НАМИ

GRPE workshop
on carbon LCA of vehicles

Russian Life Cycle Assessment Experience in Automotive Industry

1. NAMI Experience

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LCA Methodology Development

The key items

The base for LCA Methodology Development was ISO 14040-14043 standards.
The goal of LCA is to assess integral environmental impact of different automotive applications: vehicles as a whole, engines, components, fuels, energy sources.
The scope consists of following stages: materials, fluids and fuels production, energy generation, components manufacturing, assembly, use and recycling.
During inventory analysis following data collected:

- natural resources demand
- emissions to the atmosphere
- energy expenditures

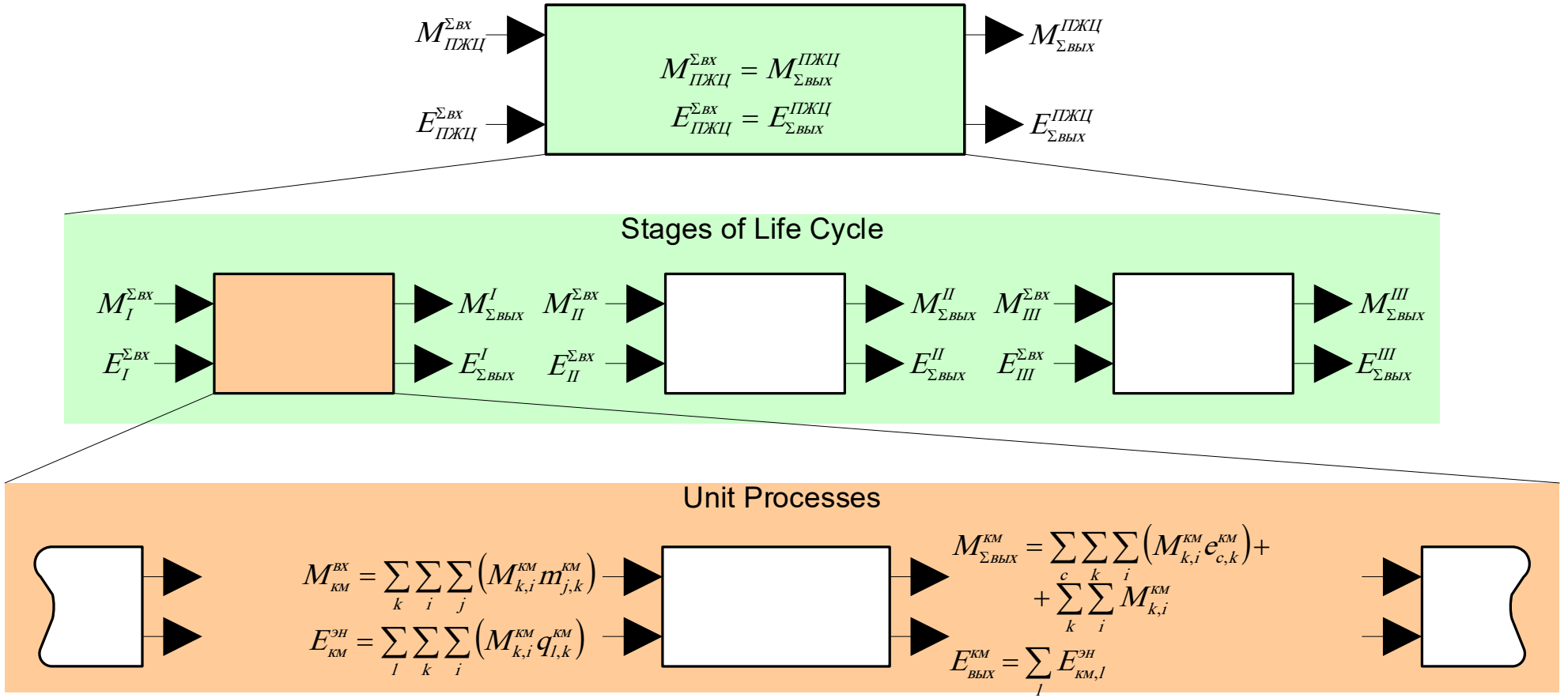
Input Inventory data then used for calculation of Total Life Cycle data.
The next stage of LCA is impact assessment. Two integral values are calculated:

- Ecoindicator 99
- Environmental burden from air pollution

The final stage interpretation of results and conclusions (which of compared variants is better, what is the most dangerous process or stage, what is the direction to improve products).

The first in Russia book about LCA was published 2001:
Zvonov V., Kozlov A., Kutenev V. Environmental safety of the vehicle in total Life Cycle, 2001, 248 p.

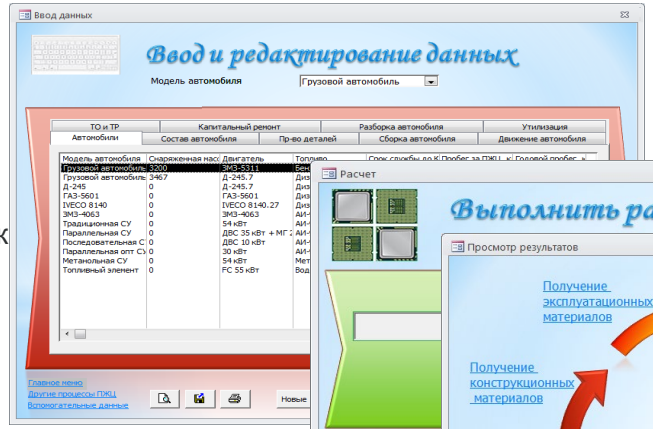
LCA Methodology Development

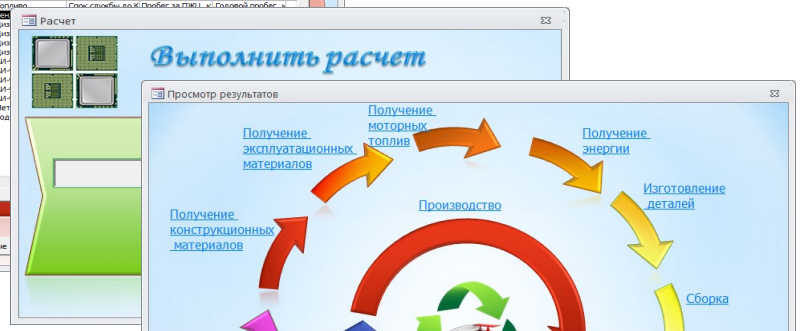


To calculate inventory data for Total Life Cycle, mathematical model was developed, which consists of formulas for 12 unit processes and 3 stages.

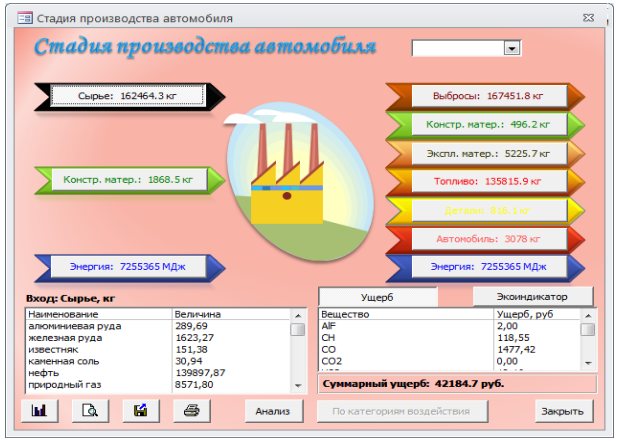
LCA Software Development

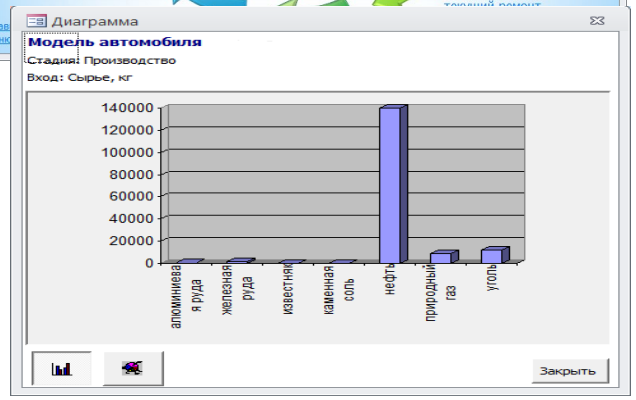
Main menu of **CarLCA** software





Windows for results reviewing





Key features of CarLCA 3.0

- the software is based on database technologies
- the software has user friendly interface
- the database consist of inventory data for many materials, fuels, energy production and different processes in the vehicle life cycle
- the software allows to calculate the environmental burden and Ecoindicator

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LCA Cases

Vehicles

Cars:
- ✓ conventional
- ✓ hybrid
- ✓ hydrogen

Heavy-duty vehicles

Buses

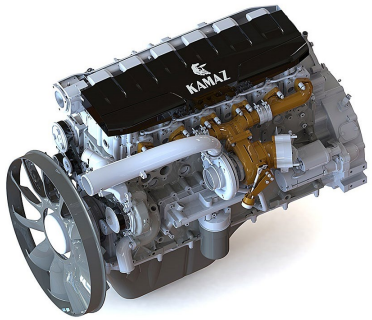
Components

Engines

Batteries

Fuel Cells

Tires



Fuels

Gasoline

Diesel

Biodiesel

Natural Gas (Compressed and Liquid)

Dimethyl Ether

Methanol

Hydrogen

Electricity

2. Case study “City bus”

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Case study “City bus”

Variants of power unit:

- Diesel engine
- CNG engine
- LNG engine
- Electric powertrain with batteries
- Hydrogen fuel cell

It is assumed in the calculations that:

- Electricity is produced at a gas power plant
- Hydrogen is produced at a large-scale chemical plant by catalytic conversion of natural gas
- The mileage of buses for the total life cycle is 1 million km

Kozlov A.V., Porsin A.V., Dobrovol’skii Y.A., Kashin A.M., Terenchenko A.S., Gorin M.A., Tikhonov, A.N., Milov, K.V. Life Cycle Assessment of Powertrains Based on a Battery, Hydrogen Fuel Cells, and Internal Combustion Engine for Urban Buses under the Conditions of Moscow Oblast //Russian Journal of Applied Chemistry. – 2021. - Vol. 94. – No. 6. – pp. 793–812. DOI: 10.1134/S1070427221060136

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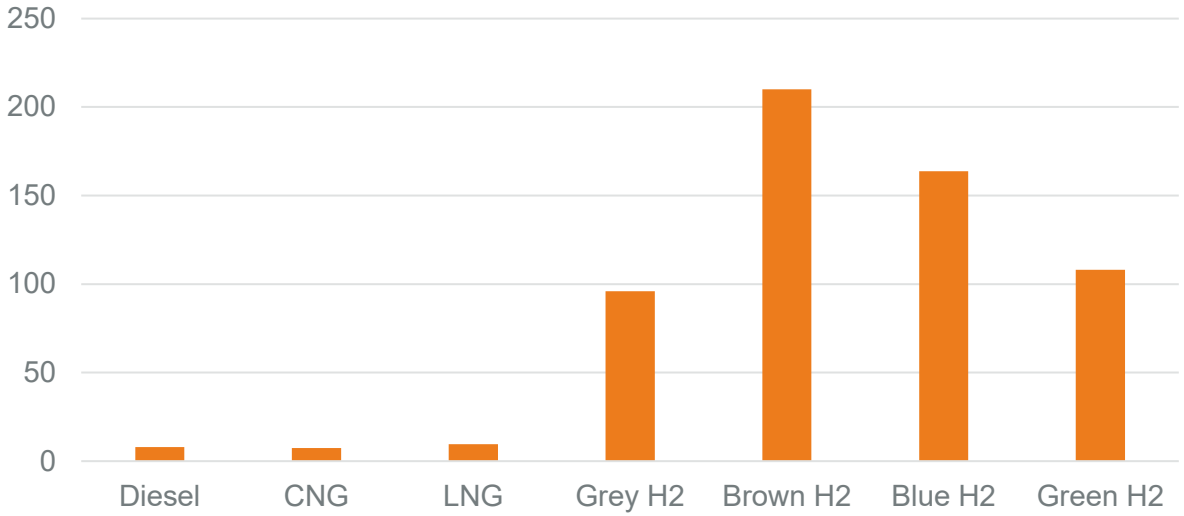
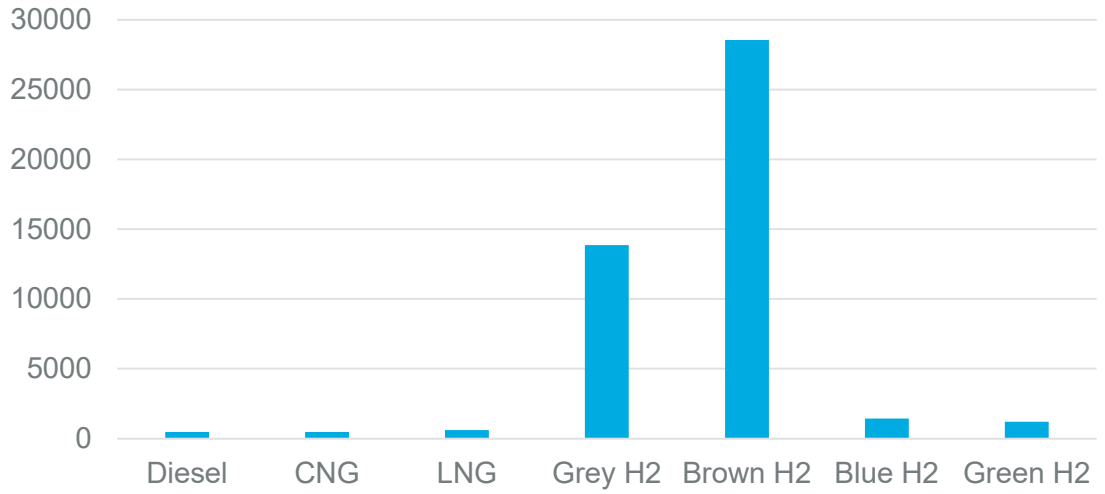
Case study “City bus”

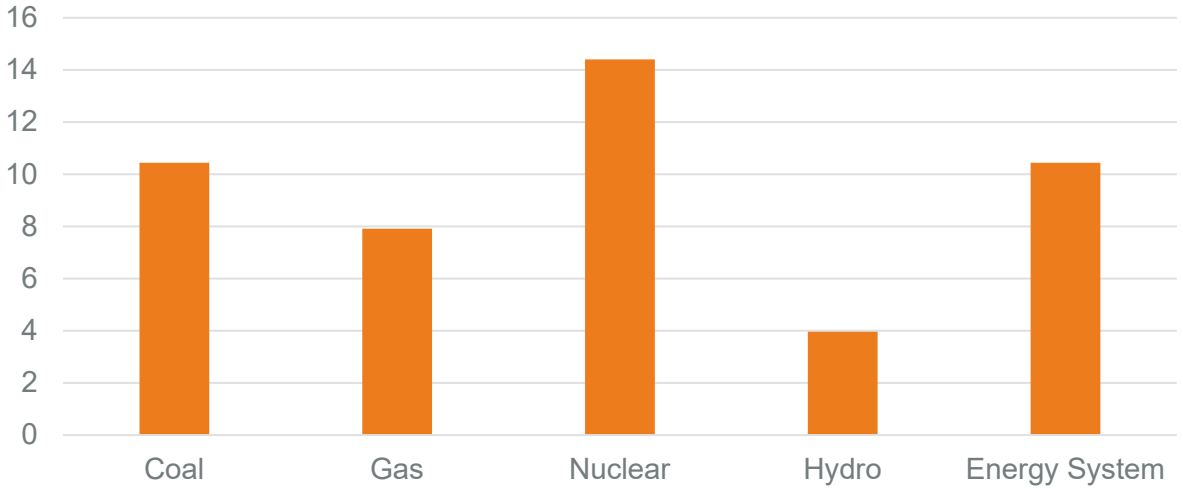
Energy consumption at production of 1 kg of fuel, MJ



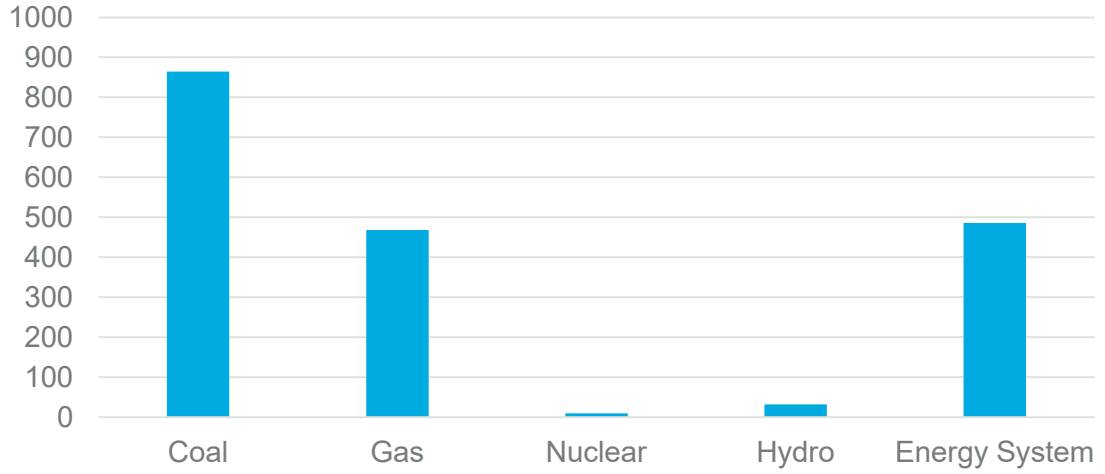
CO_2 emission at production of 1 kg of fuel, g



Energy consumption for 1 kWh of electricity generation, MJ



CO_2 emission for 1 kWh of electricity generation, g



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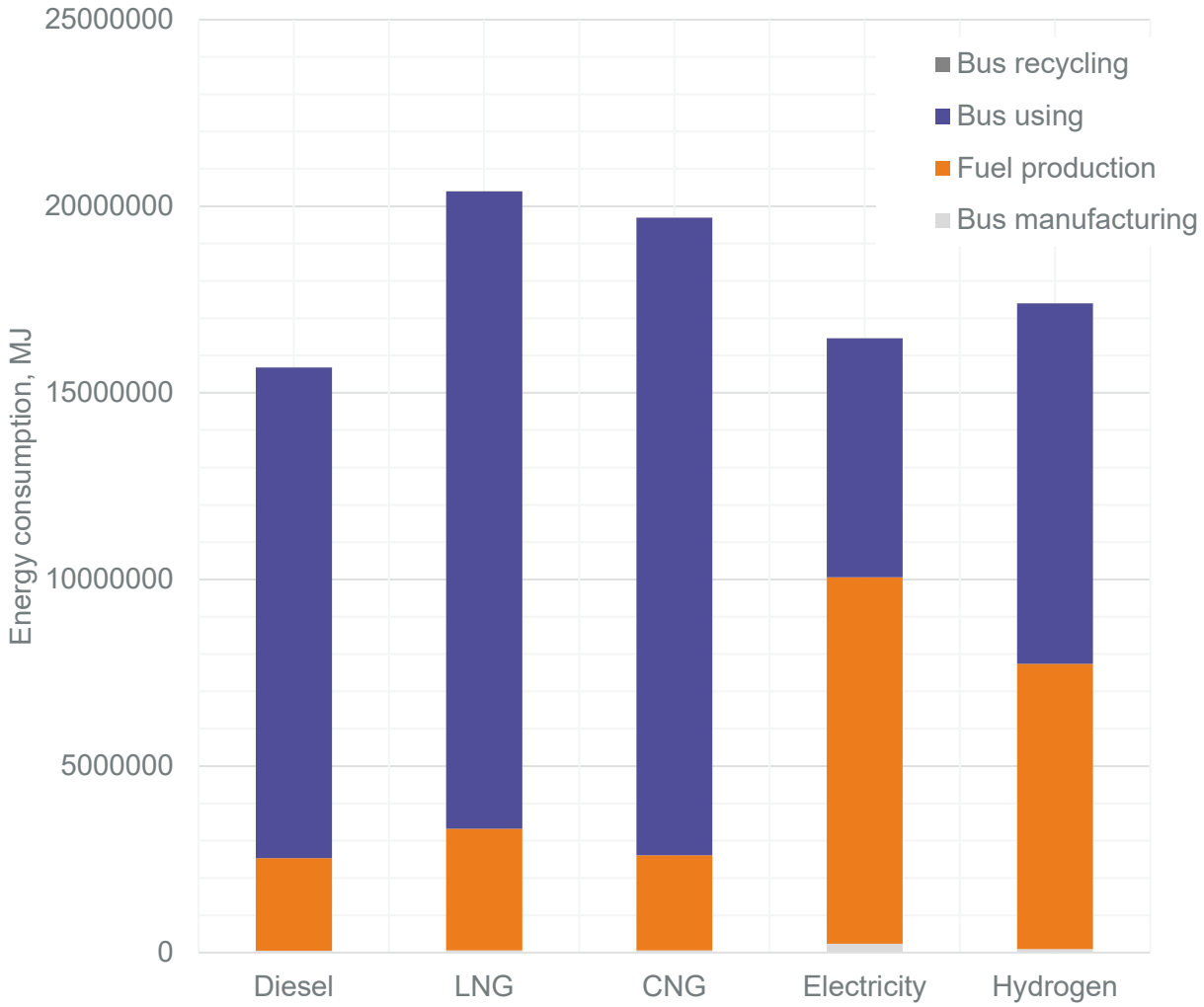
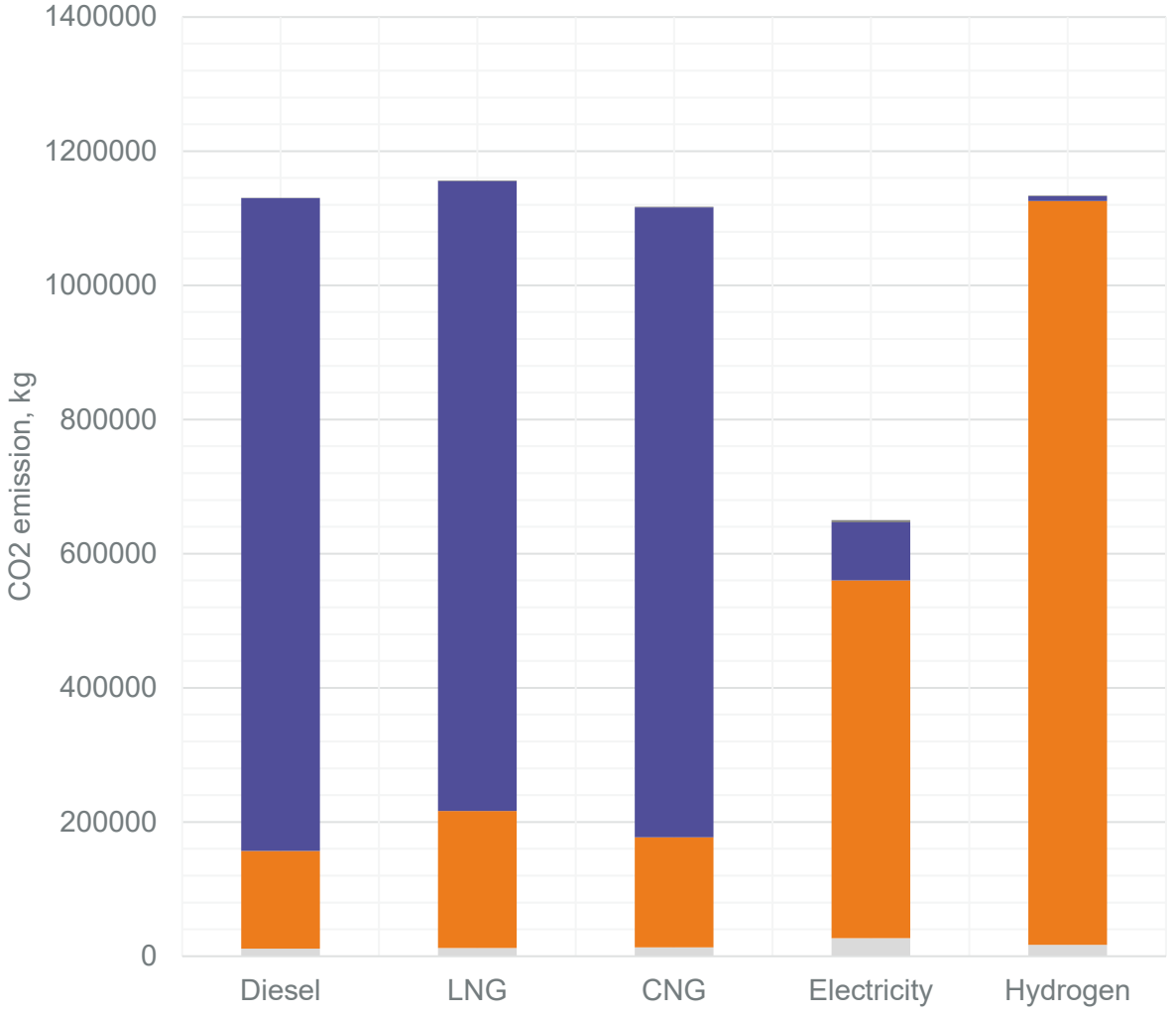
Case study “City bus”

Energy efficiency of buses, working on different fuels in life cycle

Life cycle energy consumption



Life cycle CO_2 emission



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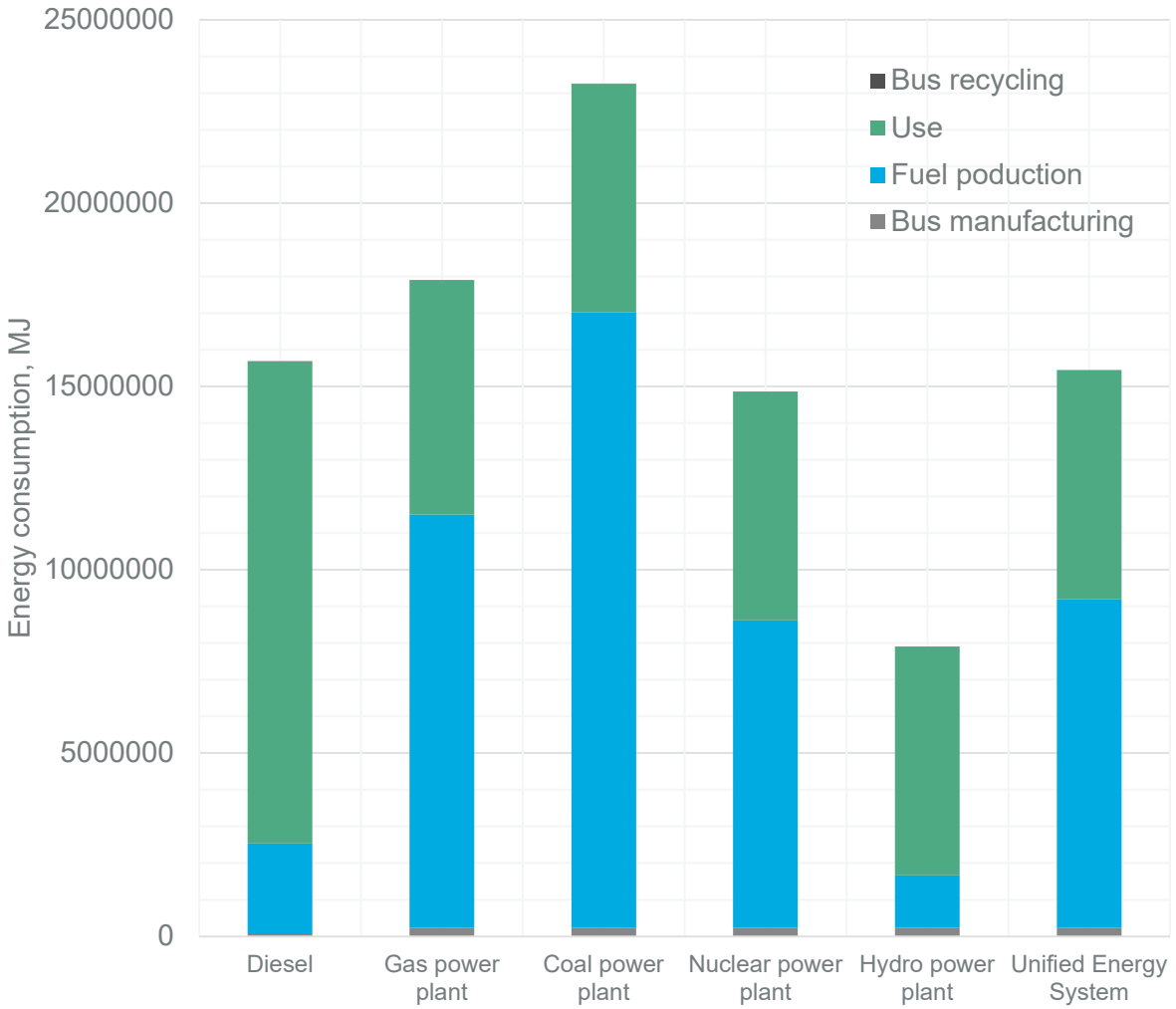
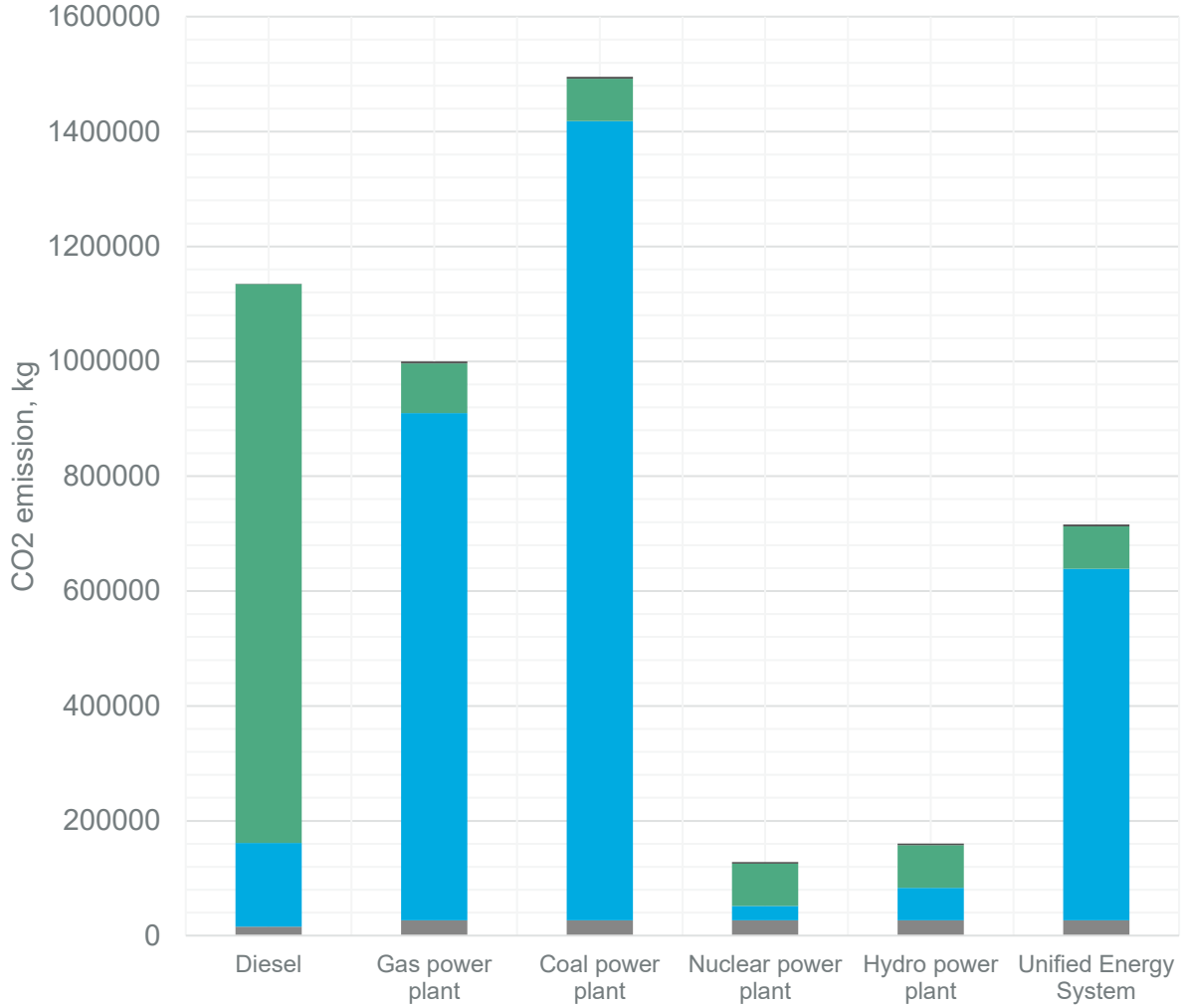
Case study “City bus”

Energy efficiency of buses, working on electricity from different sources in life cycle

Life cycle energy consumption



Life cycle CO_2 emission



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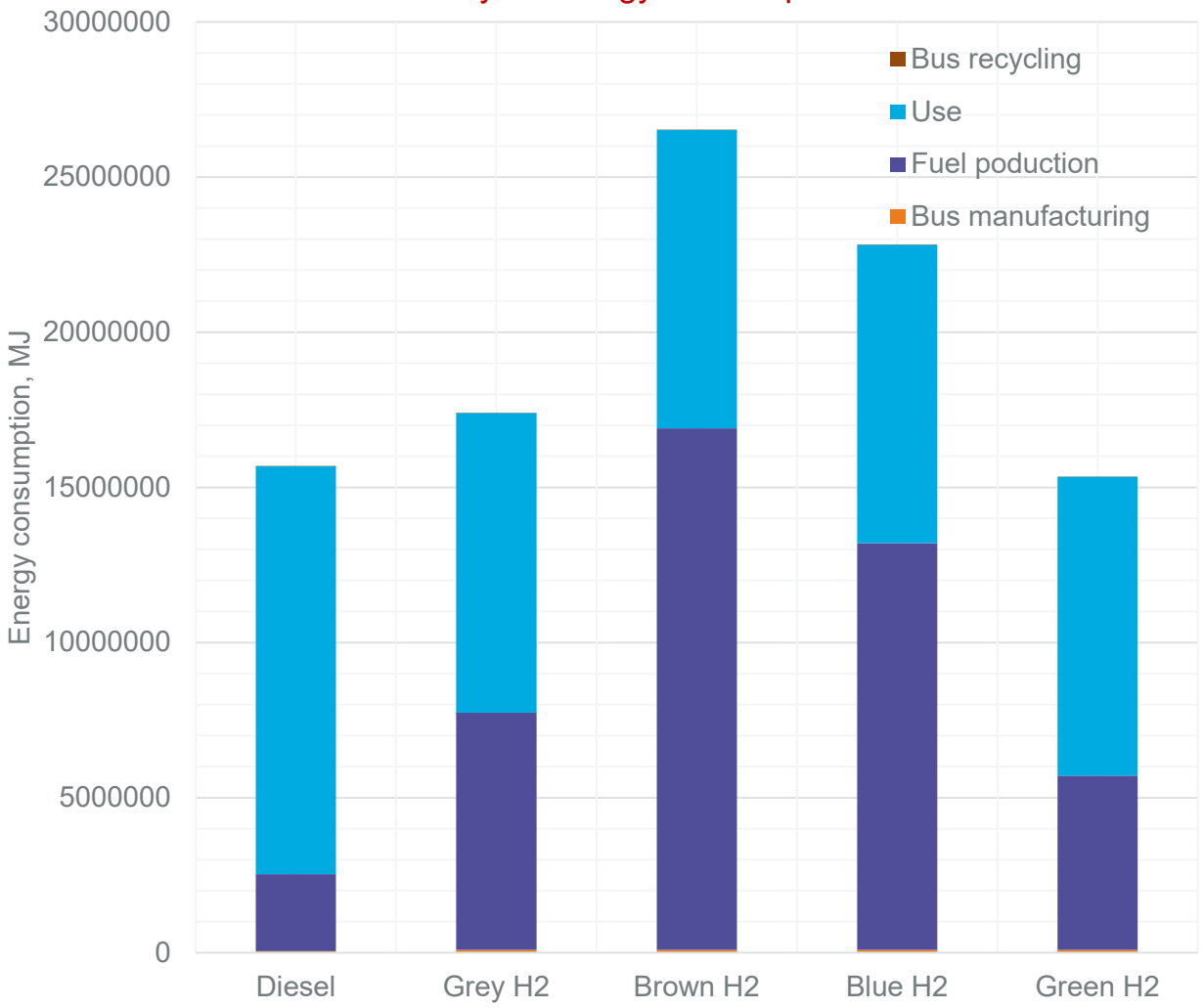
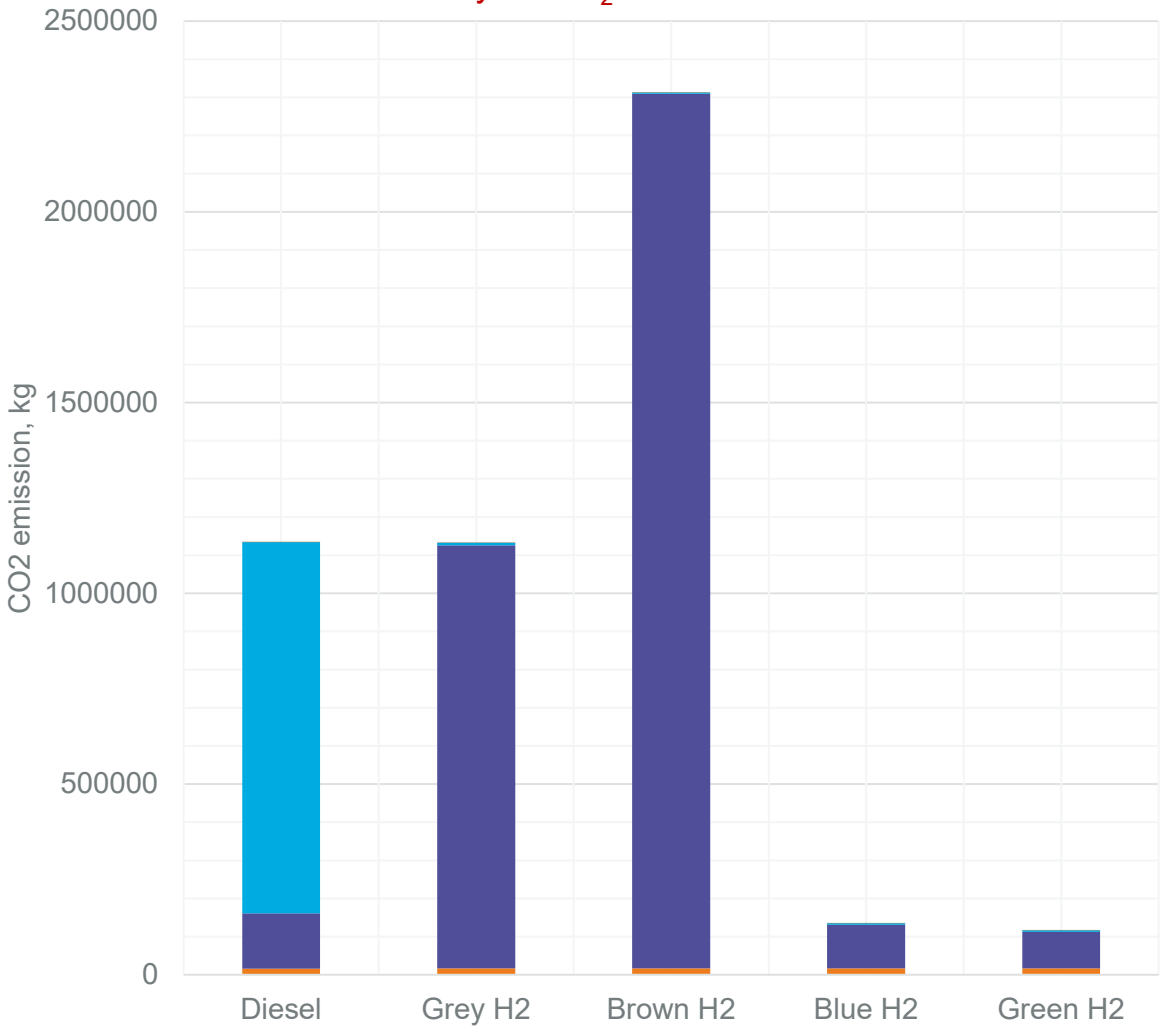
Case study “City bus”

Energy efficiency of buses, working on hydrogen from different sources in life cycle

Life cycle energy consumption



Life cycle CO_2 emission



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Case study “City bus”

Key results

An assessment of the energy efficiency of city buses running on diesel fuel, natural gas, hydrogen and an electric bus was carried out:

- At the stage of operation, the use of electric and hydrogen power units on buses makes it possible to reduce CO_2 emissions by 10 or more times.
- In the total life cycle, the electric powertrain of the bus (using electricity generated at a gas thermal power plant) can reduce CO_2 emissions by 12% compared to diesel.
- The use of energy obtained from nuclear or hydroelectric power plants can reduce CO_2 emissions in the total life cycle by 86 ... 89% when using an electric powertrain on buses compared to a diesel one.
- When producing hydrogen from natural gas with subsequent utilization of CO_2, or when producing hydrogen by electrolysis from renewable energy sources, it will reduce the emission of CO_2 by urban hydrogen buses in the total life cycle by 88 ... 90%.

Based on Russian life cycle assessment experience in automotive industry we prepared proposals for harmonized methodology development, which would be presented on GRPE session.

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Thank You for Your Attention

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