

Simplified carbon abatement calculation protocol

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The logic of this simplified carbon abatement protocol is to derive outcomes from outputs using simple and direct emission factors or carbon abatement factors.

Output > Intermediary Outcomes > Carbon Abatement Outcome

For example:

TOD implementation > increase in subway and buses ridership > modal shift from cars > carbon abatement

Green and Complete Streets and NbS > Carbon sequestration per km and per ha

Green and Complete Streets and NbS > urban cooling (in °C) > decrease in cooling energy (in KWh) > carbon abatement

TOD

Shijiazhuang Assumptions 2030

Population: 5.3 million in the central city.
Number of Cars: 4.6 million (increasing at 5% per year).

Construction Land: 560 km² in the central city.

Subway Network: 100 stations, 137 kilometers of rail after Phase II completion in 2027.

Subway Ridership: 636,000 passengers daily (12% of the core city population).

Subway Coverage: 32% of the city's commuting population within 800 meters of a station.

Daily VKT per Capita: 12 kilometers

Emission factors

Transportation Mode	Emission Factor (kg CO2 per km)
Private Cars	0.2 - 0.3
Buses (Electric)	0.05 - 0.1
Subway	0.03 - 0.05
Motorcycles	0.1 - 0.2

Detailed Insights:

- **Private Cars:** The emission factor for private cars in Shijiazhuang typically ranges from 0.2 to 0.3 kg CO₂ per km, reflecting the predominance of fuel-powered vehicles in the city.
- **Buses:** Electric buses show a significantly lower emission factor, estimated between 0.05 and 0.1 kg CO₂ per km, which indicates their efficiency in reducing carbon emissions compared to traditional fuel-based buses.
- **Subway Systems:** The subway systems in Shijiazhuang contribute relatively low emissions, with factors around 0.03 to 0.05 kg CO₂ per km, highlighting the benefits of electrified public transport.
- **Motorcycles:** Emission factors for motorcycles are generally higher than those for electric buses but lower than private cars, ranging from 0.1 to 0.2 kg CO₂ per km.

Net carbon emissions abatement from TOD interventions (tons CO₂/year) – simplified calculation

Abatement of modal shift from car to subway: $0.3 - 0.03 = 0.27$ kg CO₂ per kilometer.

Abatement of modal shift from car to electric buses: $0.3 - 0.05 = 0.25$ kg CO₂ per kilometer.

Shift to subway from 2025 to 2030: Increase of average metro ridership 636,000 - 450,000 = + 186,000 passengers per year

Shift to electric buses from 2025 to 2030 > increase of multimodality > increase of buses ridership = + 110 000 passengers / year

Formula: Transit Passenger Daily Increase x Average VKT per capita x abatement factor x 365

Shift to subways: $186,000 \times 0.27 \times 12 \times 365 =$ circa 220 million kg CO₂ = circa 220,000 tons CO₂

Shift to buses: $110,000 \times 0.25 \times 12 \times 365 =$ circa 120 million kg CO₂ = circa 120, 000 tons CO₂

TOTAL SHIFT TO TRANSIT: 340, 000 tons carbon abatement annually in 2030

NBS (Green and Complete Streets + Green and Blue Spaces)

Carbon Sequestration:

100 ha * 4.73 kg C/ha/year = 473,000 kg C/year

Convert to CO₂-eq: 473,000 kg C/year * 3.67 (CO₂/C conversion factor) = 1,737,111 kg CO₂-eq/year

Urban Cooling Effects:

Affected Floor area: 3,000,000 m²

3,000,000 m² * 14 kWh/m²/year = 42,000,000 kWh/year

42,000,000 kWh/year * 0.659 kg CO₂-eq/kWh = 27,678,000 kg CO₂-eq/year

Total Annual Carbon Abatement:

1,737,111 kg CO₂-eq/year (carbon sequestration) + 27,678,000 kg CO₂-eq/year (urban cooling) = 29,415,111 kg CO₂-eq/year = **circa 29,400 tons CO₂-eq/year**

50-year Lifecycle Carbon Abatement:

29,415,111 kg CO₂-eq/year * 50 years = 1,470,755,550 kg CO₂-eq = **circa 1.47 million tons CO₂-eq**