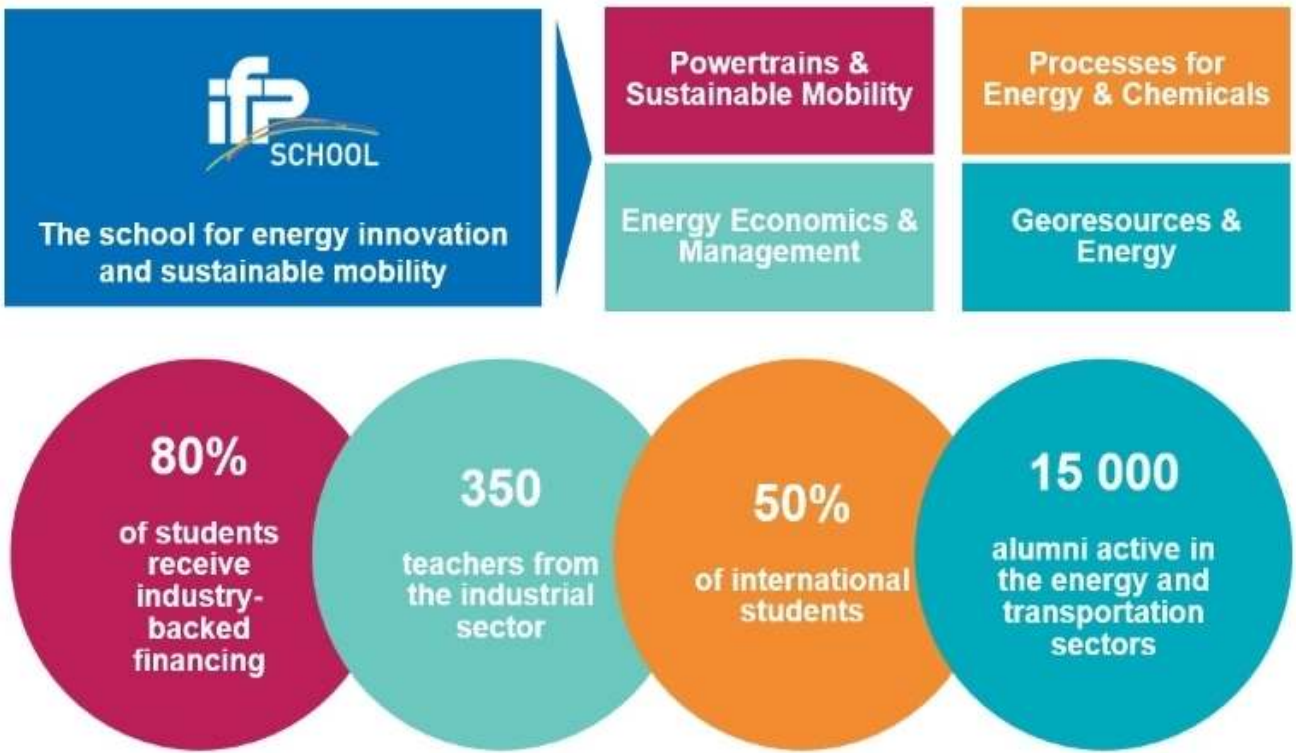
Tomorrow's Mobility

Learning by scanning

IFP SCHOOL

IFP School provides students and young professionals from across the world with Master's or Doctoral level training in the fields of energy (oil, gas, petrochemicals, powertrains, new energy technologies) meeting industry's needs and society's demands, particularly in terms of innovation and sustainable development.



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This book in interactive, but how does it work?

1. Download the ZAPPAR app on Google Play or on the Apple Store:

2. Launch the app and scan the following code

A World of energy

the Growth of energy is driven by the growth of population & wealth

The Energy mix has been changing through the 20th century

Renewables are booming but NOT VISIBLE in the global figures

the Growth of Renewable energy consumption does not mean less demand for fossil fuels!

80% of the primary energy supply comes from FOSSIL FUELS

the World Keeps consuming more & more ENERGY!

Present & Future Constraints on Energy Supply

NOT ONE SINGLE PERFECT SOURCE of ENERGY

A BALANCE between SUSTAINABILITY RELIABILITY AND COST

RESERVES are NOT going to LACK ... in the close FUTURE

the Big issue is Climate Change

The Paris agreement sets a **+2°C** goal

To achieve this we need to reach "Net **Zero** emissions" in the second half of the century

Greehouse gases emissions are driven by people, economic activity but also...

the energy intensity of GDP

and the carbon content of the energy mix

Population & GDP will probably KEEP GROWING

To cope with the 2°c objective

We need to REDUCE the CARBON INTENSITY of our GDP by 5% per year

that means
MORE RENEWABLES
MORE NUCLEAR
MORE CAPTURE & STORAGE of FOSSIL FUELS EMISSIONS

We are NOT on the right track

Transport Context and Vehicle Outlook

Motorisation rate is linked to economic levels

Electric car STOCK has been GROWING since 2010

97% of WORLD TRANSPORT relies on OIL

By 2040

of the global fleet could be ELECTRIC

POLLUTION

Global pollution

Pollution on a planet
Wide Scale

Local Pollution

Pollution on a City
Wide Scale

Transport Sector

One of the main contributor to local & global Pollution

LEGISLATION

WLTP

Worldwide Harmonized Light Vehicle Test Procedure

Compares vehicles Fuel Consumption

RDE = Real Driving Emissions

Validates that all the vehicles Sold in the E.U are CLEAN

Life Cycle Analysis

LCA

Reference method to assess the impact of a product life on the environment

INPUTS are extremely IMPORTANT!

Well-To-Wheel Analysis
used in the transport sector for thermal engines

LCA's goal is to avoid transfer of pollution

Why electric vehicles today?

Respect of the environment

Low running costs

Efficiency

Recovery braking

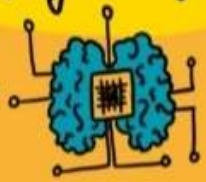
Electric Drive for Electric Vehicle

It's impossible to use an electric machine without all the devices.

An electric machine

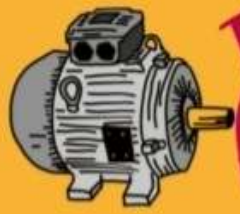
A Power electric Device

A Management system



A battery pack

that's why the main component of an electric vehicle is NOT the electric machine ... BUT the ELECTRIC DRIVE !



Electric machines fundamentals

1

AC Electric machine based on a rotating magnetic field created by 3 phase winding stator current

2

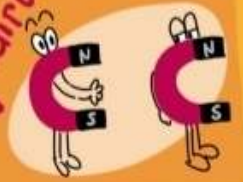
The torque is due to the interaction between rotor and stator magnetic field

3

For automotive applications main families are :

Synchronous machines

Asynchronous machines



Electric machine Design

Electric machine is a compromise between...

COSTS
WEIGHT
VOLUME
PERFORMANCE
SIZE
EFFICIENCY

TORQUE is proportional to the electric machine SIZE

Torque and the technological family choice impact :

SIZE

COSTS

PERFORMANCES

As the number of POLES ↗, the SIZE of the electric machine ↘

Power Electronics Fundamentals

Power Electronics converters are based on switching electronic devices

There are different electronic converters that perform different functions

- DC-DC converters (buck & boost)
- DC-AC converters (inverters)
- AC-DC Converters (rectifiers)

Their function is to TRANSPORT & CONTROL VOLTAGE CURRENT FREQUENCY, from the battery to load

Power electronics are MANDATORY to use with electric machines to control & manage ↗ POWER ↘ TORQUE

Power electronic Design

The main design parameters for power electronic converters are...

electric drive CURRENT

electric drive VOLTAGE

Switches are not ideal they have conduction & switching losses proportional to

- ☑ current
- ☑ voltage
- ☑ frequency

ENERGY USED

SWITCHING LOSSES

CONDUCTION LOSSES

The main control parameter to manage the electric energy flow is...

The size & the cost of the semi-conductors depends on the current value

Electric Drive Management

In a machine torque & electric current are PROPORTIONAL

Torque is the result of the magnetic fields interaction

To control the torque it is important to have :

Position sensors

&

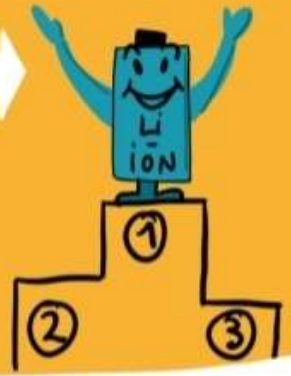
Current sensors

to have the best efficiency the relative position of the magnetic fields must be measured & controled

Battery fundamentals

Batteries are based on electro chemical reactions that need an external flow of electrons

Today the best technology for electric vehicle use is ...



The main parameters to define a battery pack are:

- V VOLTAGE
- CAPACITY
- POWER

Safety precautions must be taken in order to avoid short circuits

Battery Design

It is important to ↘ the current value through the inverter

So that the size of the drivetrain is ↘

High Voltage batteries are recommended

CAPACITY = KEY ELEMENT in the Design of electric drivetrain

A particular must be paid to the thermal management For Li-ION batteries, temperature must be kept below 40°C

However, if the battery voltage is high, both the cost & weight ↗

Additionally, the battery management system is more COMPLEX

Hydrogen and Fuel cells Vehicles

Generate **Zero CO2** and **Zero POLLUTANTS** during driving

Produced from various energy sources including **Renewables**

CO2

Poorly developed infrastructures

High Costs

LIMITED OFFER from car manufacturers

Improvement of **Fuel Cells Vehicles Technology** leading to large car range

Advantages & Limits of Electric Vehicles

DEVELOP RENEWABLE ENERGY to LOWER GREENHOUSE GASES EMISSIONS

UPGRADE THE ENERGY INFRASTRUCTURE to deal with this demand

Increase electric range by improving

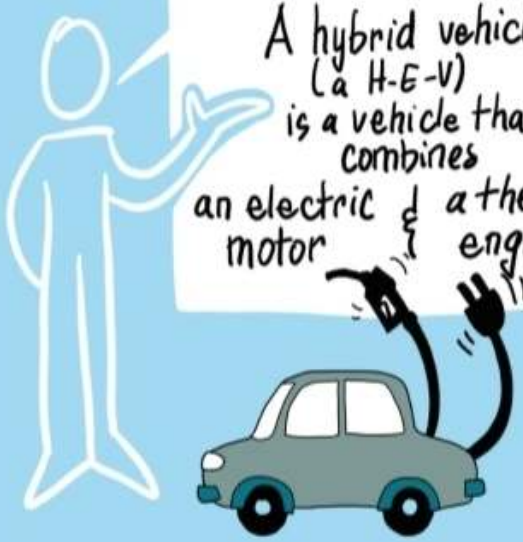
BATTERY TECHNOLOGY

CHARGING SYSTEM

Reduce the materials demand by recycling & developing new DESIGNS

Introduction to Hybrids

A hybrid vehicle (a H-E-V) is a vehicle that combines an electric motor & a thermal engine



It combines the advantages of each engine:

Lower pollutant than conventional vehicles

Higher autonomy than electric vehicles

The main advantage of HEVs is the improvement of the EFFICIENCY

This is possible because the engine:

- is optimally designed for average power demand
- works most of the time at optimal efficiency
- can recover the energy normally wasted during braking and remove long engine idling phases

Hybridization levels

micro hybrid | mild hybrid | full hybrid | Plug-in hybrid

Micro & mild hybrid use a small, low-voltage battery & perform the STOP & START function

Full & Plug-in hybrid use a big high-voltage battery & perform:
- Stop & start
- All electric propulsion
- Regeneretive braking

As you gain in hybridization

more efficiency

CO_2 Less pollutant emissions

More Complexity

More Costs !

Hybrid Vehicles Architectures

Another way to classify hybrid vehicles

depending on the way all the elements are CONNECTED TOGETHER

the architecture depends on the TYPE of VEHICLE!

Series Configuration

One power train is connected to the tires

Parallel Configuration

Both power trains have a mechanic connection to the tires

They can both propel the vehicle independently OR together

Series-Parallel Configuration

There is both

- a mechanical and an electrical link between the 2 powertrains and the vehicle
- an electrical link between the 2 powertrains

Energy Management Strategy

Supervisory algorithm that governs the electric motor and the thermal engine in a hybrid vehicle

the **SOC** State of Charge of the battery is one main parameter that determines the power split

Goal = optimize the efficiency of the whole system while providing the targeted power

In other words, to find the right combination between the electric motor & the thermal engine that reduces fuel consumption

Trends in Hybrid Vehicles

Nowadays

A lot of **research** on this area to **improve performances**

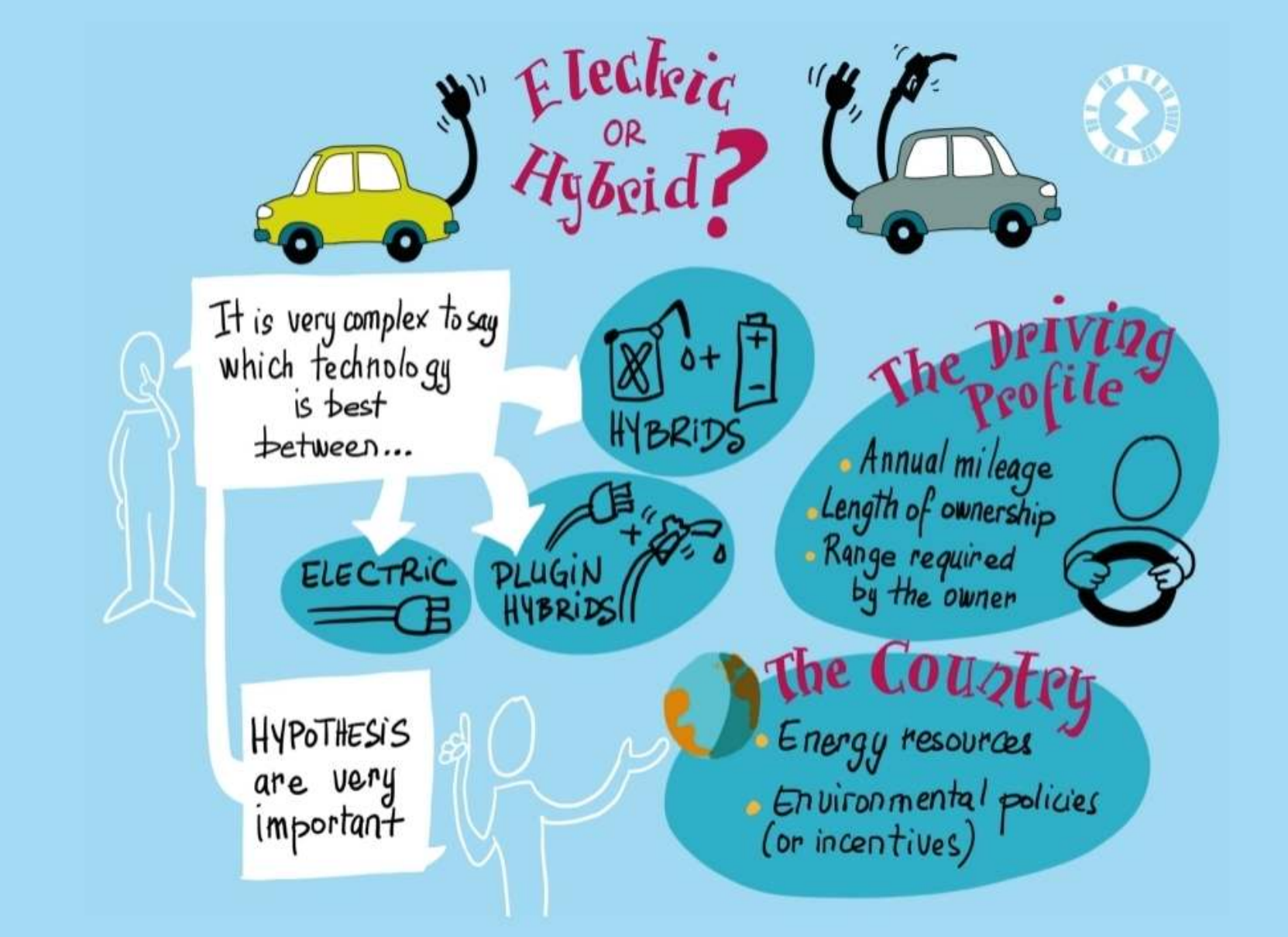
European Trend

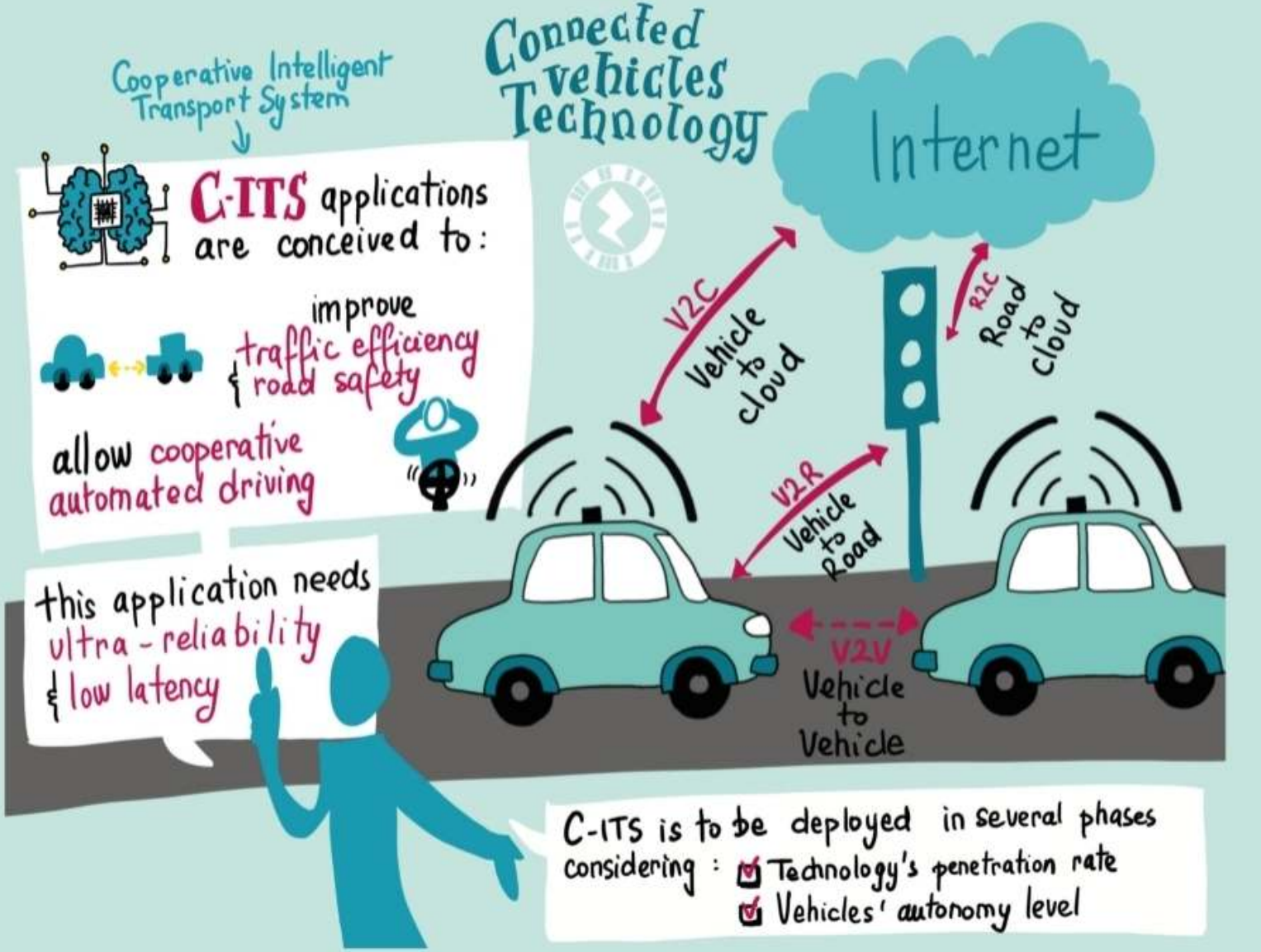
Development of **48V** mild-hybrid vehicles

Enable an **EASIER SYSTEM**

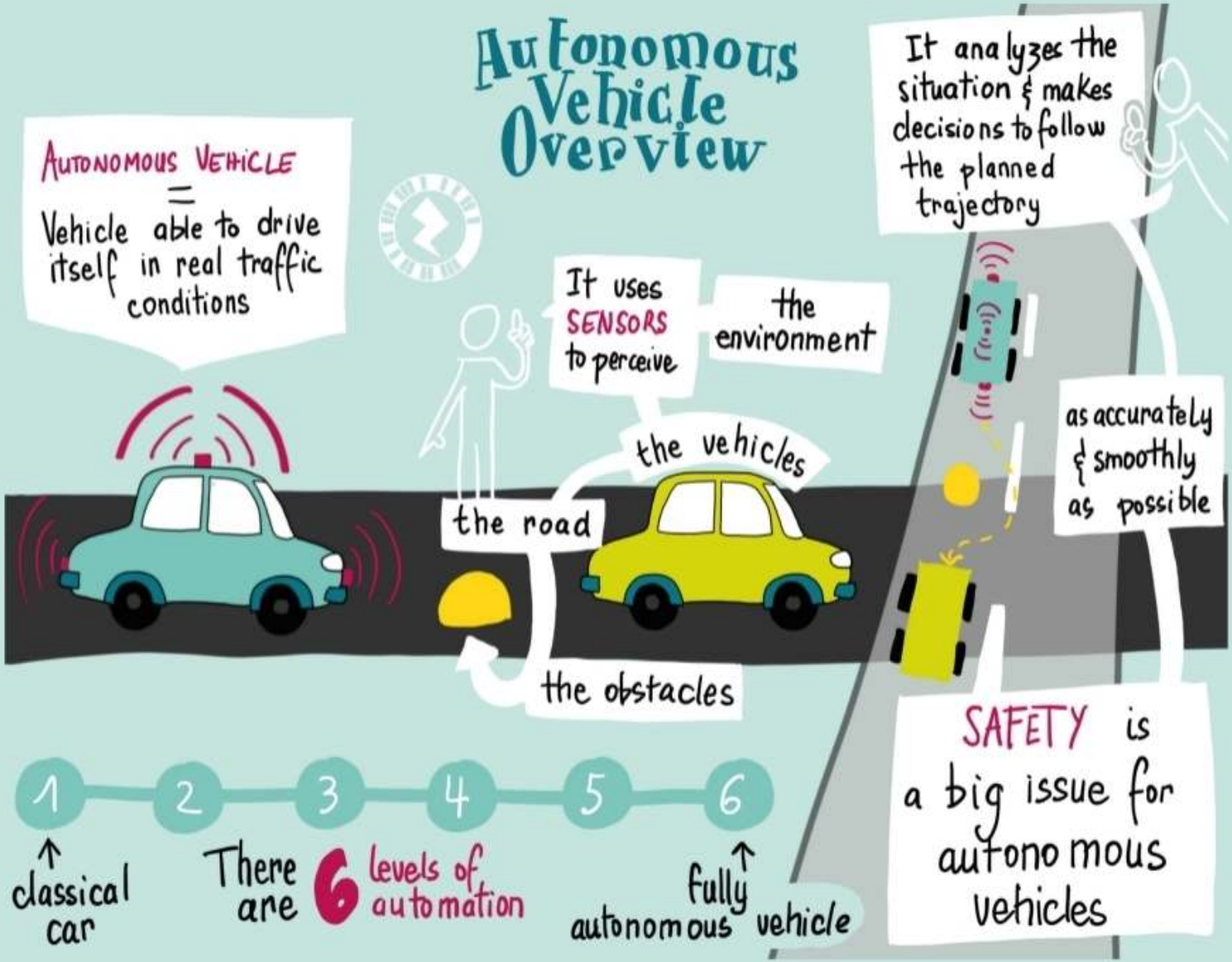
offer **BETTER PERFORMANCE** compared to 12V mild hybrid vehicles

are **MUCH CHEAPER** than the full hybrid vehicles


Electric
OR
Hybrid?
It is very complex to say which technology is best between...
HYBRIDS
ELECTRIC
PLUGIN HYBRIDS
The Driving Profile
Annual mileage
Length of ownership
Range required by the owner
HYPOTHESIS are very important
The Country
Energy resources
Environmental policies (or incentives)


Cooperative Intelligent Transport System
Connected vehicles Technology
Internet
C-ITS applications are conceived to:
improve traffic efficiency & road safety
allow cooperative automated driving
this application needs ultra-reliability & low latency
V2C Vehicle to cloud
R2C Road to cloud
V2R Vehicle to Road
V2V Vehicle to Vehicle
C-ITS is to be deployed in several phases considering :
Technology's penetration rate
Vehicles' autonomy level

Autonomous Vehicle Overview



Autonomous Vehicles Key Technologies

self-driving cars work with a lot of sensors to...

1. locate & position the vehicle
2. detect the environment
3. Figure out the infrastructures

Based on these information the vehicle plans the trajectory by using ALGORITHMS

Autonomous driving is extremely difficult because the road is shared & the environment is not controled

Automated & connected Vehicles Testing Regulation, Homologation

Homologation is the process that brings cars to the market

Homologation is composed of technical & legal regulation

As today there is NO technical regulation for advanced autonomous vehicles... The very first regulation will probably come in the middle of

Homologation tests need to be...

The impact on energy distribution & consumption

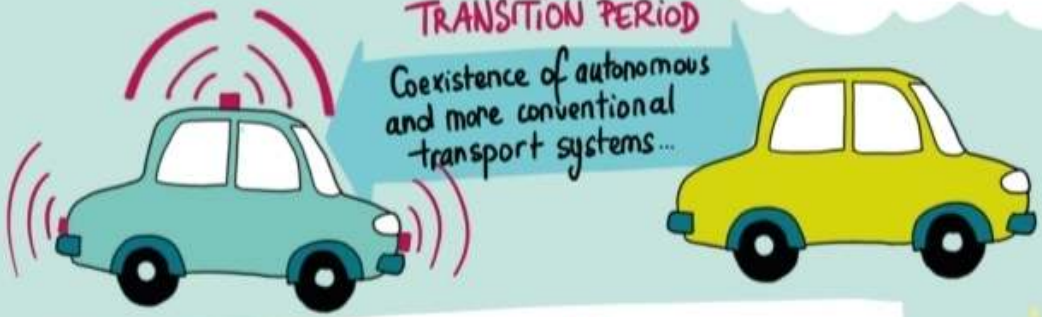
electric, shared, connected & automated vehicles

Vehicle automation is a complex subject which includes

- ☑ technology
- ☑ systemic
- ☑ economic

QUESTIONS ?

We dream about a safer, cleaner & more sustainable future with autonomous vehicles, but the future is uncertain...



MULTIPLE CHALLENGES to overcome

- ☑ the source of energy
- ☑ the distribution
- ☑ the infrastructure
- ☑ the urbanism

BIGGEST UNKNOWN SO FAR ... the CUSTOMERS' REACTION !

New forms of Mobility

Mobility is a need that results from the fact that...

we live in a place

We work

and we have social gathering to attend

The mobility context is rapidly evolving with disruptive trends

The Mobility equation takes into account

our needs for mobility

the Social issues

the environmental constraints

Governments are adapting their policies to encourage a global solution

MAAS
MOBILITY
AS A
SERVICE

New forms of Mobility

There are **7** new forms of mobility which take into account the fact that younger generations don't like the idea of owning a car

2 SCENARIOS regarding the impact of autonomous vehicles

SEAMLESS SCENARIOS

BRINGS MORE BENEFITS!

Private AUTONOMOUS SCENARIO

A lot of new mobility offers appeared in the last few years...

However, most of them are NOT ECONOMICALLY SUSTAINABLE

Tomorrow's Mobility, in collaboration with IFP Training and Vedecom, is a MOOC focusing on sustainable technologies for the automotive sector.

IFP School has created this interactive book, displaying the summaries of this MOOC as sketchnotes, using Augmented Reality technology.

Scanning each sketchnote with a specific app on your smartphone or tablet will reveal digital content.

This book has been made as an extension of the MOOC:
it is intended to entirely gather your digital training in one physical item, allowing you to remember, or simply discover the modules!

Are you ready to start scanning?

IFP SCHOOL
The school for energy innovation and sustainable mobility