Energy and Greenhouse Gas Emissions Scenarios for the Bus Rapid Transit System in Curitiba, Brazil

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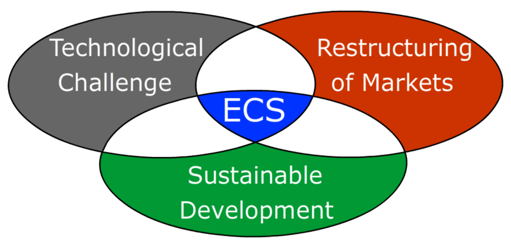

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This research is part of a project aimed at sustainable technological solutions for the improvement of urban infrastructure in Curitiba in Brazil, involving Swedish and Brazilian stakeholders.

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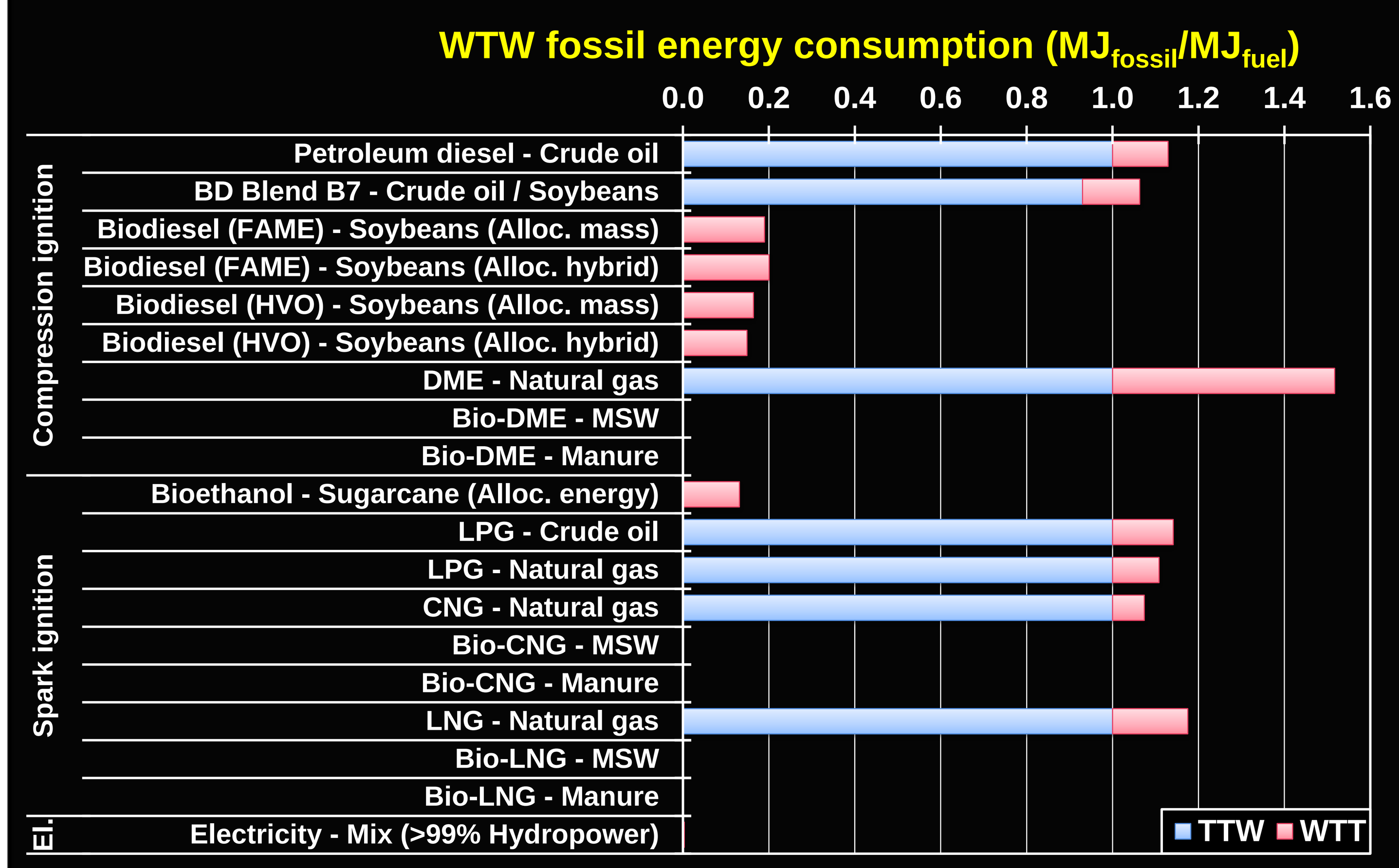
Decarbonizing the bus fleet in Curitiba

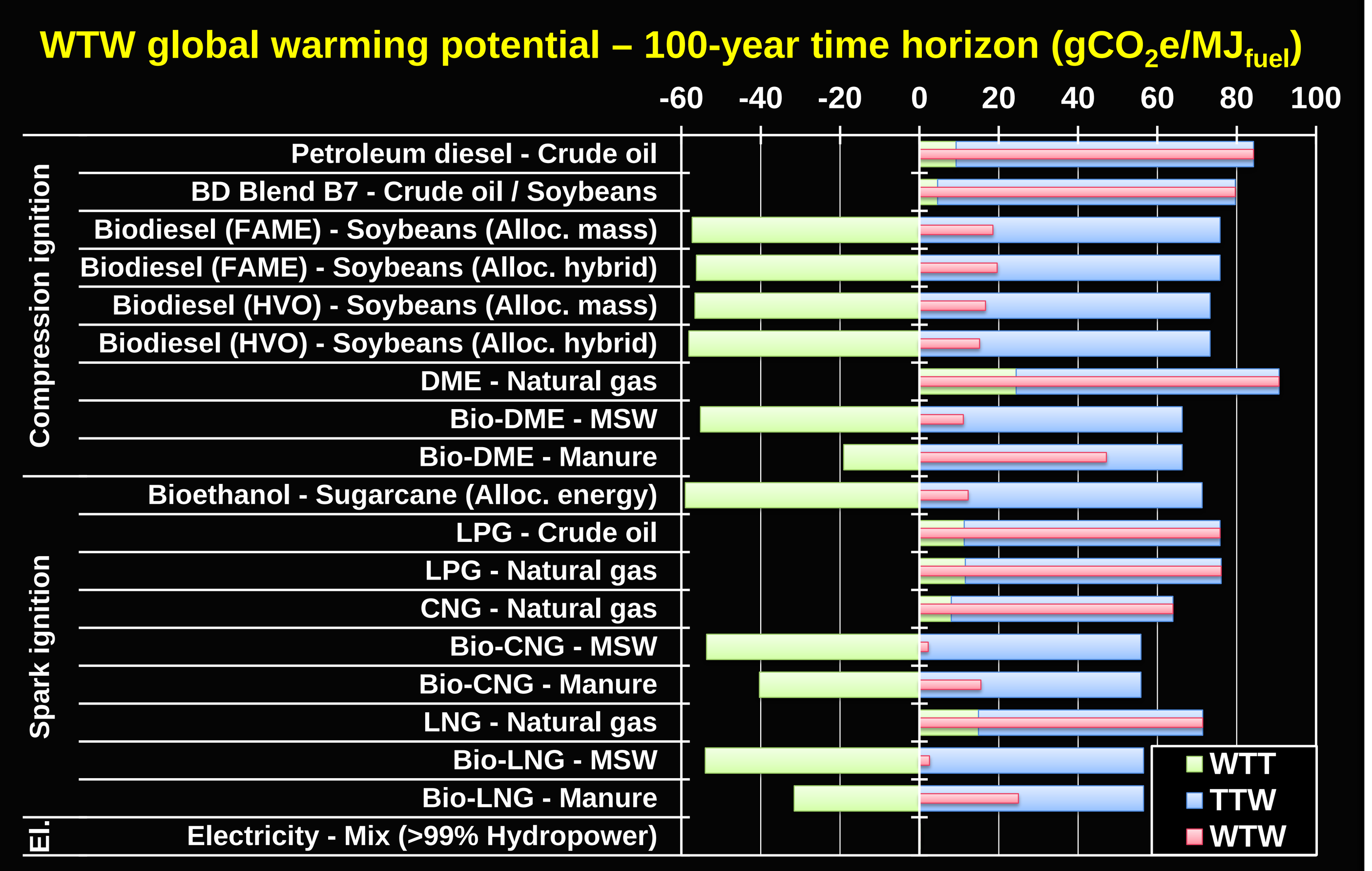
- The city of Curitiba is part of the C40 Cities Climate Leadership Group (C40) which includes commitments to promote sustainability. Public bus transport is an area of particular interest to the city.
- The accumulated distance driven by buses in the city's bus rapid transit system (BRT) was 11.2 million km in 2015. Fuel mix: 80% petroleum diesel, 20% biodiesel (FAME) [1].
- ***What impact will alternative fuels and advanced bus technologies have on the decarbonization of Curitiba's BRT system?***

Methodology

- Pathways of 13 different transport fuels derived from 9 domestic feedstock were analyzed using the GREET model [2].
- Energy and greenhouse gas emissions scenarios were modelled using the LEAP modelling tool [3].
- Real-world operation data for the BRT system were provided by the local public transport company in Curitiba [1].
- The business as usual (BAU) scenario is compared with potential future scenarios between 2016 and 2030.

Fuel Pathways – Feedstock

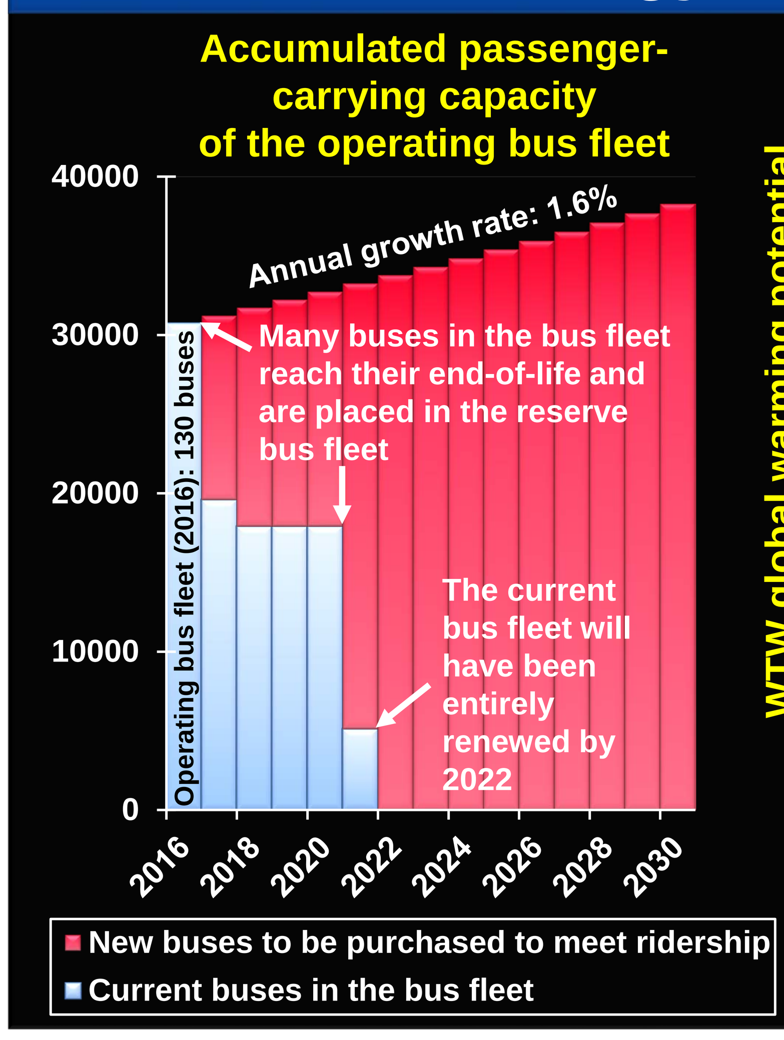


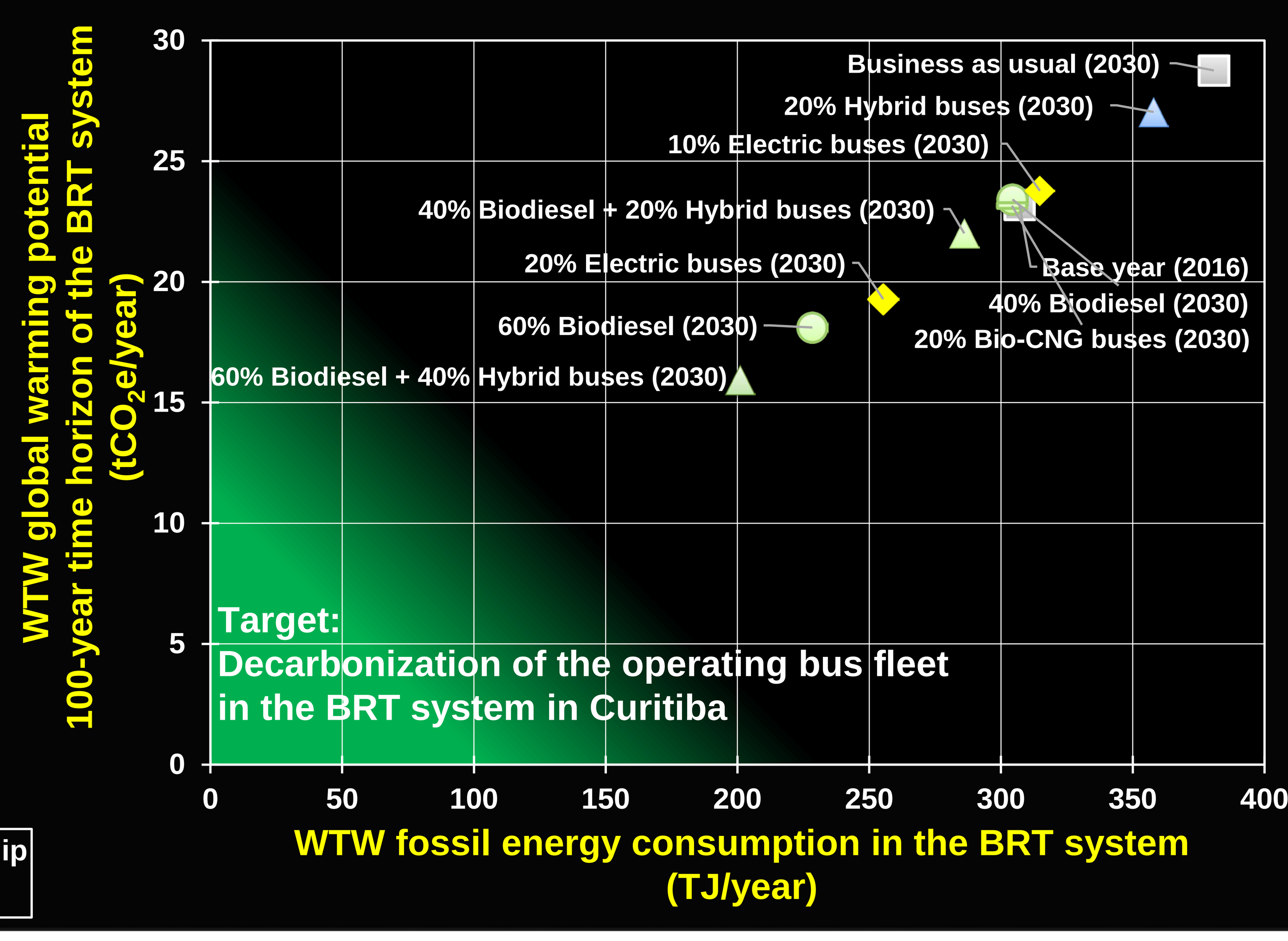


- Well-to-Wheel (WTW) fossil energy consumption accounts for all fossil energy consumed in a fuel pathway to produce and supply a fuel, covering all stages from feedstock recovery until refuelling station (Well-to-Tank (WTT)) as well as the fuel use stage (Tank-to-Wheel (TTW)). Functional unit for WTW analysis: 1 MJ of fuel produced and used. The energy content of renewable fuels is exclusively based on bioresources, i.e. no TTW fossil fuel consumption.

Abbreviations: BD Blend B7 – 7% Biodiesel (FAME) + 93% Petroleum diesel (most consumed fuel in Curitiba), FAME – Fatty acid methyl ester, HVO – Hydrotreated vegetable oil, DME – Dimethyl ether, MSW – Municipal solid waste, LPG – Liquefied petroleum gas, CNG – Compressed natural gas, LNG – Liquefied natural gas. // Co-products: Biodiesel (FAME): Soybean meal, glycerine; Biodiesel (HVO): Soybean meal, fuel gas, heavy oil; Bioethanol: Electricity.

Energy and Greenhouse Gas Emissions Scenarios 2030





- A business as usual track (BAU), i.e. no changes between 2016 and 2030, will result in an increase of both fossil energy consumption and global warming potential on a 100-year horizon (GWP_{100}) by 24% compared to 2016.
- Increasing biodiesel in the bus fleet's fuel mix from currently 20% (2016) to 40% or 60% (2030) can reduce the GWP_{100} by 19% or 37% compared to BAU, respectively. In combination with a use of 40% hybrid buses, the GWP_{100} can be reduced by 47%.
- Increasing the use of electric buses from 0% (2016) to 20% (2030) in the bus fleet can reduce both energy consumption and GWP_{100} by 33% compared to BAU.

Conclusions

✓ Energetic and environmental impacts of transport fuels depend strongly on their Well-to-Wheel pathways. The major advantage of biofuels is their exclusively bioenergy based energy content that reduce enormously fossil energy consumption and CO_2e emissions in the Tank-to-Wheel stage compared to fossil derived transport fuels.

✓ The BRT system in the city of Curitiba has large potential to become more sustainable by using local renewable resources. A partial electrification of the bus fleet is particular benefical due to the almost entirely electricity generation by hydropower in the case of Curitiba.

References:

[1] URBS – Urbanization of Curitiba S/A. Personal communication 2015.

[2] Argonne National Laboratory (ANL). The Greenhouse gases, Regulated Emissions, and Energy use in Transportation (GREET) model v1.3.0.12749. 2014.

[3] Heaps, C.G., 2012. Long-range Energy Alternatives Planning (LEAP) system. [Software version 2015.0.19] Stockholm Environment Institute. Somerville, MA, USA. www.energycommunity.org

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