Evaluating the Impact of Oxygenated Gasolines on Indonesian Vehicle Emissions Using MOVES Model

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Improving fuel quality is the most immediate and impactful strategy

Health & economic cost

USD 2.94 BILLION

annually
(~2% of GDP)

Motor vehicles are the dominant contributor to Jakarta's air pollution[2]
emitting large amounts of **$PM_{2.5}$, NO_X, CO, VOCs, and air toxics**.
Indonesia faces a critical need to reduce emissions from its motor-vehicle fleet.

Indonesia's **Euro 4** standards lag behind global norms, and EV fleet turnover will take **20–30 years,** too slow to cut emissions.

Vehicle ownership in Indonesia is rising **6% per year**, making activity reduction unrealistic[5]. Public transport infrastructure ongoing but also takes time

Indonesia must reduce transport emissions now – fuel quality improvements offer the fastest pathway.

Study Objectives

This is a quantitative evaluation of emissions of regulated pollutants (CO, PM, Nox, and VOC) and toxic air pollutants under various oxygenated gasoline blending scenarios, with a focus on the metropolitan regions of Jakarta and Surabaya.

MOVES: A Globally Recognised Emissions Model

This study uses the US EPA's MOVES model, adapted for Indonesian conditions.

No	Data	Source
1	Vehicle Population	1. Indonesia Traffic Police (*Korps Lalu Lintas Kepolisian Negara Republik Indonesia*) 2. Indonesia Central Bureau of Statistics (*Badan Pusat Statistika*) 3. Jakarta Local Environmental Agency (*Dinas Lingkungan Hidup Provinsi DKI Jakarta*) 4. Surabaya Local Environmental Agency (*Dinas Lingkungan Hidup Kota Surabaya*)
2	Fuel Characteristic	Asian Clean Fuels Association
3	Meteorological	Indonesia Meteorological, Climatological, and Geophysical Agency (*Badan Meteorologi, Klimatologi, dan Geofisika*)
4	VMT	Jakarta VKT Survey Data 2022 (CAC - Clean Air Catalyst Project Report (presented by Puji Lestari) during project launching in October 2024)
5	Average Speed Distribution	2016 Mexico City Emissions Inventory, *Secretaría del Medio Ambiente (SEDEMA) 2018*
6	Road Type Distribution	1. Indonesia Traffic Police (*Korps Lalu Lintas Kepolisian Negara Republik Indonesia*) 2. Jakarta Transportation Agency (*Dinas Perhubungan Provinsi DKI Jakarta*) 3. Field survey
7	Age Distribution	1. Indonesia Traffic Police (*Korps Lalu Lintas Kepolisian Negara Republik Indonesia*) 2. Surabaya Transportation Agency (*Dinas Perhubungan Provinsi Surabaya*) 3. Surabaya Local Environmental Agency (*Dinas Lingkungan Hidup Kota Surabaya*)

Table 1. Data Collection

What is MOVES?

MOVES
Motor Vehicle Emission Simulator

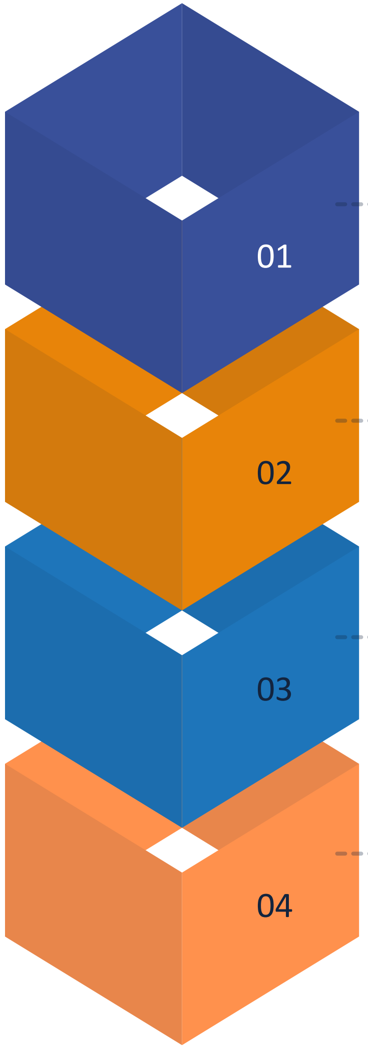
- Motor Vehicle Emission Simulator (US EPA)
- Used worldwide for transport policy and air quality planning

Localised for Indonesia

- **Cities**
  Jakarta and Surabaya
- **Local fleet composition**
- **Vehicle activity patterns**
- **Fuel properties**
- **Meteorology**

MOVES modelling enables realistic evaluation of fuel policy impacts on vehicle emissions.

MOVES for Policy Scenario Analysis

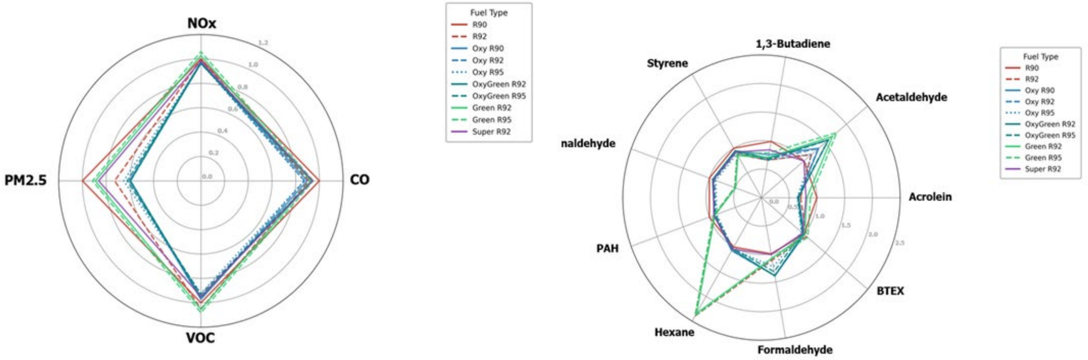


MOVES evaluates:

- Fuel formation scenarios
- Emission standard changes
- Fleet evolution impacts
- City-level emission inventories

Table 8. Case Study Fuel Blends

	1	2	3	4	5	6	7	8	9	10
Grade	Pertalite R90	Pertalite Oxy R90	Pertamax R92	Pertamax Oxy R92	Pertamax Super R92	Pertamax OxyGreen R92	Pertamax Green R92	Pertamax Oxy R95	Pertamax Green R95	Pertamax Oxygreen 92 R95
Blend	**R90**	**Oxy R90**	**R92**	**Oxy R92**	**Super R92**	**OxyGreen R92**	**Green R92 E7**	**Oxy R95**	**Green R95 E7**	**OxyGreen R95**
Year	2023	2025	2023-4	2025	2025	2025	2025	2025	2024	2025
Wt% Oxygen	0.0	1.8	2.0	2.5	0.9	2.2	2.4	2.7	3.2	2.7
Energy Content MJ/KG	43.1	42.8	42.9	42.5	42.7	43.7	42.0	41.9	42.1	43.1
RON	91.2	91.3	90.9	92.5	92.5	92.7	92.4	95.2	96.7	95.7
RVP	51	55	65	55	51	47	60	51	62	42
sulfurLevel	39	35	43	34	37	39	36	33	43	39
ETOHVolume	0.0	0.0	0.6	0.0	0.0	0.0	7.0	0.0	6.7	0.0
MTBEVolume	0.2	10.0	7.0	14.0	5.0	0.0	0.0	14.9	2.3	0.0
ETBEVolume	0.0	0.0	0.0	0.0	0.0	14.0	0.0	0.0	0.0	17.2
TAMEVolume	0	0.0	3.0	0.0	0.0	0.0	0.0	0	3.2	0
aromaticContent	31.6	26.0	21.3	24.9	30.0	24.9	29.3	26.8	26.6	26.4
olefinContent	17.6	18.2	10.5	15.7	16.7	15.7	16.3	14.9	16.8	14.7
benzeneContent	1.40	1.7	1.6	1.5	1.3	1.5	1.3	1.2	2.3	1.3
e200 %	42	55	63	59	47	59	49	57	56	59
e300 %	82	100	89	100	87	100	89	97	86	99

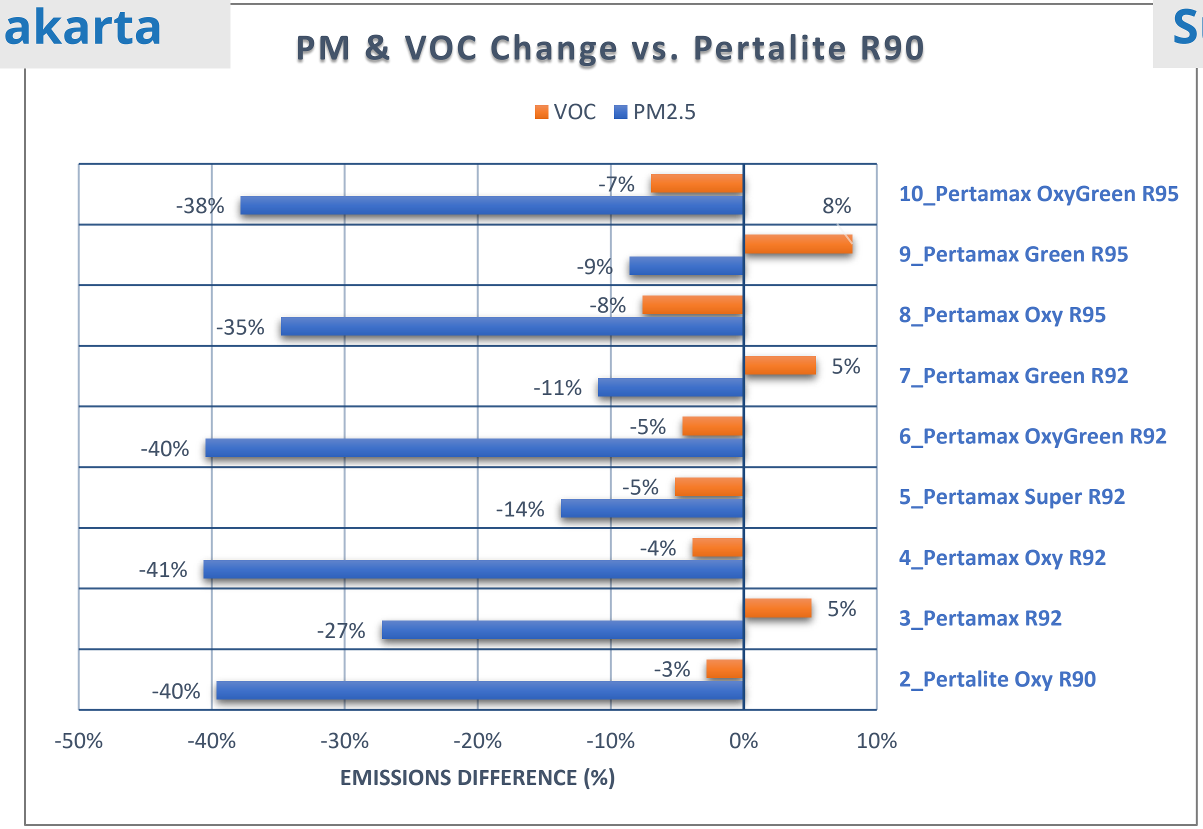


Emission Reduction for Regulated & Toxic Air Pollutants

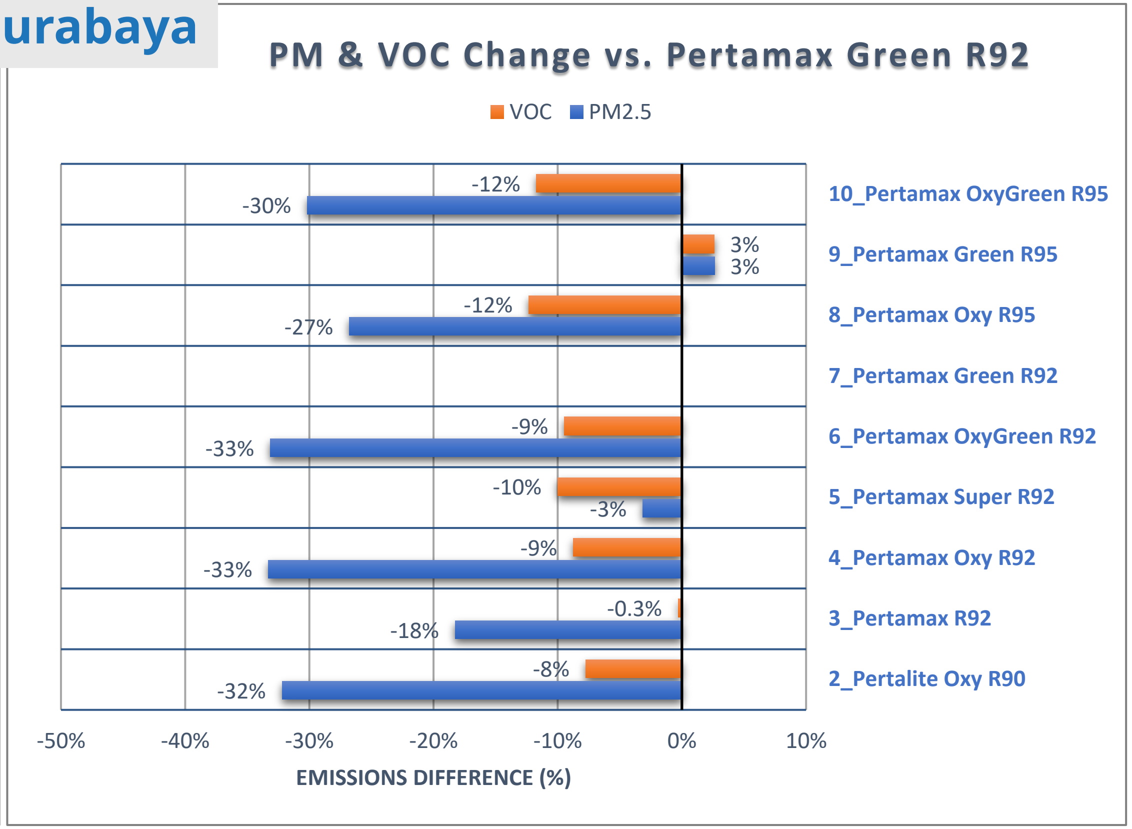
Ether is far superior oxygenate to reduce pollution: PM2.5, VOCs

The relative emission patterns between Jakarta and Surabaya were consistent. Absolute levels in Jakarta were roughly four times higher due to its larger vehicle population.

Jakarta



Surabaya



Figures show Relative Emissions Reduction Compared to Base Fuel (R90).

Summary of key findings on regulated and toxic pollutants

Oxygenated fuels reduce CO and $PM_{2.5}$, but impacts on NO_x and toxic pollutants vary; ethers outperform ethanol on all parameters.

Oxygenated fuels will reduce regulated pollutants		
All oxygenated fuels reduced CO by 4–13% and $PM_{2.5}$ by up to 41%; **MTBE/ETBE performed best**	**Ether blends decreased NO_x by 2–4%, while ethanol increased NO_x by 2–6%** from higher combustion temperatures	**Ether fuels lowered VOCs by up to 8%; ethanol raised VOCs by up to 10% because of higher volatility** (RVP).

Fuel composition strongly influences emissions – ether blends outperform ethanol across key pollutants.

MOVES simulations also revealed critical variations in toxic air pollutants from use of different oxygenates:

- **1,3-Butadiene & PAHs**: Ether-based fuels achieved up to 33% reduction in i 1,3-B and 14% PAHs, indicates improved combustion completeness and reduced aromatic content.
- **Aldehydes**: Ether and ethanol blends both reduced acrolein and propionaldehyde but ethanol-containing fuels increased acetaldehyde by 77%.
- **VOCs & Hexane**: MTBE/ETBE blends decreased BTEX by up to 6%, but ethanol blends raised BTEX and hexane by up to 140%, confirming volatility impact.
- **Styrene**: Both ether and ethanol blends lowered styrene emissions, with ethanol showing the largest reduction (up to 16%) due to improved oxidative combustion.

Fuel Policy Can Deliver Immediate Air Quality Benefits

Improving fuel quality is one of the fastest ways to reduce urban emissions.

- Prioritise low-volatility ether oxygenates
- Support full Euro IV implementation
- Reduce high-octane aromatic content
- Establish MOVES-Indonesia for ongoing policy analysis

Fuel quality decisions today can deliver immediate improvements in urban air quality.

Policy Implications

The study highlights that:

Oxygenate type matters. Ether blends (MTBE/ETBE) outperform ethanol in reducing key pollutants.

Prioritise ether-based oxygenates for metropolitan areas such as Jakarta and Surabaya.

Phase out High Octane Mogas Component (HOMC) in low-RON fuels to reduce particulate formation.

Strengthen fuel quality regulations alongside Euro IV standards
- oxygenate content
- volatility limits
- aromatic thresholds

Establish a national MOVES-Indonesia framework for continuous emissions monitoring and policy evaluation.

Oxygenate blends (MTBE/ETBE) could be a good solution to cut CO, NOx and $PM_{2.5}$ emission from transport sectors in the near term.

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Thank you!

For any questions, please contact puji_L@itb.ad.id

Emission Reduction (%)

Figures show Relative Emissions Reduction Compared to Base Fuel (R90). MTBE-blended fuels are in white, ETBE-blended fuels are in grey, and ethanol-blended fuels are in green.