	909	5.990	4.416	6.144	1.040	810	824	146	74.777
2024		54.525	860	8.197	1.061	6.989	5.151	7.168	1.213	945	961	170	87.240
2025		56.750	895	8.532	1.104	7.274	5.362	7.460	1.263	983	1.000	177	90.801
2026		62.314	983	9.368	1.212	7.987	5.887	8.192	1.386	1.080	1.099	194	99.703
2027		63.427	1.000	9.536	1.234	8.130	5.992	8.338	1.411	1.099	1.118	198	101.483
2028		64.540	1.018	9.703	1.256	8.273	6.098	8.484	1.436	1.118	1.138	201	103.264
2029		65.652	1.035	9.870	1.277	8.415	6.203	8.631	1.461	1.138	1.157	205	105.044
2030		65.652	1.035	9.870	1.277	8.415	6.203	8.631	1.461	1.138	1.157	205	105.044
Particip. by mach. type (Avarage last 5 years)		**62%**	**1,0%**	**9,4%**	**1,2%**	**8,0%**	**5,9%**	**8,2%**	**1,4%**	**1,1%**	**1,1%**	**0,2%**	

3) Adjusting the sales projection for the total market

4) Distribution of Projected Sales by Machine Type

Anfavea: 65,000 in 2023
https://www.cnnbrasil.com.br/economia/anfavea-preve-queda-de-35-das-vendas-de-maquinas-agricolas-em-2023

Machine Sales Estimate (1990 – 2030)

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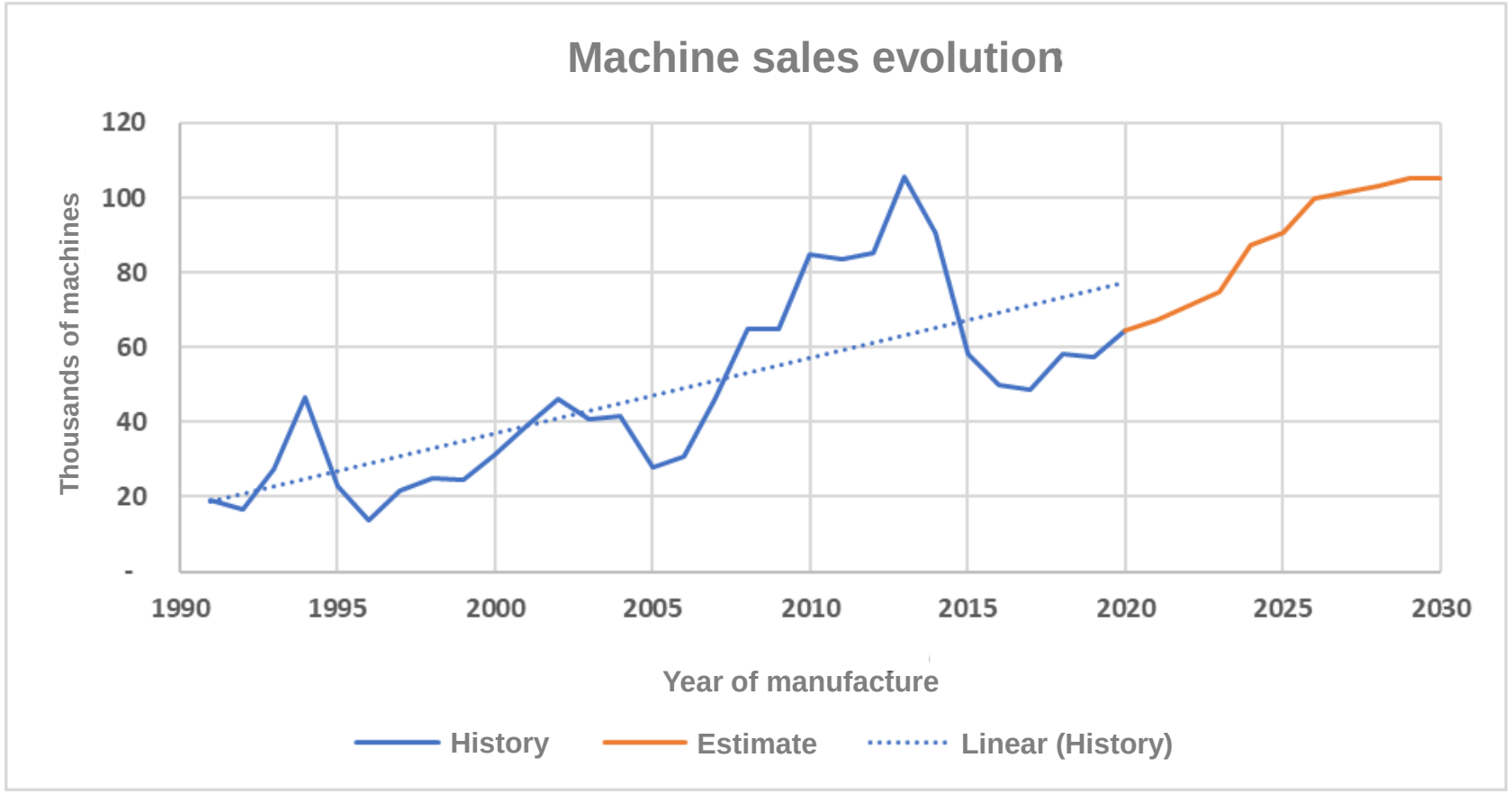

Defining Scraping Curves

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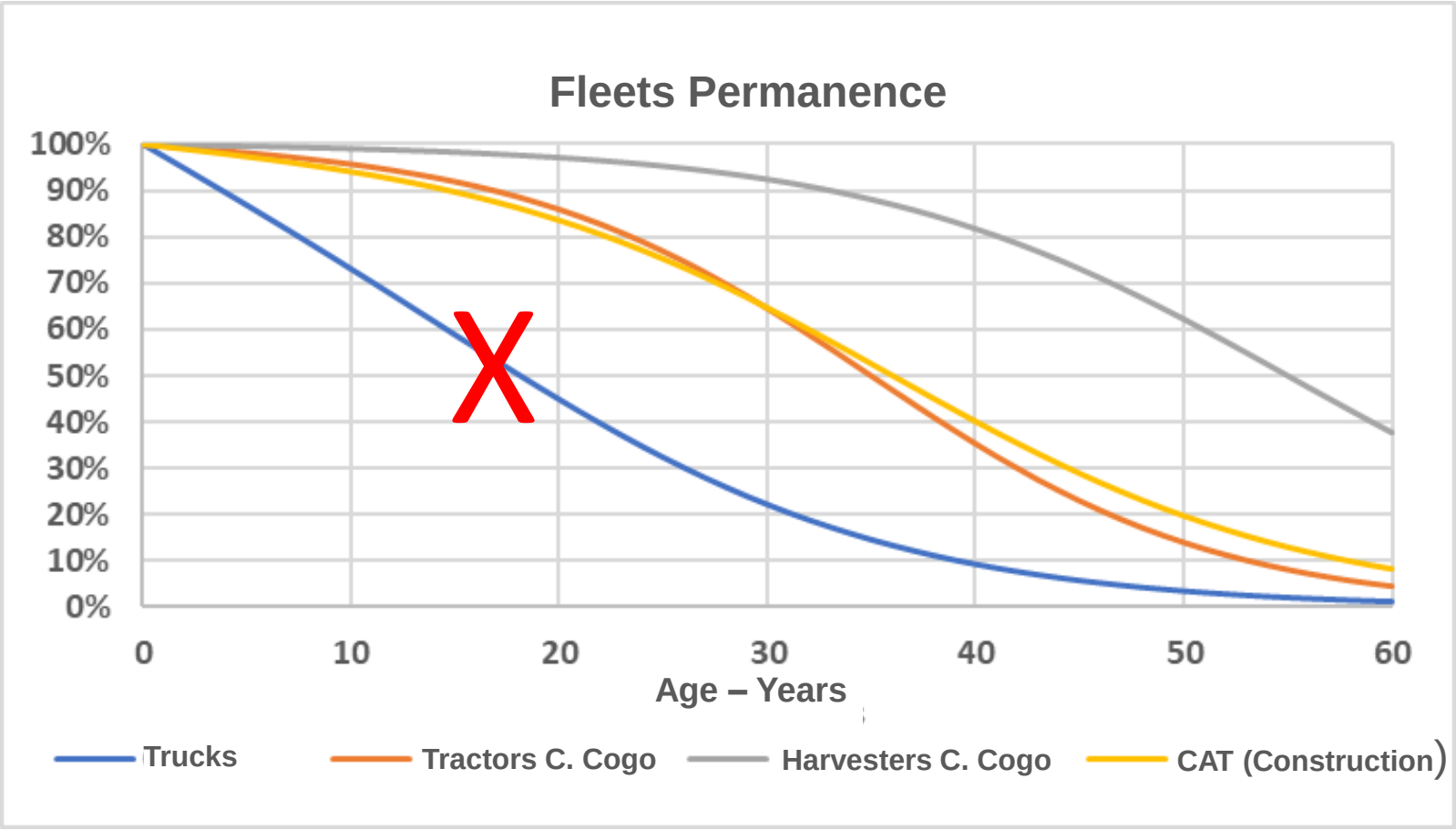
Gompertz: (1/(1+EXP(a*(idade-t0))))+(1/(1+EXP(a*(idade+t0))))

Constants	Trucks	Tractors Carlos Cogo	Harvesters Carlos Cogo	Construction
t0	17	35	55	36
a	0,1	0,12	0,1	0,1

	Remaining fleet - approximation by Gompertz curve			
Year of manufacture	Trucks	Tractors C. Cogo	Harvesters C. Cogo	Construction CAT
2010 a 2020	79%	97%	99%	95%
1999 a 2009	48%	87%	97%	85%
1988 a 1998	23%	64%	92%	64%
pré 1988	6%	21%	65%	25%



- Experience of the São Paulo I/M Program showed that the permanence of fleets according to age follows Gompertz-type curves
- For comparison, the truck curve was initially taken
- Field data for tractors, harvesters, and construction machines enabled approximation by new Gompertz curves
- The curves showed very different behaviors of the trucks, whose curve was abandoned in the estimates

Estimation of the Circulating Fleet

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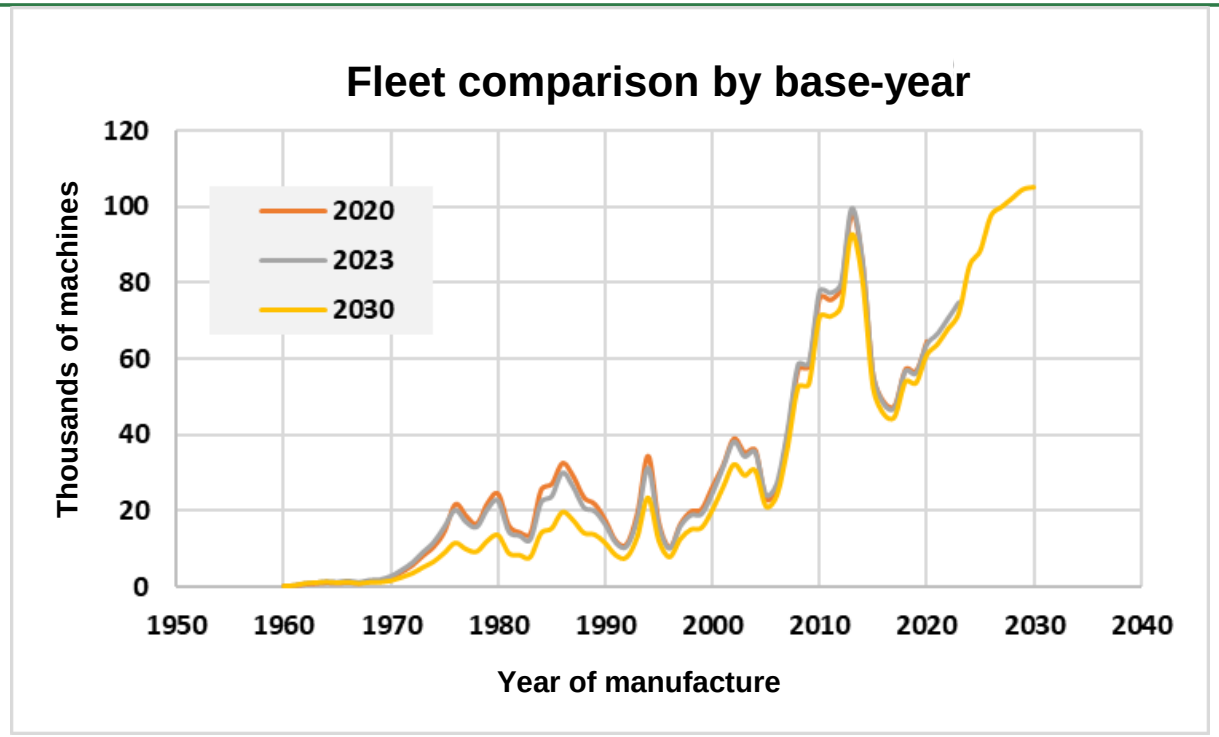

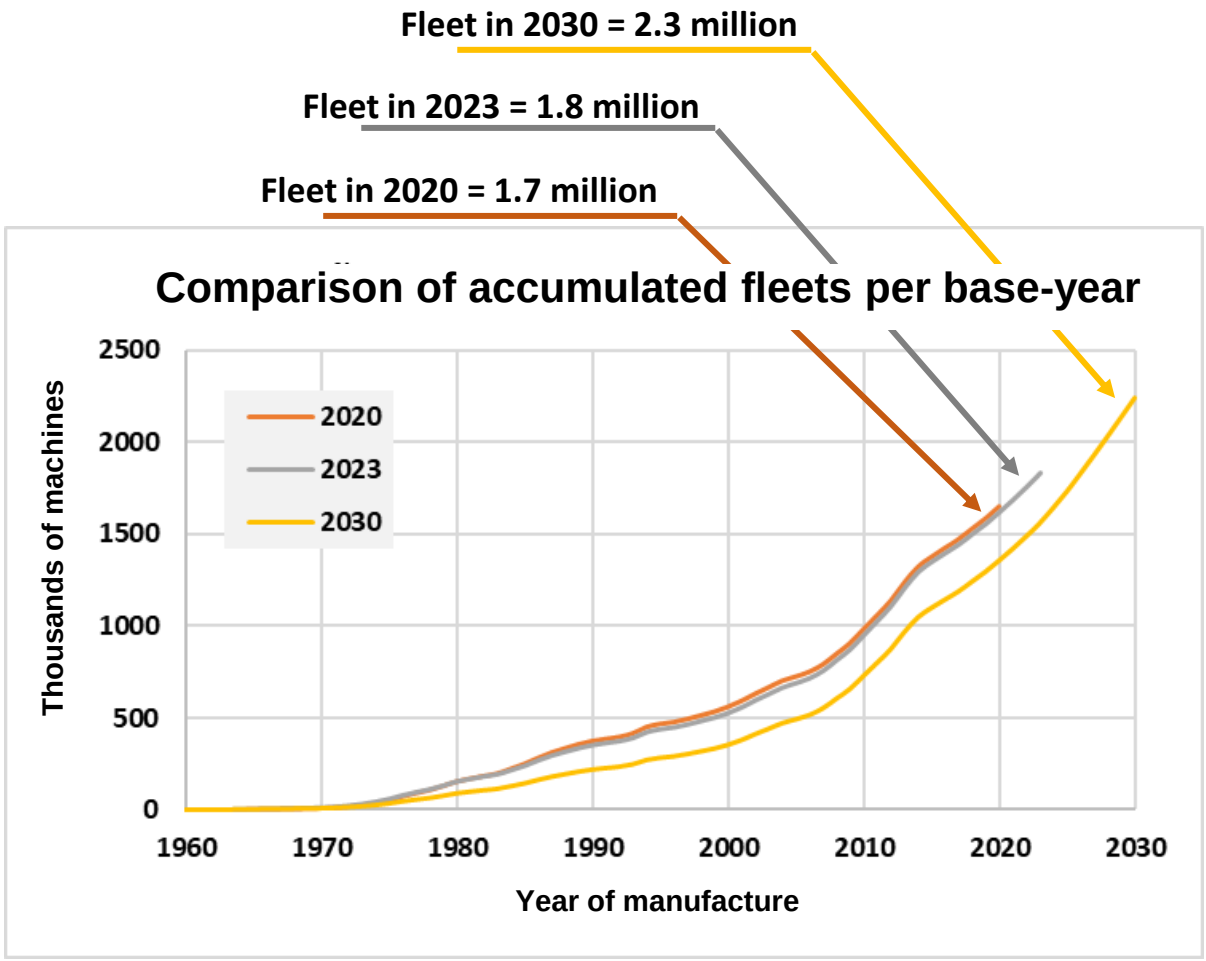

Estimate of the Circulating Fleet - Assumptions

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Emissions standard	≤ 75 kW	> 75 kW
Tier 1	Until 2018	Until 2016
MAR-I	≥ 2019	≥ 2017

Size distribution			
Machine	**P**	**M**	**G**
Agricultural Wheeled Tractors	75%	22%	3%
Wheel tractors	60%	30%	10%
Construction treadmills Tractors	45%	40%	15%
Wheel loaders construction	30%	17%	53%
Hydraulic excavators construction	25%	60%	15%

Uses		
Machine Type	**Agricultural (%)**	**Construction (%)**
Motorized Growers	100%	0%
Wheel Tractors	70%	30%
Treadmill Tractors	30%	70%
Grain harvesters	100%	0%
Cane harvesters	100%	0%
Retro-excavators	30%	70%
Wheel loaders	0%	100%
Hydraulic excavators	10%	90%
Motor graders	0%	100%
Compactor rollers	0%	100%
Mini-loaders	0%	100%
Telescopic lifters	0%	100%

Current Fleet Estimate – 2023

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	Agricultural (fleet)		Construction (Fleet)		Total
	Tier 1	MAR-I	Tier 1	MAR-I	
Motorized Growers	54.163	-	-	-	54.163
Small Wheel Tractors	539.229	105.143	184.878	36.049	1.227.374
Medium Wheel Tractors	146.947	42.069	85.878	24.586	
Big Wheel Tractors	20.038	5.737	28.626	8.195	
Treadmill Tractors	8.622	1.288	-	-	33.034
Small Treadmill Tractors	-	-	9.053	1.352	
Medium Treadmill Tractors			8.047	1.202	
Big Treadmill Tractors			3.018	451	
Grain harvesters	151.393	41.399	-	-	192.792
Cane harvesters	3.979	5.357	-	-	9.336
Retro-excavators	28.524	8.742	66.556	20.399	124.221
Small Wheel loaders	-	-	13.394	6.276	65.567
Medium Wheel loaders			6.775	4.372	
Big Wheel loaders			21.122	13.629	
Hydraulic excavators	3.870	3.579	-	-	74.488
Small Hydraulic excavators	-	-	10.025	6.735	
Medium Hydraulic excavators			20.897	19.327	
Big Hydraulic excavators			5.224	4.832	
Motor graders	-	-	18.665	6.056	24.720
Compactor rollers	-	-	14.959	4.719	19.679
Mini-loaders	-	-	14.403	3.794	18.197
Telescopic lifters	-	-	308	849	1.157
TOTAL	956.764	213.314	511.827	162.823	1.844.727

Agricultural total	1.170.078	63%
Construction total	674.649	37%

Total MAR-I	376.136	20%
Total TIER 1	1.468.591	80%

Circulating Fleet in 2023

Circulating Fleet Projection - 2030

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	Agricultural (fleet)		Construction (Fleet)		Total
	Tier 1	MAR-I	Tier 1	MAR-I	
Motorized Growers	38.411	-	-	-	**38.411**
Small Wheel Tractors	435.636	326.812	149.361	112.050	**1.452.281**
Medium Wheel Tractors	117.008	106.644	68.381	62.324	
Big Wheel Tractors	15.956	14.542	22.794	20.775	
Treadmill Tractors	6.311	3.248			**31.864**
Small Treadmill Tractors	-	-	6.627	3.410	
Medium Treadmill Tractors			5.891	3.031	
Big Treadmill Tractors			2.209	1.137	
Grain harvesters	139.845	106.026	-	-	**245.871**
Cane harvesters	3.937	13.721	-	-	**17.657**
Retro-excavators	24.825	24.762	57.926	57.777	**165.290**
Small Wheel loaders	-	-	12.211	18.092	**101.010**
Medium Wheel loaders			6.146	11.026	
Big Wheel loaders			19.161	34.374	
Hydraulic excavators	3.537	9.026	-	-	**125.629**
Small Hydraulic excavators	-	-	9.210	19.057	
Medium Hydraulic excavators			19.101	48.739	
Big Hydraulic excavators			4.775	12.185	
Motor graders	-	-	17.022	15.273	**32.295**
Compactor rollers	-	-	13.664	11.900	**25.564**
Mini-loaders	-	-	13.261	11.148	**24.409**
Telescopic lifters	-	-	288	2.142	**2.430**
TOTAL	**785.465**	**604.779**	**428.027**	**444.439**	**2.262.710**

Agricultural total	**1.390.245**	**75%**
Construction total	**872.466**	**47%**

Total MAR-I	**1.049.218**	**57%**
Total TIER 1	**1.213.492**	**66%**

Circulating Fleet in 2030

Power, Consumption and Labor Estimates

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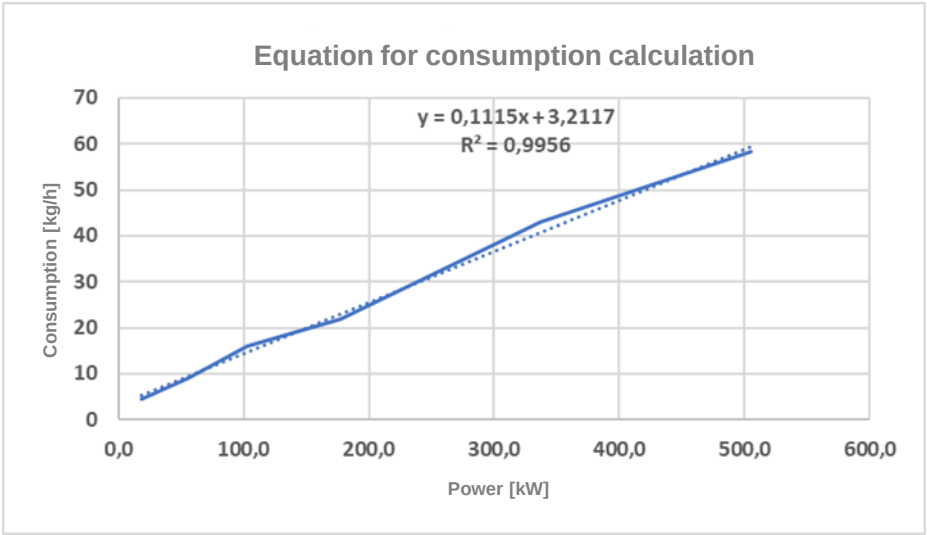
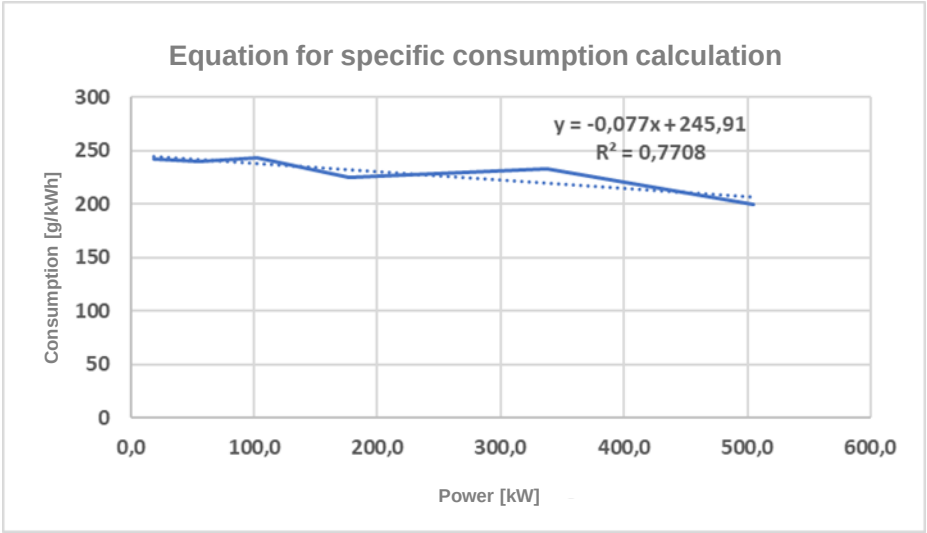
Agriculture	Average power (kW)	Consumption (L/h)	Consumption (g/kWh)	Work (h/year)
Motorized growers	10	5	246	400
Small Wheel Tractors	54	11	245	740
Medium Wheel Tractors	116	19	245	1.443
Big Wheel Tractors	216	32	244	2.119
Treadmill Tractors	83	15	245	2.000
Grain harvesters	224	33	244	750
Cane harvesters	224	33	244	2.420
Retro-excavators	43	9	246	1.875
Hydraulic excavators	89	16	245	2.400

Construction	Average power (kW)	Consumption (L/h)	Consumption (g/kWh)	Work (h/year)
Small Wheel loaders	54	11	245	800
Medium Wheel loaders	116	19	245	1.500
Big Wheel loaders	216	32	244	4.000
Small Treadmill Tractors	116	19	245	2.100
Medium Treadmill Tractors	140	22	245	2.500
Big Treadmill Tractors	290	42	244	3.800
Retro-excavators	64	12	245	1.720
Small Blades Loaders	74	14	245	2.300
Medium Blades Loaders	120	20	245	2.567
Big Blades Loaders	220	33	244	3.100
Small Hydraulic excavators	75	14	245	2.967
Medium Hydraulic excavators	118	19	245	2.733
Big Hydraulic excavators	234	35	244	3.533
Motor graders	130	21	245	2.000
Compactor rollers	113	19	245	1.733
Mini-loaders	45	10	246	1.067
Telescopic lifters	78	14	245	1.000

Consumption and specific consumption regressions made based on the average certification data provided by the IMT





Emissions Factor Calculation Assumptions

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EPA Tier 1 - nonroad diesel engine emission standards (g/kWh)

Engine power	Tier	Year	CO	HC	NMHC+NOx	NOx	PM
kW<8	1	2000	8	1,3	10,5	9,2	1
8≤kW<19	1	2000	6,6	1,2	9,5	8,3	0,8
19≤kW<37	1	1999	5,5	1,2	9,5	8,3	0,8
37≤kW<75	1	1998	11,4	1,3	-	9,2	1
75≤kW<130	1	1997	11,4	1,3	-	9,2	1
130≤kW<225	1	1996	11,4	1,3	-	9,2	0,54
225≤kW<450	1	1996	11,4	1,3	-	9,2	0,54
450≤kW<560	1	1996	11,4	1,3	-	9,2	0,54
kW≥560	1	2000	11,4	1,3	-	9,2	0,54

- Unregulated Machine emissions cannot be determined.
- That is why it has been assumed (conservatively) that all Machines meet the EPA/Tier 1 maximum limits.

Approval data IMT MAR-I - Average exhaust emissions – Cycle C1 (g/kWh)

Power Range	CO [g/kWh]	HC [g/kWh]	NOx [g/kWh]	PM [g/kWh]
0 - 37 [kW]	2,224	0,628	5,281	0,247
37 - 75 [kW]	1,174	0,166	3,895	0,179
75 - 130 [kW]	1,082	0,169	3,391	0,131
130 - 225 [kW]	0,923	0,135	3,222	0,104
225 - 450 [kW]	1,237	0,093	3,357	0,093
450 - 560 [kW]	1,004	0,062	3,716	0,041

- For Machines marketed after the MAR-I term, the average values provided by the IMT were used.

Inventory Methodology

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Calculation Methodology Example	Fleet	Estimated data per machine				Calculation	Emission Factors (g/kWh)				Emission per machine ($g_{pollutant}/kg_{fuel}$)				Annual Emission per machine (kg/year)			
		Avarage Power (kW)	Consumpt. (L/h)	Work (h/year)	Consumpt. Spec. (g/kWh)	Consumption (kg_fuel/year)	CO	HC	NOx	MP	CO	HC	NOx	MP	CO	HC	NOx	MP
Small Wheel Tractor	200.415	54	11,0	800	245	7.424	11,4	1,3	9,2	1,00	46	5	37	4	345	39	278	30
Medium Wheel Tractor	93.568	116	19,1	1500	245	24.216	11,4	1,3	9,2	1,00	47	5	38	4	1.127	128	909	99
Big Wheel Tractor	31.189	216	32,3	4000	244	109.252	11,4	1,3	9,2	0,54	47	5	38	2	5.099	581	4.115	242
Small Treadmill Tractors	10.181	116	19,1	2100	245	33.906	11,4	1,3	9,2	1,00	47	5	38	4	1.578	180	1.273	138
Medium Treadmill Tractors	9.049	140	22,3	2500	245	47.054	11,4	1,3	9,2	0,54	47	5	38	2	2.191	250	1.768	104
Big Treadmill Tractors	3.394	290	42,1	3800	244	135.077	11,4	1,3	9,2	0,54	47	5	38	2	6.319	721	5.100	299
Retro-excavators	69.792	64	12,3	1720	245	17.823	11,4	1,3	9,2	1,00	46	5	37	4	828	94	668	73
Small Blades loaders	13.764	74	13,6	2300	245	26.364	11,4	1,3	9,2	1,00	46	5	37	4	1.225	140	989	107
Medium Blades loaders	6.971	120	19,6	2567	245	42.585	11,4	1,3	9,2	1,00	47	5	38	4	1.982	226	1.599	174
Big Blades loaders	21.732	220	32,8	3100	244	85.999	11,4	1,3	9,2	0,54	47	5	38	2	4.014	458	3.240	190
Small Hydraulic excavators	10.280	75	13,7	2967	245	34.337	11,4	1,3	9,2	1,00	46	5	38	4	1.596	182	1.288	140
Medium Hydraulic excavators	21.455	118	19,4	2733	245	44.741	11,4	1,3	9,2	1,00	47	5	38	4	2.082	237	1.680	183
Big Hydraulic excavators	5.364	234	34,7	3533	244	103.536	11,4	1,3	9,2	0,54	47	5	38	2	4.835	551	3.902	229
Motor graders	19.174	130	21,0	2000	245	35.413	11,4	1,3	9,2	0,54	47	5	38	2	1.648	188	1.330	78
Compactor rollers	15.360	113	18,7	1733	245	27.325	11,4	1,3	9,2	1,00	47	5	38	4	1.271	145	1.026	112
Mini-loaders	14.757	45	9,7	1067	246	8.778	11,4	1,3	9,2	1,00	46	5	37	4	407	46	329	36
Telescopic lifters	314	78	14,1	1000	245	11.883	11,4	1,3	9,2	1,00	46	5	38	4	552	63	446	48

Diesel density (0.845) x W/h x h/year

1000*g/kWh issue/consumption

Emission (g/kg) * consumption (kg/year)/1000

Results – Total Fleet 2023

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Emissions	Base year	Fleet	CO (ton/year)	HC (ton/year)	Nox (ton/year)	MP (ton/year)	CO2 (ton/year)
Machines – Agriculture	2030	1.390.245	530.610	61.984	530.371	40.390	62.915.258
Machines – Construction	2030	872.466	627.112	73.255	663.195	46.068	85.160.992
Total 2030		**2.262.710**	**1.157.722**	**135.239**	**1.193.566**	**86.457**	**148.076.250**
Machines – Agriculture	2023	1.170.078	599.690	69.060	522.827	44.535	50.704.598
Machines – Construction	2023	674.649	692.516	79.638	619.165	48.439	63.205.050
Total 2023		**1.844.727**	**1.292.206**	**148.697**	**1.141.991**	**92.974**	**113.909.648**
Machines – Agriculture	2020	1.122.436	631.670	72.466	528.995	46.689	47.619.076
Machines – Construction	2020	621.351	723.219	82.802	613.589	49.868	57.008.531
Total 2020		**1.743.787**	**1.354.889**	**155.267**	**1.142.584**	**96.557**	**104.627.607**
Inventory MMA – heavy vehicles (Forecast from 2007 to 2020)		**4.620.000**	**917.000**	**88.000**	**1.135.000**	**42.225**	**258.000.000**
		38%	148%	176%	101%	229%	41%

- Machine fleet is slightly greater than 1/3 of total diesel road vehicles (38%)
- Machine fleet emissions can be up to ~2.3 times higher (depending on pollutant)
  - Nox emission per machine is **2.5 times** higher than automotive.
  - PM emission per machine is **6 times** higher than automotive.
- The total CO_2 emission (therefore fuel consumption) of the Machines is about 40% of the emission of the road vehicles.
- Total Circulating Fleet of machines emits less CO_2, but are up to 2.3 times more polluting → **Requirement MAR-II**

The impact of emissions from Agricultural and Highway Machines is very relevant, especially when we take into account that **Construction Equipment**, responsible for the majority of emissions, is on the construction sites of **large urban centers**.

Results – Prioritization

	Prioritization by Category: Base MAR-I 2030					
	CO	HC	NOx	MP	CO2	Fleet
Wheel Tractor	42%	44%	42%	45%	41%	61%
Hydraulic excavators	19%	17%	18%	17%	18%	8%
Blades loaders	15%	15%	15%	15%	16%	6%
Grain harvesters	8%	8%	9%	7%	9%	10%
Retro-excavators	6%	6%	6%	8%	6%	8%
Cane harvesters	3%	3%	4%	3%	4%	1%
Motor graders	2%	2%	2%	2%	2%	1%
Treadmill Tractors	2%	2%	2%	2%	2%	1%
Compactor rollers	1%	1%	1%	1%	1%	1%
Mini-loaders	0%	0%	0%	1%	0%	1%
Telescopic lifters	0%	0%	0%	0%	0%	0%
Motorized growers	0%	0%	0%	0%	0%	0%

	Wheel Tractors MAR-I 2030				
	CO	HC	NOx	MP	CO2
Small Wheel Tractor	14%	14%	14%	17%	12%
Medium Wheel Tractor	17%	18%	16%	17%	16%
Big Wheel Tractor	11%	11%	12%	10%	13%
Σ other categories	16%	16%	16%	17%	16%

	Priorization by power range: Base MAR-I 2030				
	CO	HC	NOx	MP	CO2
130 - 225 [kW]	36%	36%	38%	33%	40%
75 - 130 [kW]	34%	37%	33%	34%	33%
37 - 75 [kW]	23%	23%	23%	29%	21%
225 - 450 [kW]	7%	4%	6%	4%	6%
0 - 37 [kW]	0%	0%	0%	0%	0%
450 - 560 [kW]	0%	0%	0%	0%	0%

Feasibility economical

Power	Agriculture	Construction
Small Wheel Tractor	54	54
Medium Wheel Tractor	116	116
Big Wheel Tractor	216	216
Treadmill Tractors	82,7	
Small Treadmill Tractors		116
Medium Treadmill Tractors		140
Big Treadmill Tractors		290
Grain harvesters	224,3	
Cane harvesters	224,3	
Retro-excavators	42,9	64
Small Blades loaders		74
Medium Blades loaders		120
Big Blades loaders		220
Hydraulic excavators	89,4	
Small Hydraulic excavators		75
Medium Hydraulic excavators		118
Big Hydraulic excavators		234
Motor graders		130
Compactor rollers		113
Mini-loaders		45
Telescopic lifters		78

Economic Viability

- 75 to 225 kW category accounts for approximately 70% of emissions of all → 1ST PRIORITY pollutants
- 37 to 75 kW category accounts for another 20% to 30% of all pollutant emissions → **2nd PRIORITY**

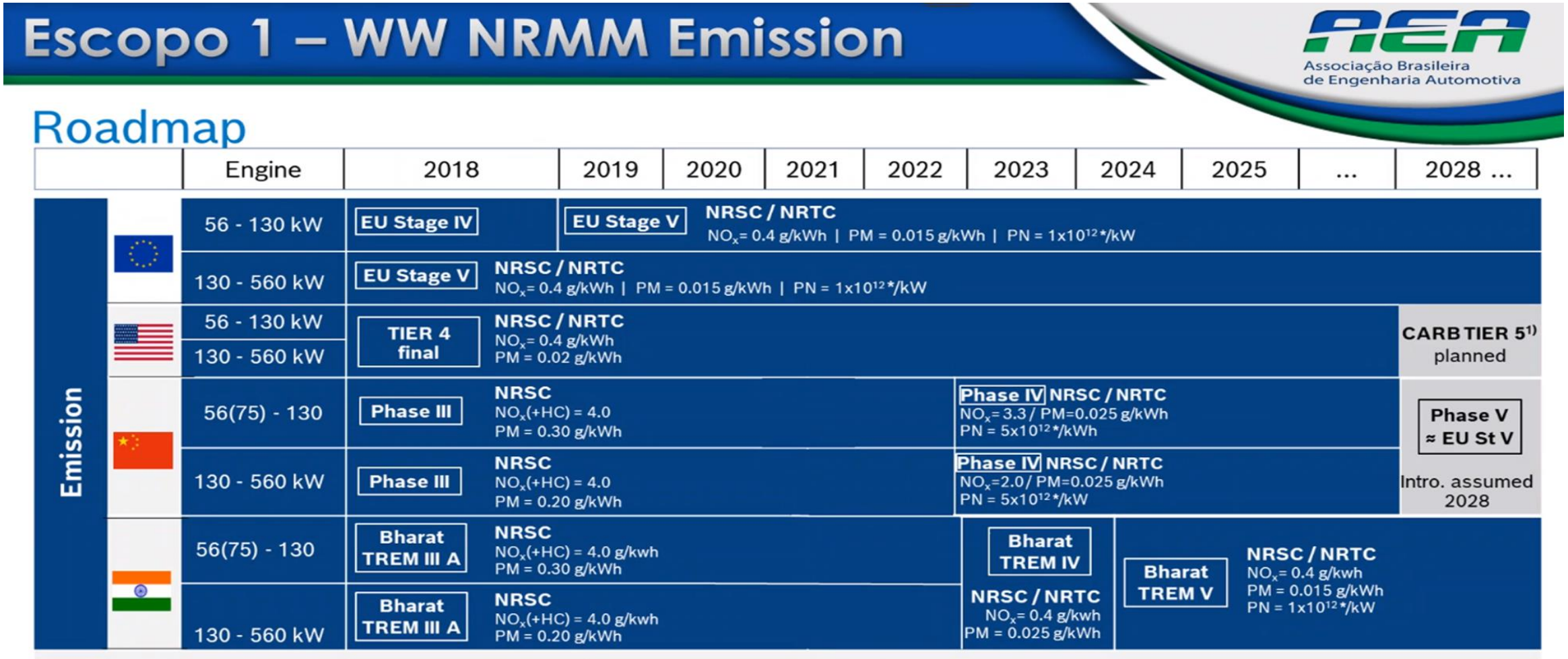
Results – Deployment Strategies

- All the rationale used in the construction of the inventory, which clearly suggests a progressive strategy for the implementation of a new phase of the MAR-I Program, was discussed and approved at the AEA Off-Road CT.
- As a conclusion of Phase 1 of the inventory, the authors consider it possible to study strategies that are feasible technologically and economically due to available resources, considering, for example, the following hypotheses:

	Power (kW)				
Power range of MAR-I	**19 a 37**	**37 a 75**	**75 a 130**	**130 a 560**	
(Sub-division Mauá)	idem	idem	idem	**130 a 225**	**225 a 560**
Priority as a function of NOx (by power range)	**0%**	**23%**	**33%**	**38%**	**6%**
Years after publication	**MAR-I**	**4**	**3**	**3**	**5**

- In the MAR I phase four categories were defined as a function of engine power
- In the data raised by the IMT, the highest power category is subdivided into two
- Due to the impact on NOx emissions, it is possible to prioritize the implementation of the MAR II phase:
  - 75 to 225 kW → deployment 3 years after publication;
  - 37 to 75 kW → deployment 4 years after publication;
  - 225 to 560 kW → deployment 5 years after publication;
  - 19 to 37 kW → maintained in MAR I phase
- Considering that the impact on the final cost of the product is greater for the technological upgrade of small machines compared to large machines, the category of 37 to 75 kW can be subdivided (e.g. the final TIER IV), granting an additional year for the 37 to 56 kW engines, and reduce to 3 years the term for the engines above 225 kW

Global Overview - NRMM Issues



Source: AEA

In South America:

- → Chile has adopted Tier 4F /Stage V since October 2023
- → Colombia has already formalized Tier 4i/Stage IIIB adoption, starting in July 2024
- → Peru is initiating conversations about regular emissions but not yet defined

May result in technological barrier for exports of Brazilian Machinery and Components!

Global Overview - NRMM Emissions (continued)

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COUNTRY	CURRENT STANDARD	NEXT PHASE
Australia	None	Some public tenders already ask for Tier 4F /Stage V, but without formal definition of national implementation (possibly Tier 4F /Stage V - Jul/2026)
Singapore	Tier 2	No formal definition (possibly Tier 4F /Stage V - 2026)
Japan	Tier 4F Equiv.	-
South Korea	Stage V	-

S10 Diesel availability

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- THE S10 DIESEL IS INCREASINGLY AVAILABLE AND HAS ALREADY EXCEEDED 60% OF NATIONAL CONSUMPTION
- PETROBRÁS HAS PUT IN ITS PLANNING THE END OF THE SALE OF THE S500 DIESEL BY 2026
- ANP TO DISCUSS S500 DISCONTINUATION SCHEDULE

brasilpostos

CURSOS E TREINAMENTOS ANUNCIE AQUI SOBRE NÓS

Início › Combustíveis › Petrobras prevê fim do S-500

Combustíveis

Petrobras prevê fim do S-500

A Academia Brasil Postos oferece mentorias, cursos, consultorias que permitem ao revendedor desenvolver-se na gestão do posto e da loja de conveniência.

A empresa também pretende investir, até 2026, US$ 2,6 bilhões na expansão da capacidade de suas refinarias, para produção adicional de mais de 300 mil barris por dia do óleo diesel S-10.

"Ao final desse prazo, todo o óleo diesel produzido pela Petrobras será S-10", garante em nota.

ISTOÉ Dinheiro

EDIÇÃO Nº 1309 27.01

ESTILO ECONOMIA NEGÓCIOS TECNOLOGIA FINANÇAS GIRO COLUNISTAS

GIRO

Fim do diesel S500 agrega incerteza à venda de refinarias da Petrobras, dizem fontes

Diesel S10 pode se tornar obrigatório no Brasil; PL tramita no Senado

Senado avalia a proposta de só permitir a venda do diesel S10 no uso rodoviário. Se aprovado o PL, o diesel S500 deixará de circular no País

Final Considerations

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Thank You

This inventory of emissions from agricultural and road machinery relied on an invaluable contribution from the Technical Commission for Off-Road Vehicles and Generators of the AEA – Brazilian Association of Automotive Engineering and its associates, whose criticisms and suggestions improved the criteria adopted and brought greater balance to the emissions inventory.

The authors thank these contributions and hope to continue counting on these collaborators in the next phase of the work, which will focus on discussing the best strategies for the implementation of new phases of the Program and should use the same concepts developed here for the analysis of scenarios for the second phase of MAR-II of the PROCONVE to be suggested to CONAMA.