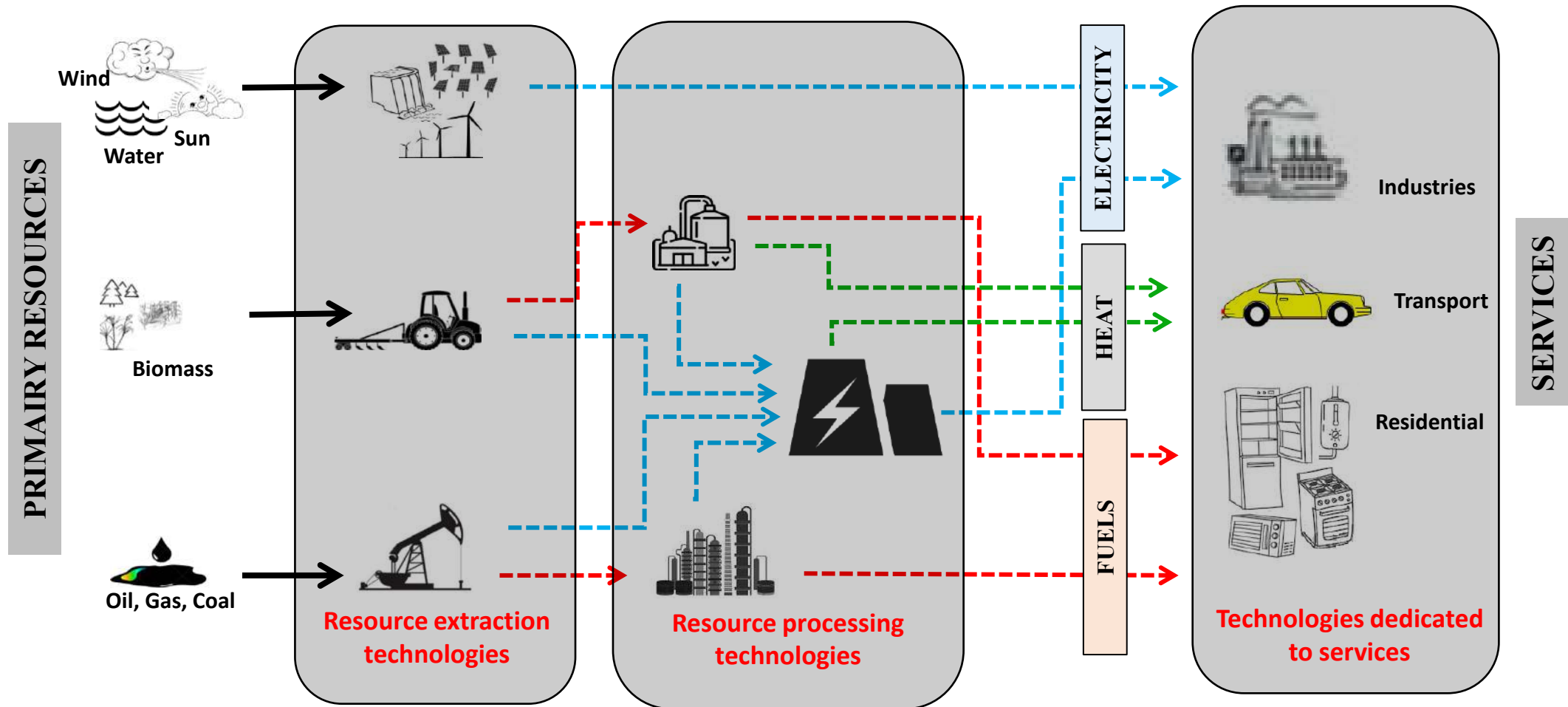


Method of Integrated Assessment for Air, Climate and Energy Strategies

Alain Clappier



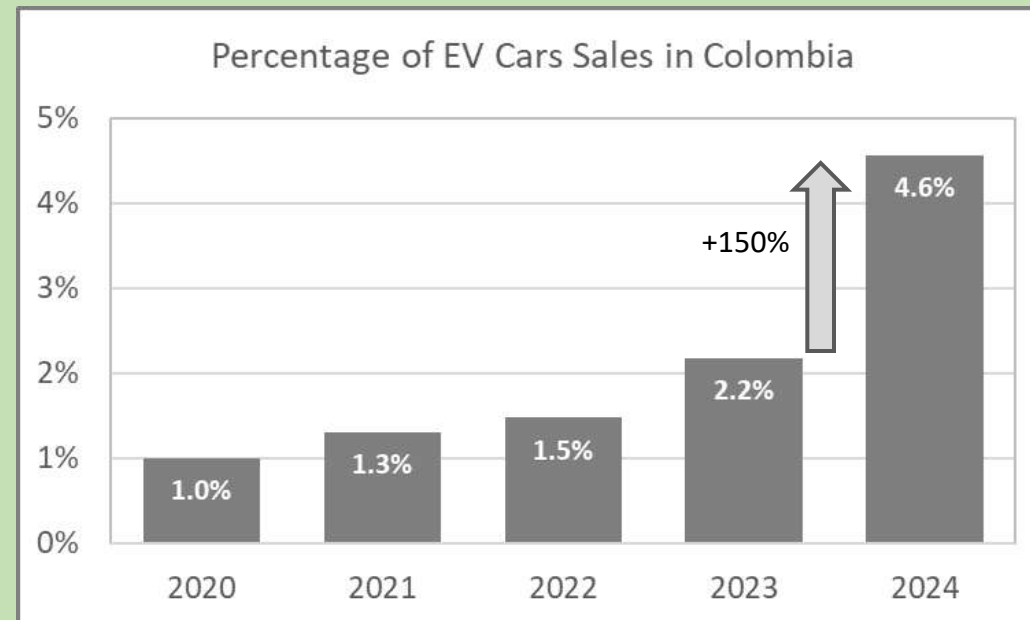
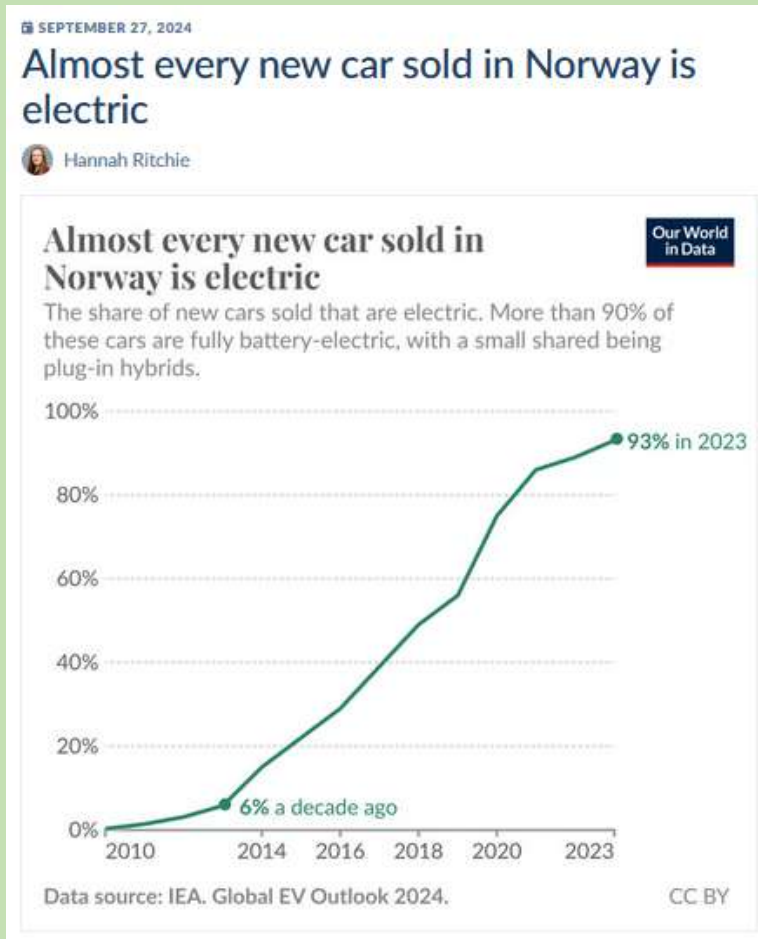
ENERGY SYSTEM



EVOLUTION OF THE ENERGY DEMAND

EXAMPLE OF ELECTRIC CARS

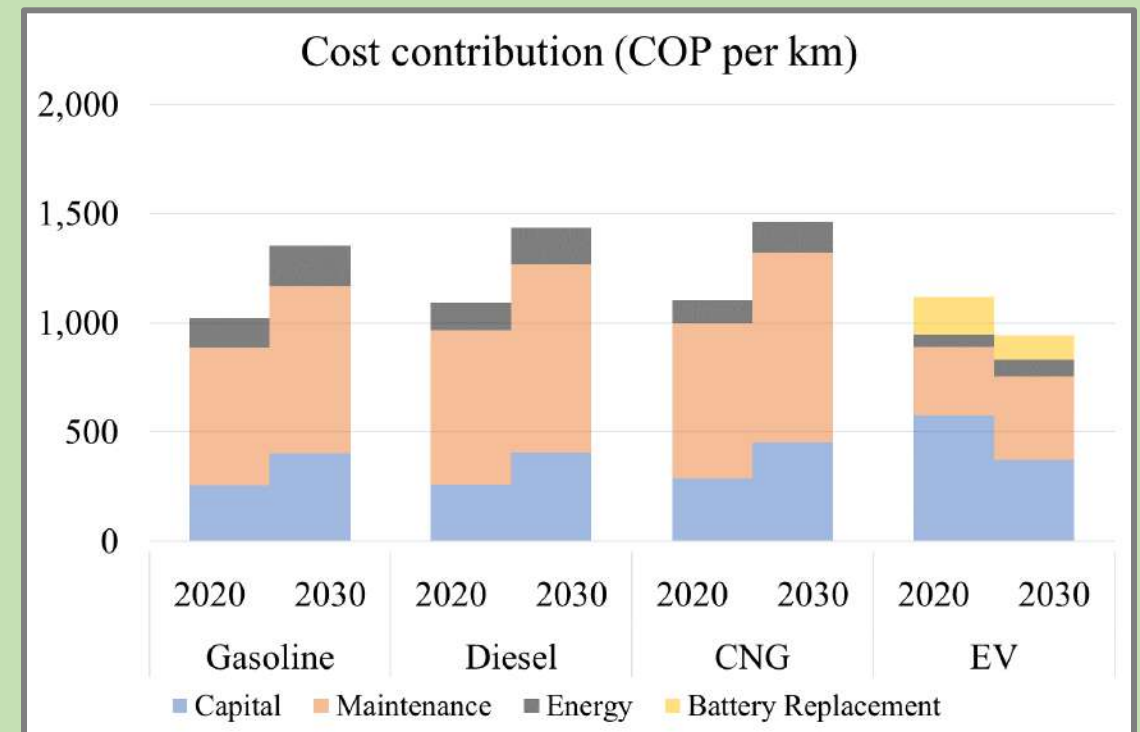
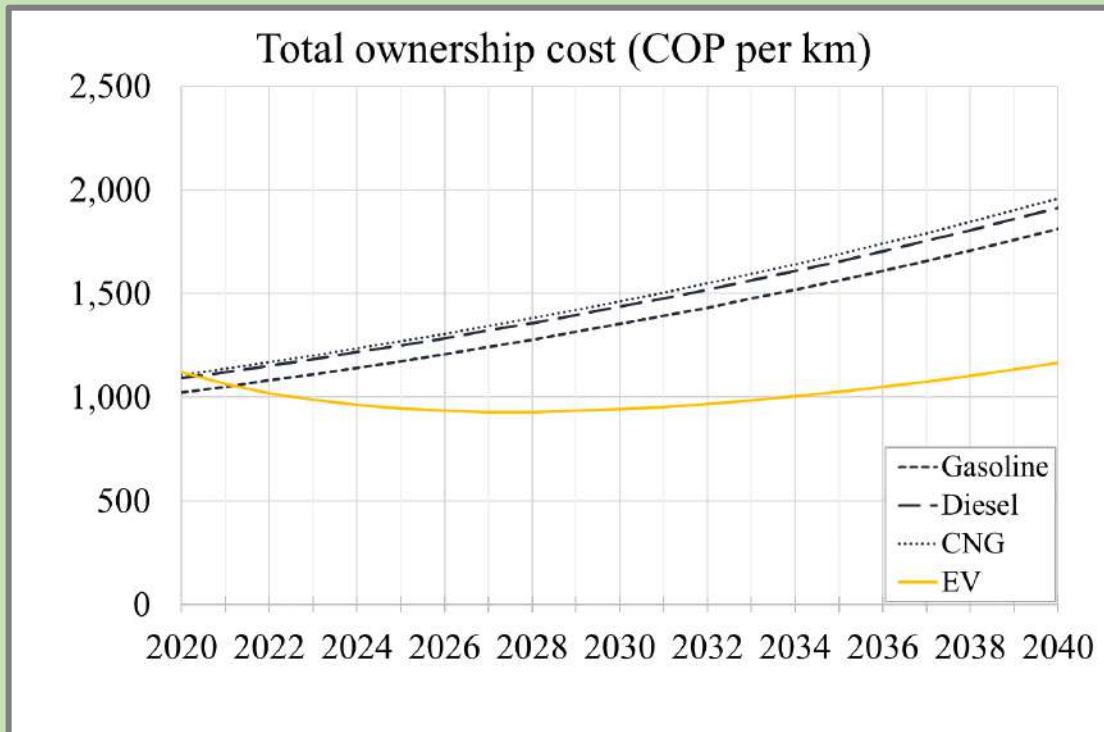
Electric technologies are disrupting the transportation sector.



EVOLUTION OF THE ENERGY DEMAND

EXAMPLE OF ELECTRIC CARS

Electric vehicles become the cheapest

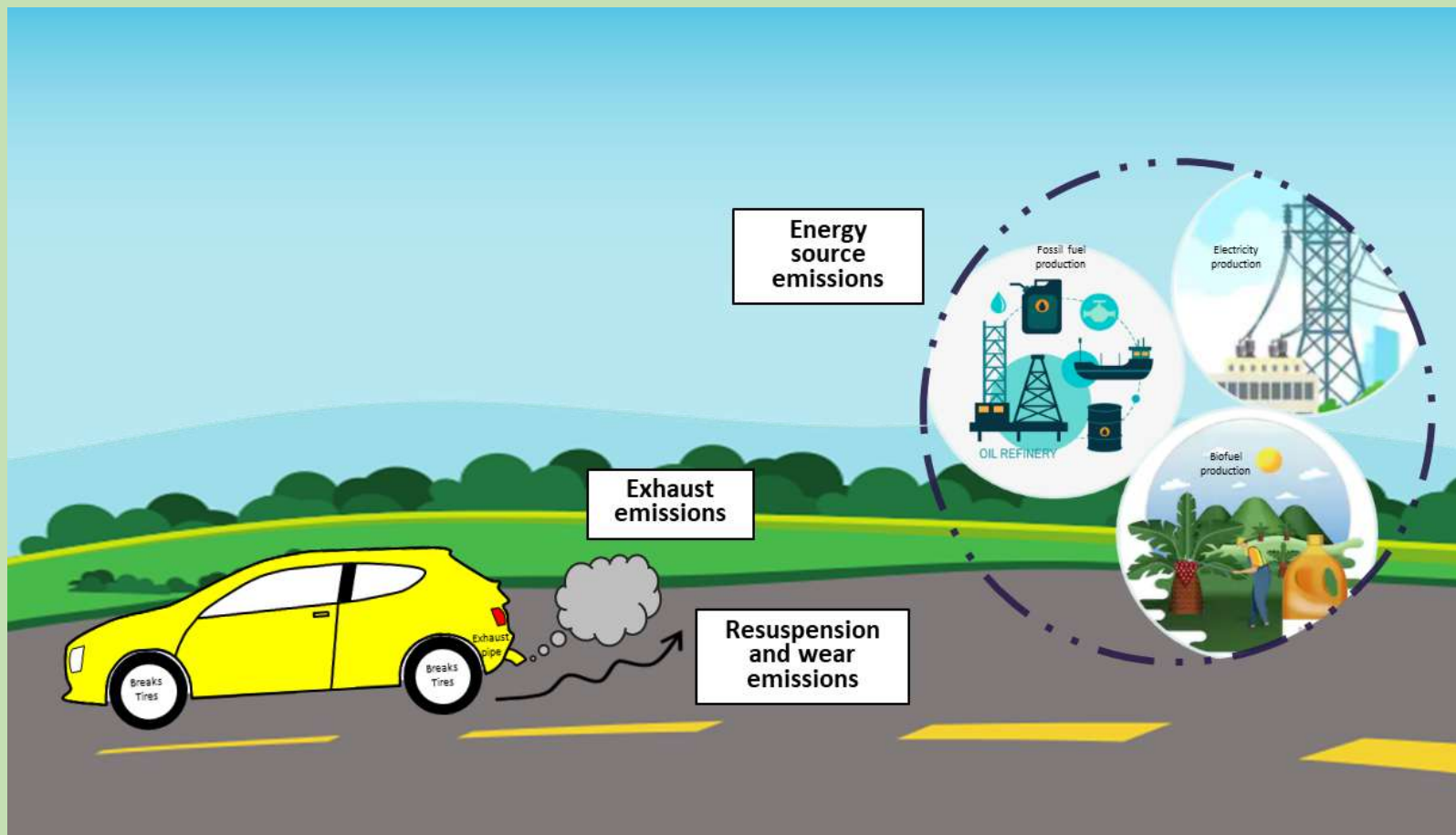


Cuellar-Alvarez Y., A. Clappier, N. Y. Rojas-Roa, P. Thunis, S. Mangones and L. C. Belalcazar-Ceron 2024: Emissions and ownership-cost of conventional and electric passenger vehicles in Bogota, Colombia, Transportation Research Part D, 128, 104105.

EVOLUTION OF THE ENERGY DEMAND

EXAMPLE OF ELECTRIC CARS

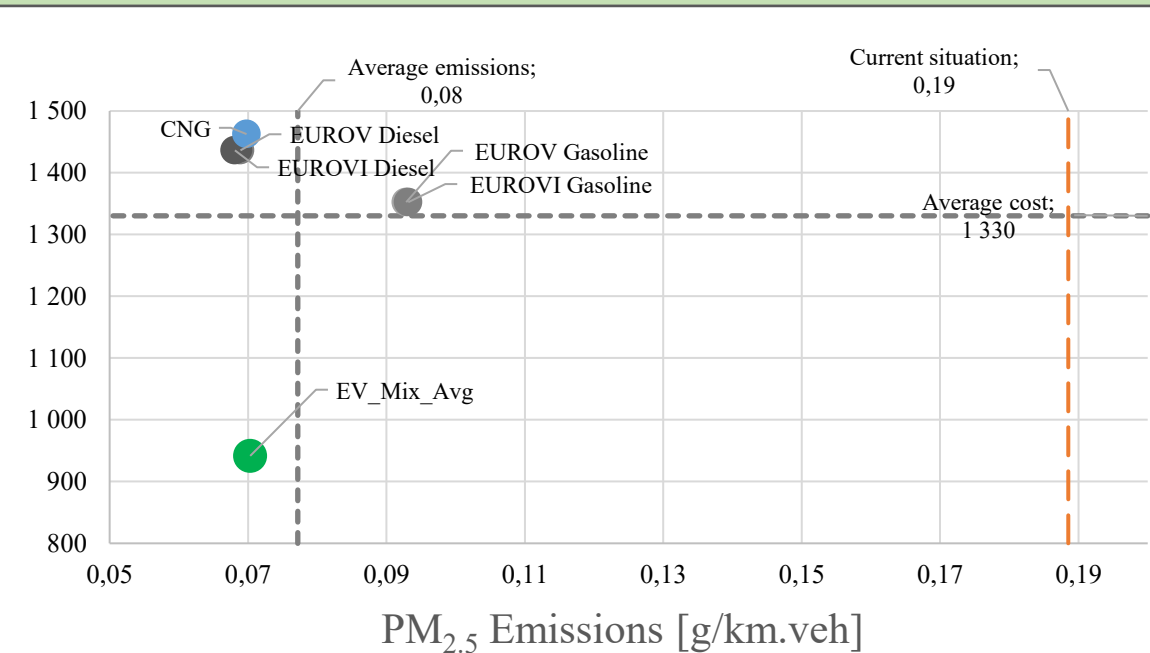
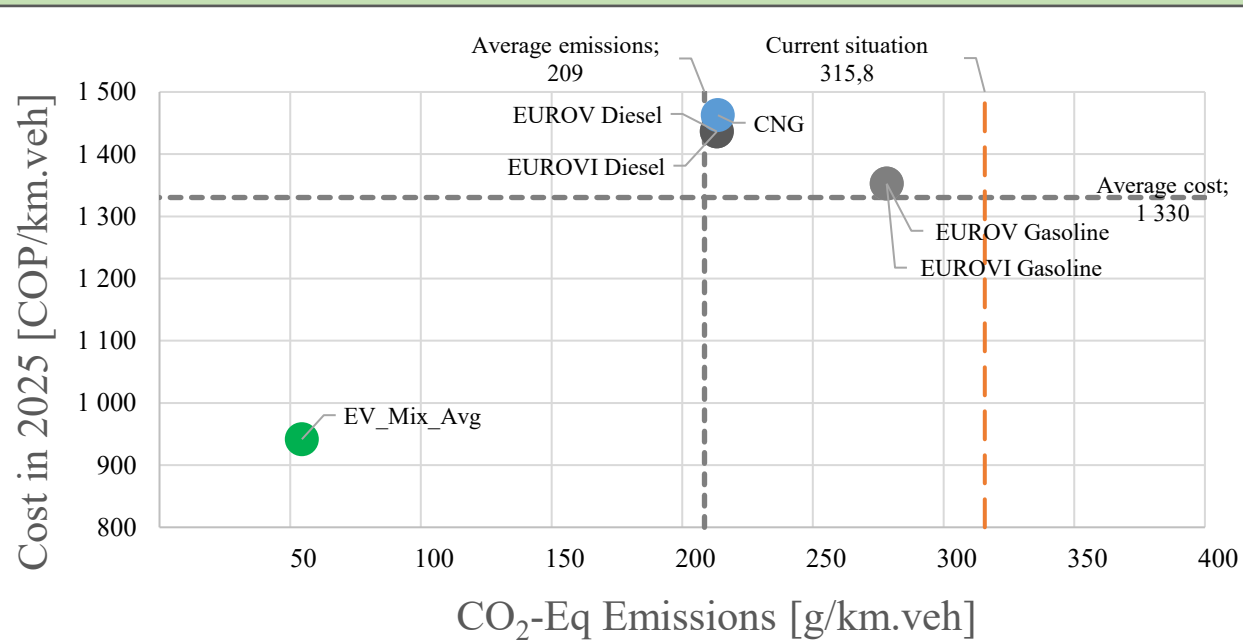
Well to wheel emissions



EVOLUTION OF THE ENERGY DEMAND

EXAMPLE OF ELECTRIC CARS

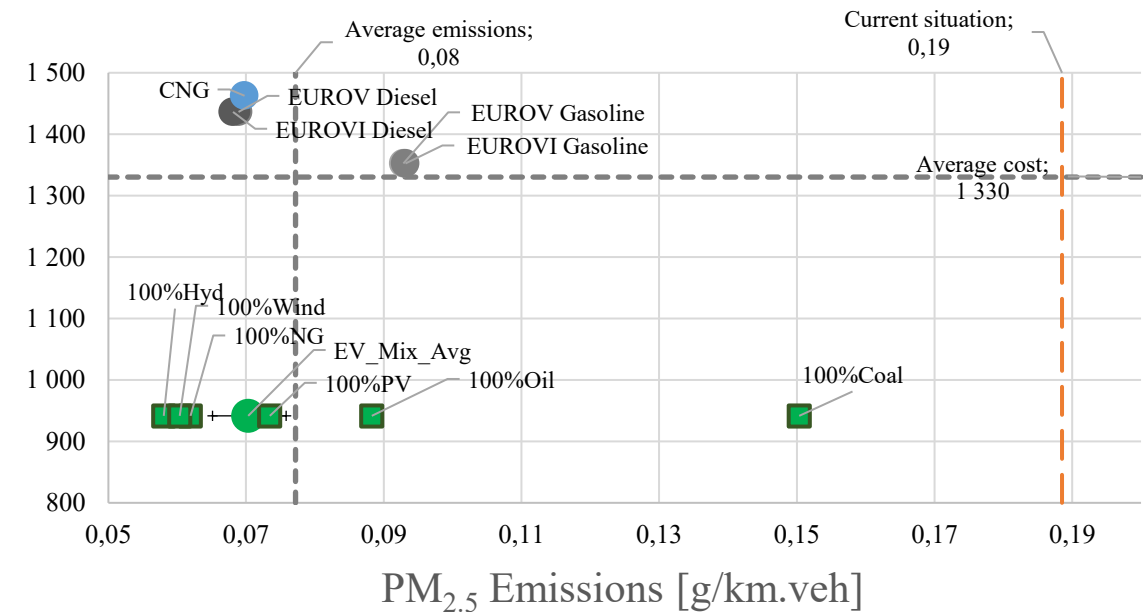
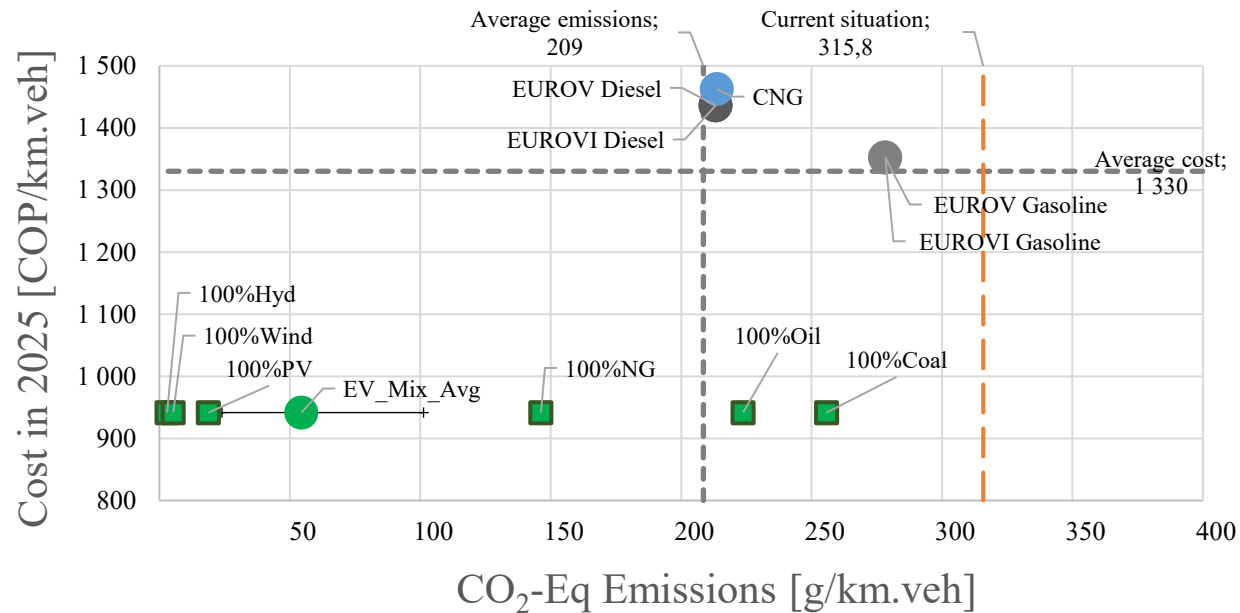
The introduction of electric cars will lead to a decrease in CO₂ emissions, but not in PM_{2.5}.



EVOLUTION OF THE ENERGY DEMAND

EXAMPLE OF ELECTRIC CARS

Emissions resulting from the use of electric vehicles depend on the electricity generation mix.



EVOLUTION OF THE ENERGY DEMAND

EXAMPLE OF ELECTRIC CARS



Electricity required by the electric vehicles in Bogota.

	Current fleet energy [GWh]	EBVs energy [GWh]	Reduction	HEVs energy [GWh]	Reduction
Passenger cars	17 440	4 011	77%	12 876	26%
Taxis	3 335	767	77%	2 462	26%
Rigid buses	3 611	975	73%	3 130	13%
Articu. buses	600	126	79%	404	33%
Motorcycles	2 000	220	89%	706	65%

EBVs: Electric battery vehicles
HEVs: Hydrogen electric vehicles

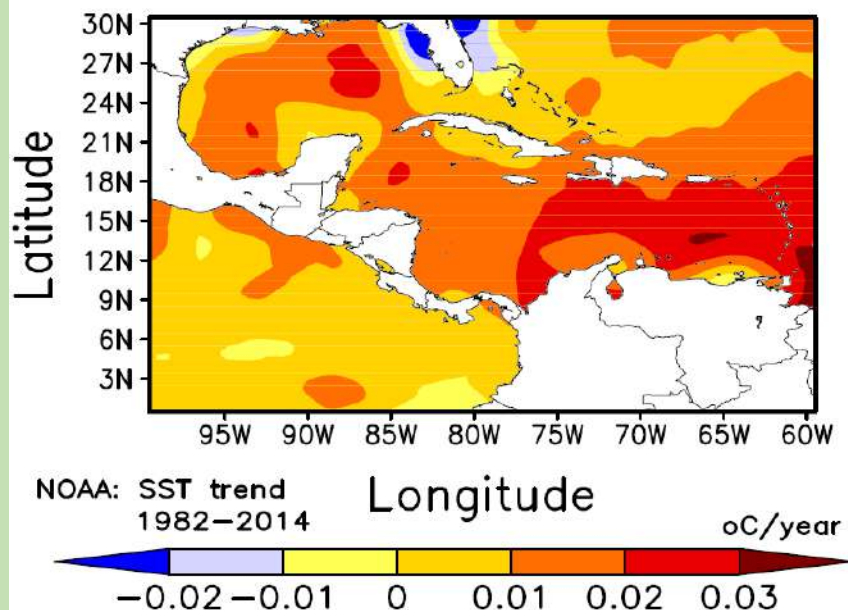
Electricity consumption in Bogota: 10 398 GWh/yr

Increase of electric consumption due to electric vehicles (%)	EBVs	HEVs
Passenger car	39%	124%
Passenger cars + Taxis + Moto	48%	154%
All passenger vehicles	59%	188%

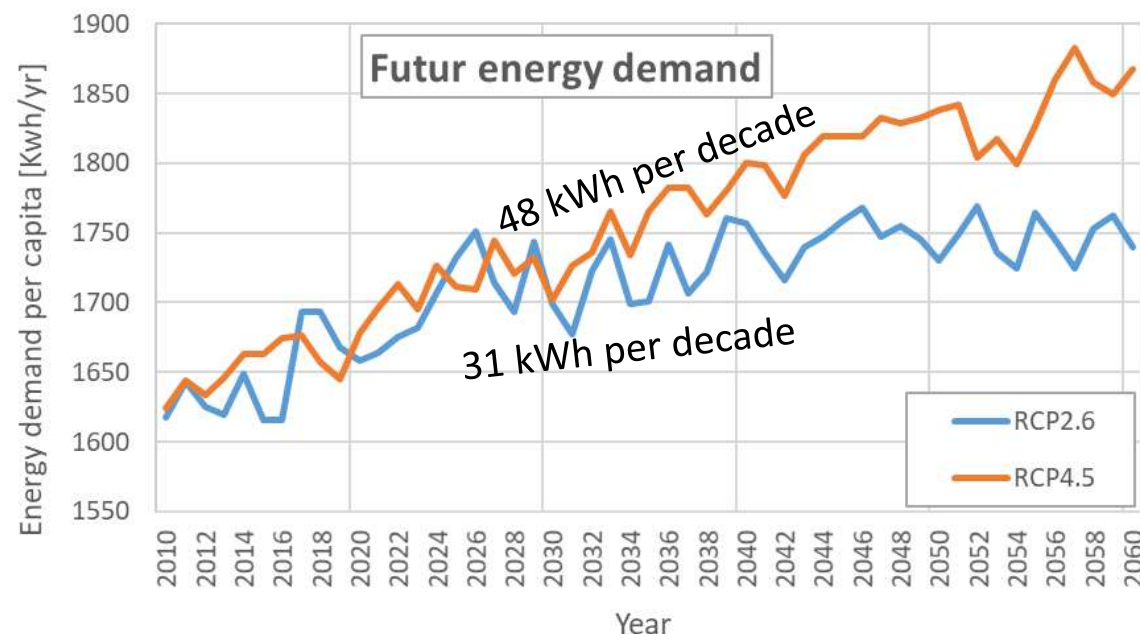
EVOLUTION OF THE ENERGY DEMAND

Climate change will lead to temperature elevations and an increase of energy consumption in the residential sector (air conditioning).

Sea surface temperature trend between 1980 to 2013 in Carribean region



Energy trend between 2010 to 2060 in Carribean region



Moises E. Angeles et al.: Impacts of climate change on building energy demands in the intra-Americas region, Theor Appl Climatol (2018) 133:59–72

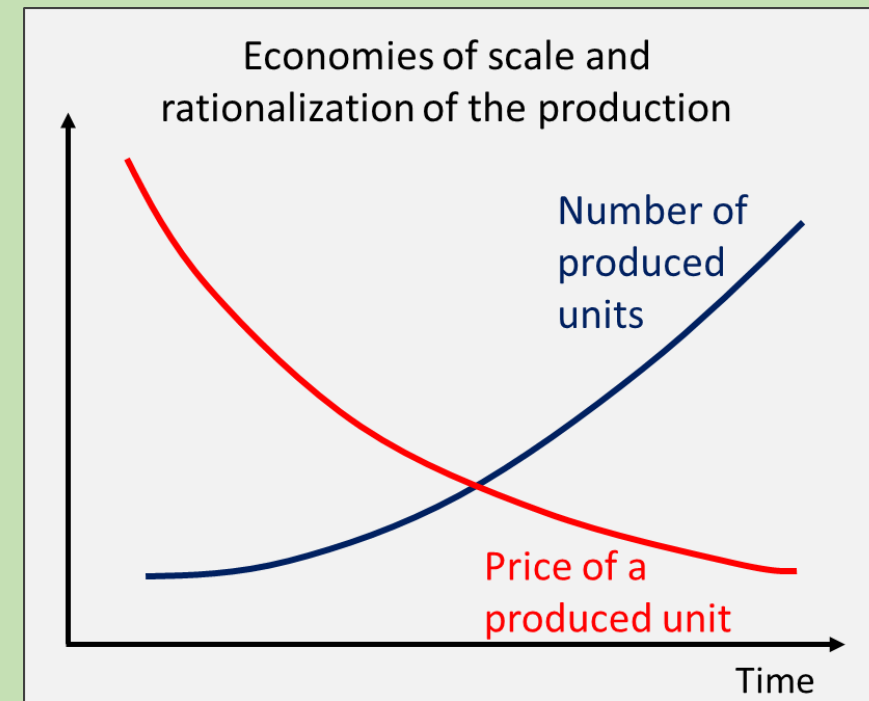
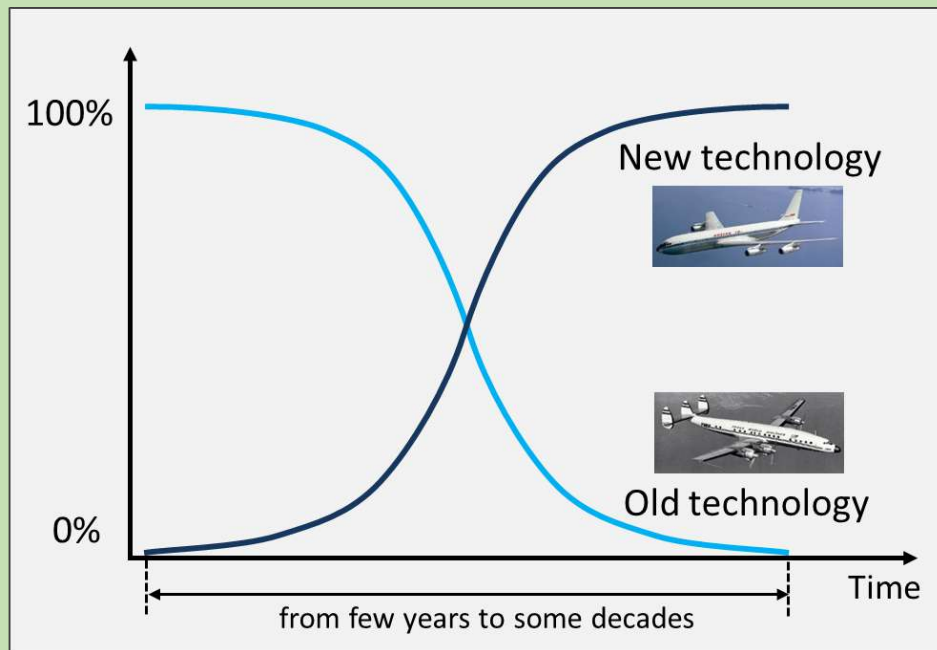
TECHNOLOGY SUBSTITUTION



The adoption of new technology is driven by the law of supply and demand. A new technology becomes established on the market when it is **sufficiently attractive** (it provides a service that the others do not offer, or offer less effectively, its usage cost is lower than others...).

The **selling price** of a technology depends on the profit margin that its producer and seller want to retain, but more importantly, on the **costs of its production**.

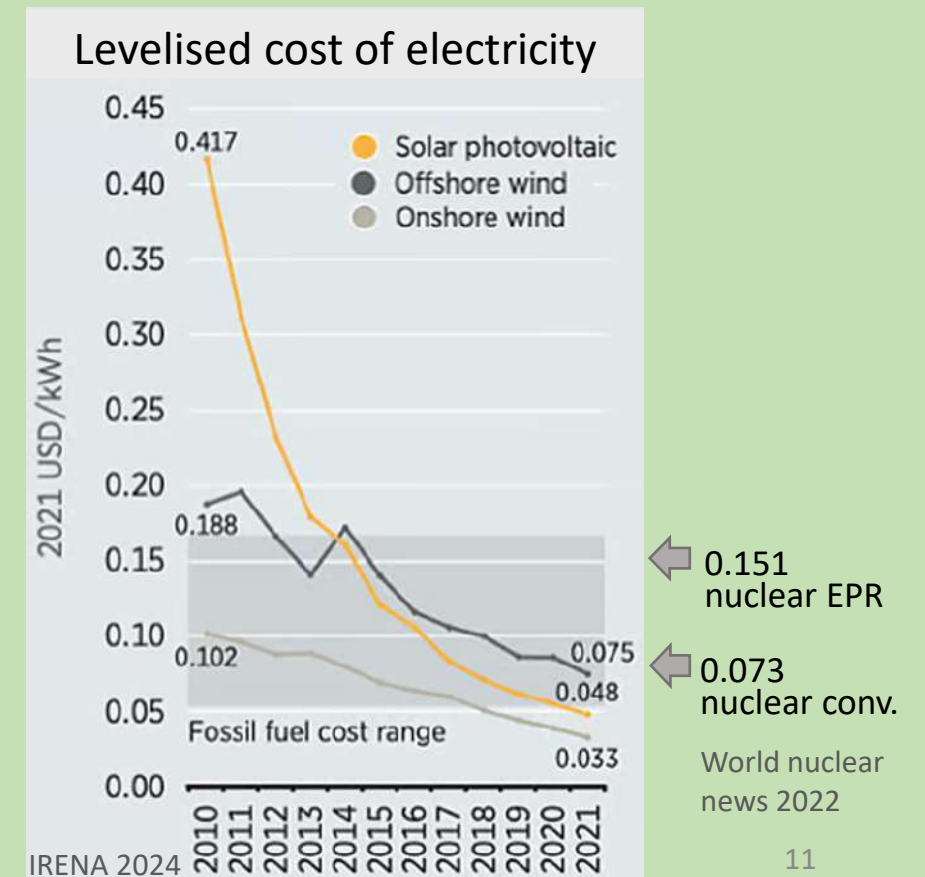
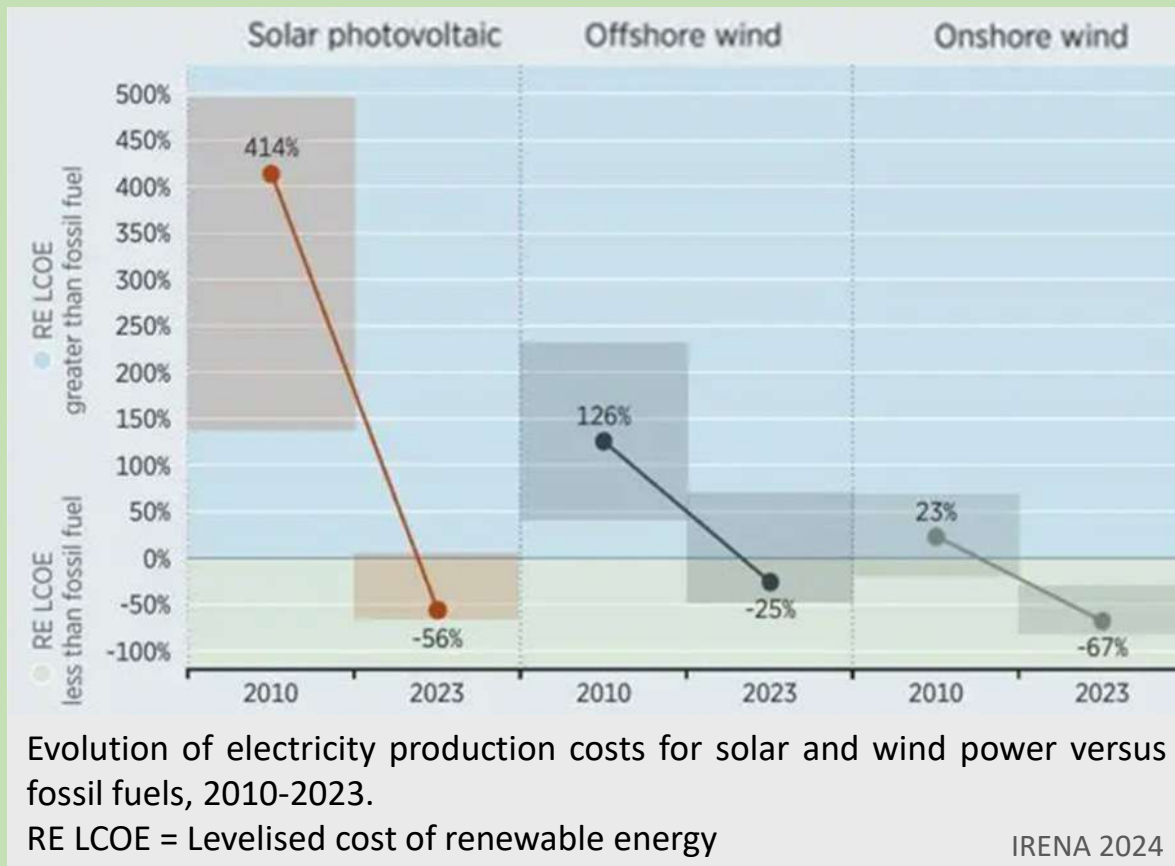
In general, a new technology is more expensive than those already in use but provides a better service. As this new technology gains market share, its production benefits from economies of scale, causing the cost of producing each unit to decrease.



TECHNOLOGY SUBSTITUTION

Solar pannels ans wind turbines

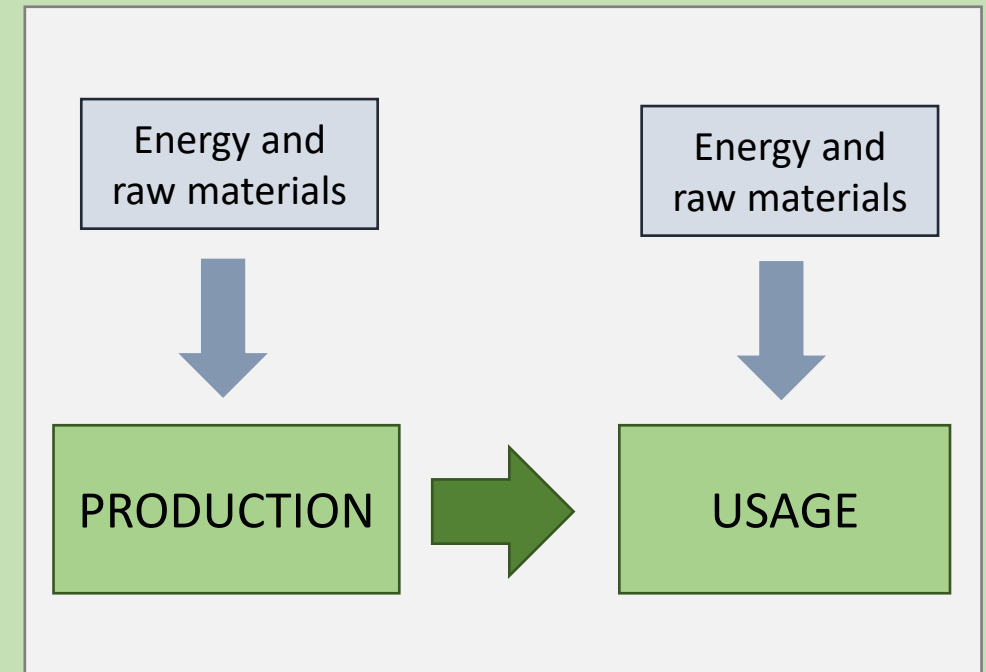
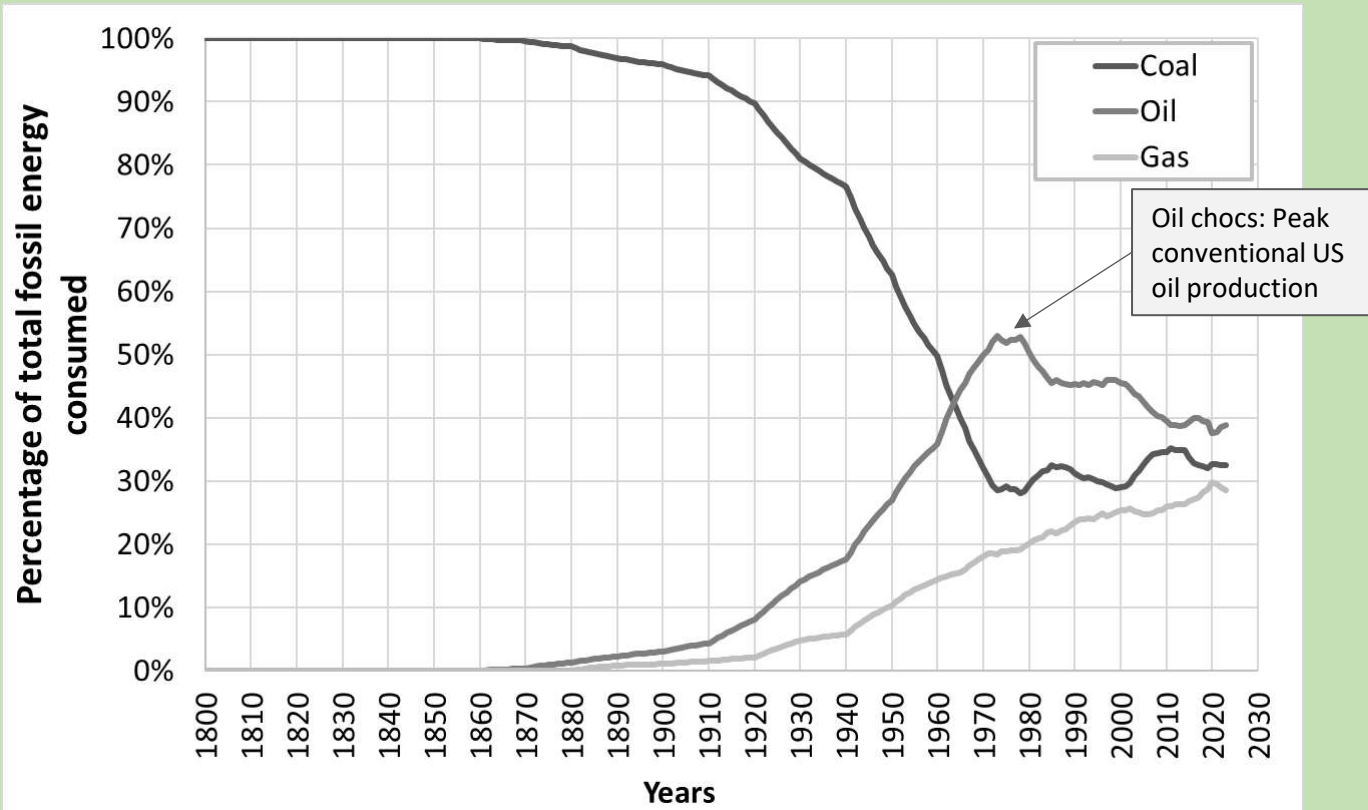
The mass production of wind turbines and solar panels considerably lowers their energy production costs.



LIMITATIONS TO SUBSTITUTION

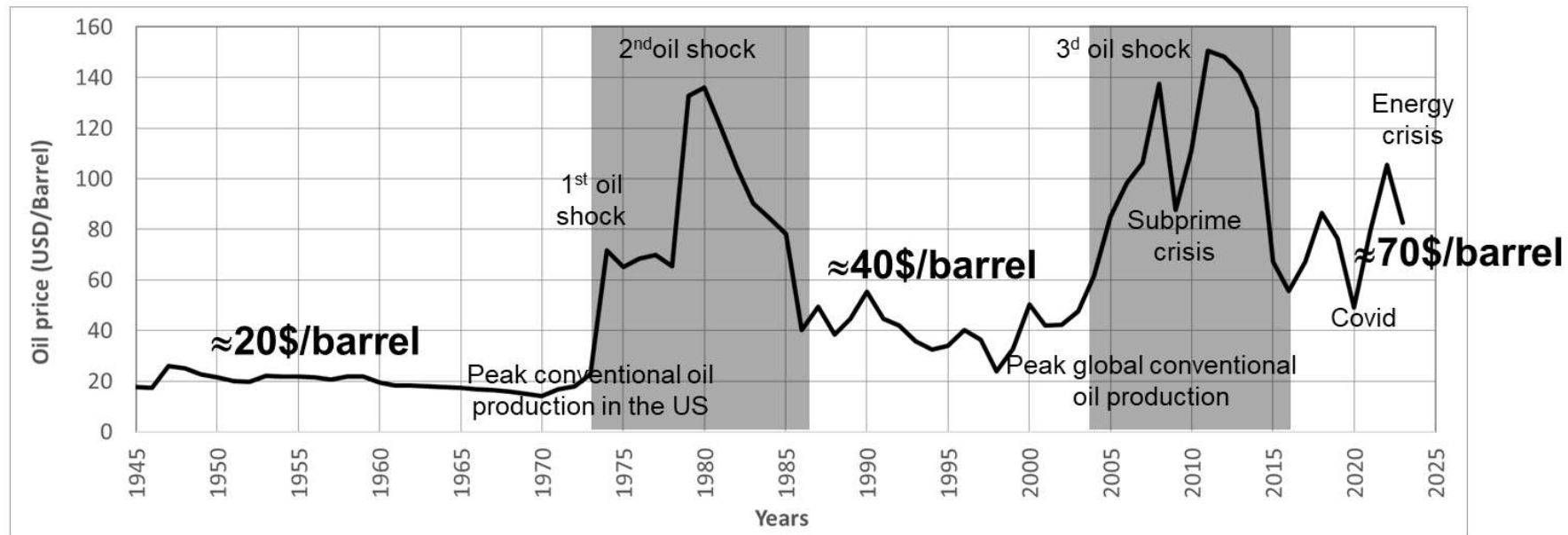
Available resources for technologies using oil

Complete substitution can only take place if the resources needed to manufacture and use a technology are sufficient.



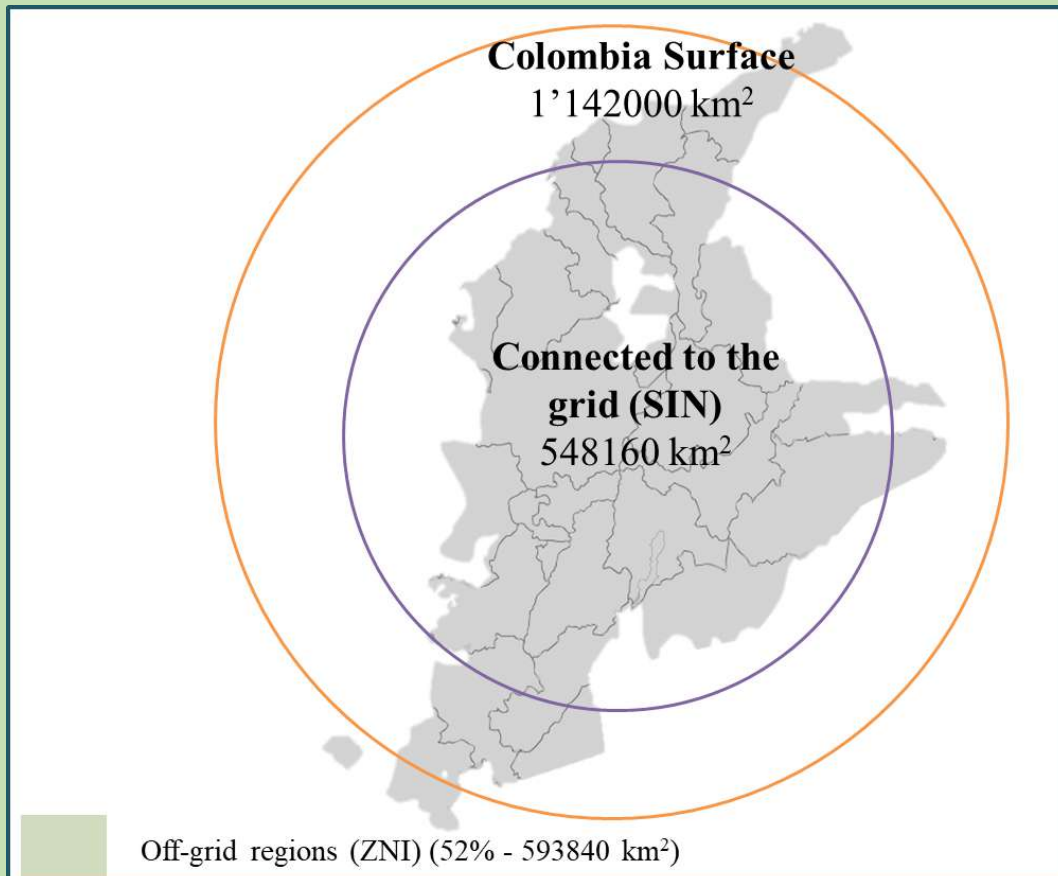
LIMITATIONS TO SUBSTITUTION

Available resources for technologies using oil



LIMITATIONS TO SUBSTITUTION

Land space for solar pannels and wind turbines : example of solar in Colombia



The land area needed to install wind turbines or solar panels can become a significant limiting factor.

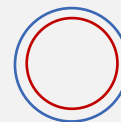
Areas needed to supply 100% of the **Colombian** electricity demand with PV panels.



Utility Solar Photovoltaic

603-822 km²

(0.11% - 0.15%) of the “interconnected country surface”



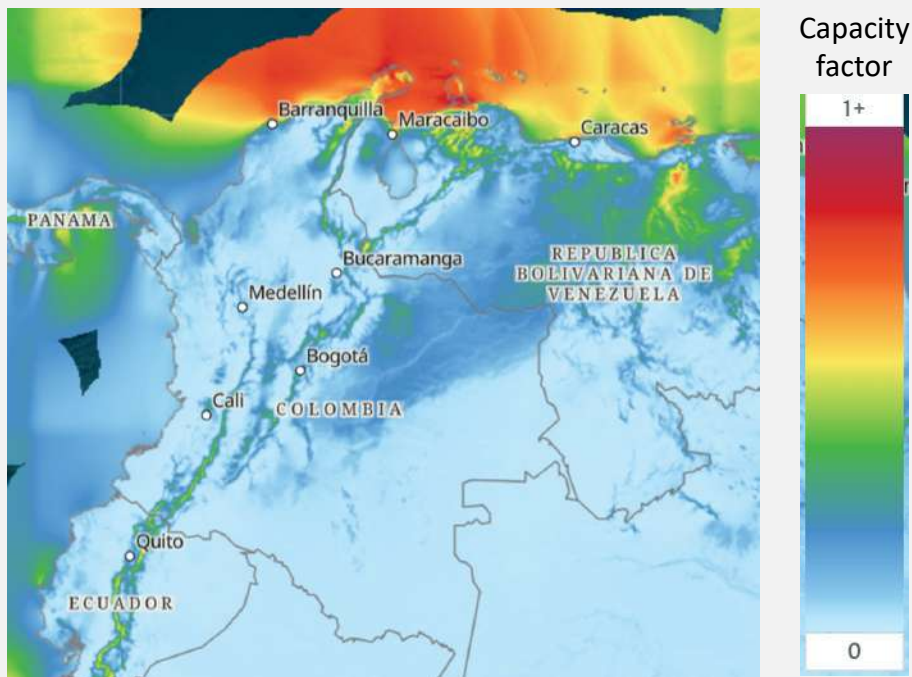
Biofuels

13'704- 23'022 km²

(2.5% - 4.2%) of the “interconnected country surface”

LIMITATIONS TO SUBSTITUTION

Land space for solar pannels and wind turbines : example of wind in Colombia



Wind resources are extremely limited in Colombia, except in the north (in Guajira).

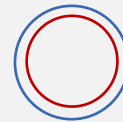
Areas needed to supply 100% of the **Colombian** electricity demand with wind turbines (in Guajira).



Onshore Wind Turbines

1096-3289 km²

(0.2% - 0.6%) of the “interconnected country surface”



Biofuels

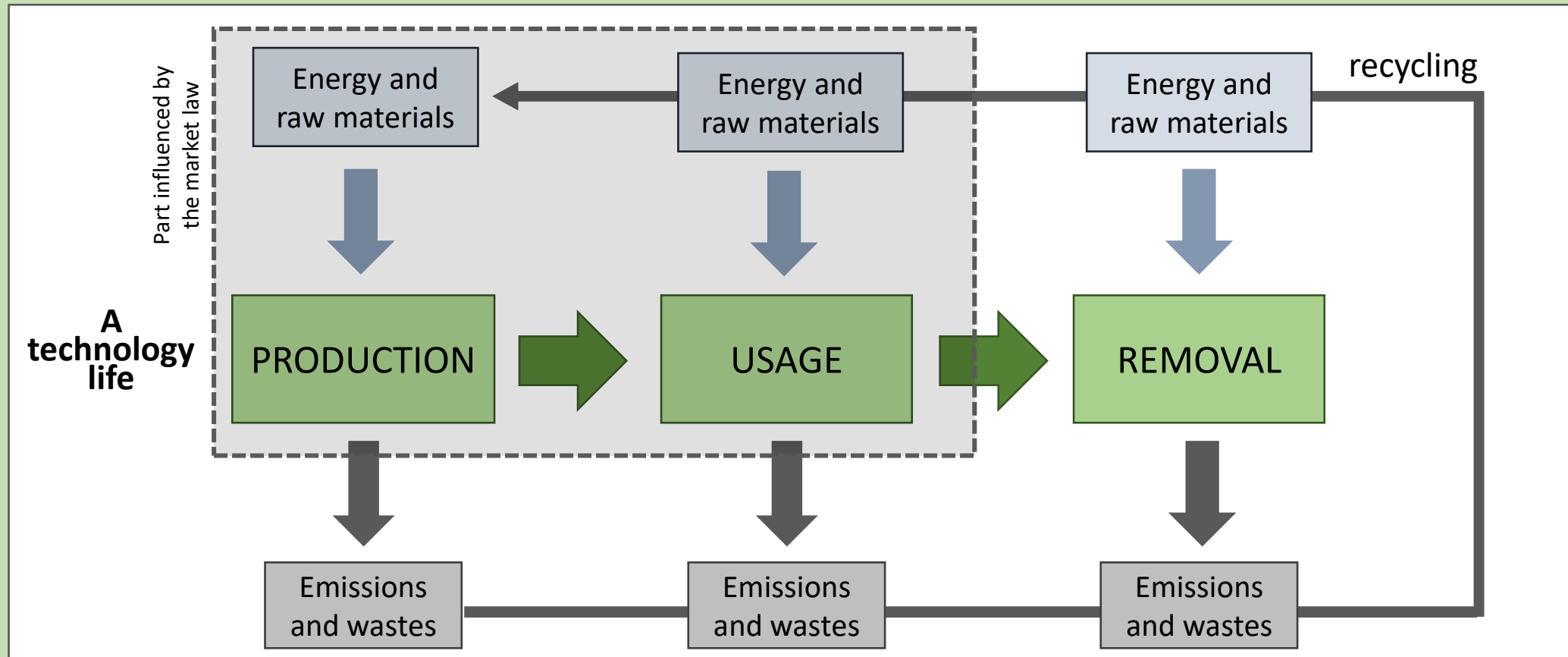
13'704- 23'022 km²

(2.5% - 4.2%) of the “interconnected country surface”

CONSIDERATION OF THE ENVIRONMENT

Production and usage costs will take into account environmental aspects through the availability of resources necessary for the production and use of the technology. However, these are not the only environmental impacts of a technology, as it will produce emissions and waste throughout its lifecycle (production, use, and removal).

Legislation is needed to make less polluting technologies competitive, even if their costs are higher.

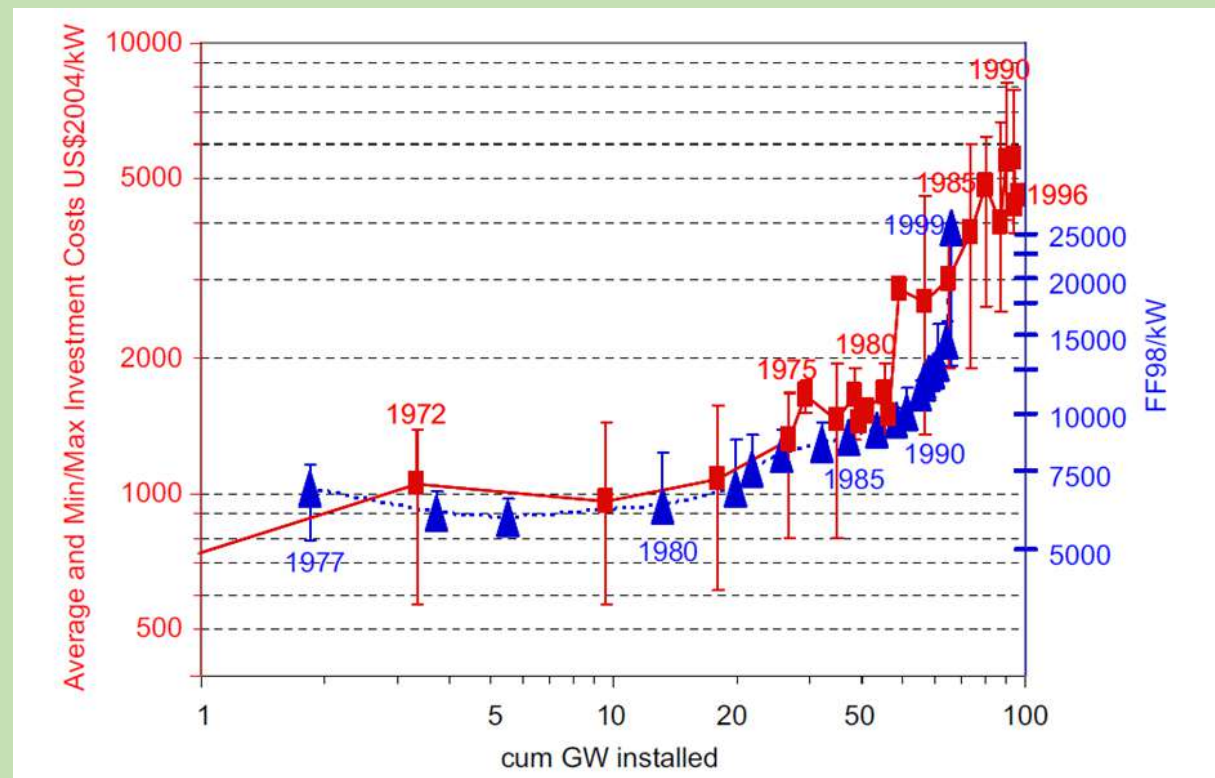


NUCLEAR ENERGY: THE EXCEPTION



Nuclear energy is an exception because, in its case, the environmental risks are so high that they are directly factored into the production and usage costs. Moreover, risk management, by definition, is never entirely predictable, so it is inevitable that incidents will occur, and they must be taken into account as they arise. This will gradually increase production and operating costs.

Evolution of nuclear energy investment costs as a function of installed capacity
(France in blue, USA in red)



ENERGY STRATEGY DESIGN AND DECISION SUPPORT



*Developing energy strategies involves creating and comparing different scenarios,
BUT this process is complicated by:*

- ☐ *the virtually limitless combinations of energy sources and demand distributions,*
- ☐ *the many criteria that need to be taken into account.*

COST ESTIMATION

Energy produced and installed capacity

The cost of electricity generation depends on the size and number of installations required, as well as the amount of energy produced.



Installed capacity in TW



Energy production in TWh

Total annualized cost: $TAC_t^{(SC)} = IC_{tc}^{(SC)} \times CIC_{tc} + EP_{tc}^{(SC)} \times CEP_{tc}$

$$CIC_{tc} = AC_{tc} + FC_{tc}$$

Investment costs Fixed costs

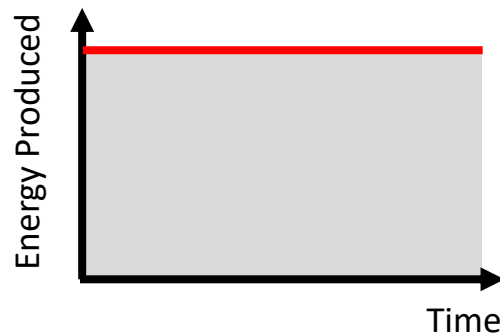
$$CEP_{tc}^{(SC)} = VC_{tc} + \frac{FUC_{tc}}{\eta_{tc}}$$

Variable costs Fuel costs
Efficiency of fuel usage

COST ESTIMATION

Ratio between installed capacity and energy produced

Constant production:



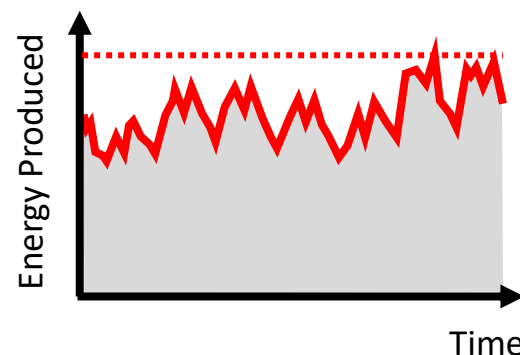
Installed capacity



Energy produced

Non constant production:

- Maintenance
- Demand variability
- Resources availability



Installed capacity



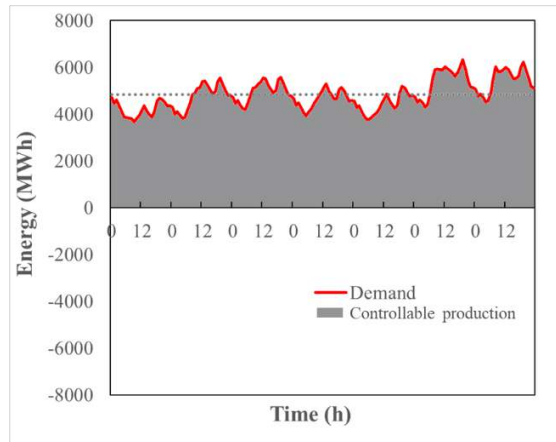
Energy produced

$$RIE_{tc}^{(SC)} = \frac{IC_{tc}^{(SC)}}{EP_{tc}^{(SC)}}$$

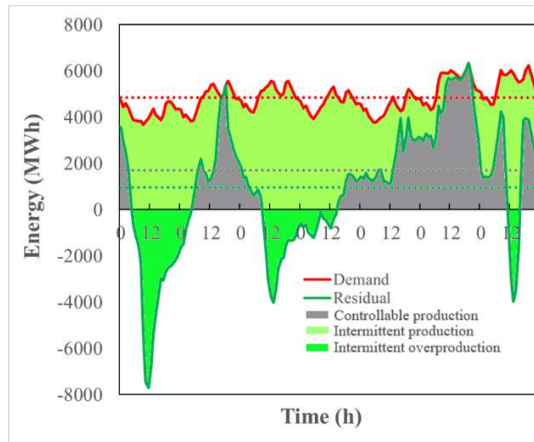


COST ESTIMATION

Intermittent and controllable energy sources

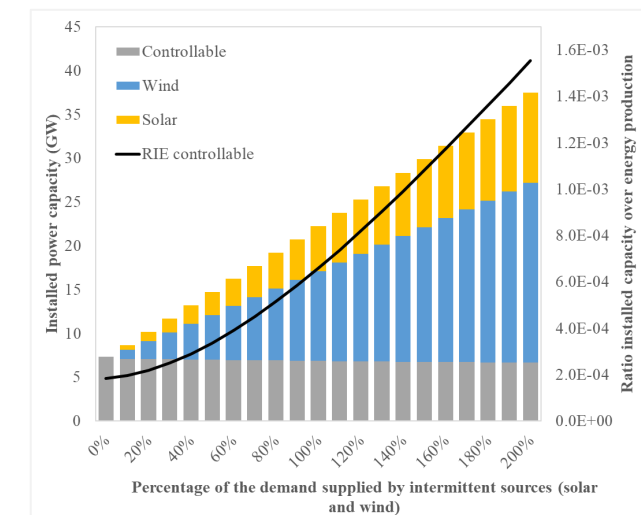
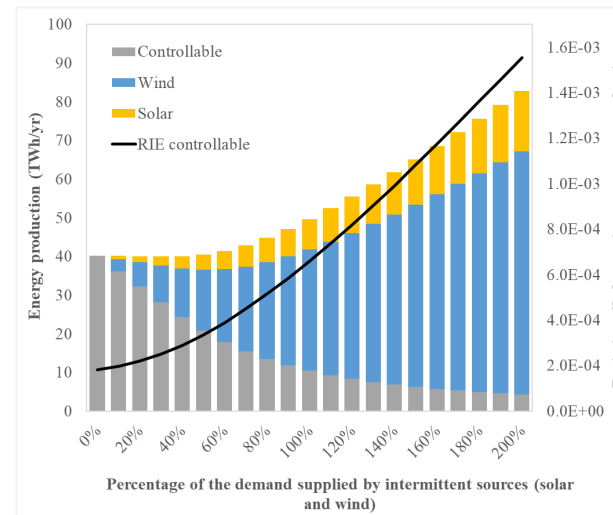


without intermittent sources



with intermittent sources

The ratio of installed capacity to energy produced for controllable sources increases as more intermittent sources are integrated into the electricity mix.



COST ESTIMATION

Levelized cost of electricity

Total annualized cost [\$]:

$$TAC_{tc}^{(SC)} = EP_{tc}^{(SC)} \times CEP_{tc} + IC_{tc}^{(SC)} \times CIC_{tc}$$

Levelized cost of electricity [\$/TWh]:

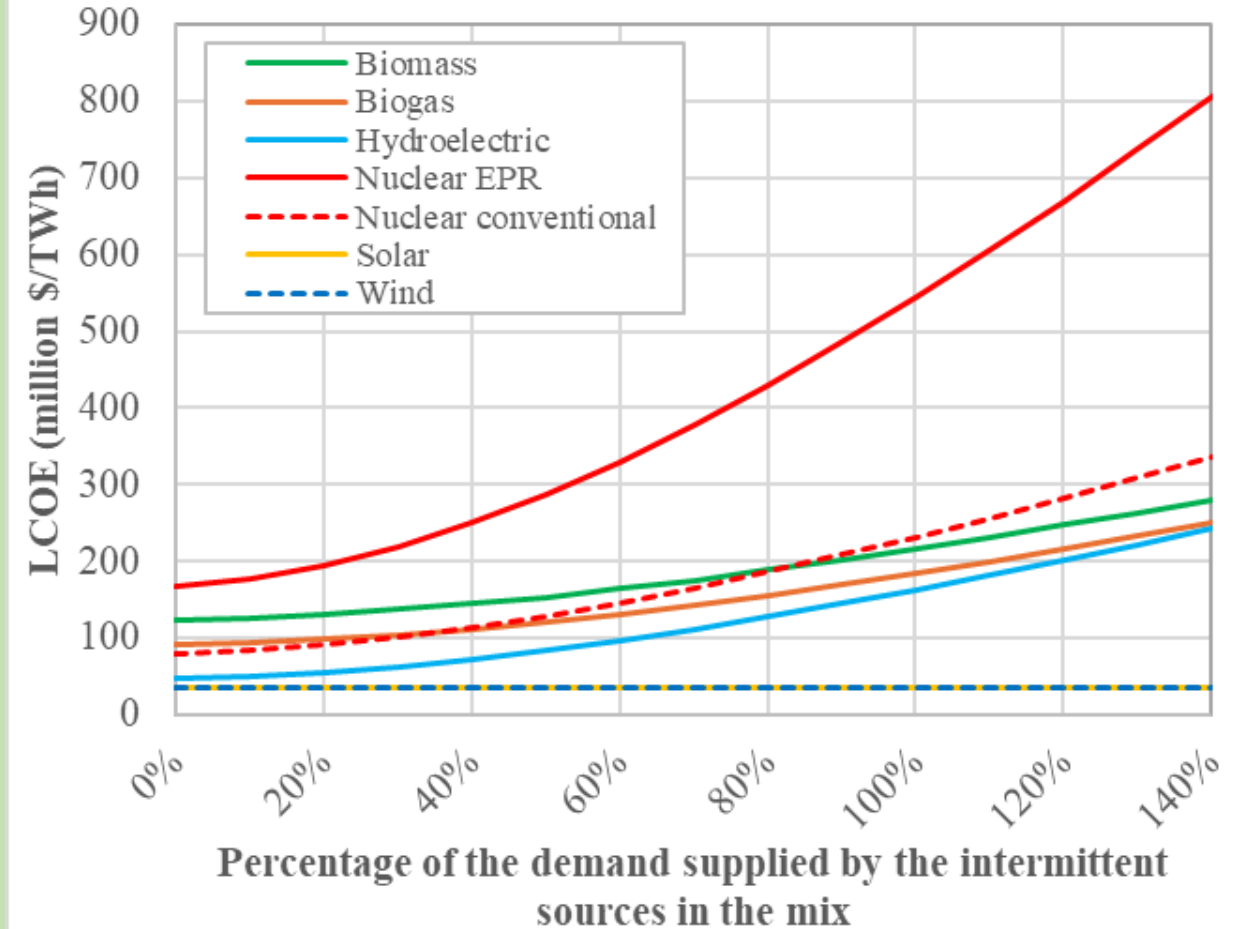
$$LCOE_{tc}^{(SC)} = CEP_{tc} + RIE_{tc} \times CIC_{tc} \quad RIE_{tc} = \frac{IC_{tc}^{(SC)}}{EP_{tc}^{(SC)}}$$

$$LCOE_{tc}^{(SC)} = LCOE_{tc}^0 + RIE_{cont}^{(SC)} \times CIC_{tc}$$

Levelized cost of electricity for any scenarios

Levelized cost of electricity without intermittent sources

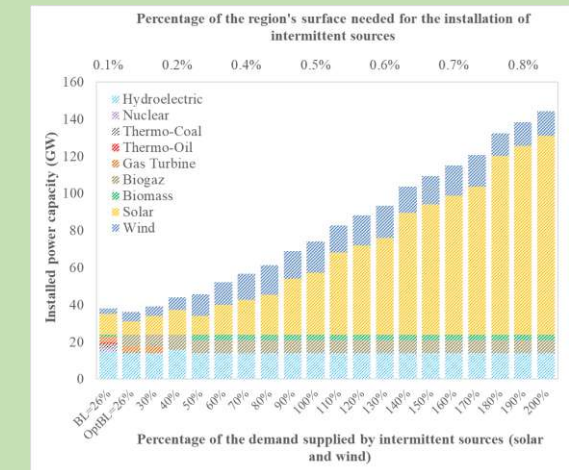
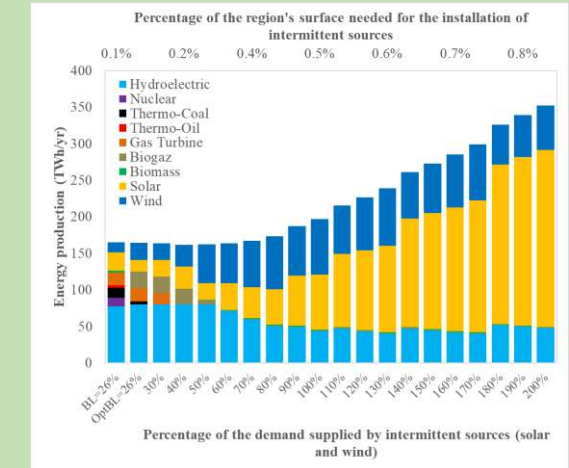
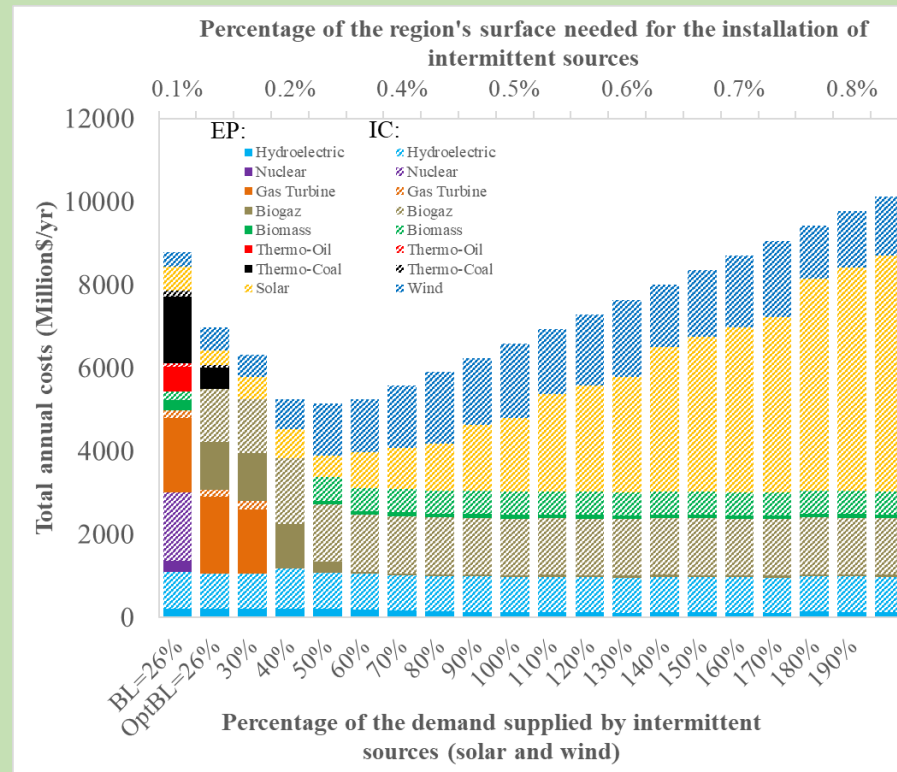
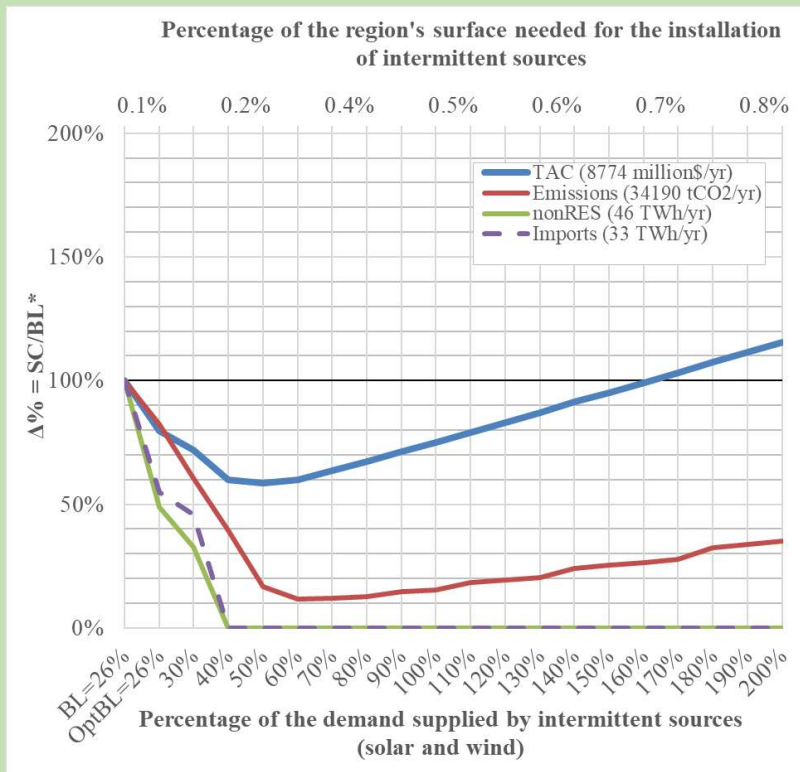
Investment and fix costs



COLOMBIA'S 2050 STRATEGIC SCENARIO

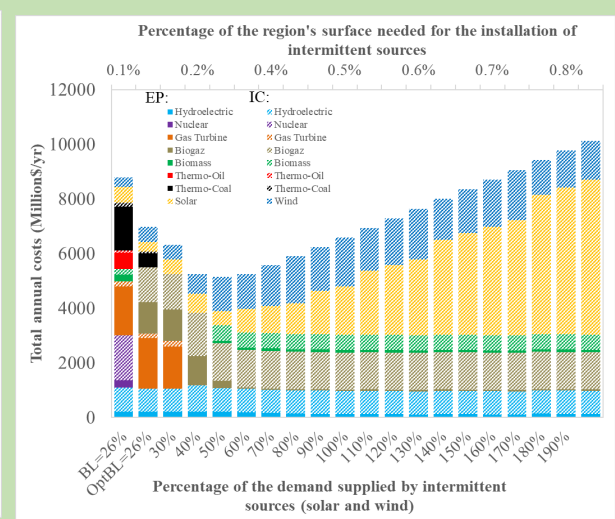
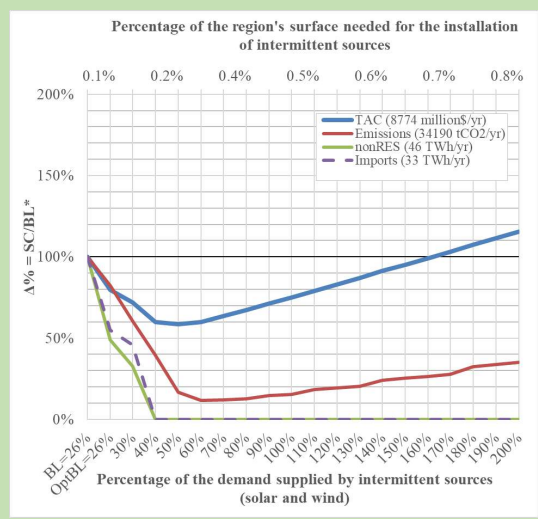


UPME scenario "Disrupción": electric demand 151 TWh in 2050.



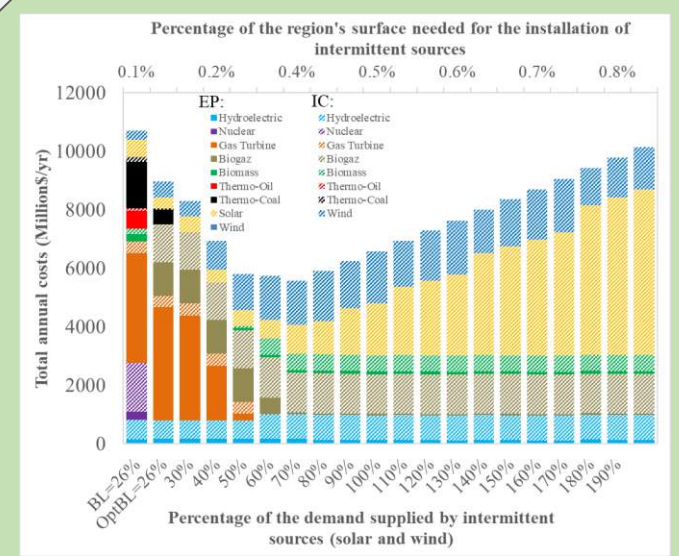
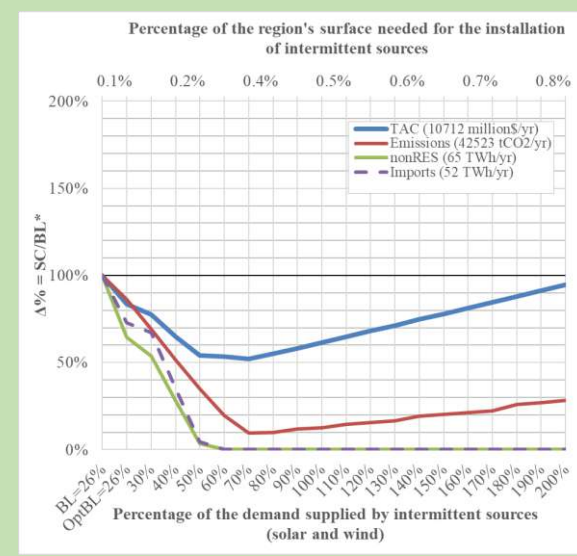
COLOMBIA'S 2050 STRATEGIC SCENARIO

UPME scenario "Disrupción": electric demand 151 TWh in 2050.



80 TWh max hydro production

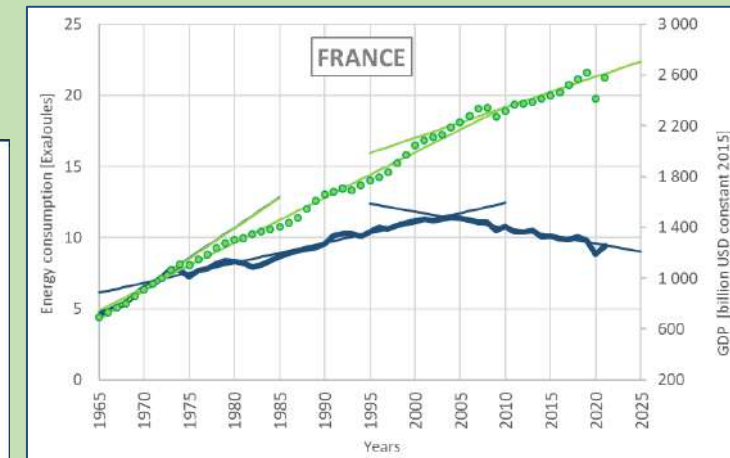
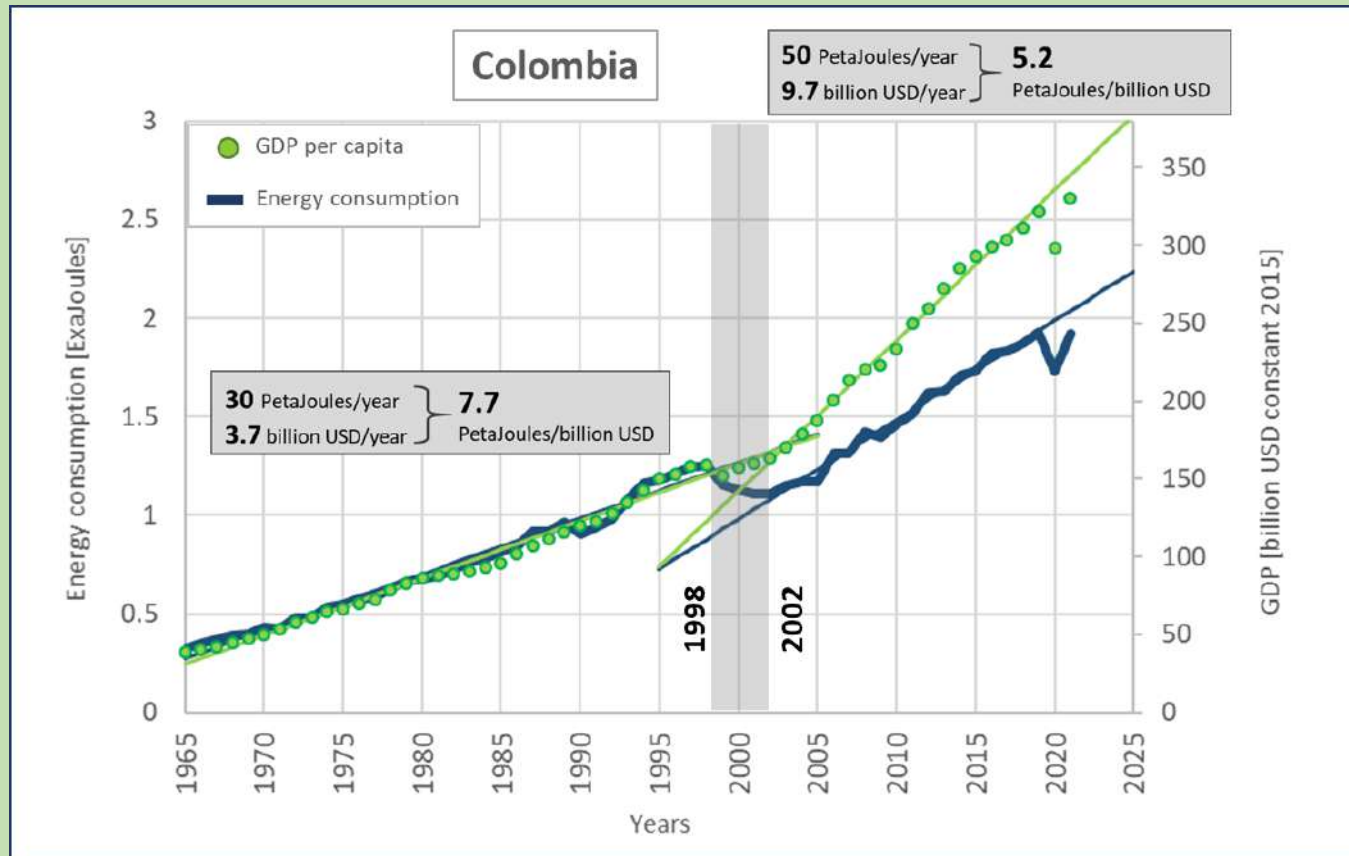
60 TWh max hydro production



ECONOMY EFFICIENCY



Energy efficiency of Colombia has improved

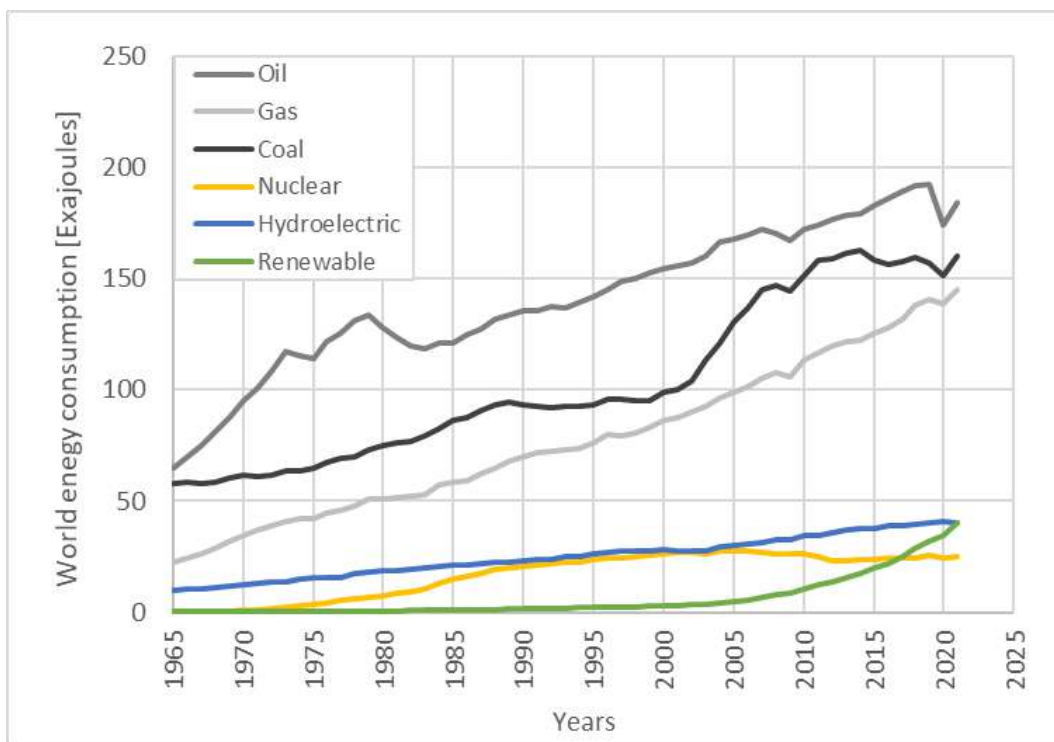




Muchas gracias !

THE WORLD IS CHANGING

Our economy is changing to mitigate the causes of global warming (especially in the energy sector)



Renewable energy consumption is the consumption that is growing the most during the last 10 years (especially wind and solar)

	2011-2016	2016-2021
Oil	0.7%	-0.1%
Gas	1.0%	1.4%
Coal	-0.1%	0.2%
Nuclear	-0.4%	0.5%
Hydroelectric	1.1%	0.4%
Solar	38.5%	20.8%
Wind	11.2%	8.9%
Geothermal, biomass	3.9%	3.7%

from BP Statistical Review of World Energy2021

LIMITATIONS TO SUBSTITUTION

Available resources for solar pannels and wind turbines

Solar panels and wind turbines rely on **rare earth elements**, but these resources are relatively abundant and required only in limited quantities for their production.



THE WORLD IS CHANGING

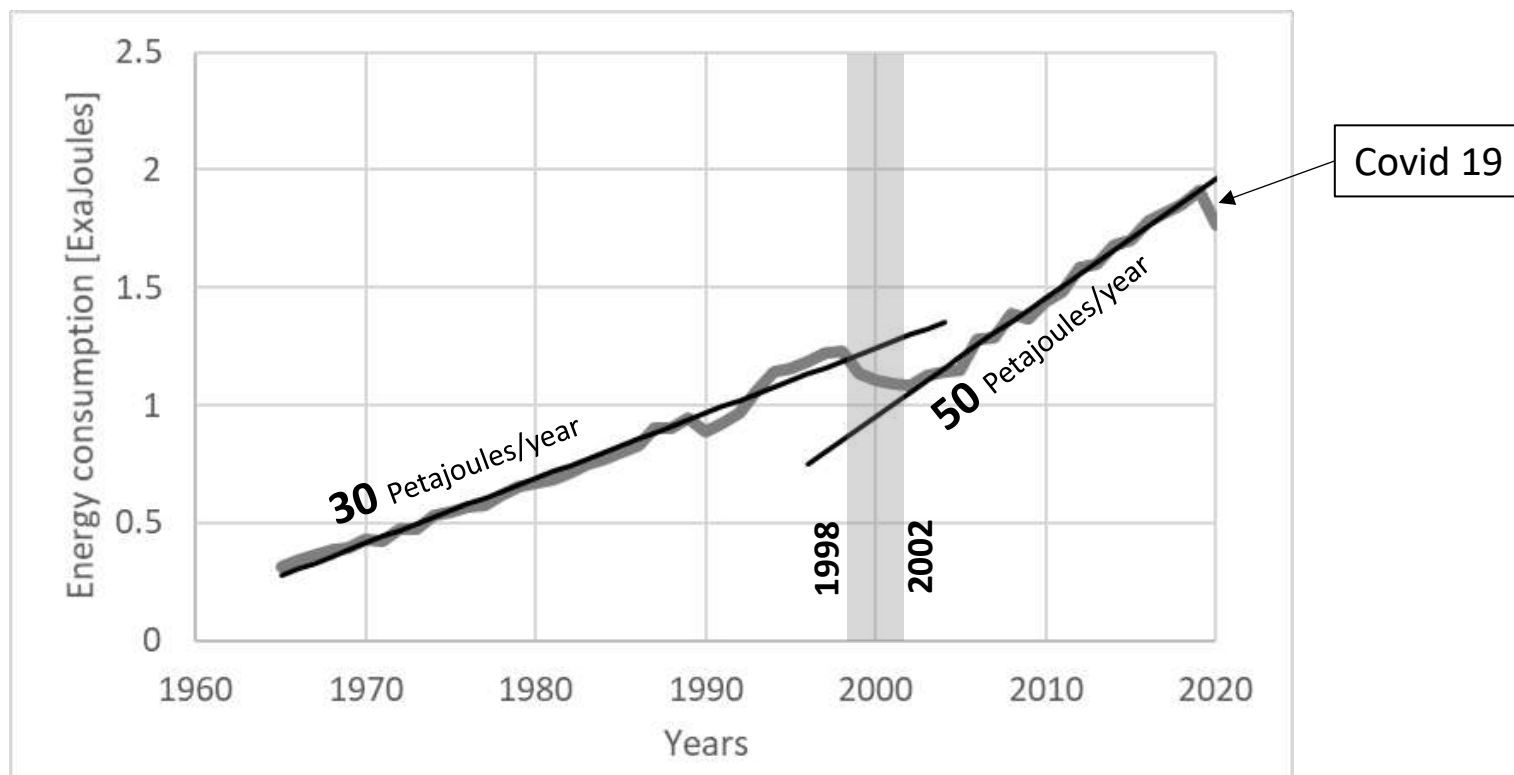


How will these changes affect Colombia

and how can the country adapt?

EVOLUTION OF THE ENERGY DEMAND

Energy demand is increasing in Colombia



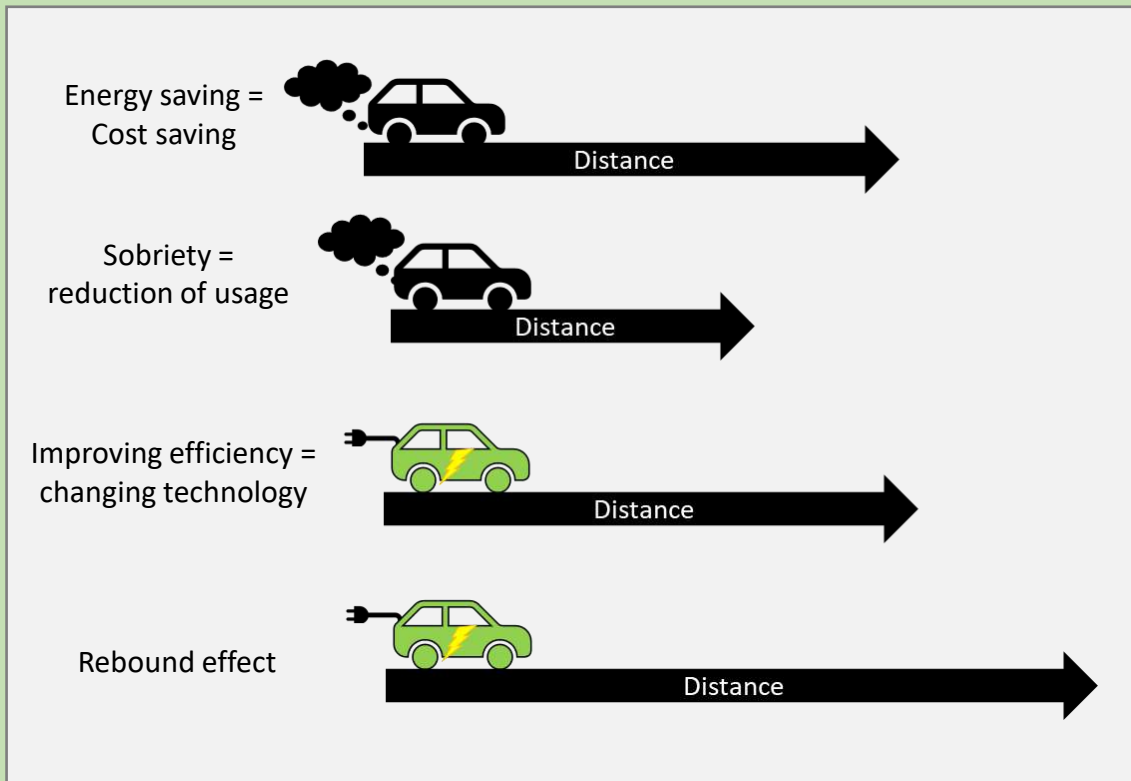
REBOUND EFFECT (JEVONS PARADOX)



The rebound effect refers to the phenomenon where improvements in energy efficiency or resource use lead to an increase in overall consumption, rather than a decrease.



William S. Jevons
(1835-1882), UK



Energy efficient vehicles: If a vehicle (car, airplane...) becomes more energy-efficient, it often becomes cheaper as well. This can lead people to travel more frequently or over longer distances, offsetting the energy savings.

Energy-efficient appliances: If people buy energy-efficient refrigerators or washing machines, they might use them more often or for longer periods, thinking that they are saving energy. However, the increased usage may negate the energy savings.

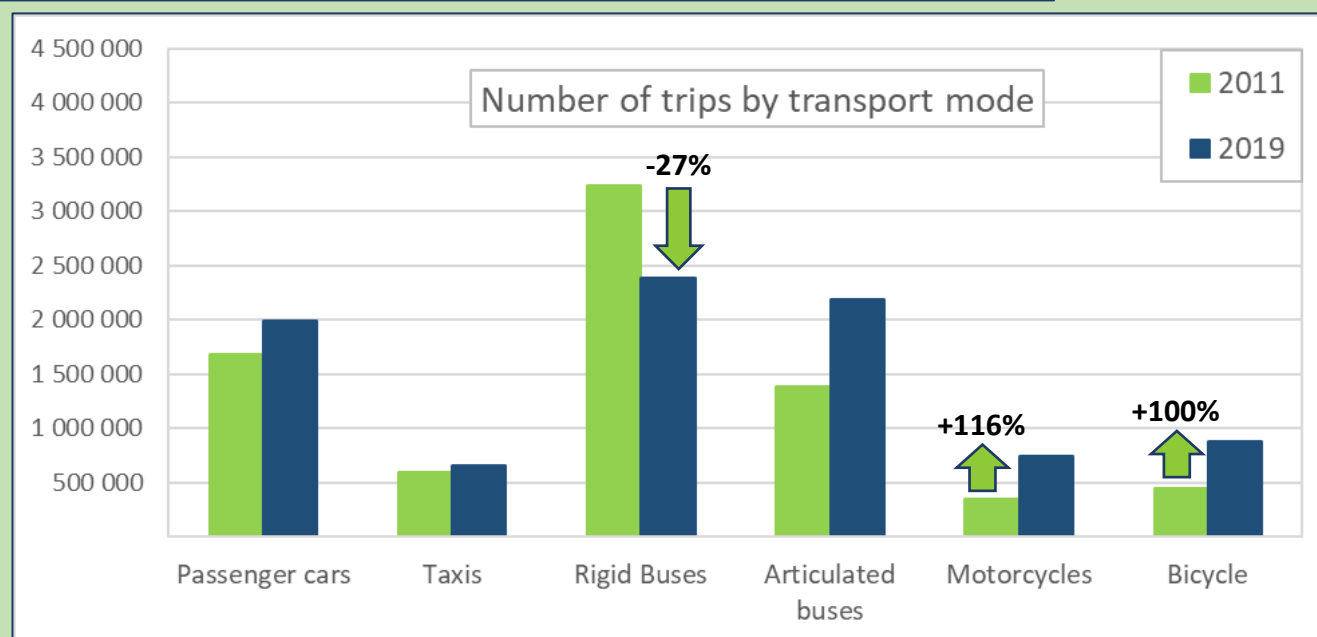
LED lighting: When households switch to LED bulbs, which consume less energy, they may end up using more lights or leaving them on longer because the cost of energy is lower, leading to increased overall energy consumption.

Smart thermostats: A smart thermostat that reduces heating and cooling costs might lead people to increase the temperature or use their heating or cooling systems more often, since they know it's more efficient.

Every time someone saves money, they are likely to use it to consume more energy and increase their impact on the environment.

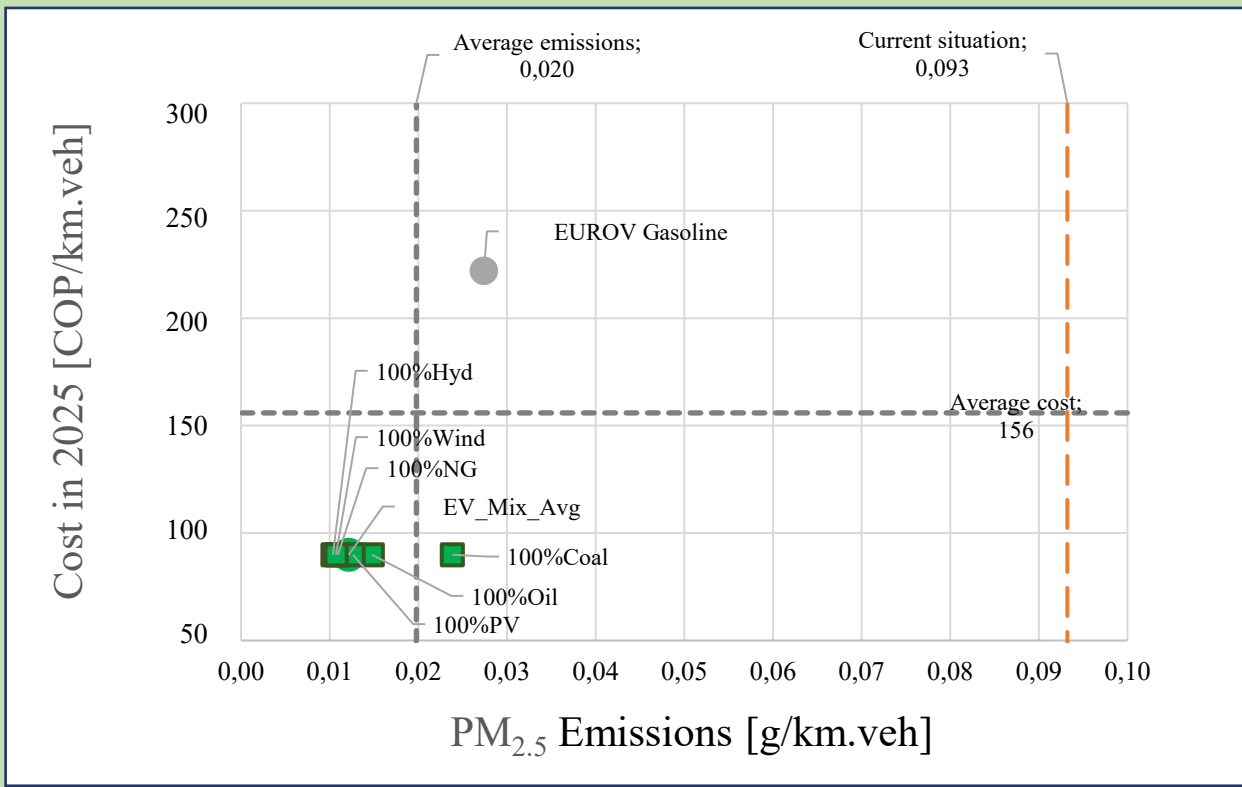
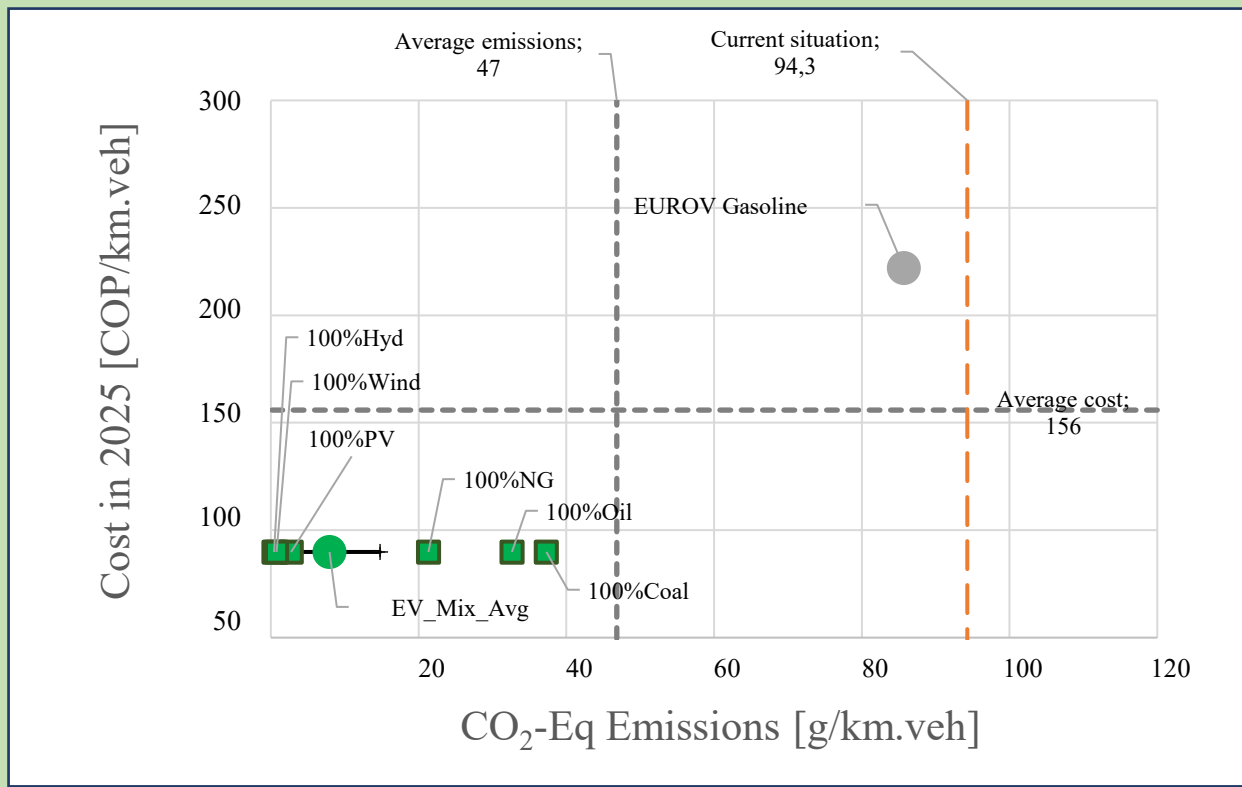
EVOLUTION OF THE ENERGY DEMAND

Trends of the repartition between the different transport modes.



EVOLUTION OF THE ENERGY DEMAND

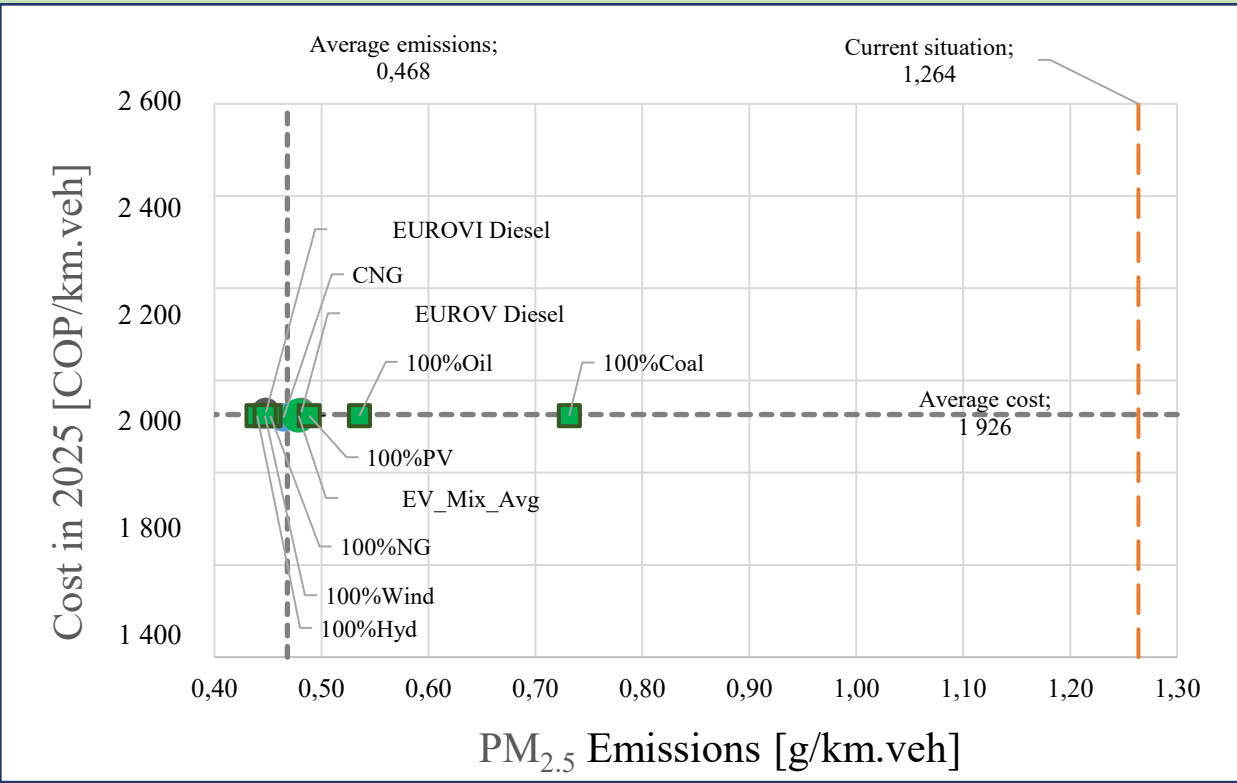
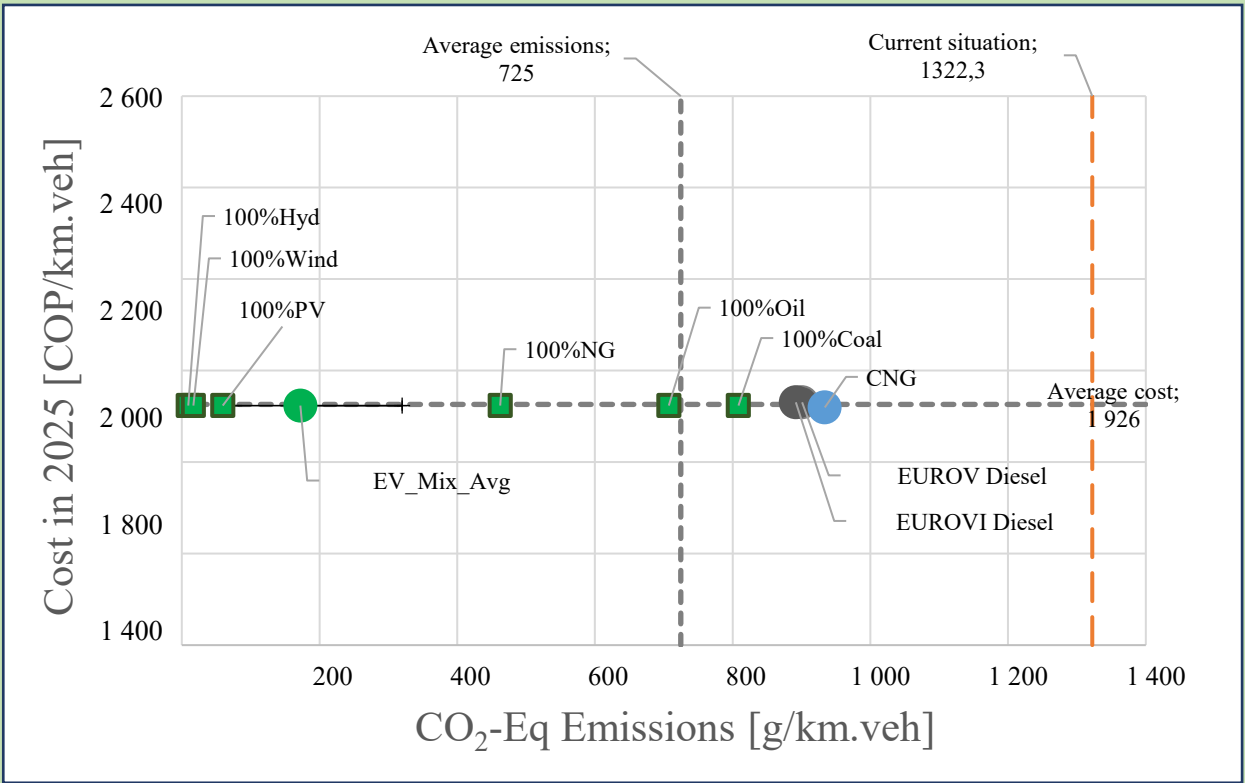
Electric motorcycles are cheaper and will reduce CO₂ and PM emissions of more than a factor 2



Motorcycles can be a good alternative but mortality is more than 20 times greater then for cars. Investment on infrastructure for security is necessary.

EVOLUTION OF THE ENERGY DEMAND

In 2025, electric buses are still not cheaper, they reduce CO₂ emissions but not PM emissions



EVOLUTION OF THE ENERGY DEMAND

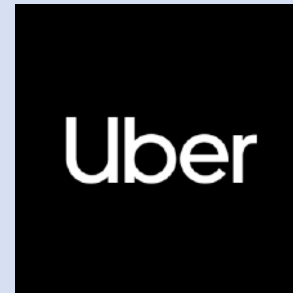
Share the vehicles is one the issue to reduce the gas emissions.

Car pooling

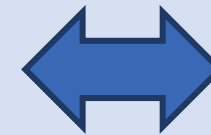


BlaBlaCar connects individuals through an application. Drivers wishing to make available, in exchange for a fee, places available in their car for a specific journey.

Cab service



Uber connects individuals with drivers through an application. In exchange for a fee, individuals ask a driver for a specific destination.



EVOLUTION OF THE ENERGY DEMAND



In the future, Colombian energy demand will continue to increase especially the electric demand of the transport and residential sectors.

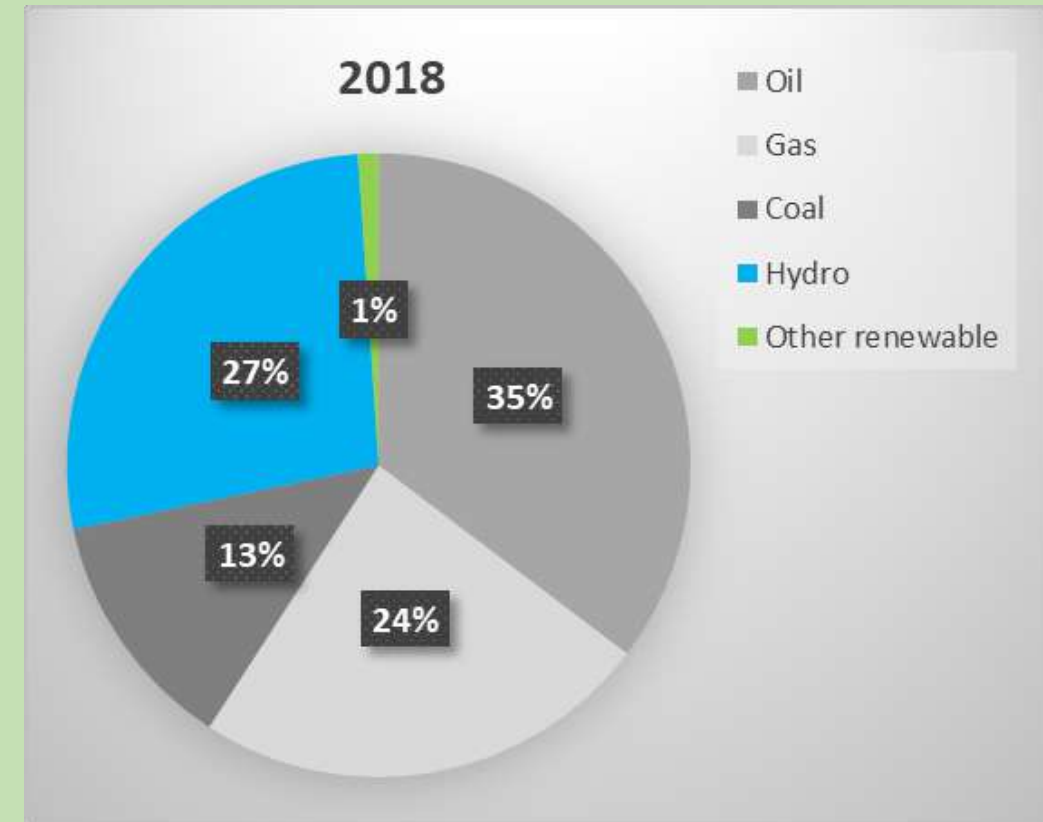
How will it possible to supply it?

COLOMBIAN ENERGY MIX: STRENGTHS AND WEAKNESSES



Colombia is fully energy independent,

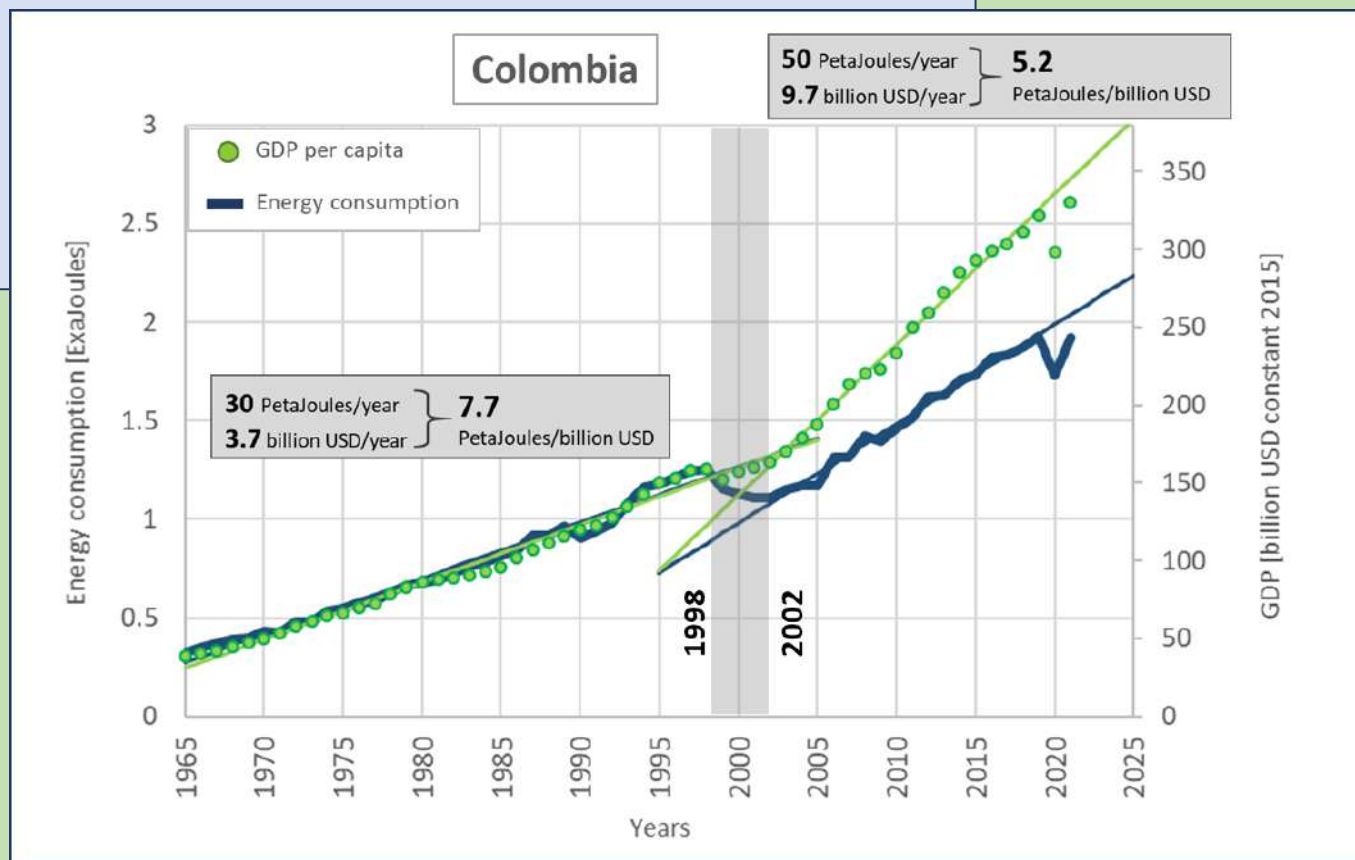
2018	Production	Consumption
Oil [barrels per day x 1000]	866	342
Gas [billion cubic meter]	12.9	13.0
Coal [million tonnes]	84.3	5.9



COLOMBIAN ENERGY MIX: STRENGTHS AND WEAKNESSES



Colombia is fully energy independent, and **its energy efficiency in terms of economic growth has improved but...**

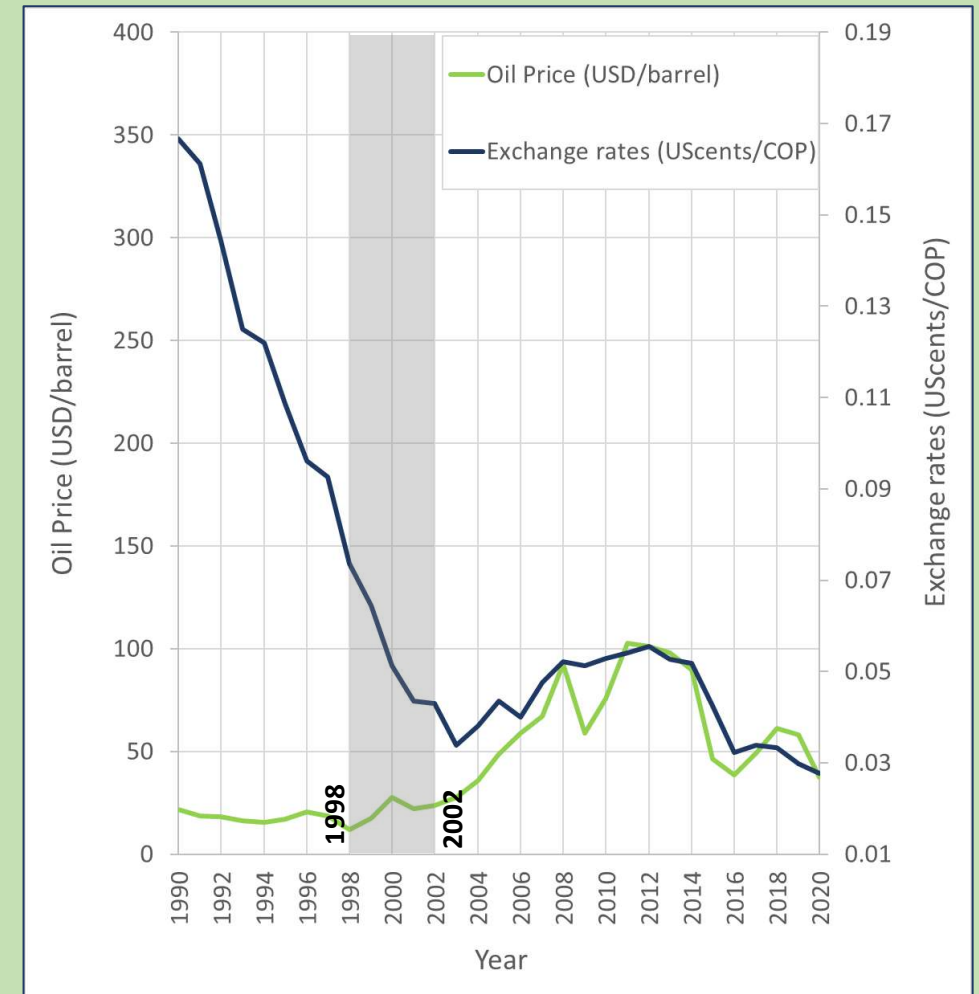


COLOMBIAN ENERGY MIX: STRENGTHS AND WEAKNESSES



Colombia is fully energy independent, and its energy efficiency in terms of economic growth has improved but...

- ❑ the national economy depends strongly from the oil market

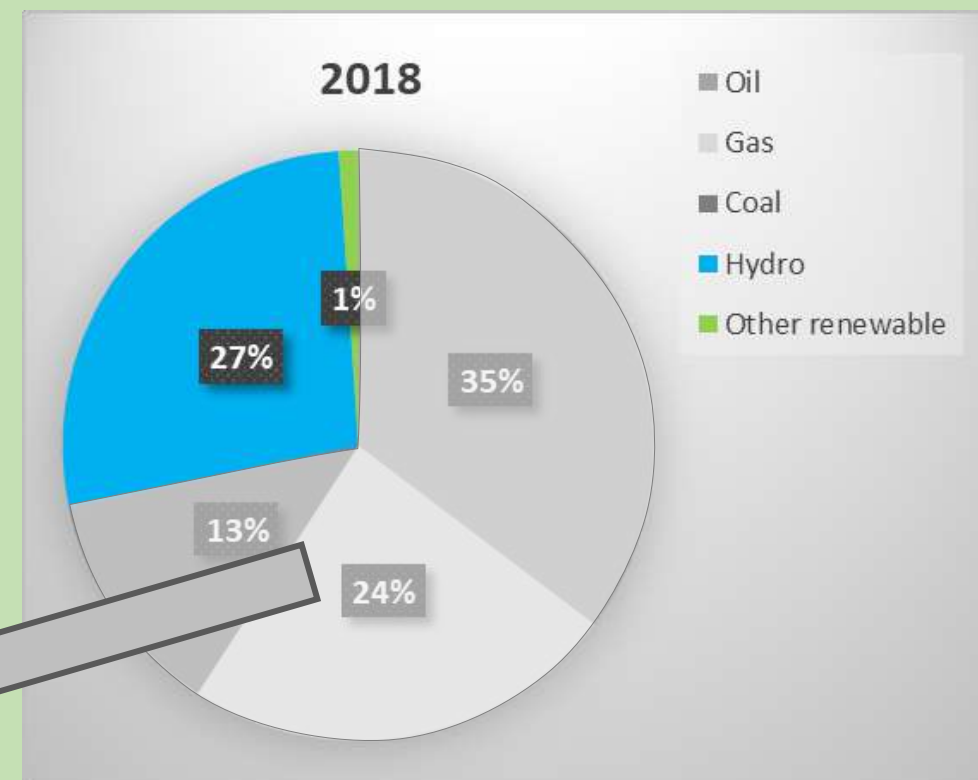


COLOMBIAN ENERGY MIX: STRENGTHS AND WEAKNESSES

Colombia is fully energy independent, and its energy efficiency in terms of economic growth has improved but...

- ❑ the national economy depends strongly from the oil market
- ❑ the sustainability of energy resources is weak:
less than 10 years of oil and gas reserves remain.

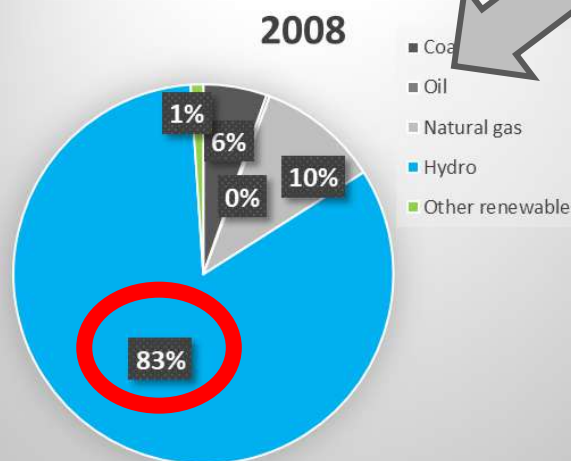
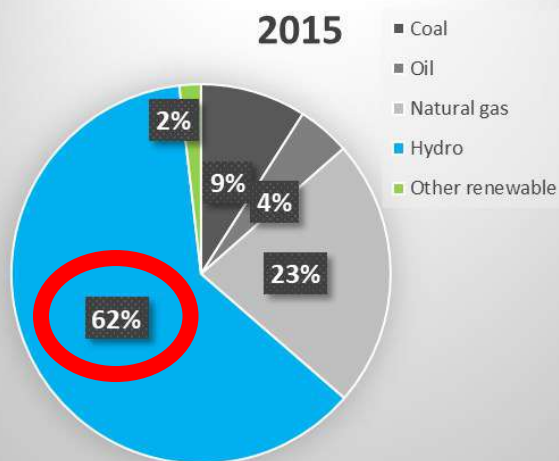
2018	Years
Oil	5.6
Gas	8.3
Coal	58



COLOMBIAN ENERGY MIX: STRENGTHS AND WEAKNESSES

Colombia is fully energy independent, and its energy efficiency in terms of economic growth has improved but...

- ❑ the national economy depends strongly from the oil market
- ❑ the sustainability of energy resources is weak:
less than 10 years of oil and gas reserves remain.
hydrological resources are affected by climate change



ALTERNATIVE ENERGY MIX IN COLOMBIA



How to move to a sustainable and environmentally friendly energy mix in Colombia?

- ☐ Oil and Gas : less than 10 years of reserves and it emit greenhouse gases
- ☐ Coal : more reserves but it emit more greenhouse gases (low energy efficiency) and other pollutants (Particulate Matter)
- ☐ Hydroelectricity: can be further developed (17 GW to 57 GW, UPME, 2018) but remain vulnerable to climate change.
- ☐ **Biomass : ?**

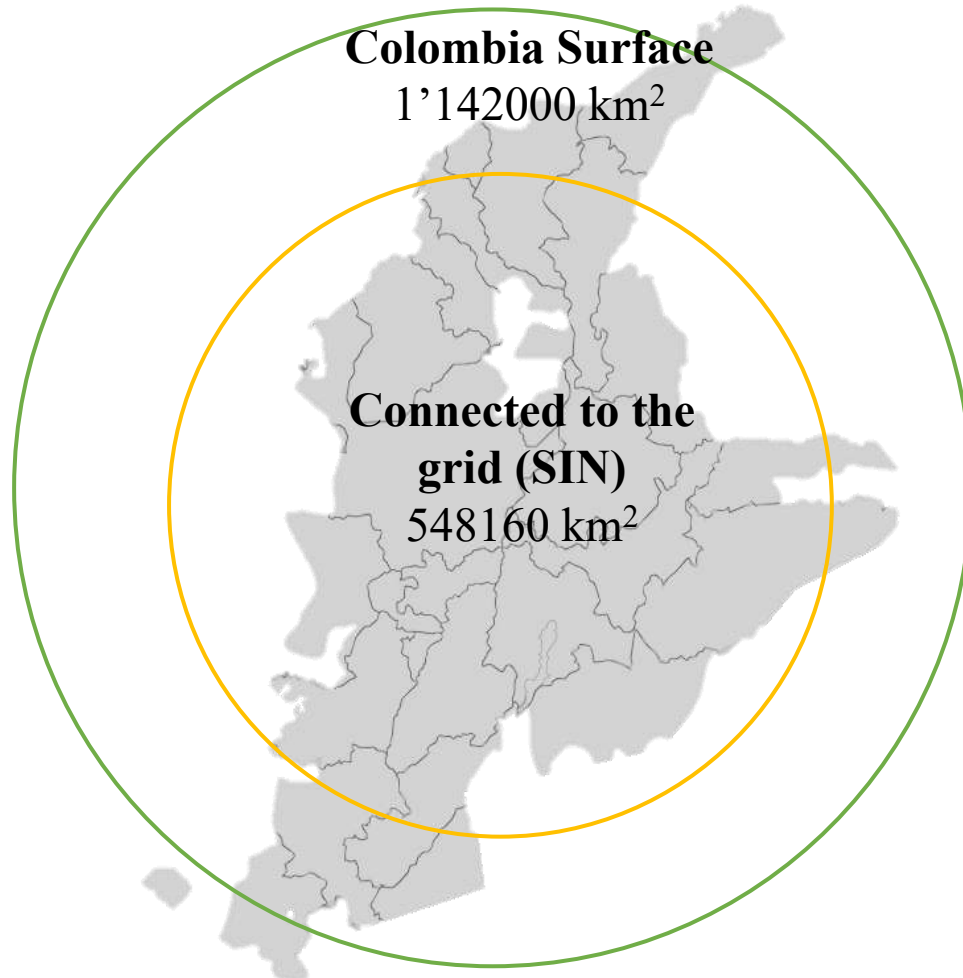
ALTERNATIVE ENERGY MIX IN COLOMBIA



Areas needed to supply 100% of the **Cuban** electricity demand (projection in 2030) with

- ☐ biomass (bagasse and Marabu wood)
- ☐ wind turbines
- ☐ PV panels

WIND AND SOLAR RESOURCES



Off-grid regions (ZNI) (52% - 593840 km²)

Areas needed to supply 100% of the **Colombian** electricity demand with:

- ☐ wind turbines
- ☐ PV panels



Onshore Wind Turbines

1637-6197 km²

(0.30% - 1.13%) of the “interconnected country surface”



Utility Solar Photovoltaic

931-1008 km²

(0.17% - 0.18%) of the “interconnected country surface”

WIND AND SOLAR RESOURCES



Cost compared to other technologies.

The cost of solar and wind energy is constantly decreasing (in many countries, it is already the cheapest way to produce energy).

Technologies	Total Annual Cost (USD/MWh)	Carbon Cost (USD)	Compensated Cost (USD)
Concentrated Solar Power (CSP)	245	0	245
Solar Photo Voltaic (PV)	57	0	57
Wind Turbine Offshore	61	0	61
Wind Turbine Onshore	37	0	37
Marine-Wave	180	0	180
Water - Hydroelectric	38	0	38
Geothermal	112	0	112
Biomass	136	0	136
Cycle Nuclear	69	0	69
Gas Turbine (CCGT)	133	17	150
Thermoelectric oil	73	29	101
Thermoelectric coal	43	28	71
Generation Set Diesel	108	33	142
Generation Set Fuel Oil	108	33	142
Generation Set Gas	201	24	225
Generation Set Oil	108	33	142

WIND AND SOLAR RESOURCES



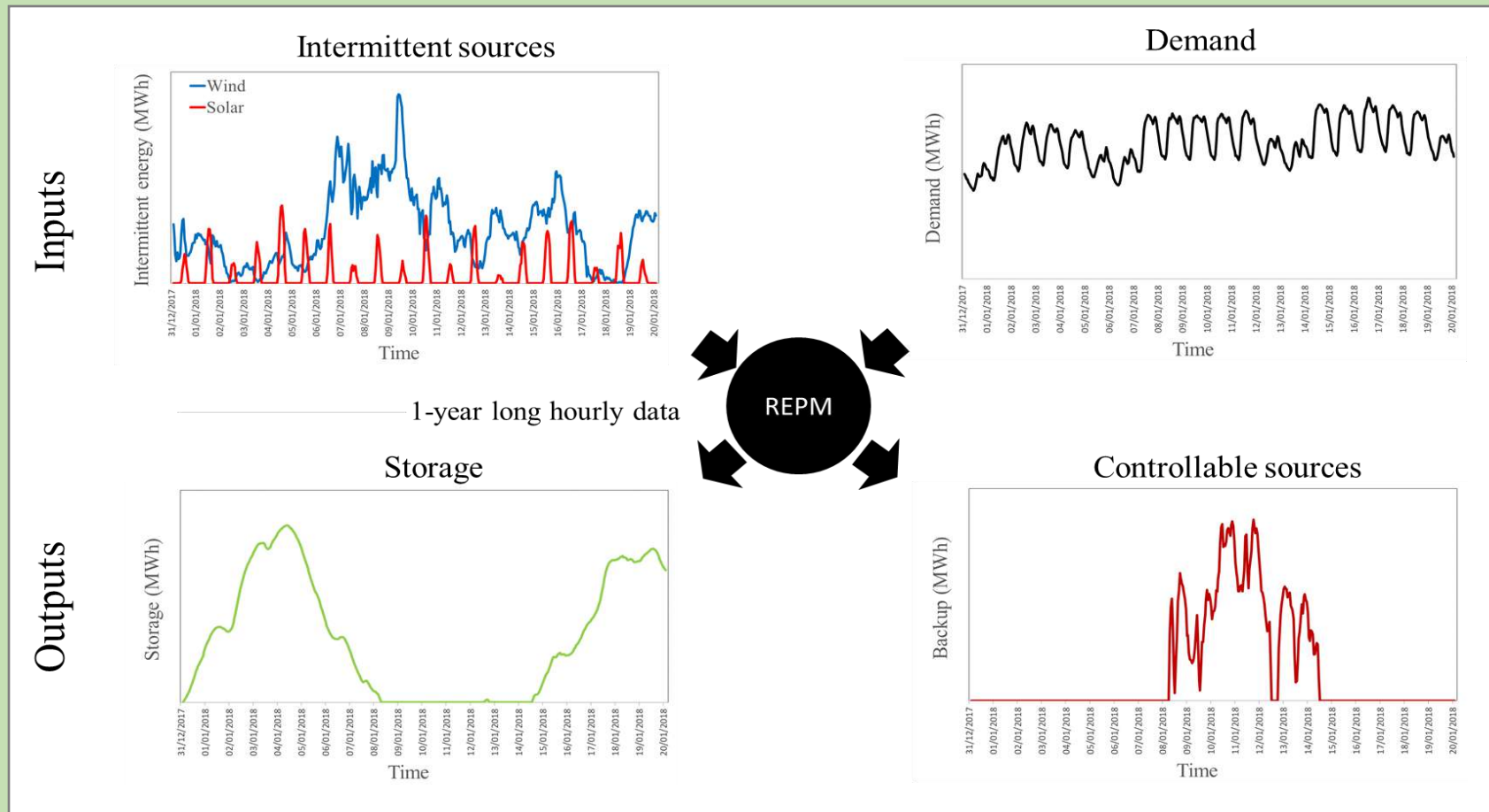
Cost compared to other technologies.

Technologies	Total Annual Cost (USD/MWh)	Carbon Cost (USD)	Compensated Cost (USD)	Capital Cost (%)	Fix Cost (%)	Variable Cost (%)	Fuel Cost (%)
Concentrated Solar Power (CSP)	245	0	245	96%	4%	0%	0%
Solar Photo Voltaic (PV)	57	0	57	85%	15%	0%	0%
Wind Turbine Offshore	61	0	61	72%	28%	0%	0%
Wind Turbine Onshore	37	0	37	59%	41%	0%	0%
Marine-Wave	180	0	180	83%	12%	6%	0%
Water - Hydroelectric	38	0	38	70%	23%	8%	0%
Geothermal	112	0	112	82%	16%	1%	0%
Biomass	136	0	136	55%	10%	0%	34%
Cycle Nuclear	69	0	69	56%	14%	6%	24%
Gas Turbine (CCGT)	133	17	150	5%	2%	1%	92%
Thermoelectric oil	73	29	101	29%	5%	3%	63%
Thermoelectric coal	43	28	71	53%	8%	5%	34%
Generation Set Diesel	108	33	142	22%	7%	2%	69%
Generation Set Fuel Oil	108	33	142	22%	7%	2%	69%
Generation Set Gas	201	24	225	11%	3%	1%	85%
Generation Set Oil	108	33	142	22%	7%	2%	69%

Solar and wind energy require a higher initial investment but cost much less during their use.

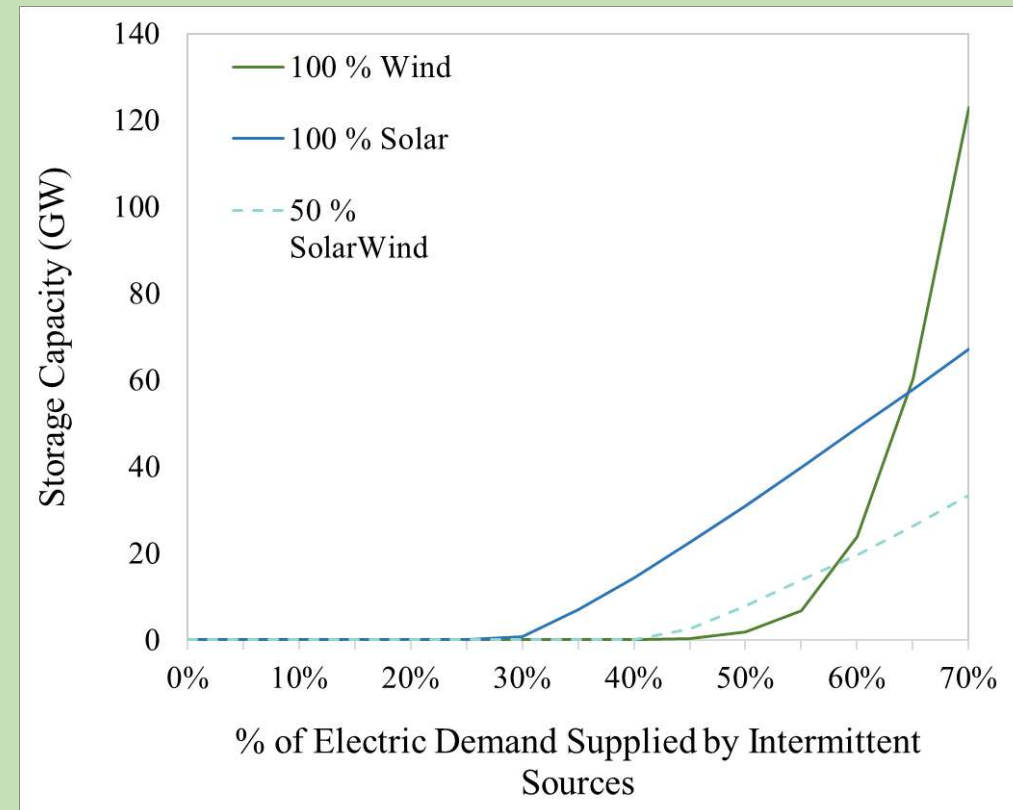
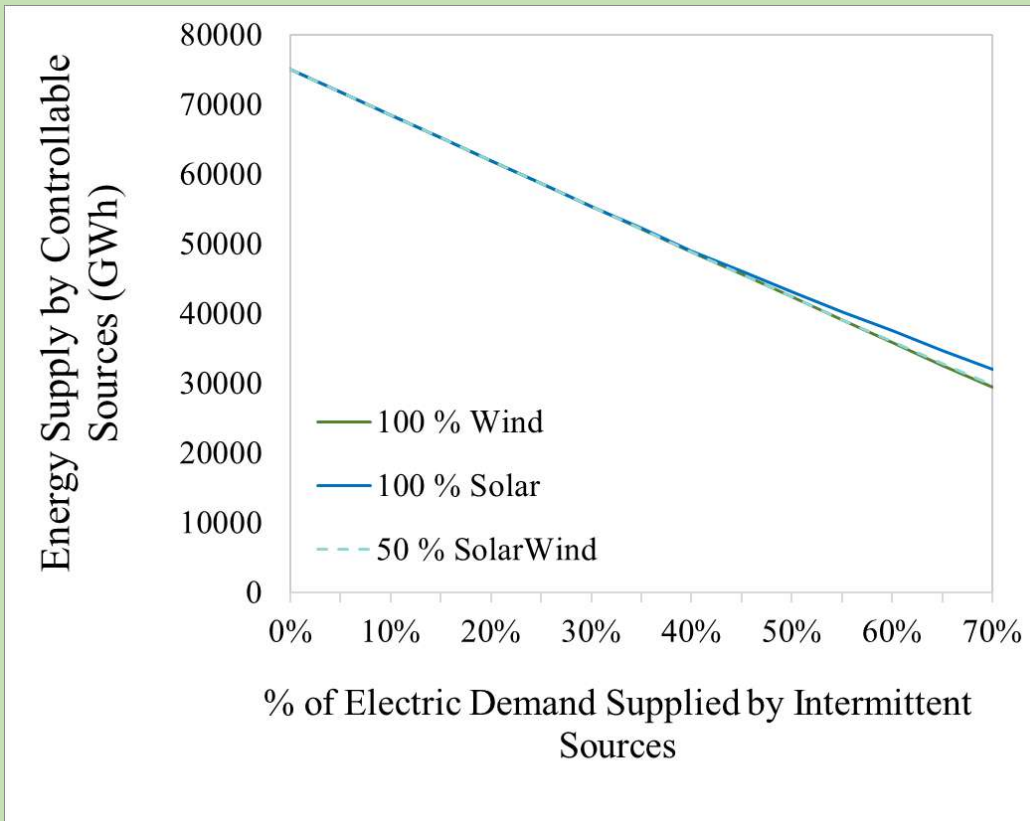
ENERGY STORAGE

Model to estimate the storage capacity needed by the introduction of Intermittent sources into the energy mix.



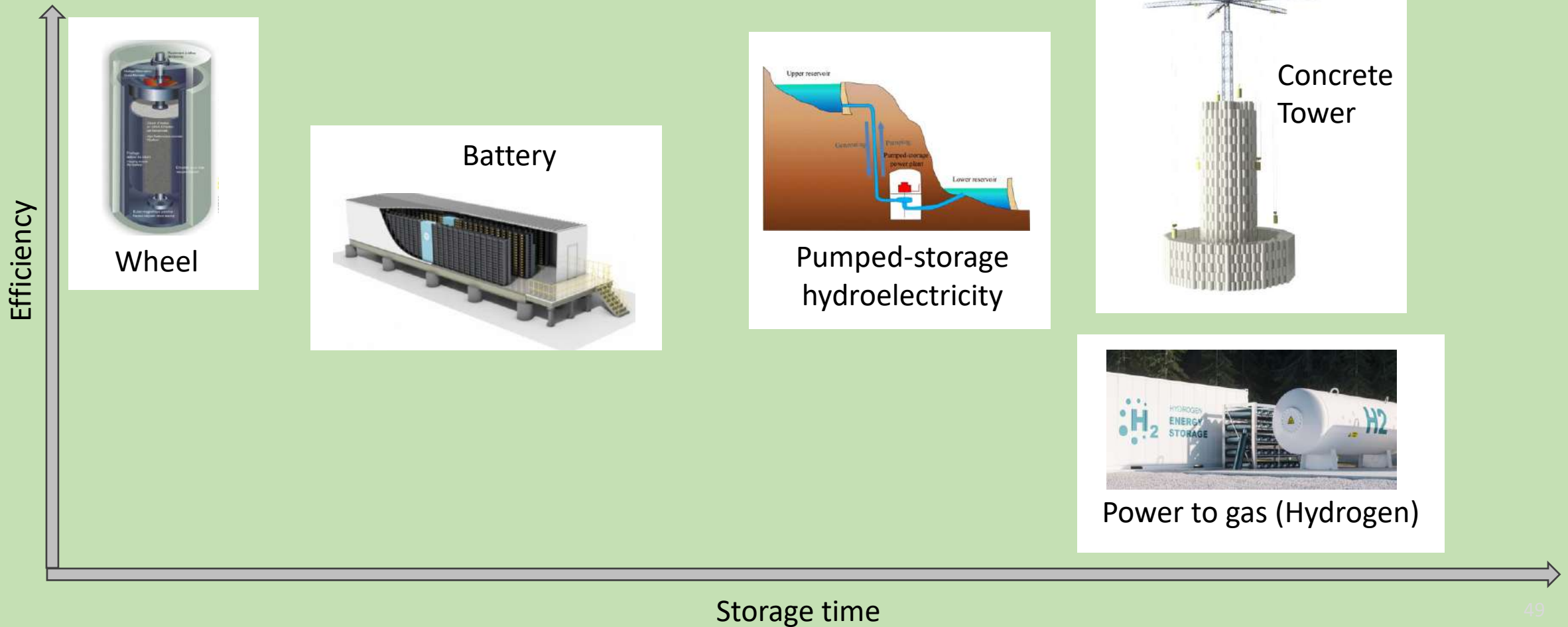
ENERGY STORAGE

The introduction of intermittent sources into the energy mix requires significant storage capacity.



ENERGY STORAGE

Different storage technologies.



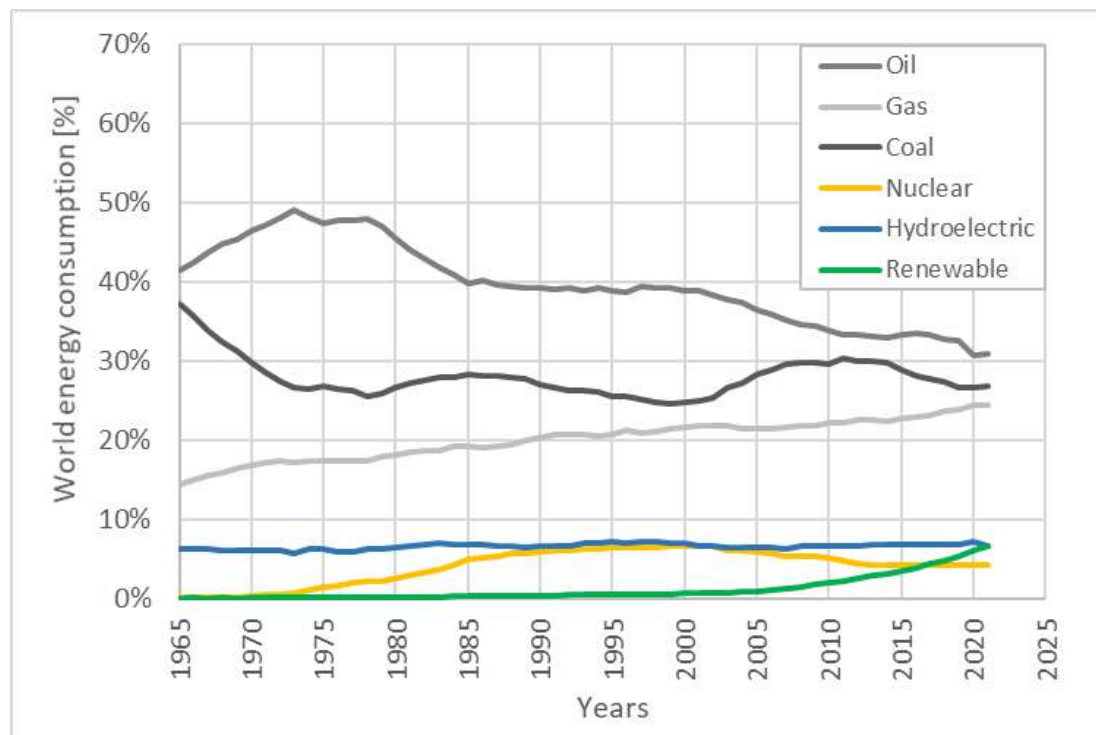
CONCLUSIONS



- ❑ Climate change is underway and accelerating. In the very best case, it will take decades to control it.
- ❑ The world economy is adapting to implement the energy transition. The countries that anticipate the transition will strengthen their economy in the long term, the others will suffer the crisis...

THE WORLD IS CHANGING

Our economy is changing to mitigate the causes of global warming (especially in the energy sector)



Renewable energy consumption is the consumption that is growing the most during the last 10 years (especially wind and solar)

	2011-2016	2016-2021
Oil	0.7%	-0.1%
Gas	1.0%	1.4%
Coal	-0.1%	0.2%
Nuclear	-0.4%	0.5%
Hydroelectric	1.1%	0.4%
Solar	38.5%	20.8%
Wind	11.2%	8.9%
Geothermal, biomass	3.9%	3.7%

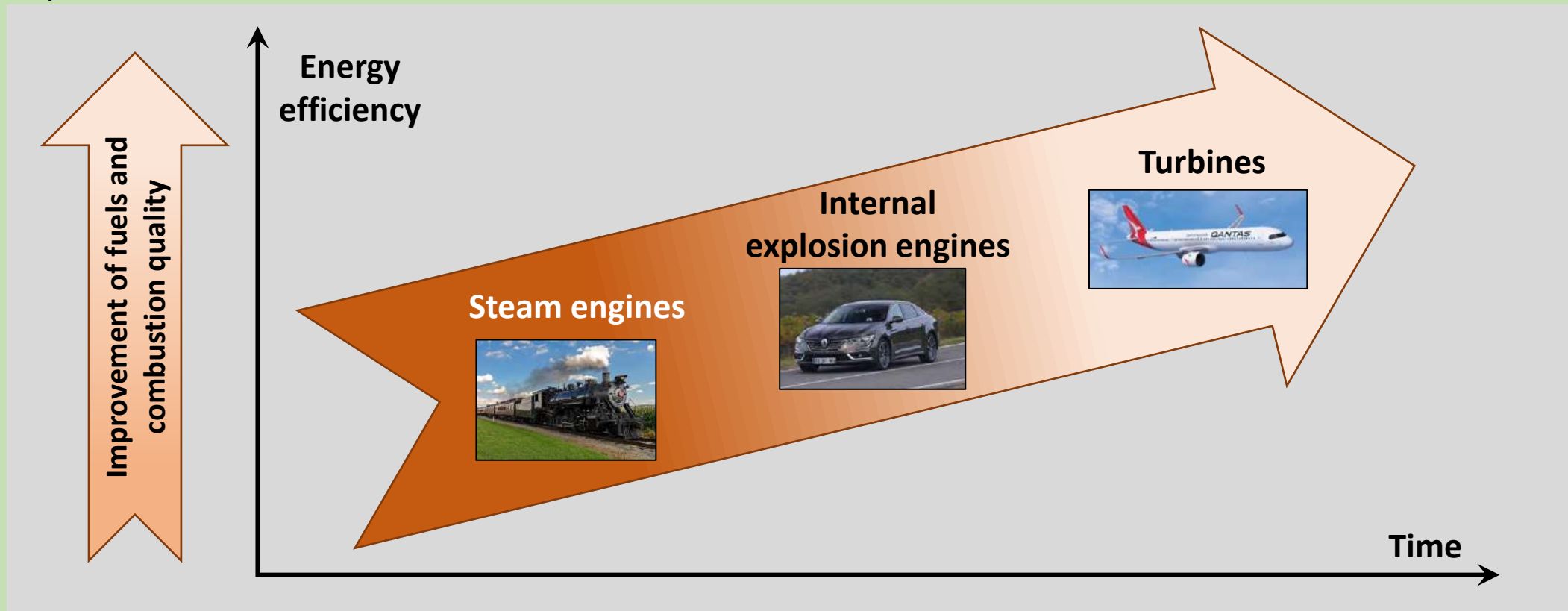
from BP Statistical Review of World Energy2021



TECHNOLOGICAL EVOLUTION

A trend naturally driven by market law

Technologies are naturally progressing to reduce their production and use costs by improving energy efficiency, among other things. At the same time, they provide more and more services. In transport, for example, they enable us to travel further, faster and/or more individually.



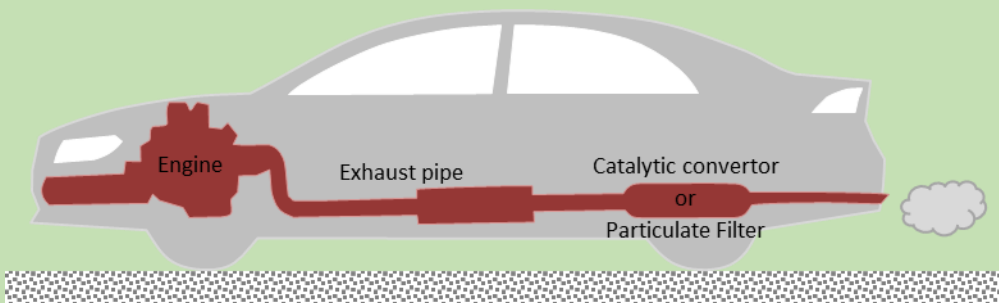
TECHNOLOGICAL ADPTATION

Implementing specific devices to reduce pollution

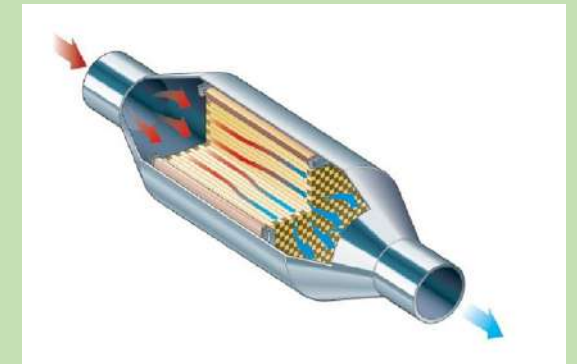
The spontaneous trend of technological progress is the improvement of energy efficiency. The **efficiency gain is not enough to completely reduce pollution**, as part of this gain is used to increase the activity of the technologies (rebound effect) and some pollutants such as **NO_x**, for example, **are emitted even when the combustion and fuel are of good quality**.

Additional devices may be required to capture pollutants. The additional costs generated by these devices increase production costs, making the technologies less attractive and hindering substitution.

Example of vehicles



Catalytic converter for
gasoline engine



Diesel Particulate Filter

DIFFERENT TYPE OF REGULATION

Decide which Best Available Technology (BAT) must be used



European Union directives

	Years	1993	1996	2001	2006	2011	2015
	Standards	EURO 1	EURO 2	EURO 3	EURO 4	EURO 5	EURO 6
Diesel cars emissions [g/km]	NO _x	0.97 (+HC)	0.7 (+HC)	0.5	0.25	0.18	0.08
	PM	0.14	0.08	0.05	0.025	0.005	0.0045
Petrol cars emissions [g/km]	NO _x	0.97 (+HC)	0.5 (+HC)	0.15	0.08	0.06	0.06
	PM	-	-	-	-	0.005	0.0045

Prohibit the use of polluting technologies



Vehicles air quality certificates: Crit'air vignettes						
Electric and hybrid cars	All					
Petrol private car		Euro 5 & 6	Euro 4	Euro 2 & 3		
Diesel private car			Euro 5 & 6	Euro 4	Euro 3	Euro 2

DIFFERENT TYPE OF REGULATION



Subsidies the use of less polluting technologies

Government

Polluters



Many European countries have implemented large-scale **scrappage schemes** to promote the replacement of old, polluting vehicles with modern, less polluting ones. This measure also has the advantage of stimulating the automotive industry.

In France, a **conversion premium** is granted to **buy a recent low-polluting car** and remove from circulation an old car (diesel before 2011 or gasoline before 2006). This premium varies from **1000 to 5000 euros** depending on the vehicle purchased and the income level of the buyer.

Taxing the use of polluting technologies

Government

Polluters



In Switzerland, the **Ordinance on the Incentive Tax on Volatile Organic Compounds** requires users of VOCs (i. e. manufacturers who place them on the market or use them as well as persons who commercialize VOCs in wholesale) to apply for the tax.

The tax is calculated on the basis of the quantity of VOCs used and a rate of **3 Swiss francs per kilogram of VOCs used**.

Tax is refunded if the VOC users can prove that measures have been taken to **reduce VOC emissions by at least 50%**.

DIFFERENT TYPE OF REGULATION



Emission trading



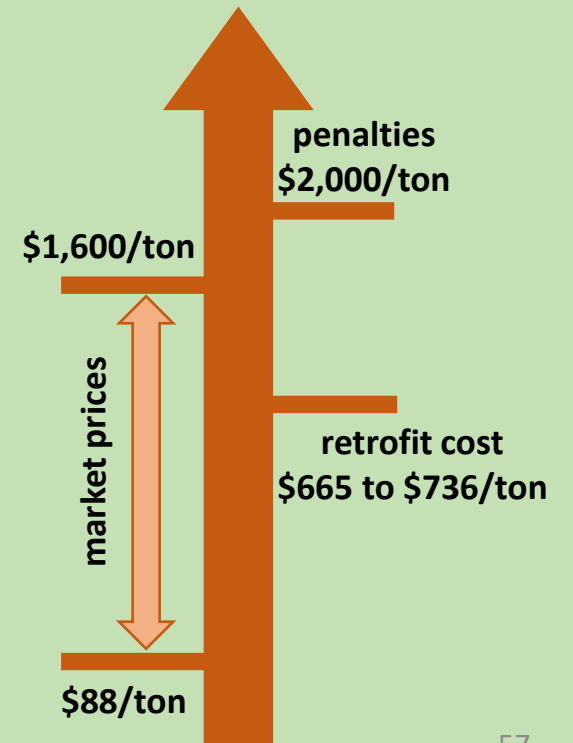
In 1990 the **US Clean Air Act** established the allowance market system known today as the **Acid Rain Program**.

The **U.S. government imposes penalties on companies that emit SO₂ of \$2,000 per ton emitted**, which is substantially higher than the **cost of retrofitting pollution control equipment** (scrubbers) on existing units, estimated at **\$665 to \$736 per ton** of SO₂ emitted.

Each year the **U.S. Environmental Protection Agency auctions off to the highest bidder about 250,000 pollution allowances** that enable companies to emit one ton of SO₂. Companies are allowed to **buy and sell these emission allowances on the Chicago Board of Trade** (like soybeans, rice or any other commodity).

In addition to companies, the allowance market can also be affected by the intervention of associations such as the **Acid Rain Retirement Fund (A.R.R.F.)**. A.R.R.F. is a non-profit, all-volunteer environmental education organization that raises funds and bids alongside polluters at annual auctions to obtain as many allowances as their funds can buy. **A.R.R.F. permanently removes the allowances it buys from the market**, thereby reducing SO₂ emissions into the atmosphere.

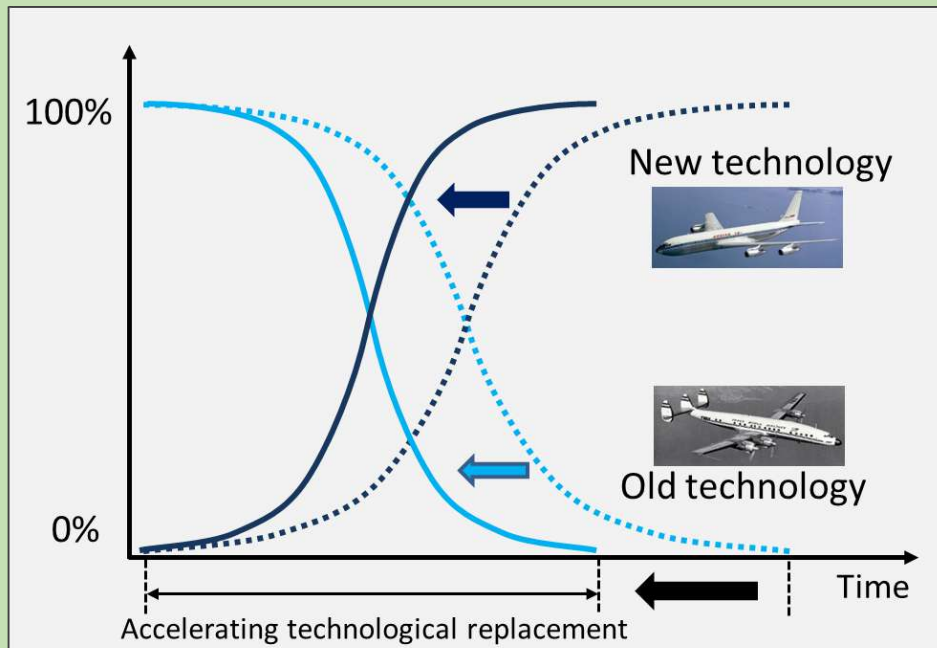
The **price of an SO₂ allowance is determined by the law of supply and demand**. In **2005**, the price peaked at just over **\$1,600/ton**. At that price, it was cheaper to install scrubbers and reduce air pollution than to buy SO₂ allowances and continue to pollute. Subsequently, the market price for SO₂ allowances fell to about **\$88/ton in August 2009**.



PLANNED OBSOLESCENCE



Programmed obsolescence is the intentional design of products with a limited lifetime, rendering them obsolete or less functional over time, encouraging consumers to replace them sooner than necessary. It can take several forms:



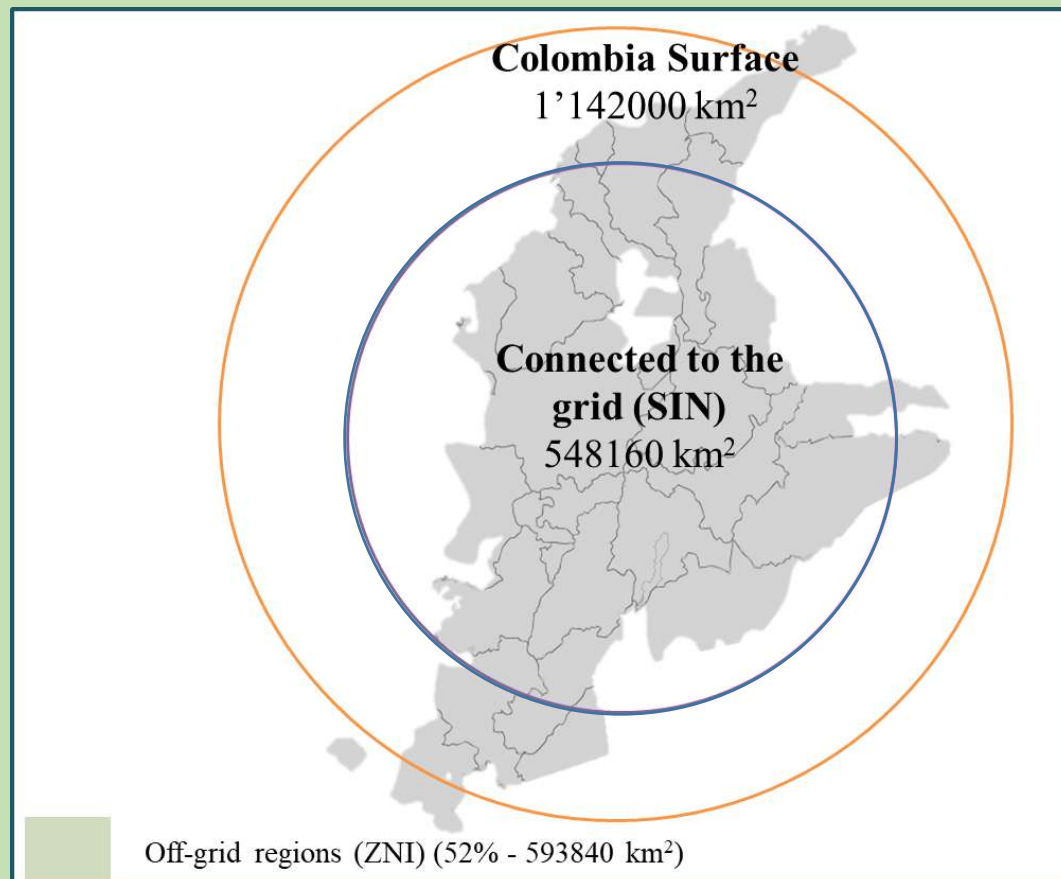
Technical Obsolescence: Products are designed with a limited lifespan using fragile components or non-repairable parts, leading to frequent breakdowns after limited use.

Software Obsolescence : Devices become outdated due to unsupported or incompatible software, despite still functioning hardware-wise.

Aesthetic (Psychological) Obsolescence: Consumers are encouraged to replace products that still work due to changing designs, fashion trends, or social pressures.

Obsolescence by Incompatibility: Manufacturers change connectors or standards, making older products incompatible with new accessories or updates.

Indirect Obsolescence (Cost of Repair): Repairing a product becomes impractical due to high costs, unavailable parts, or deliberate design choices that discourage repair.

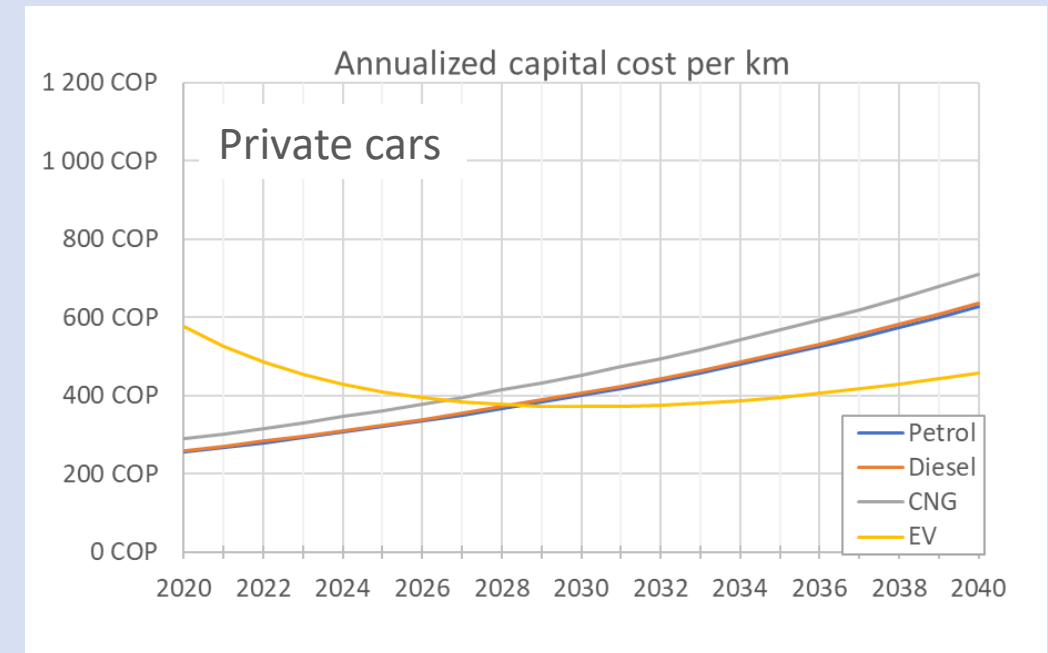


EVOLUTION OF THE ENERGY DEMAND



Despite a cost which is already low, the fraction of electric car in Bogota is still very low. That can be due to a number of barrier which prevents a faster renewal:

- ✓ The **capital cost** of an electric car is currently significantly higher than for a conventional car.
- ✓ The **refueling time** of an electric car is much higher than for a conventional car
- ✓ The **autonomy** of electric cars is still significantly lower than for a conventional car
- ✓ The **charging stations** are still scares and difficult to find in Bogota and more generally in Colombia



All these barriers should be removed in the future. The performance of the charging stations and the autonomy of the electric cars are constantly improved. A large number of charging stations can easily be implanted all over the country. The capital cost of electric cars is decreasing and should become lower than for the conventional car in the next 6 to 9 years.