

***The future of road mobility : can gas vehicles be a credible
alternative for road transportation decarbonisation?***

**Gabin MANTULET,
Adrien BIDAUD, Silvana MIMA**

Plan

I – Energy context

II – Mobility trends

III – Methodology

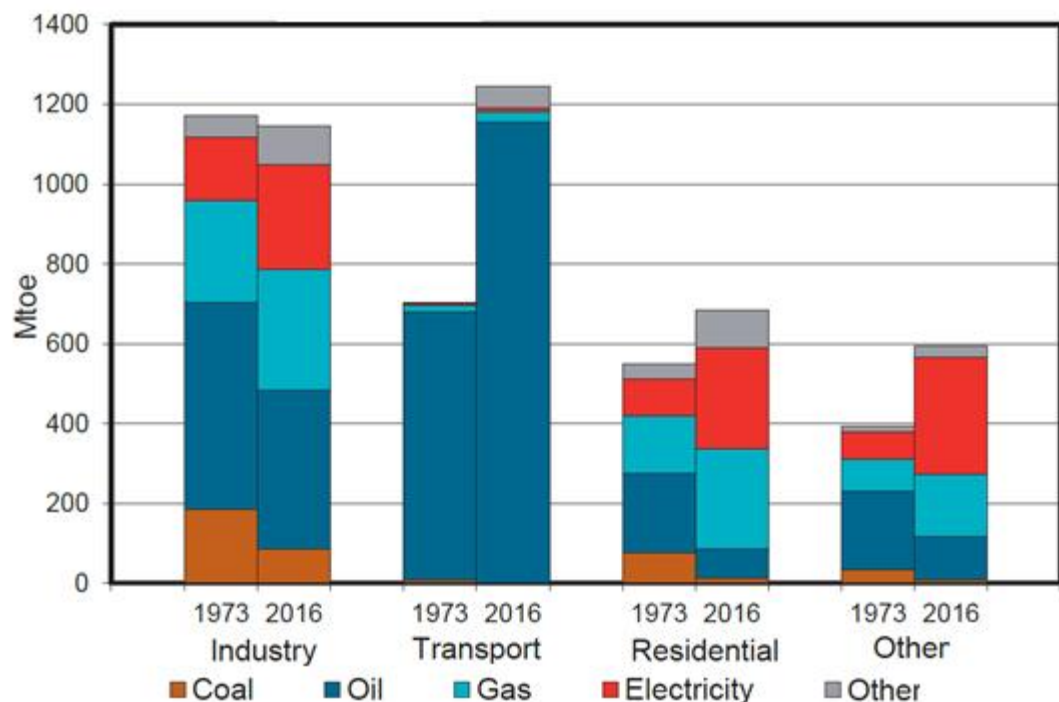
IV – Modelling results

V – Conclusions and perspectives

I – Energy context

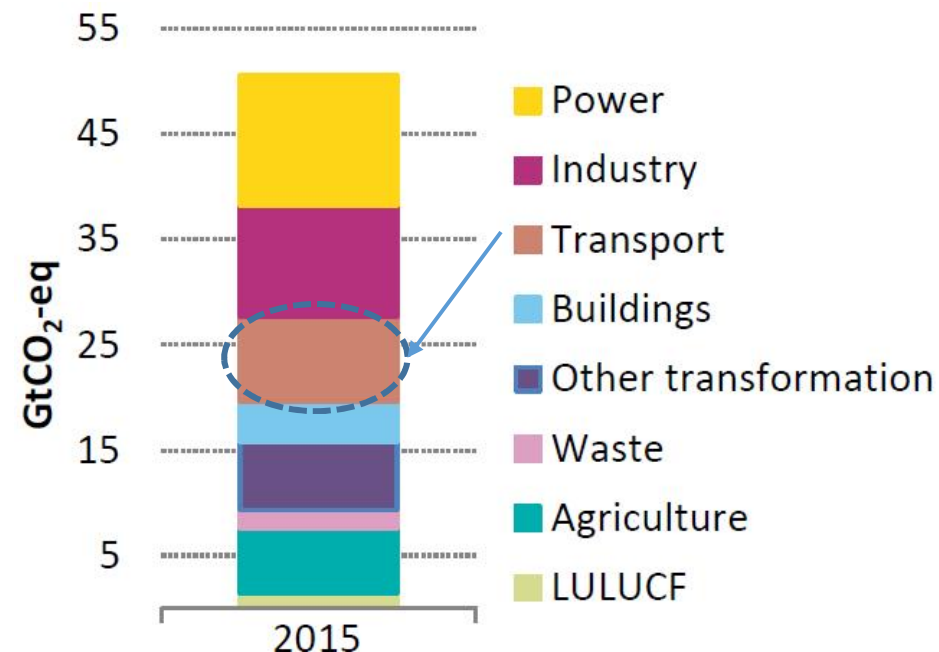
World primary energy consumption is 80% made with fossil fuels (coal, oil, gas)

World energy consumption by sector



Source : IEA, World Energy balances, 2018

Transportation sector relies on OIL



Source : European Commission, Joint Research Centre, GECO 2018

Transport represent around 20% of world CO₂eq emissions in 2015
Road transport represents $\frac{3}{4}$ of transport CO₂ emissions

**Challenges with climate change : decarbonisation of energy consumption ...
and a decarbonisation of transportation because of **oil dependancy****

I – Energy context: concerns and policies for transportation sector

Mobility issues

- Mobility needs fulfillment
- Global warming
- Air pollution
- Oil producers and fuel prices variation dependency
- Energy security → **monopoly of oil**

Policies incentives and measures

- Carbon tax on fuels
- Bonus/malus on cars according to their technology and their CO2/particle emissions
- Quotas for sales for the different type of cars
- Subventions for clean cars or infrastructures development
- Urban tolls
- Incentives for using other and softer transportation modes (public transport, bike, etc.)

Target: phase out conventional cars sales

Pays	Date
FRANCE	2040
NORWAY	2025
GERMANY	2030
THE NEDERLANDS	2030
THE UK	2040 (Scotland 2032)
INDIA	2030
ISLAND	2030
DENMARK	2030
SPAIN	2040
CHINA	2050

→ A need to change mobility technologies but difficult

→ Which alternatives can we use?

Plan

I – Energy context

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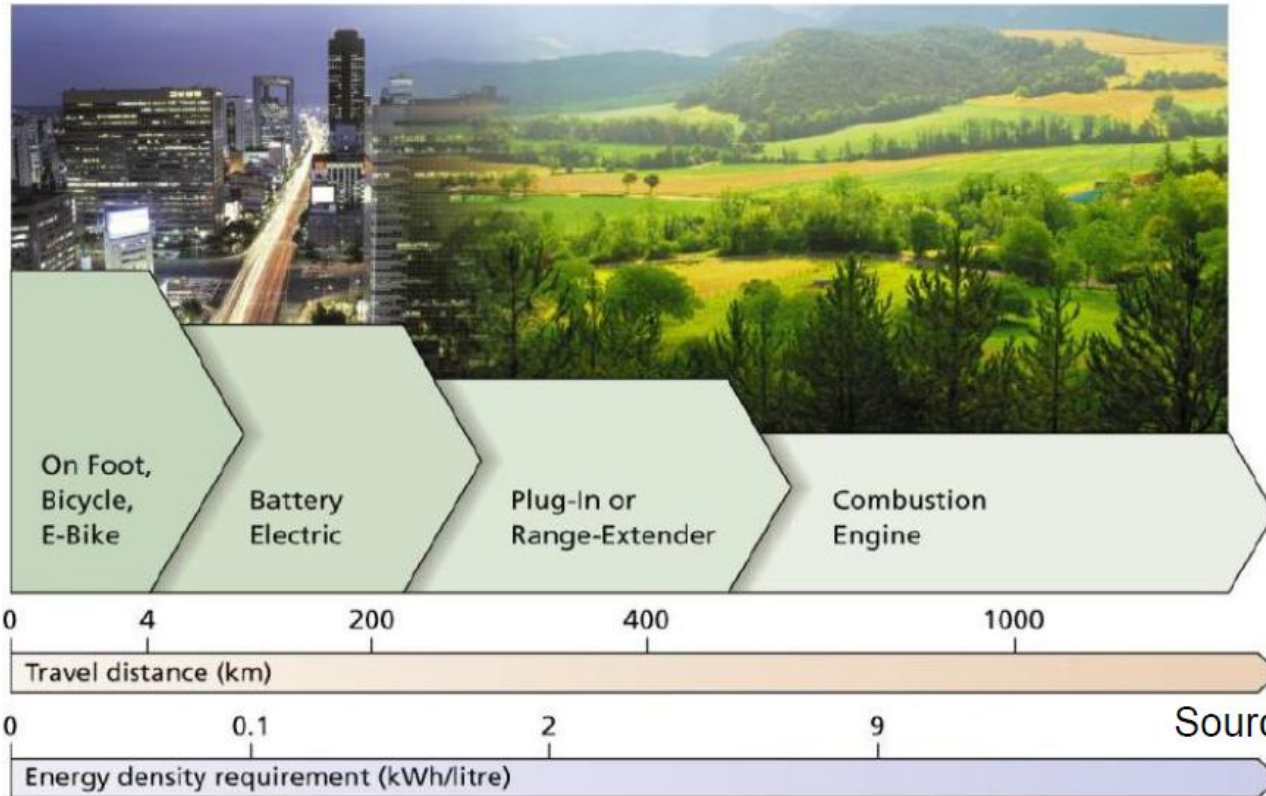
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II – Mobility trends

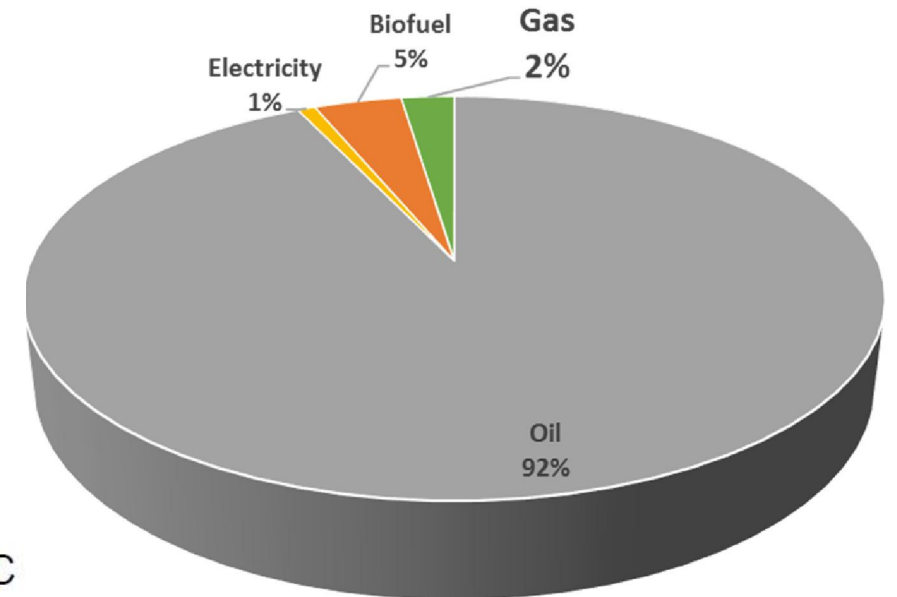
The optimal engine for each mobility need

- <5km : human. No cars for very shorts travels
- 5km<>400km : Electric/Hybrid
- >400km : Oil/Gas



BUT in reality, we use ...

Road mobility energy consumption - 2018



Source: French car manufacturers committee (CCFA)

II – Mobility trends

Road transportation technologies main characteristics : +/- aspects

	Vehicle performances		Recharge		Climate impacts		Costs	
	Autonomy (km average)	Per km fuel consumption	Charging stations network	Length of recharge	Air pollution	CO2 releases (well to wheel)	Vehicle cost (€/vehicle average)	Fuel cost
Gasoline	800			Minutes			22000	
Diesel	800			Minutes			22000	
Plug in hybrid	800			Minutes/hour for battery			33000	
Electric	300			Hours			29000	
Hydrogen	600			Minutes			44000	
Gas	600			Minutes			26000	

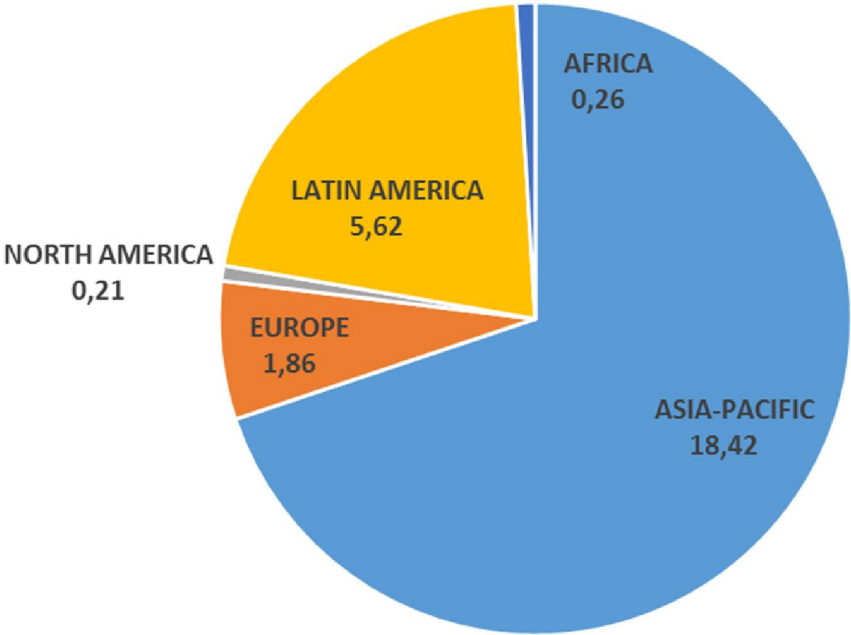
II – Mobility trends : Natural gas vehicles (NGV) deployment

Number of alternatives vehicles and share - World

	Number of vehicles (million)	Share
Total vehicles	1 400	
Total electric+hybrid	3	0,2%
Total NGVs	26	1,8%
Total hydrogen	<0,001	0%

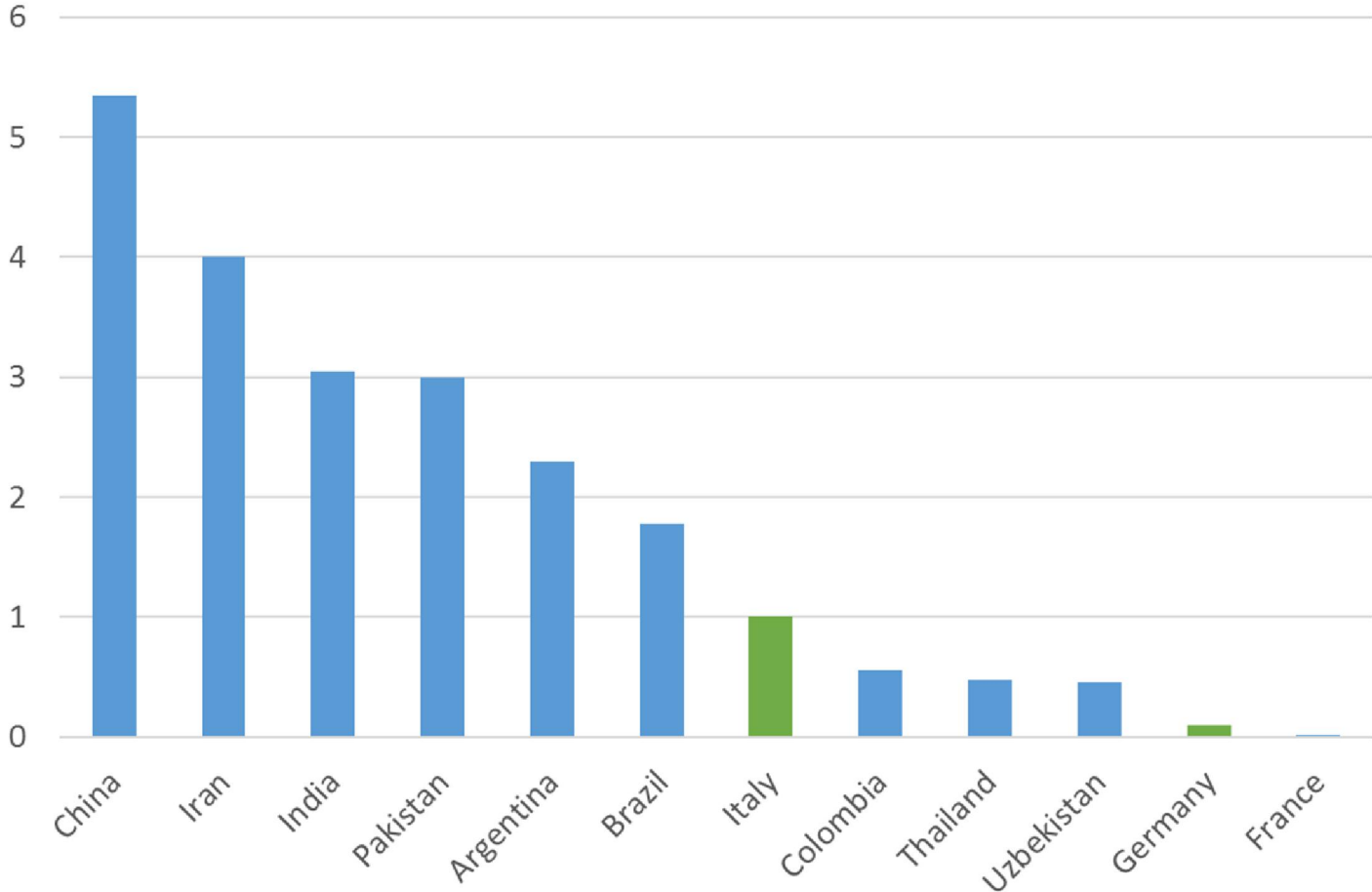
Source: Frost & Sullivan's, "Global Electric Vehicle Market Outlook 2018,"

Number of Natural Gas Vehicles (millions) - World - 2018



Source: Natural Gas Vehicle Knowledge Base

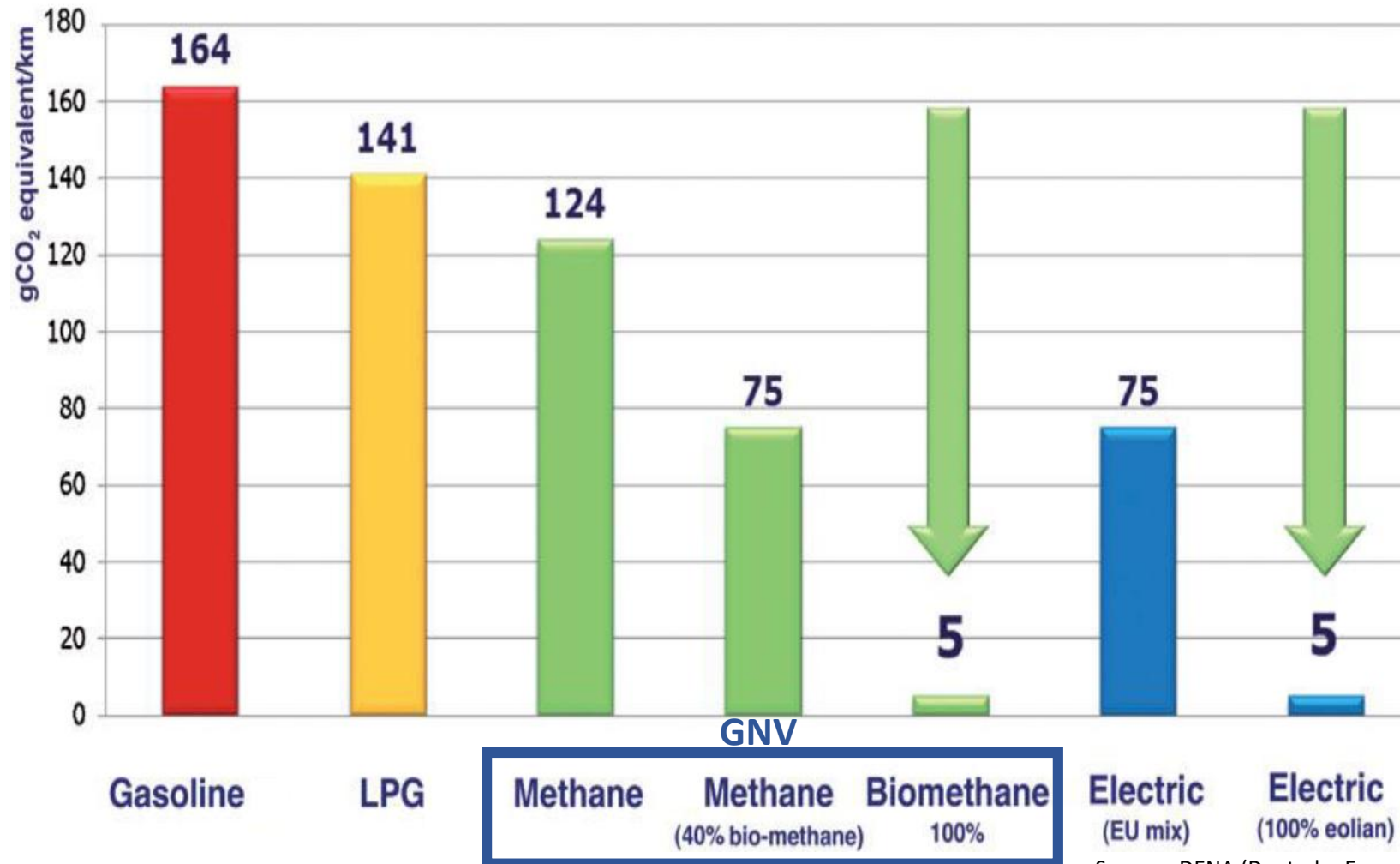
NGVs vehicles number (millions) - 2016



Source: Statista

II – Mobility trends : Environmental benefits of natural gas in transport

CO₂ emissions with a 'well-to-wheel' cycle

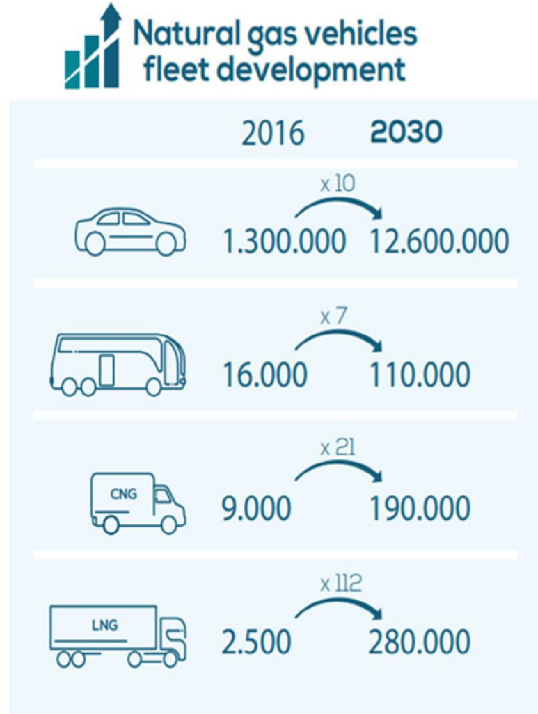
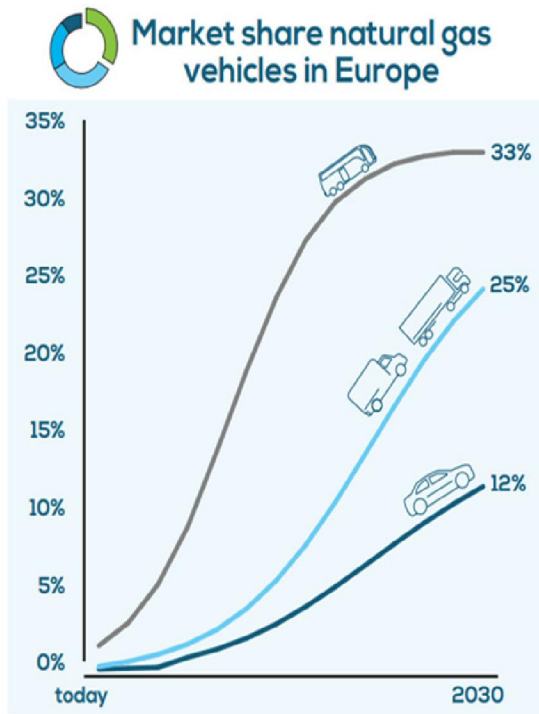


GNVs emissions are lower (-25%) than gasoline cars and even biomethane emissions are comparable to those of electric engines powered by low carbon sources.

II – Mobility trends : the question

Will **gas vehicles** really be a credible alternative for future mobility?

Advantages	Drawbacks
The same autonomy we are used to with oil cars	Charging stations network not very developed
Less CO2 emissions than conventionals	Still emit CO2 compared to electric and hydrogen motors
No air pollution	For the moment, using a majority of fossil natural gas : dependancy of gas producers, gas prices, etc.
Still developed in some countries : proof of efficiency	



Source: NGVA Europe

Ambitious objectives

Method : using a long term energy model, POLES, to analyze future transportation mix according to some scenarios

Plan

I – Energy context

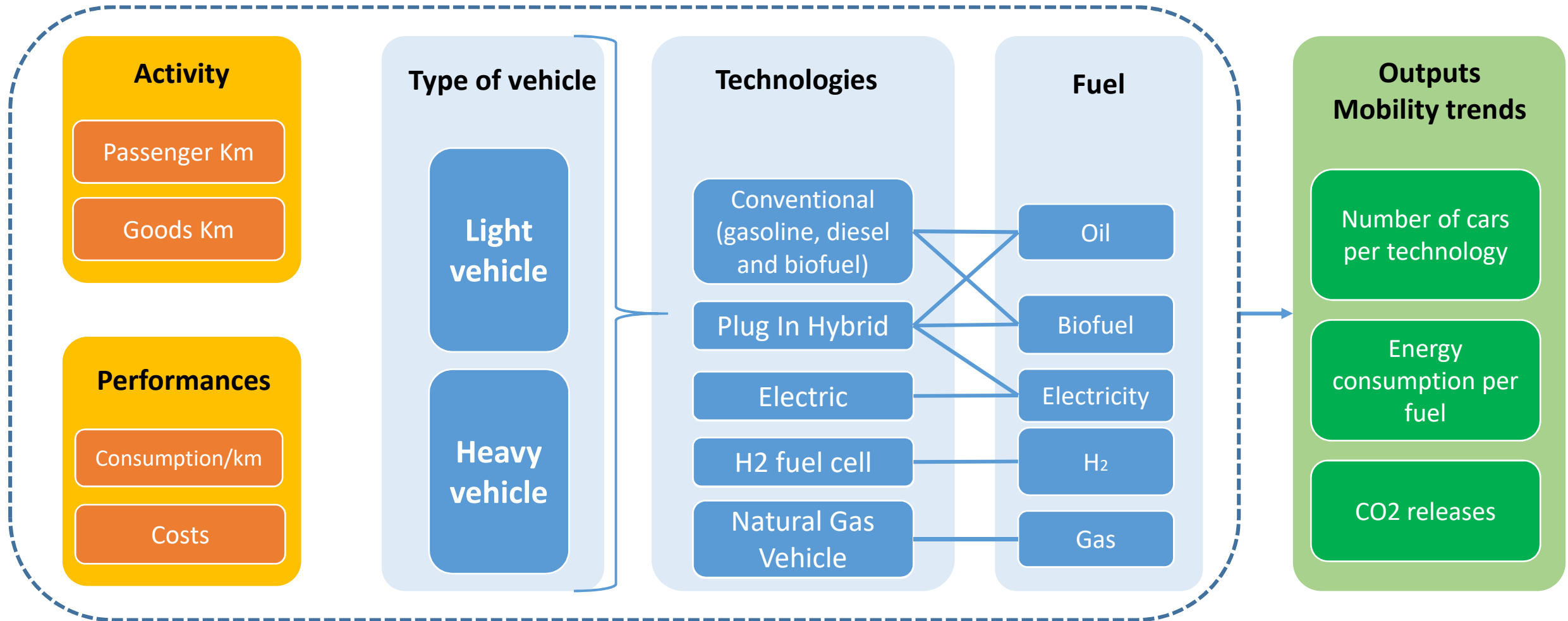
II – Bibliography trends

III – Methodology

IV – Modelling results

V – Conclusions and perspectives

III – Methodology: mobility modelling in the POLES model



Yearly recursive simulation up to 2100

III – Methodology: 4 scenarios

- | | |
|---|---------------------|
| → A reference case: a business as usual projection, built for comparison | Baseline |
| → A climate constraint scenario defined to limit global warming under 2°C | 2°C |
| → The same climate constraint scenario with more progress for non oil fuelled vehicles* <ul style="list-style-type: none">• Vehicle costs : -20%• Infrastructures : +20% development for charging stations• Performances : - 20% consumption/km | 2°C clean |
| → The same climate constraint scenario with more progress for non oil fuelled vehicles with lower demand <ul style="list-style-type: none">• Demand (exogenous) for mobility: -30%** : changes in people behaviour | 2°C clean LD |

* Electric, H₂, gas

** Hypothesis based on Gruber et al, that are not prices base.

Plan

I – Energy context

II – Green gas process

III – Methodology

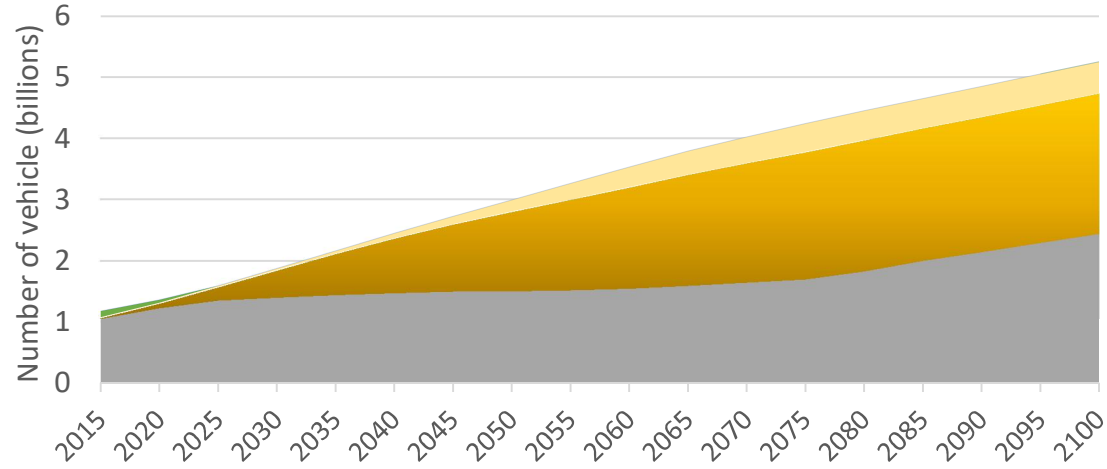
IV – Modelling results

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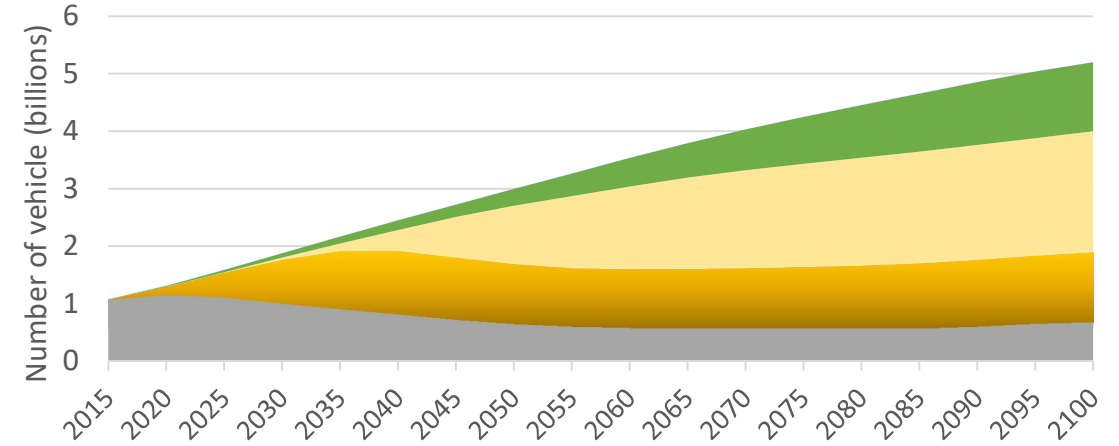
IV – Results

Road transportation mix

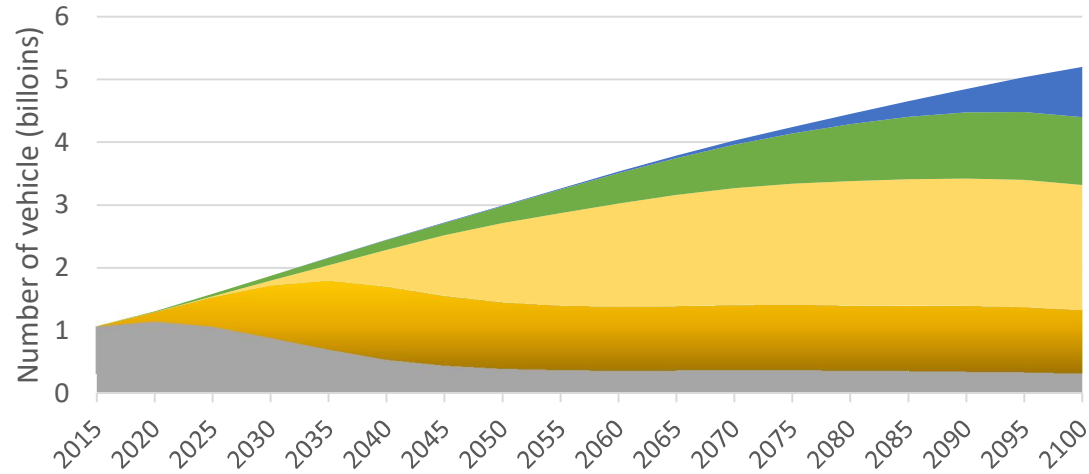
Baseline



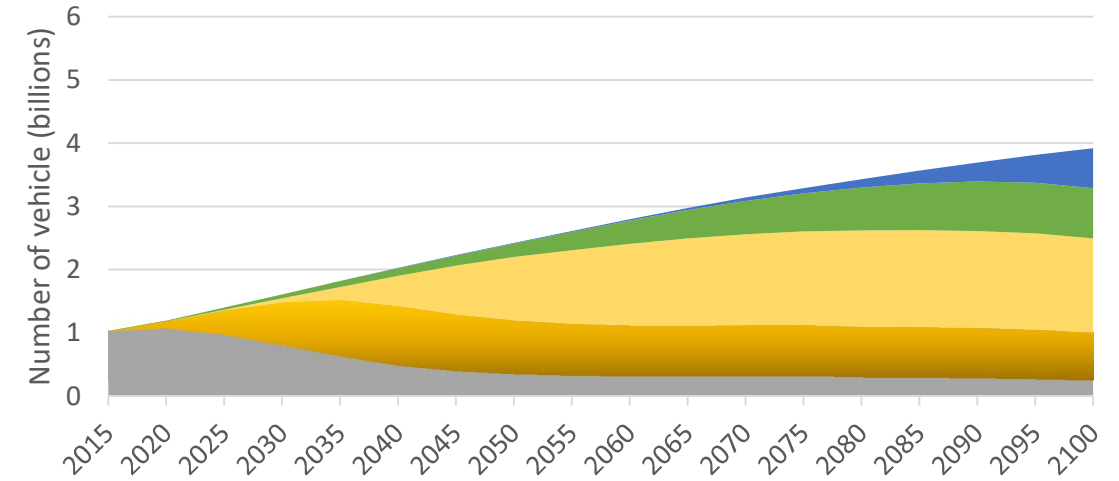
2°C



2°C clean



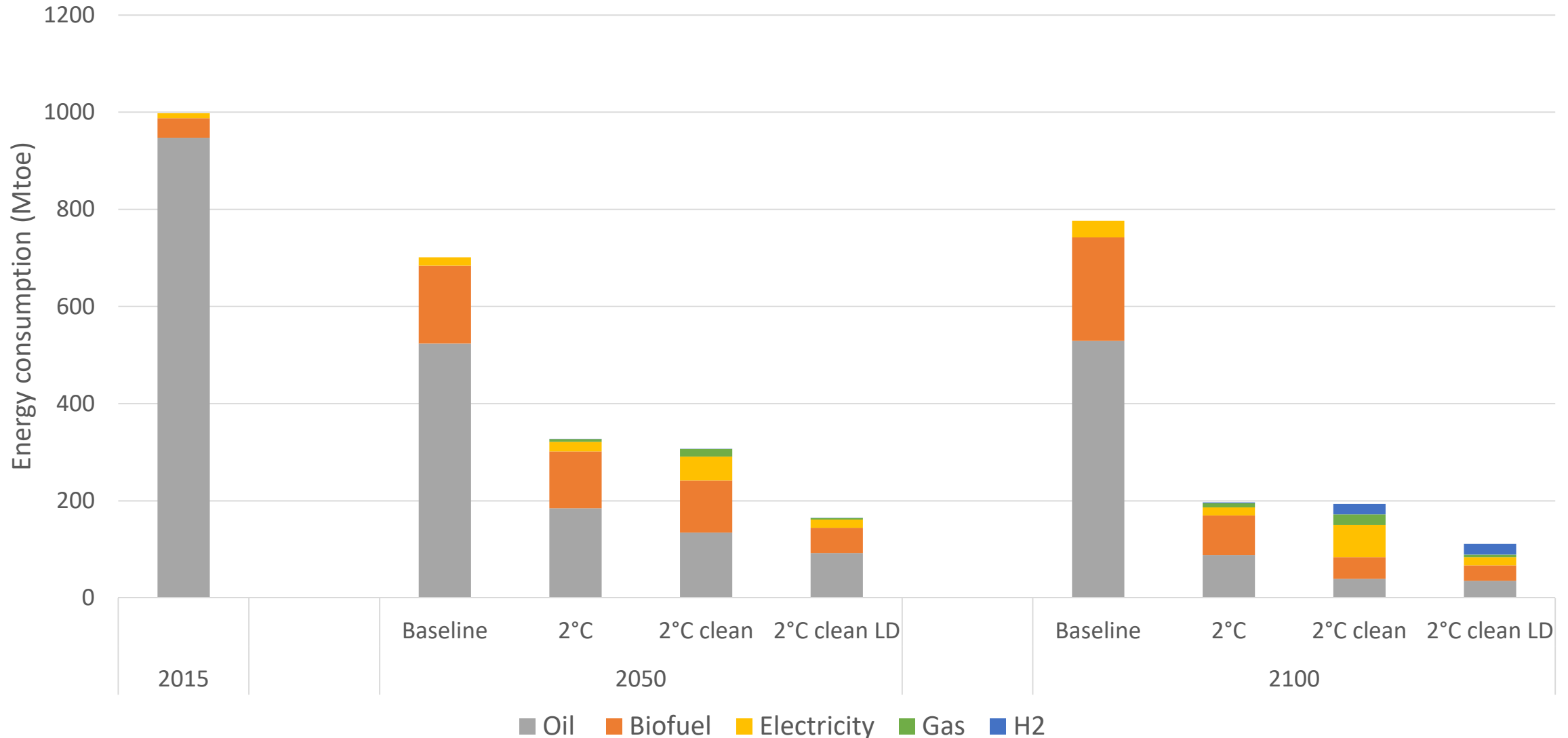
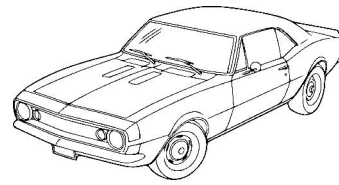
2°C clean LD



■ Conventional ■ Plug in hybrid ■ Electric ■ Gas ■ H2

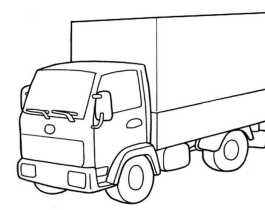
IV – Results

Light vehicles fuel consumption

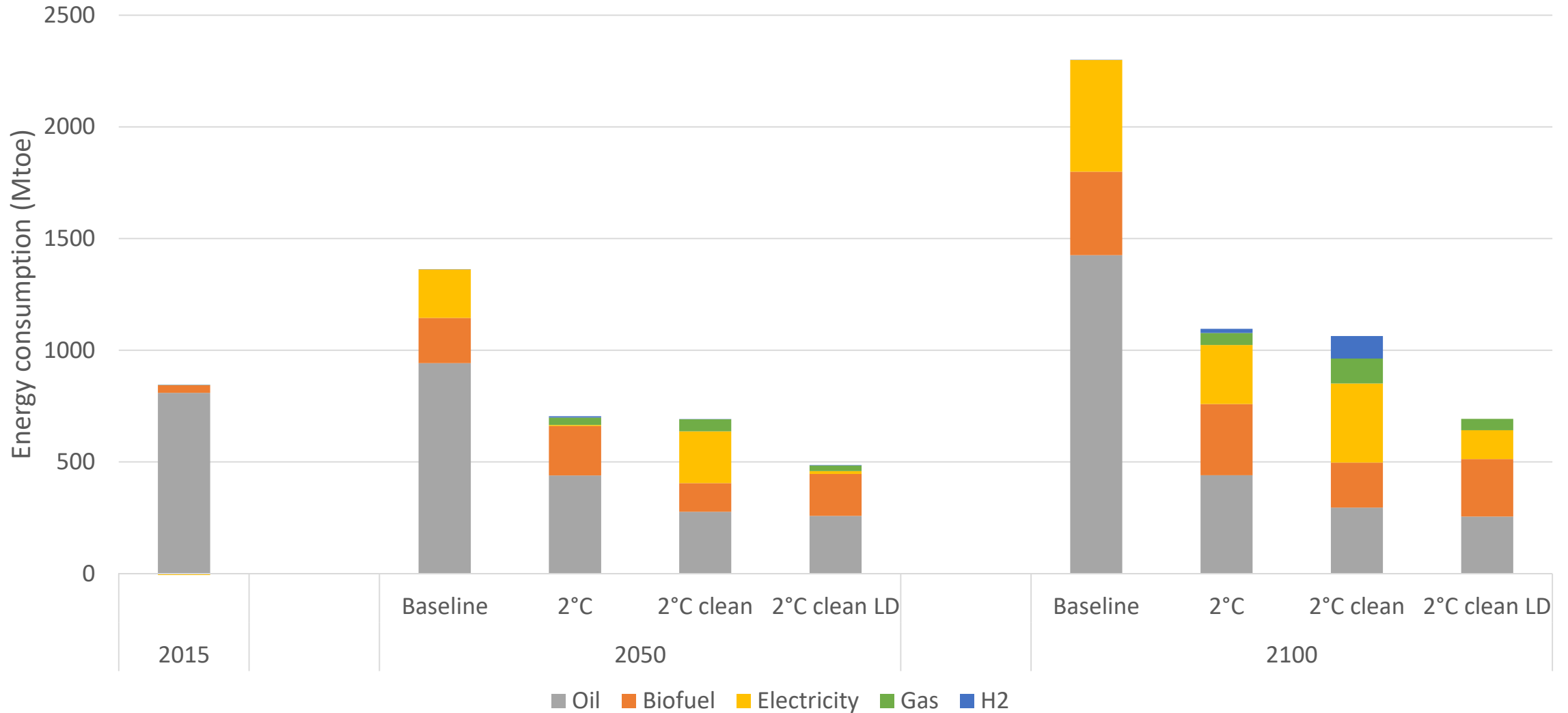


Few NGVs for light vehicles but gas can reach 10% of energy consumption

IV – Results



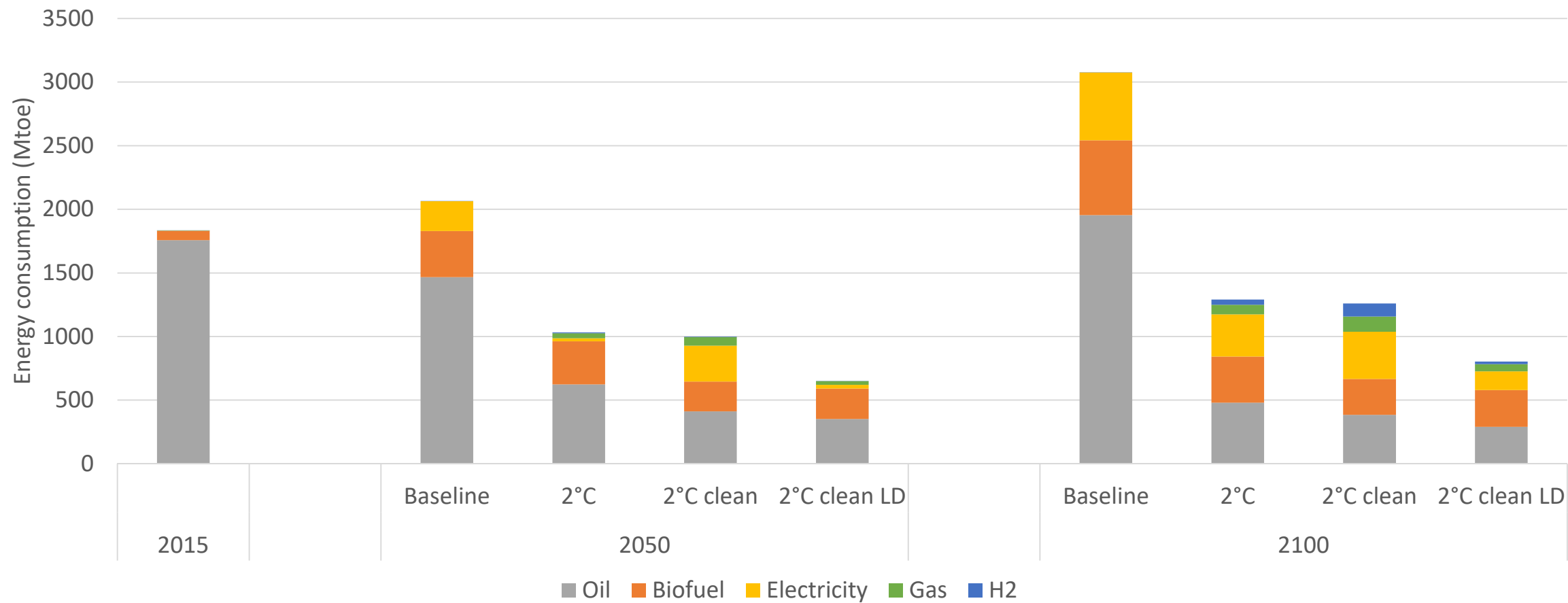
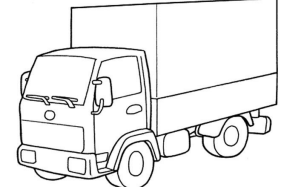
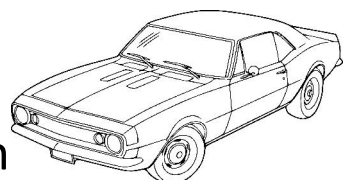
Trucks and bus vehicles fuel consumption



More NGV in trucks and buses (can reach 25% of the park in 2100)

IV – Results

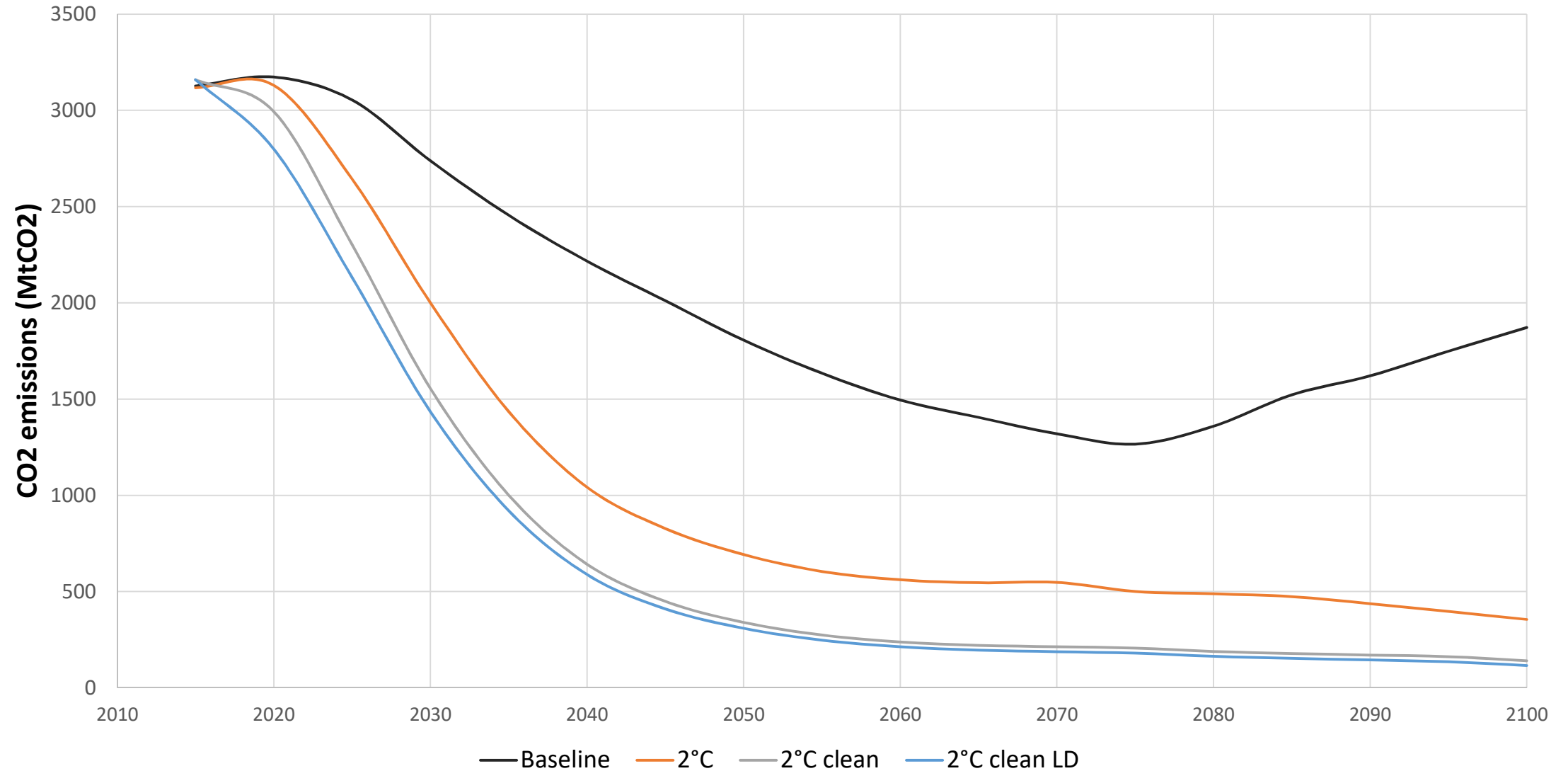
Road transport : total fuel consumption



Gas vehicle a relevant alternative for goods, public transport and fleets¹⁸

IV – Results

Road transport CO₂ emissions



Less CO₂ emissions transport with larger NGVs penetration

Plan

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The study

- A model based approach on the future of road mobility in a decarbonisation context (2°C warming mitigation)
- A particular focus on gas vehicles and their role in mobility mixes

State of the art

- NGVs are nowadays the **most developed fleet of non conventional (ICE) vehicles**
- NGVs are a **promising alternative** for conventionals especially in fleets, long transportation modes and trucks

Outlines from simulations output

- NGVs as a catalyst for transportation energy consumption reduction (idem for CO₂ emissions reductions) with an **appreciable development for heavy vehicles**
- The speed of the NGV diffusion **largely depends on performance improvements and government push on infrastructure development** (subsidies for vehicle acquirement, tax advantages for gas...)
- NGV is unlikely to widely transform road transportation energy mix, but it can be **an alternative among others**

Further steps

- Study the influence of greening gas network for NGVs deployment
- The competition of gas/biogas for NGVs between others energetic valorization of biomass (biofuel, electricity, heat...) that are also key for energy systems decarbonisation.

Thank you for your attention

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Bibliography and resources

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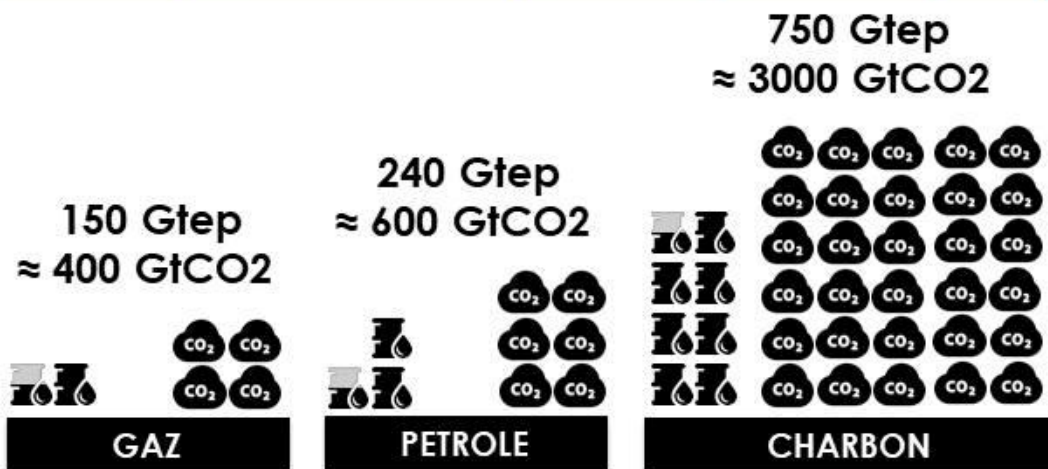
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www.Gaz-Mobilite.fr

I – Energy context: decarbonisation of energetic system



Ce qu'il nous reste (réserves prouvées) :



TOTAL : ≈ 4000 GtCO₂

Gaz à effet de serre équivalents (100 GtCO₂eq)

Énergie équivalente (100 Gtep)

BUDGÉTISONS LE CARBONE

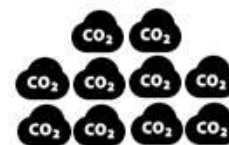
TIC, TAC...



Emissions GES actuelles

≈ 50 GtCO₂/an

Ce que nous pouvons encore émettre :



≈ entre 800 et 1000 GtCO₂

À répartir sur les différentes énergies !

**Notre budget 2°C
(66% de chance de rester sous 2°C)**

Entre 20% et 25% des réserves prouvées

Entre 1% et 2% des ressources

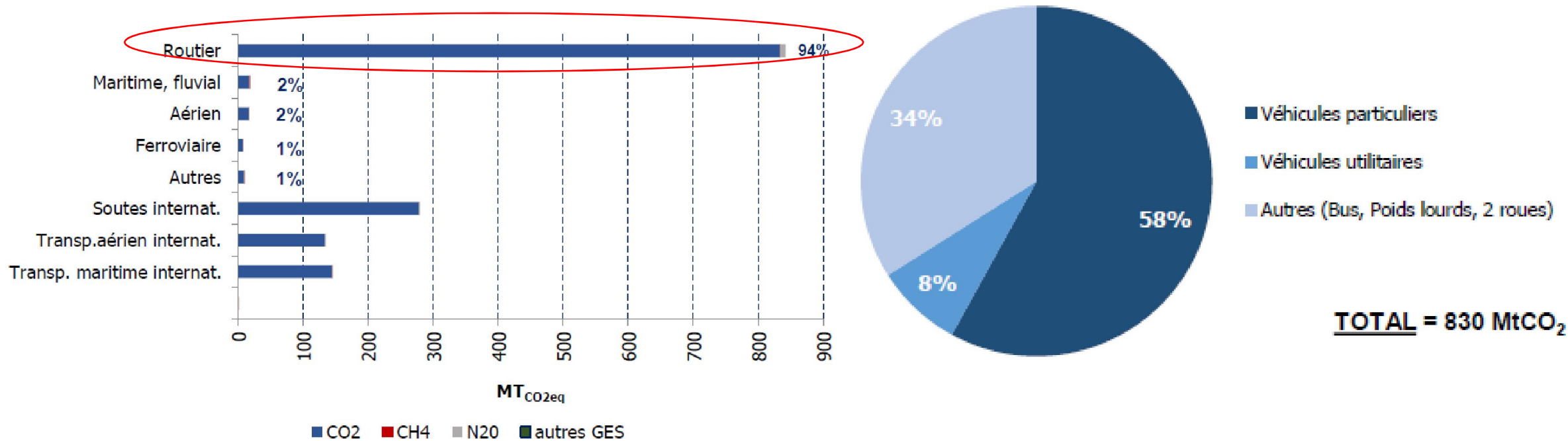
Temps restant à émissions constantes :

20 ans



Source : Avenir Climatique, IPCC AR5 WG3, BP Statistical Review 2016

I – Energy context: need of transportation decarbonisation

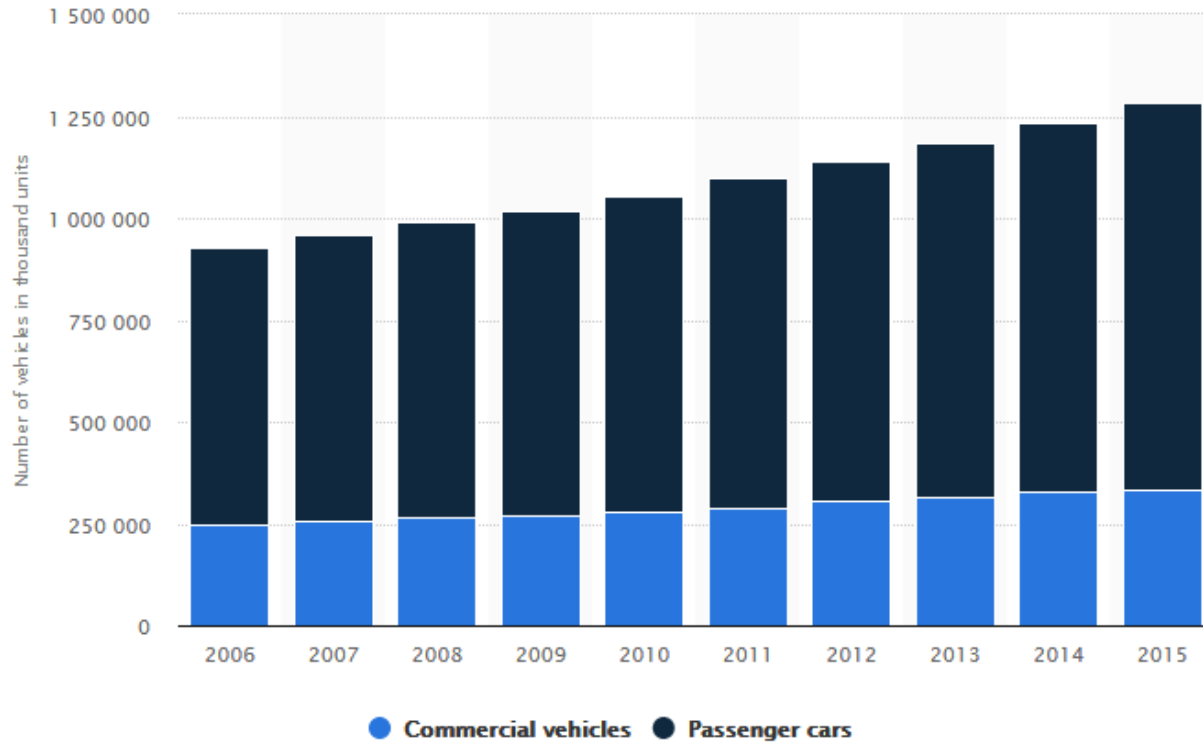


European Union - 2016

The relevance of road transportation in transportation sector emissions

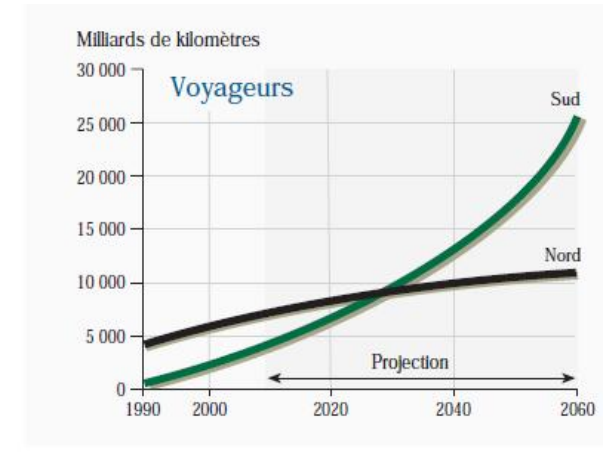
II – Mobility trends

Road transportation features and projections



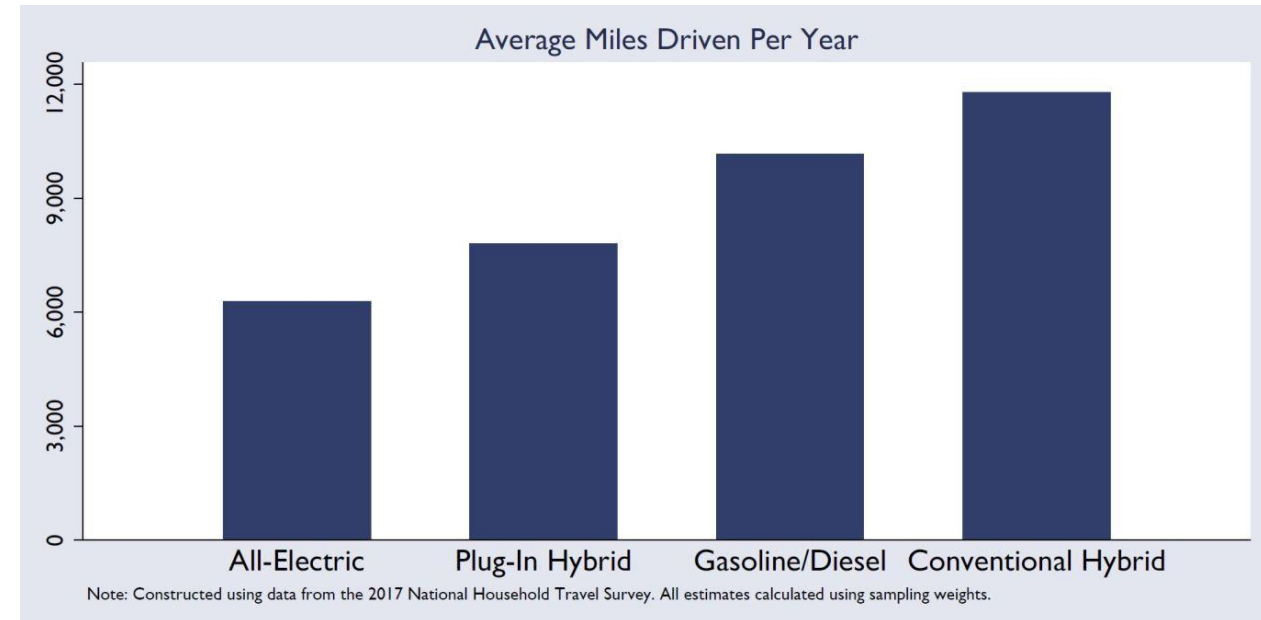
Number of vehicles – world

Around 4% annual growth



Prévisions mondiales de la demande de transports routiers

<http://www.cartografareilpresente.org/article59.html>



EVs are driven significantly less than other types of vehicles.

II – Mobility trends

Italy NGV deployment

Immatriculations par filière énergétique

Du 1er janvier au 31 août 2018

Technologie	Immatriculations	Parts de marché
Diesel	739.045	53.74%
Essence	455.665	33.14%
GPL	89.062	6.48%
GNV	31.645	2.30%
Hybride	53.513	3.89%
Hybride rechargeable	3.144	0.23%
Electrique	3.098	0.23%