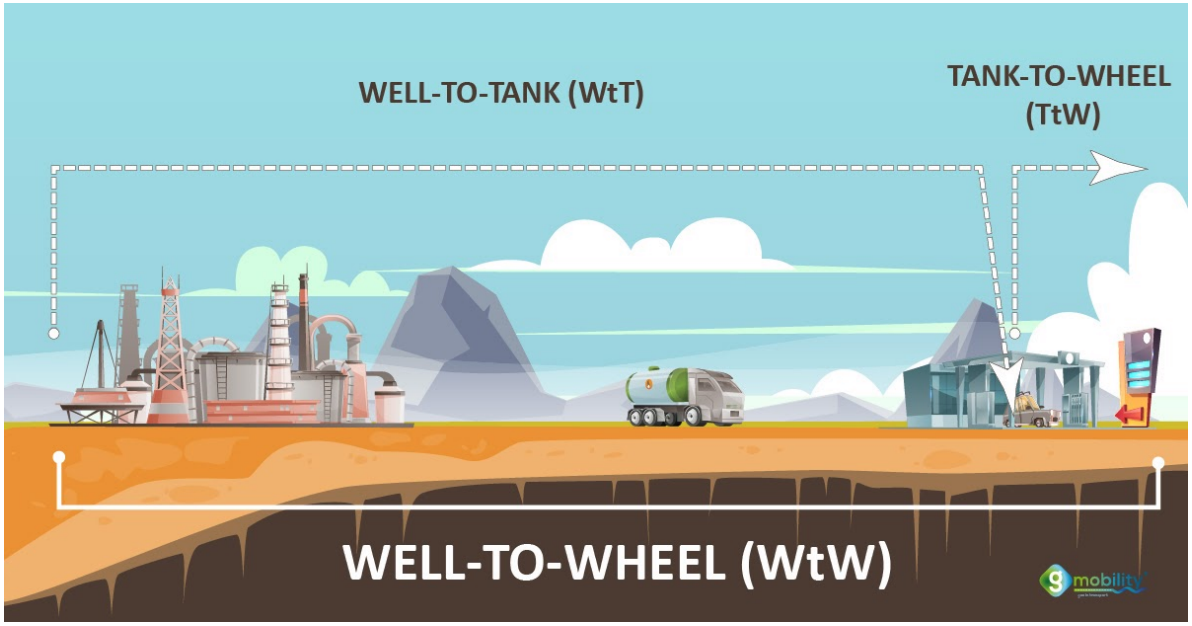
Well-to-Wheel – How to better understand it

In this article, we set out to understand what Well-to-Wheel (WtW) is without overcomplicating it. It is possibly one of the most important measurements that we can do to accurately evaluate and compare vehicle emissions.

We live during an era of **technology transition** and in the next decades, we will see the coexistence of several solutions. Internal combustion engines integrate electrified technologies more and more (for example electrified auxiliaries, mild hybrid and hybrid architectures) moving to full electric

propulsions (BEV, REEV, FCEV). In parallel, on the fuel side, you will see more and more renewable components, from advanced biofuels to new synthetic pathways.

Well-to-Wheel (in short WtW) is the first step in comparing the efficiency of different solutions towards *Greenhouse Gas* (GHG) emissions. Those GHG emissions are so crucial to mitigate because simply put, they cause climate change.



> *You will see more and more renewable components, from advanced biofuels to new synthetic pathways.*

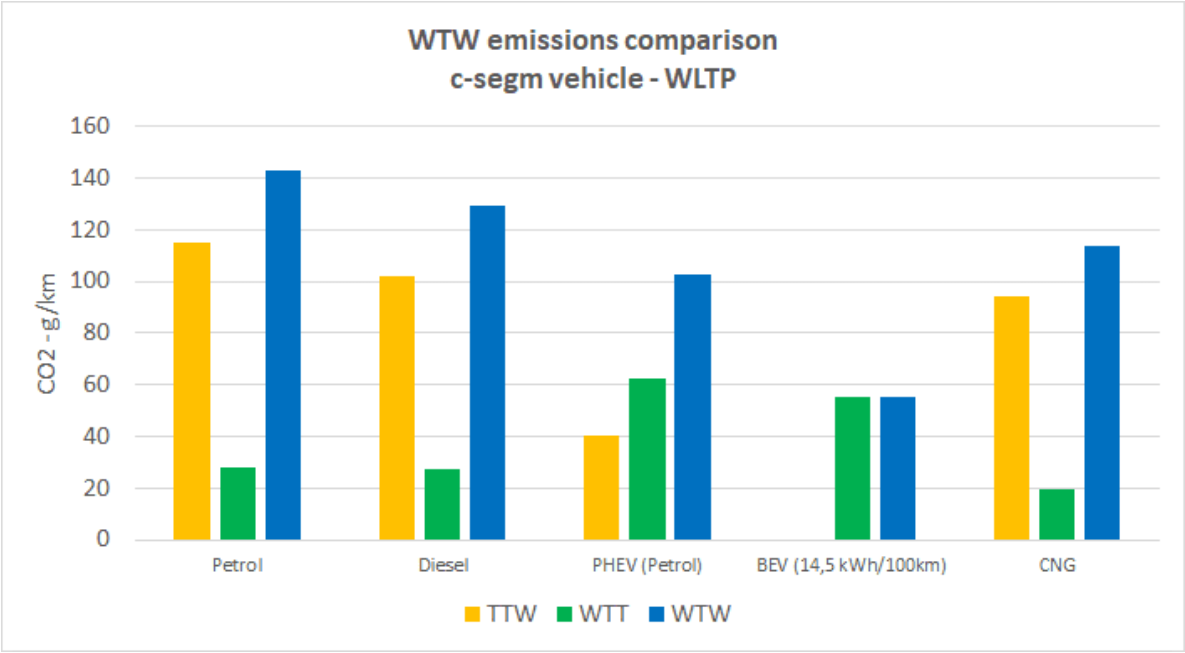
Comparing emissions on a WTW basis

When we compare different powertrain

architectures and fuels, the combination of what is measured at the tailpipe and what is generated by the use of such a fuel (or electricity, or both as in the case of PHEVs), is shown in the following figure, relating to a so-called 'medium passenger cars' (C-segment). Fuel economy and energy consumption for electrified solutions have been agreed internally at NGVA Europe (BEV consumption at 14,5 kWh/100km), while WtT data has been elaborated starting from the last dataset presented by Concawe at EUSEW and anticipating the Version 5 of the WtW Study from the JEC Consortium.

We have compared for you several types of vehicles based on the same vehicle but using a different fuel, or more broadly speaking – the energy to move from point A to point B.

So, let's compare Petrol, Diesel, Plug-in Hybrid on petrol (PHEV), Battery-Electric (BEV) and compressed Natural Gas vehicle (CNG).



There are some immediate conclusions from this simple example:

• On a TtW basis, electrified solutions offer the best performance (These are the emissions coming directly from the vehicle.)

• Considering the current EU energy mix (106 gCO2/MJ), WtT CO2 contribution from BEV is approximately the double compared to conventional fuels
(These are the emissions coming from the fuel or in the case of electric vehicles – the production of electricity.)

• On a WtW basis, BEVs offer better performance thanks to the better efficiency of the powertrain.

Looking at natural and renewable gas

Natural gas has a direct effect on tailpipe emissions as, for the same

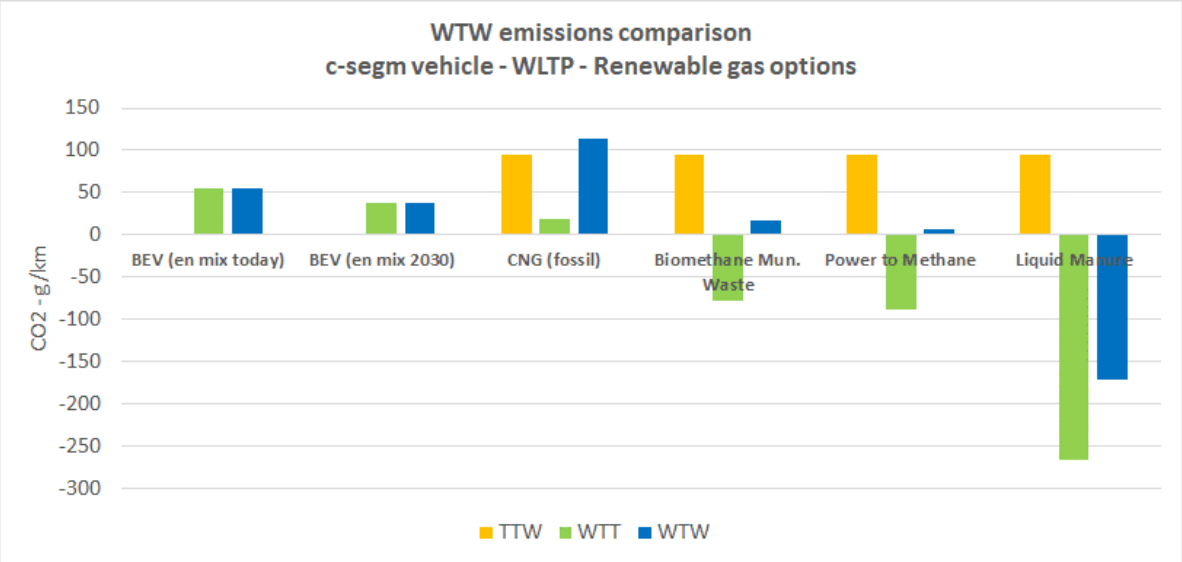
energy, the CO2 generated is approximately 23% lower than of conventional fuels.

In this section, we only compare CNG solutions with battery electric vehicles looking to today and 2030 energy mix.

So, how then, is performance affected when we consider renewable gas?

In the following picture, we have considered BEV considering the current EU energy mix (106 g CO2/MJ) and what JEC (JRC, EUCAR, CONCAWE) are projecting in 2030, corresponding to 72g CO2/MJ. Well-To-Wheel emissions generated by the BEV in 2030 correspond to 37 g CO2/km.

A CNG car, with 94 g CO2/km tailpipe emissions, generates 114 gCO2/km at WtW level when fed with natural gas (fossil).



On the other hand, when we consider the different options coming

from the conversion of **biomasses** (e.g. municipal waste and liquid manure) or from the combination of H2 (hydrogen) and CO2 to provide synthetic methane, the benefits are much larger.

On a WtW basis CO2 emissions are as follows:

• With biomethane from municipal waste 17 g CO2/km

• With Power to Methane 7 g CO2/km

• With biomethane from liquid manure -171 g CO2/km (yes, you read that correctly – negative emissions, meaning a positive overall effect because the effect is that strong)

This means we have a powerful technology TODAY to tackle GHG emissions into the atmosphere!

• With biomethane from municipal waste, the CNG vehicles perform better than BEVs.

• With Power-to-Methane, the carbon neutrality target is achievable.

• When we convert liquid manure into biomethane we have negative emissions. But what does that mean?

It means that we are capturing and converting CO2 emissions from the atmosphere, so we are providing the same behaviour as a forest... absorbing CO2.

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