Climate and Air Quality Scenarios for E-Bus Deployment:

Deep Dive City Ho Chi Minh City, Vietnam

City Characteristics

Ho Chi Minh City (HCMC) is the largest city in Vietnam with a population of approximately 9 million[1]. It is located in south-eastern Vietnam on the banks of the Saigon River, covering an urban area of about 2,000 km2, resulting in a population density of around 4,300 inhabitants per square km[2]. The metropolitan area has a population of over 21 million with a density of about 700 inhabitants per km2. The city has experienced steady population growth, from 6 million inhabitants in 2006 to 9 million in 2019. HCMC has a Human Development Index of 0.795, which is above the national average of 0.703 and the second-highest in Vietnam[3]. The annual GDP of HCMC is estimated to be around USD 166.8 billion[4].

The city's topography is flat, ranging from sea level to 25m elevation, and it is located in the tropical climate zone. The average annual temperature is 27.2 degrees Celsius, with monthly averages ranging from 25.6 to 28.9 degrees Celsius. The city experiences an average annual rainfall of 1.909 mm[5].

Transport system

The transport system in HCMC relies on private motorcycles, with a modal share of 80%. Active mobility accounts for 19%, while public transport (4%), private cars (1%) and other modes (3%) play a minor role.

---

[1] C40 Cities, 'Ho Chi Minh City'.

[2] C40 Cities.

[3] General Statistics Office of Vietnam, 'Chỉ Số Phát Triển Con Người Việt Nam Giai Đoạn 2016 – 2020'.

[4] C40 Cities, 'Ho Chi Minh City'.

[5] Climate Data, 'Ho Chi Minh City Climate: Temperature Ho Chi Minh City & Weather By Month'.

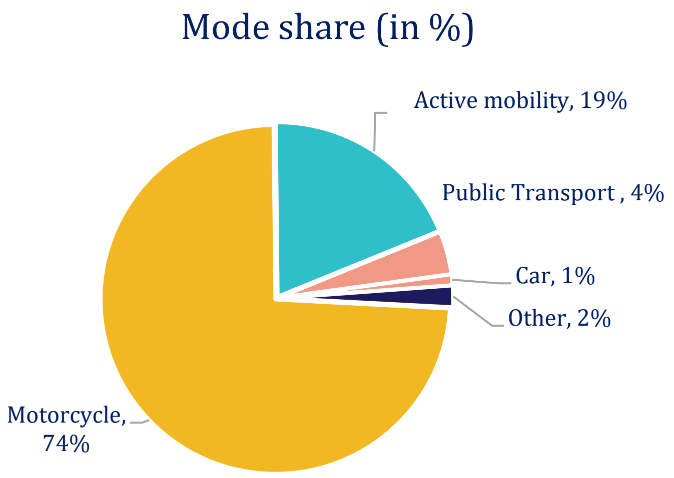


Figure 1: Modal Split in HCMC. Source: (Centre for Liveable Cities and Urban Land Institute 2017)

HCMC plans to extend its public transport system, including Mass Rapid Transit and Bus Rapid Transit corridors, and to achieve a public transport share of 25% of city travel by 2020 and 60% after 2030. The high share of fossil-fuelled motorbikes contributes to serious air quality and health issues: A C40 report assumes that "the annual average concentration of fine Particulate Matter (PM2.5) is three times higher than World Health Organisation. Around 7,300 premature deaths every year are attributable to the current PM2.5 levels."[6].

Climate and air pollution targets

Air pollution is one of the key issues in HCMC. It is reported that the $PM_{2.5}$ concentration in HCMC is three times above WHO´s recommendation, with which 40% of it comes from the transport sector, particularly motorbikes [7]. To tackle the issue, HCMC plan to convert 1.300 diesel buses to CNG and encourage the use of electric motorbikes instead of gasoline-powered ones[8].

On a national scale, Vietnam commits to reaching net zero emissions by 2050 according to the Nationally Determined Contribution (NDC)[9].

Targets and policies related to the procurement of e-buses

The current bus fleet consists of 2100 ICE buses and 77 e-buses. The first 29 km e-bus route was opened in March 2022. Four additional routes are planned as pilot routes in HCMC [10]. HCMC aims to have 270 e-buses by 2025 and to achieve full electrification of an expected bus fleet of 2293 vehicles by 2030. The adjusted Master Plan of HCMC to 2040 emphasises

---

[6] C40 Cities, 'Ho Chi Minh City'.
[7] C40 Cities, 'Ho Chi Minh City: Benefit of Urban Climate Action'.
[8] C40 Cities.
[9] Socialist Republic of Vietnam, 'Vietnam Nationally Determined Contribution'.
[10] Changing Transport, 'Launch of the First E-Bus Route in Ho Chi Minh City'.

the "integrated urban development with the public transport system (TOD), other high-speed traffic, including public underground traffic and surrounding underground urban space, linking public transport with use land"[11].

The e-Bus Emissions Assessment Tool (eBEAT)

The eBEAT tool is co-developed by TUMI E-Bus Mission and SOLUTIONSplus. It is a bus stock model that integrates the evolution of the bus fleet based on the number of new entrants, considering sizes (for e-buses), fuel split and emission standards, a vehicle survival curve, new vehicle technology improvements, and vehicle degradation. The tool aims at a better understanding of the impact of an accelerated procurement of e-buses in cities in Asia, Africa, and Latin America.

The tool can calculate time-series estimations of emissions based on existing plans and targets for e-bus procurement and on 'what-if' scenarios that consider external factors such as changes in the national energy mix or transmission losses in the electricity grid. The calculator goes beyond greenhouse gas emissions and captures air pollutants and energy consumption.

While the calculator uses city-specific data on procurement plans and targets or vehicle-km, it also provides default values to reduce data requirements. Users can adapt default values for the e-bus and the 'what-if' scenario.

Impact of accelerated e-bus procurement on emissions

High-capacity, efficient, clean, and high-service-quality passenger transport modes such as electric buses (e-buses) play a critical role in accelerating the reduction of emissions from urban transportation.

To analyse the impacts of the accelerated e-bus procurement, we have developed two scenarios, viz., a base scenario and an enhanced scenario. The parameters that are used in each scenario are summarized in the table below:

Parameters	Base Scenario		Enhanced Scenario	
	2030	2050	2030	2050
Fleet Stock	2.290	0	2.290	4.620
T&D Losses	9%	9%	8%	5%
% of Renewable Energy	47%	58%	61%	75%

In the **base scenario**, we have considered procurement targets set by the city (i.e. 270 e-buses by 2025). The data was obtained from the TUMI e-bus network website and updated

[11] Vietnam Industry and Trade Information Center, 'Adjusted Master Plan of Ho Chi Minh City to 2040, Vision to 2060'.

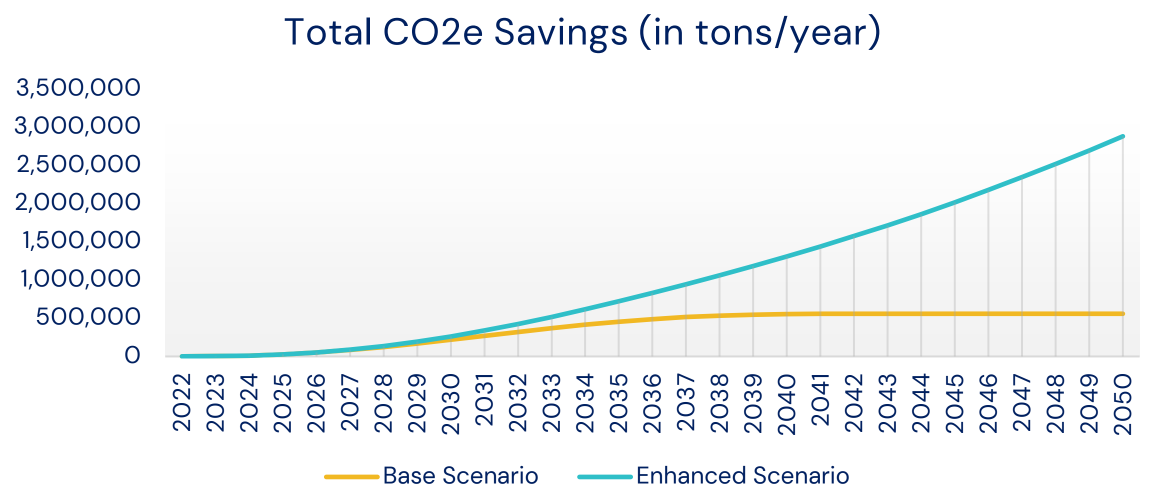
figures from the TUMI partners. Moreover, we assumed a moderate increase in the share of renewable energy sources in the electricity mix to 58% and constant transmission & distribution losses of 9%.

In the **enhanced scenario**, a key assumption was that the entire bus fleet is electrified by 2030, according to HCMC's procurement policy. The fleet size up to 2050 was estimated based on the population growth in the city. We assumed the fleet availability per 1000 inhabitants would remain unchanged until 2050. This will lead to a fleet size of 4,620 vehicles in 2050, and a total of 10,720 e-buses including retirements up to 2050. In addition, we assumed that the future electricity mix has a higher share of renewable energy 75% and that transmission and distribution losses will gradually be reduced to 5% by 2050.

The tool estimates the cumulative savings for emissions and energy consumption by shifting to e-bus. Conventional urban buses are predominantly fuelled by diesel engines, emitting black carbon (BC), a harmful and carcinogenic particle. Other emissions that are analysed are the most crucial air pollutants source that significantly affects human health and environmental quality, such as NO_x and particulate matter (PM). The following table gives a snapshot of the cumulative savings from shifting to e-buses according to the base and enhanced scenarios:

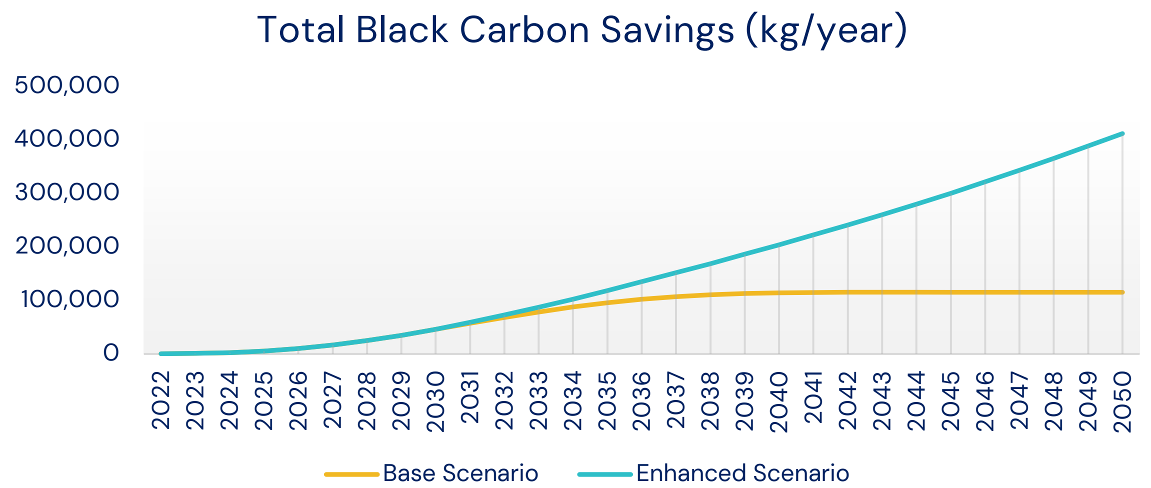
Category (unit)	Base Scenario		Enhanced Scenario	
	Up to 2030	*Up to 2050*	*Up to 2030*	*Up to 2050*
BC (tons)	46	115	46	412
CH_4 (tons)	14	36	15	134
CO (tons)	752	1.867	757	6.761
CO_2 (kilo tons)	218	558	262	2.879
CO_2e (kilo tons)	219	559	263	2.884
N_2O (tons)	2	5	2	22
NMVOC (tons)	22	50	25	231
NO_x (tons)	2.516	6.277	2.557	23.246
PM_{10} (tons)	77	193	78	714
$PM2_{.5}$ (tons)	55	138	56	504
SO_x (tons)	-11	-26	-9	-48
TSP (tons)	102	255	103	945
Energy consumption (MWh)	730.000	1.830.000	740.000	6.970.000
Energy consumption (TOE)	60.000	160.000	60.000	600.000

By shifting to e-buses, the base scenario shows a reduction of 219 ktCO2e emissions by 2030. In the long-term, until 2050, the reduction amounts to about 559 ktCO2e. Meanwhile, the enhanced scenario shows a 263 ktCO_2e reduction by 2030 and the number significantly increases to 2.884 ktCO_2e by 2050.

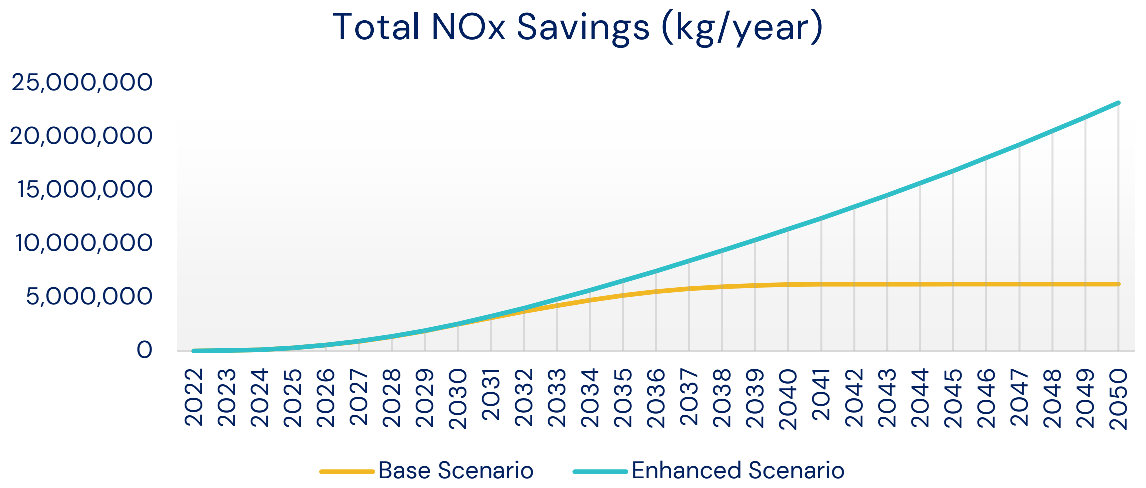


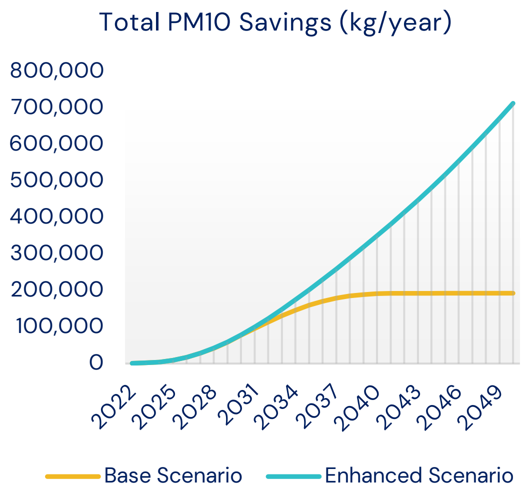
Electric buses not only decrease greenhouse gas emissions but also improve air quality in the local area. The transition towards e-buses is expected to save the city a significant amount of black carbon, with an estimated 46 tons in 2030 and 115 tons by 2050 in the base scenario. Furthermore, the base scenario also predicts a significant reduction of about 6.277 tons of NOx and 331 tons of particulate matter saved by 2050. These figures demonstrate the clear benefits that switching to electric buses can bring to the environment and the local community.

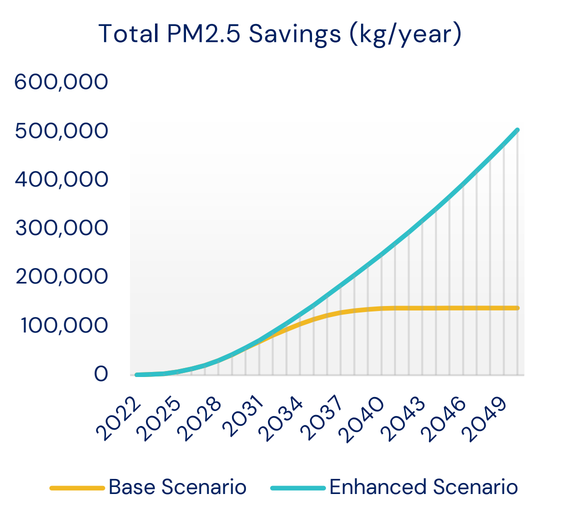
In the enhanced, scenario the reductions in black carbon, NOx and particulate matter by 2050 are 412 tons, 23.246 tons and 1.218 tons, respectively. The savings from the enhanced scenario are almost four-fold to the base scenario. Thus, improving the current target may potentially reach or even exceed the level of savings that are estimated by the enhanced scenario.



Total NOx Savings (kg/year)







Emission reduction potential at a national level

As mentioned in the NDC in 2022, Vietnam targeted 15,8% emissions below BAU by 2030 and aims to be climate neutral by 2050[12]. In 2020, IEA reported that 37 Mt of CO_2 were emitted by the transportation sector in Vietnam, of which 86% were emitted from road transportation[13].

On a national level, E-BEAT estimates that the average annual CO_2 savings per bus in Vietnam for the enhanced scenario are 30 tonnes and 40 tonnes in 2030 and 2050, respectively. Assuming the steady growth of bus fleet size to population ratio and a 75% shift from ICE buses to e-buses, it is estimated that the annual CO_2 savings will reach 7 Mt in 2030 and 17 Mt in 2050. To put into context, the number is then compared to the 2020 road transport emission level. It shows that by shifting the ICE buses into e-buses, Vietnam will

[12] Climate Action Tracker, 'Viet Nam'.
[13] IEA, 'Greenhouse Gas Emissions from Energy'.

reduce 21% and 55% of its road transport emission in 2030 and 2050, respectively. Furthermore, the savings percentage can potentially increase to 73% in 2050 by shifting 100% of buses from ICE buses to e-buses.

References

C40 Cities. 'Ho Chi Minh City', 2019. https://c40.my.salesforce.com/sfc/p/#36000001Enhz/a/1Q000000Mn6a/WibjcbH19NI5_D8WTeIFzVCXx5VYZ51T2T3uLkUBppk.

———. 'Ho Chi Minh City: Benefit of Urban Climate Action', 2022. https://www.c40.org/wp-content/uploads/2022/02/Ho-Chi-Minh-City-%E2%80%93-Upgrading-the-Bus-Fleet-from-Diesel-to-CNG-Promoting-the-Uptake-of-E-bikes.pdf.

Changing Transport. 'Launch of the First E-Bus Route in Ho Chi Minh City', 2022. https://changing-transport.org/launch-first-e-bus-route-vietnam/.

Climate Action Tracker. 'Viet Nam', 2022. https://climateactiontracker.org/countries/vietnam/.

Climate Data. 'Ho Chi Minh City Climate: Temperature Ho Chi Minh City & Weather By Month'. Accessed 13 June 2023. https://en.climate-data.org/asia/vietnam/ho-chi-minh-city/ho-chi-minh-city-4235/.

General Statistics Office of Vietnam. 'Chỉ Số Phát Triển Con Người Việt Nam Giai Đoạn 2016 – 2020', 2021. https://www.gso.gov.vn/wp-content/uploads/2022/03/HDI_report_V15-official-version.pdf.

IEA. 'Greenhouse Gas Emissions from Energy', 2022. https://www.iea.org/data-and-statistics/data-product/greenhouse-gas-emissions-from-energy-highlights.

Socialist Republic of Vietnam. 'Vietnam Nationally Determined Contribution', 2022. https://cdn.climatepolicyradar.org/navigator/VNM/1900/viet-nam-ndc-2022-update_10296d915d6c41432126ac399e5dc69a.pdf.

Vietnam Industry and Trade Information Center. 'Adjusted Master Plan of Ho Chi Minh City to 2040, Vision to 2060', 2022. http://asemconnectvietnam.gov.vn/default.aspx?ZID1=14&ID8=118295&ID1=2.