NUMERO: **2540A** ANNO: 2022

A P P U N T I

STUDENTE: Metelli Luca

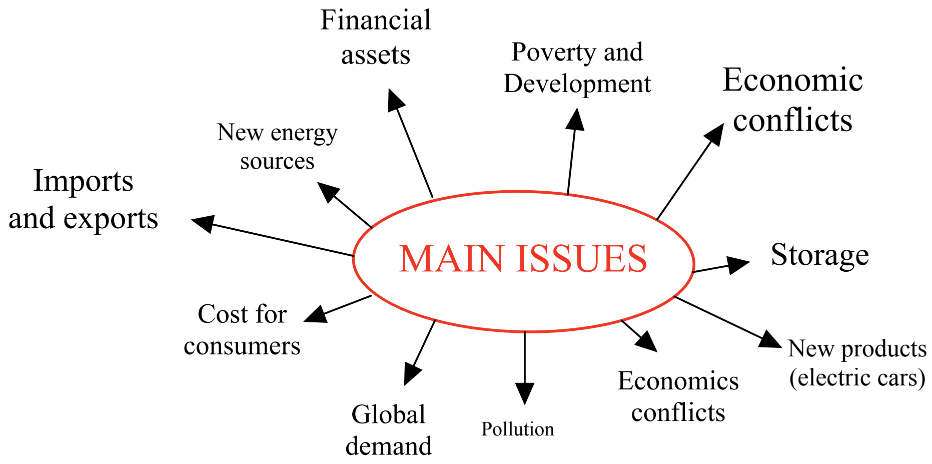
MATERIA: Appunti di Economia dell’Energia - Prof. Chiaramonti

Introduction to the course

What Energy Economics is about?

We try to investigate the current energy trends and policies that should apply and bring in concrete actions.

The main background of this course is the **climate issue** which is driving, at least until the ongoing Ukrainian war crisis, the energy transition, policies and technologies.
The main issues we have to address?



In the last few years, many significant changes occurred, given the pandemic and other important energy and economic crisis worldwide.

We'll cover the so-called **regulations of energy market**, when the government needs to take over in order to reduce the demand and the payment.
Regulation is a sort of intervention by policy makers in order to avoid too high prices for consumers or introduce more security energy-wise.
The price that you pay for energy (the bill), in many cases, is not made by the companies, but by independent authorities, governmental agencies, that make elaborations and analysis in order to set the price for final uses and consumes.
(Seminar with ARERA and IREN)

First module

This first module covers some topics:

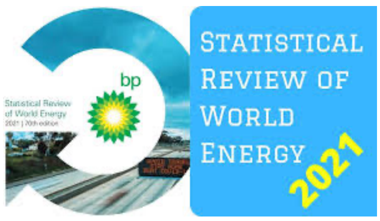
- How we **asset energy consumption** all over the world —> Energy information sources
- Energy statistics : BP
- Regions and Countries grouping
- Energy balances
- Energy sources, reserves and production
- PNIEC (Italian National Plan on Energy and Climate): this part is from 2019 (dated), in the meantime many things happened, first of all the commitment from the EU to reach -55% reduction in greenhouse gas emissions, and 0 level in 2050, a very short time.

In some more developed areas of Africa, instead, there are mainly very old energy system, therefore they have to take a really big jump in order to achieve the kind of technological implementation already set in the rest of the world.
But there's a possibility to address this target: in fact, a few years, for instance, photovoltaic was a very expensive technology, while now it's become far more affordable.
Furthermore, now we take other advantages from it, due to its decentralized nature, and especially in countries like this, where the infrastructure prices are relevant.
We have to be able to see the overall picture of the transition and the main issues which occur with it (infrastructure cost a lot, we have to think about technologies attempting to deal with this problem).
It's very easy to set up an exaggerated goal (e.g. to reach a certain level of emissions within a looming date), however we face a lot of problems when we have to design a road map to achieve these targets.
How do I get there? One thing is to draw a line from where we are to where to have to go, but another thing is to draw a line which is dual from here to there, considering all the constraints playing a role in the whole scenario.
We have to talk about the impact in bringing on a large scale a certain innovative technology, applying demonstrated solution on a large scale.
How much time do I need to bring one technology from demo to then replicate it tens of times, and then we can see the impact (we can't look at the technology on its own).

US Energy Information Administration (EIA)
US Department of Energy
USDA (Department of Agriculture)

They publish regularly reports for example on the consumption in certain area of the world

Regarding the statistics: how much coal is China consuming? how much natural gas the Middle East is consuming? etc..



A very good summary is given by **BP Statical Review of World Energy**, ti gives an immediate feeling of how energy is being produced and consumed, how the situation is evolving in different regions of the world.
There are also others, such as ExxonMobil's "The Outlook for Energy".

Over the last years, before the pandemic, investments shifted towards renewable energy and cleaner technologies, and yet the majority of consumption was on fossil.
So, finance is a strong driver, when investors decide to follow the new trends, then the companies have to start to react, and one typical reaction is to invest in exploration.
In the long term (as in current case) we may lack on supplies.
The pandemic created a dramatic fall in demand, in many sectors also 100% such as in aviation.
But, when the demand rises again, then you miss the investments you've not done before, since there's a shift between the investment time and the benefits you get from there.
There's a time shift in this kind of investment that makes impossible, unless you plan it, to have

The Order of Magnitude

It's important to have a clear idea of these kinds of order of magnitude in energy consumption. Energy resources and consumption at global or national level are usually expressed as EJ (exajoule) or MTOE (megatonnes of oil equivalent).
There are quick converter factors which can be used.

Convert to:	TJ	Gcal	Mtoe	MBtu	GWh
From:	multiply by:				
TJ	1	238.8	2.388×10^{-5}	947.8	0.2778
Gcal	4.1868×10^{-3}	1	10^{-7}	3.968	1.163×10^{-3}
Mtoe	4.1868×10^{4}	10^{7}	1	3.968×10^{7}	11 630
MBtu	1.0551×10^{-3}	0.252	2.52×10^{-8}	1	2.931×10^{-4}
GWh	3.6	860	8.6×10^{-5}	3 412	1

Prefix	Symbol	Base 10
yocto-	y	10^{-24}
zepto-	z	10^{-21}
atto-	a	10^{-18}
femto-	f	10^{-15}
pico-	p	10^{-12}
nano-	n	10^{-9}
micro-	µ	10^{-6}
milli-	m	10^{-3}
centi-	c	10^{-2}
deci-	d	10^{-1}
(unit)	--	10^{0}
deca-	D	10^{1}
etto-	h	10^{2}
kilo-	k	10^{3}
mega-	M	10^{6}
giga-	G	10^{9}
tera-	T	10^{12}
peta-	P	10^{15}
exa-	E	10^{18}
zetta-	Z	10^{21}

Important definitions (they might be in the exam)

Tonne of oil equivalent (TOE)

TOE is a unit of measurement of energy consumption, whose multiples are also used to express large amounts of energy. It is defined as the amount of energy released by burning one tonne of crude oil. **IEA** defines **1 TOE** equal to **41.868 MJ** (approximately 42 gigajoules) but this exact value is defined **by convention**, since different crude oils have different calorific values. Depending on where you extract crude oil, you might get slightly different chemical components or contaminants, therefore the calorific value might change.
According to BP, **in 2018** primary energy world consumption accounted for almost 14.000 MTOE.
While **in 2020**, it accounted for about 13 thousand MTOE (a decrease versus the previous years, due to the pandemic, and the several lockdowns all over the world)

Total Primary Energy Demand (TPED)

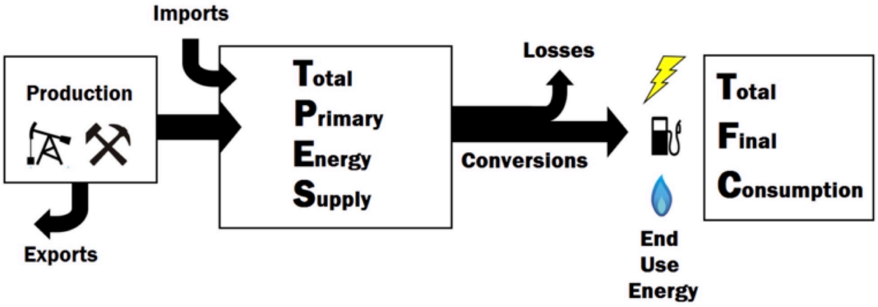
Total primary energy demand represents **domestic demand only** and is broken down into *power generation*, other *energy sector* and total *final consumption.*

Primary Energy Consumption (PEC)

Primary energy consumption refers to the **direct use at the source**, or **supply to users without transformation**, **of crude energy**, that is, energy that has not been subjected to any conversion or transformation process.
It deals with the primary energy source, not converted, without any kind process.

Total Final Consumption (TFC)

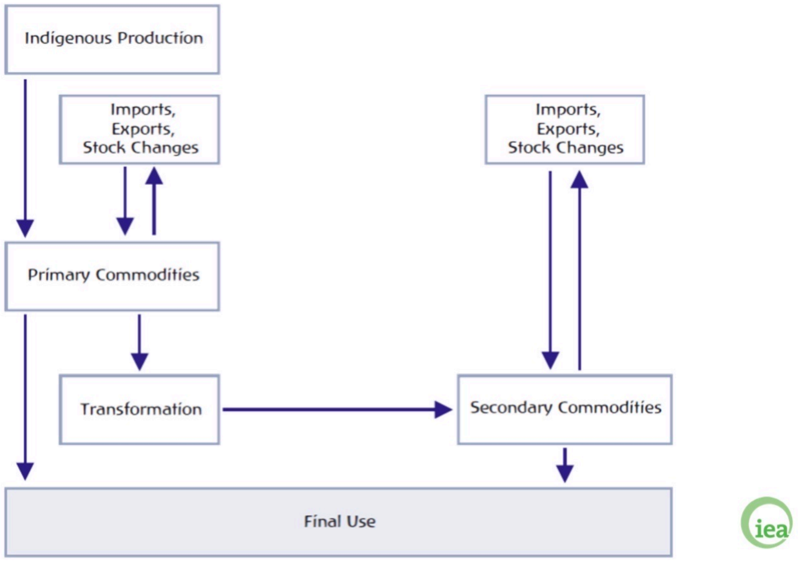
Total final consumption (TFC) is **the sum of consumption by the different end-use sectors**.
TFC is **broken down** into energy demand in the following sectors: *industry* (including manufacturing and mining), *transport, buildings* (including residential and services) and other



Energy Flows of a Country/Area

Energy products

Primary: Extracted or captured **directly from natural resources**
Physical and chemical characteristics remain unchanged
Eg. Crude Oil, Hard Coal and Natural Gas
Primary electricity is obtained from sources such as hydro, wind, solar PV, tide and wave power
Secondary: Primary commodities **transformed into a secondary form of energy**
Transformation changes the form of the energy.
Eg. Coke-oven Coke from coking coal



Main Commodity Flows

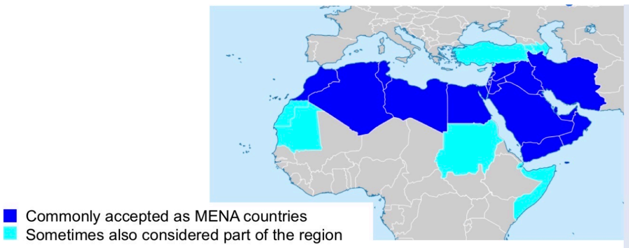
We trade about 7 times what we physically produce, and these intermediate financial transitions have a certain price.
Which is the biggest difference between the financial market and the industrial market?
Obviously, the main one is **speed of variation**: financial market is extremely nervous, it can change from one day to the next one, and it can be dramatic if you have an industry.

The strategic vision of these actors may be quite different from the OPEC members, most of the tension in the past occurred exactly for disagreement between these two groupings.

EU (European Union)

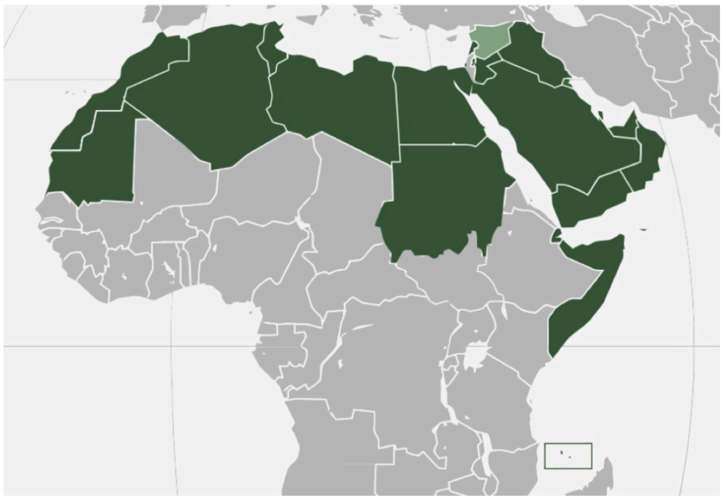
Members (now 27, after Brexit):
Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark,
Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia,
Lithuania, Luxembourg, Malta, Netherlands, Poland, Portugal, Romania,
Slovakia, Slovenia, Spain, Sweden

MENA (Middle East and North Africa)



It is an acronym often used in academic and business writing. The term generally covers an extensive region, extending from Morocco in northwest Africa to Iran in southwest Asia. It generally includes all the Arab Middle East and North Africa countries, as well as Cyprus, Iran, Israel and Turkey.

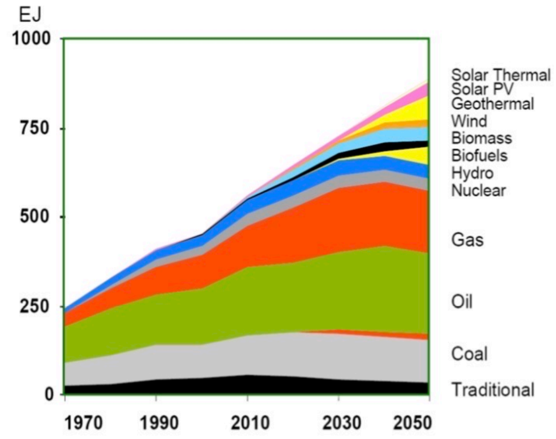
The League of Arab States



It is a regional organization of Arab countries in and around North Africa, the Horn of Africa and Arabia, whose aim is to "draw closer the relations between member States and co-ordinate collaboration between them, to safeguard their independence and sovereignty, and to consider in a general way the affairs and interests of the Arab countries". Member Countries are Algeria, Bahrain, Comoros, Djibouti, Egypt, Iraq, Jordan, Kuwait, Lebanon, Libya, Mauritania, Morocco, Oman, Palestine, Qatar, Saudi Arabia, Somalia, Sudan, Syria (presently seated by Syrian opposition), Tunisia, United Arab Emirates and Yemen, while Eritrea is an observer state.

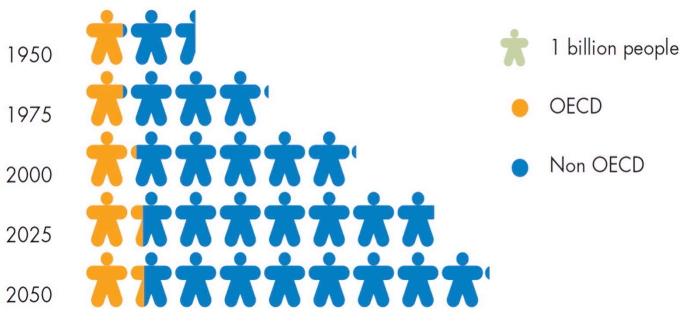
Understanding which are the interests of the various groups can help to get why certain actions are taken or not.

How a big fuel company such as Shell used to look at **future projections** (in 2002)?
For example the predicted development of solar energy was ridiculous compared to what actually happened, in fact the ground-breaking entrance of China in the market of production of technological components for photovoltaic components led to a big change.



Shell - 2002

Ciò che questa immagine ci viene a dire è che in un sistema globale di carattere energetico, il tempo con cui si va valuta l'evoluzione è 50ennale. E quando una sistema, come quello di adesso, diventa sempre più frenetico, agitato, cambiano le regole in gioco in fretta, risulta difficile eseguire delle previsione effettivamente accurate su intervalli di tempo simili.
The key point is that whatever happens in the energy sector is because of the policy, that develops and changes in certain way, leading to another problem, which is the stability of this policy.
If today there's a policy which covers the next 5 years, for example, there is **no alignment between the industrial and the economic times**, in order to develop new industries, new processes, new plants.
In 99% of cases, it's not an industry who invests in a project, but it's usually a financial character. We have to convince to investors that the business is not at risk, and this produces a lot of revenues.



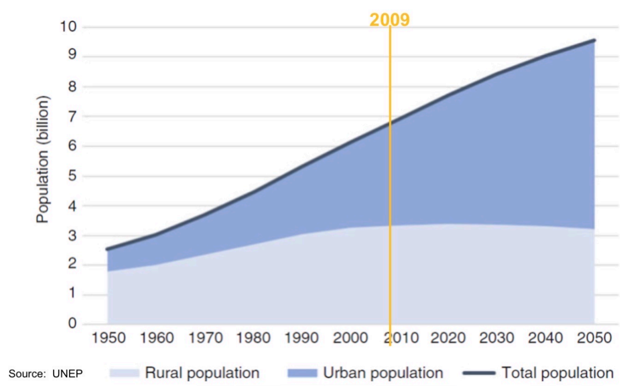
World population has more than doubled since 1950 and is set to increase by 40% by 2050.....
Source: Shell energy scenarios to 2050 (2008)

Energy is the base of economic and social growth.
It stands behind any kind of activity, and this obviously leads to demographic growth.
Long term demographic trends drive the growth of demand
In the last year demand was partially covered by supply; in the future this is not assured
Energy supply is made up of several different markets

Intrinsic volatility of commodity prices

Feed stock: raw materials (materie prime)

In 2009, the urban population exceeded the rural population.
It's a very complex matter, because <u>urban areas tend to be more energy efficient</u>, you can have system integration, optimisation of energy network, you have common services, shared



Questo è inevitabile poichè a seconda della fonte, si possono fare delle assunzioni un pò diversi alla base, ad esempio la BP nel calcolare il consumi di energia primaria, ha calcolato l'equivalente di carburanti fossili necessari per generare la stessa quantità di elettricità, assumendo un'efficienza di conversione del 38%, che è il valore medio per la generazione termoelettrica nei paesi OECD:
Mentre ad esempio la IEA procede in modo leggermente differente, assumendo un efficienza di conversione del 33%.

Nel 1971 la Cina rappresentava solo il 7% dello share per il TPES, e gli USA il 29%, mentre nel 2016 la situazione è praticamente invertita con il 22% della Cina e il 16%.
Scenari completamente cambiati.

STATISTICAL REVIEW OF WORLD ENERGY, 2021 (BP)

Questo documento presenta un'affidabile fotografia di quella che è la situazione energetica globale al momento.
Nel 2020 evidente crollo su tutti settori, un pò come nel 2008 in successione alla crisi finanziaria.
In particolare si studiano gli andamenti dal '95 ad oggi.
Si nota una crescita non troppo ripida per il petrolio, un incremento più marcato per il gas naturale, e infine imponente per il carbone.
Motivo alla base di questa differenziazione nella crescita dell'impiego a queste fonti fossili è legato al peso sull'equilibrio globale enorme che hanno avuto le economie emergenti, che sfruttano ancora fonti energetiche più sporche.
In generale si è passati da poco sotto i 400 EJ di consumo energetico globale, ad essere vicini ormai ai **600 EJ** nel 2021.
Notabile una crescita significativa da parte dei consumi dalle rinnovabili, soprattutto a partire dal 2007.
Osserviamo che petrolio e gas hanno avuto due trend opposti in percentuali di share.
Ovviamente vedere la percentuale di share del petrolio diminuire, è sempre da considerare rispetto ai consumi totali di energia primaria, mentre i suoi valori assoluti sono in continua crescita.

Modelli di consumi regionali nel 2020

Il portfolio (mix energetico) di consumi in percentuali di share delle varie fonti energetiche, cambia molto considerando diverse regione del mondo.
Considerare sempre che le percentuali sono sempre relative ai consumi di quella singola regione.
Bisogna tenere a mente che per rendere un sistema economico più stabile possibile, la **diversificazione** delle fonti risulta fondamentale.

Studiando gli andamenti di materiali critici come il cobalto o il Litio, in seguito al processo intensivo di elettrificazione, e all'aumento vertiginoso della domanda, si nota il prezzo è seguito delle importanti oscillazioni, generalmente crescenti.
Cruciale il fatto che i depositi più importanti sono nelle mani solo di alcune regioni, in Africa, Cina, e Russia.
Nel momento in cui avremo quasi elettrificato tutto, ci troveremo, da Europa, nel pugno dei Paesi che esportano e detengono queste risorse diventate ormai essenziali,

PNIEC - Piano Nazionale Integrato Energia e Clima

Le direttive Europee prevedevano che tutti gli Stati Membri realizzassero entro la fine del **2019** dei Piano nazionali integrati sull'energia e clima.
Perciò, questo documento è la diretta conseguenza di una imposizione dall'Europa.
Questo tipo di piano prevede 5 dimensioni:

1. Decarbonizzazione
2. Efficienza energetica
3. Sicurezza energetica (tema apparso realmente con il REDII)
4. Mercato interno
5. Ricerca, innovazione, e competitività

Si parlava (nel 2019) di una riduzione complessivo dei gas a effetto serra rispetto ai livello del 1990 del 40% per l'UE, entro il 2030, che è poi diventato il 55% al momento.

I settori ETS (emission trading scheme) comprendono tutte le aziende particolermente emettitori di gas serra ed energivore (acciaio, industria chimica, cemento, aviazione, etc.), anche chiamato "hard to abate", difficili da decarbonizzare.
I settori non-ETS comprendono ad esempio i trasporti, edilizia, etc..

L'intensità energetica IE: è il rapporto tra Consumo interno lordo (di energia) e Prodotto Interno Lordo.
È un indicatore approssimativo dell'efficienza energetica di un sistema economico, mettendo a confronto i consumi energetici che dobbiamo sostenere per generare ricchezza.
IE è identificata con energia consumata/valore aggiunto, ma ci sono settori dove questo non è l'indicatore: nei trasporti l'energia è commisurata ai passeggeri o merci trasportate, per le famiglie non si usa il valore aggiunto ma altri indicatori relativi ai servizi energetici.
L'Italia al 2020 è dipendente all'incirca per il 75% per gli approvigionamenti energetici. Ben tre quarti del totale.

Energy policy

The world is changing, and it's changing quickly.

In 1896 there was already an essay published by Arrhenius, which dealt with the influence of the carbon dioxide in the atmosphere.

Development of International policies associated with energy and climate

Technologies and process development were driven by the policy pathway.
In 1992, there was the UN framework Convention on Climate Change, but then in **1997** there was the **Kyoto Protocol** which had extended the former convention.
During the 90's there was an effort aiming to develop an international consensus and a strong attempt to develop emission level which could be accepted by the several nations worldwide.
In Europe, at that time there was a first step of a serious development of technologies, such as:

- Biofuels: research on fundamentals and process development
- Energy and Transport: same interests above
- Agriculture: focus on maximising the yield crops
- Bio-products: introduction of first Biopolymers by Novamont ('91-'92)

The **Kyoto Protocol** (1997) followed the **Rio Earth Summit** in 1992, the protocol was aiming to ask developed countries to reduce greenhouse gas (GHG) emissions by 2012, comparing these emissions levels to those in 1990 (reference).
It provided detailed methods and mechanisms for how the emission reductions could be achieved, measured and verified.
It wasn't agreed by all the members of UNFCC (United Nations Framework Convention on Climate Change, members who attended Rio Summit in 1992).
It was adopted in 1997, but it **entered** into force on February 16th in **2005**.
It's evident that a long time was necessary to set and implement these rules and restrictions.
In **2012** there was the **Doha amendment**, which established the Kyoto Protocol's 2013-2020 seecond commitment period.

Finally we reached the **Paris Agreement** in 2015, which officially replaced the Kyoto Protocol, and was signed at COP21 (the specific conference which toke place in Paris the same year). This new agreement aimed to limit global warming "well below" 2 degrees, possibly below 1.5 degrees, above pre-industrial levels, if feasible.

There were two directive in 2003:

- **Biofuel Directive 2003/30/CE:** aiming to reducing carbon emissions from transports (there's still gas emissions in biofuels combustion, but features way lower level than tradition fuel). The aim was replacing 5.75% of all transport fossil fuels (petrol and diesel) with biofuels by 2010. The directive also called for an intermediate target of 2% by 31 December 2005. *Biofuels* can be regarded as:
- pure
- blended in mineral oil derivatives
- liquids derived from biofuels such as ETBE (Etil-terzial-butil-etere), it's an organic compound derived from ethanol, which by approximately 50% is renewable (a gasoline much cleaner).

- Member State Implementation into national legislation by December 2010 (almost 18 months from the signing of the directive).

Fuel Quality Directive 2009/30/EC

- Further tightening environmental quality standards for a number of fuel parameters,
- Enabling more widespread use of ethanol in petrol (E10) with transitory regulations (protection grade E5) for older cars and derogations for petrol vapour pressure subject to EC approval
- Increase of allowed biodiesel content in diesel to 7% (B7) by volume, with an option for more than 7% with consumer info
- Introducing a mechanism for reporting and reduction of the life cycle GHG emissions from fuel
- Reduction in life cycle GHG emissions from energy supplied. Binding target of 6% between 2011-2020 as first step, while leaving open the possibility to increase the future level to 10%.
- To that effect, in a 2012 review, the Commission will need to assess a further increase of the ambition level of 2% from other technological advances, such as the supply of electricity for use in transport. A further 2% is envisaged to be achieved by the use of CDM credits for flaring reductions not linked to EU oil consumption.

We have to bear in mind the *difference* between **target** and **commitment**: the commitment is a binding agreement, and if you don't comply with the fixed target (adempiere all'obiettivo), you will be financially penalised for not achieving that goal. Instead, a target is a kind of an aspiration, like "i wish to accomplish this goal within a certain date", but nothing really happens if you don't sort out this target.
The binding target of a commitment (namely called a *mandate*, *obligation*) involves the monetary consequences whether you are not able to respect the agreed goal.

EU Climate and Energy Package

It stands behind the RED, and was initially proposed in 2007, and then adopted by **2009**.
The purpose is to define targets by 2020, in a package called "**20-20-20 by 2020**", and the goals were:

- 20% **reduction** in EU *greenhouse gas emissions* from 1990 levels;
- 20% **increase** in the *share* of EU *energy consumption* produced from *renewable* resources;
- 20% **improvement** in the EU's energy *efficiency*
- ...furthermore, 10% **biofuels** in *transport* sector

A package is something that incorporates several legislations, so it is above a directive, and this specific package contains four core legislative acts:

- the revised **Emissions Trading System** (EU ETS) Directive, which is a scheme that regulates the big polluters, the large companies operating in sector like thermal power generation, or airlines, the large chemical industries, and so on;
- the **Effort Sharing Decision** (ESD);
- the **Renewable Energy Directive** (the already seen RED);
- the **Carbon Capture and Storage Directive.**

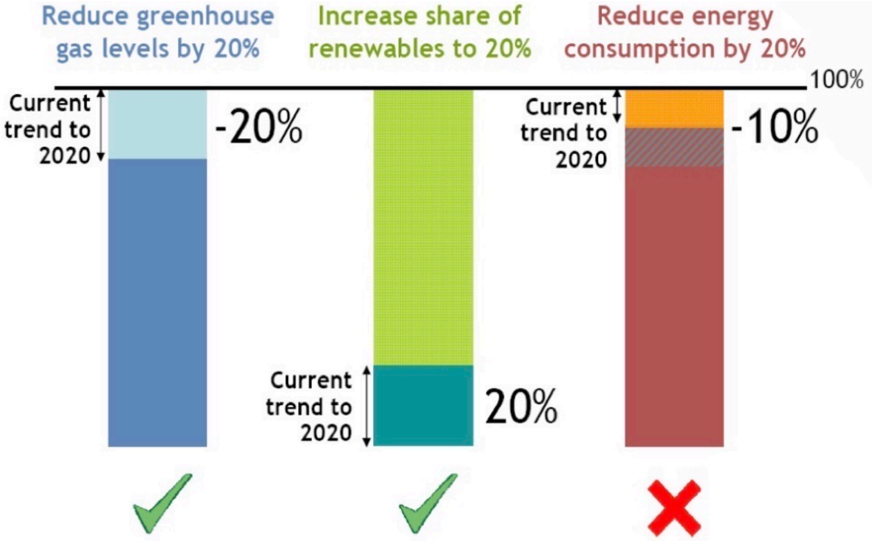
Focusing on the Renewable Energy Directive (2009)

Of course we already have passed 2020, and what about those targets?

If you look at all the 3 different target areas imposed:

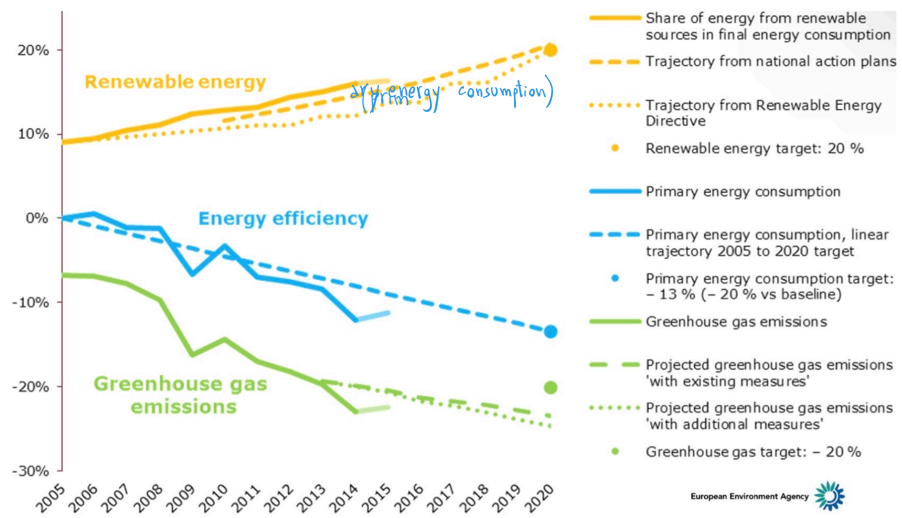
- Reduce Greenhouse gas levels by 20%;
- Increase share of renewables to 20 %;
- Reduce energy consumption by 20% (improving energy efficiency)

Which was our status in 2011?



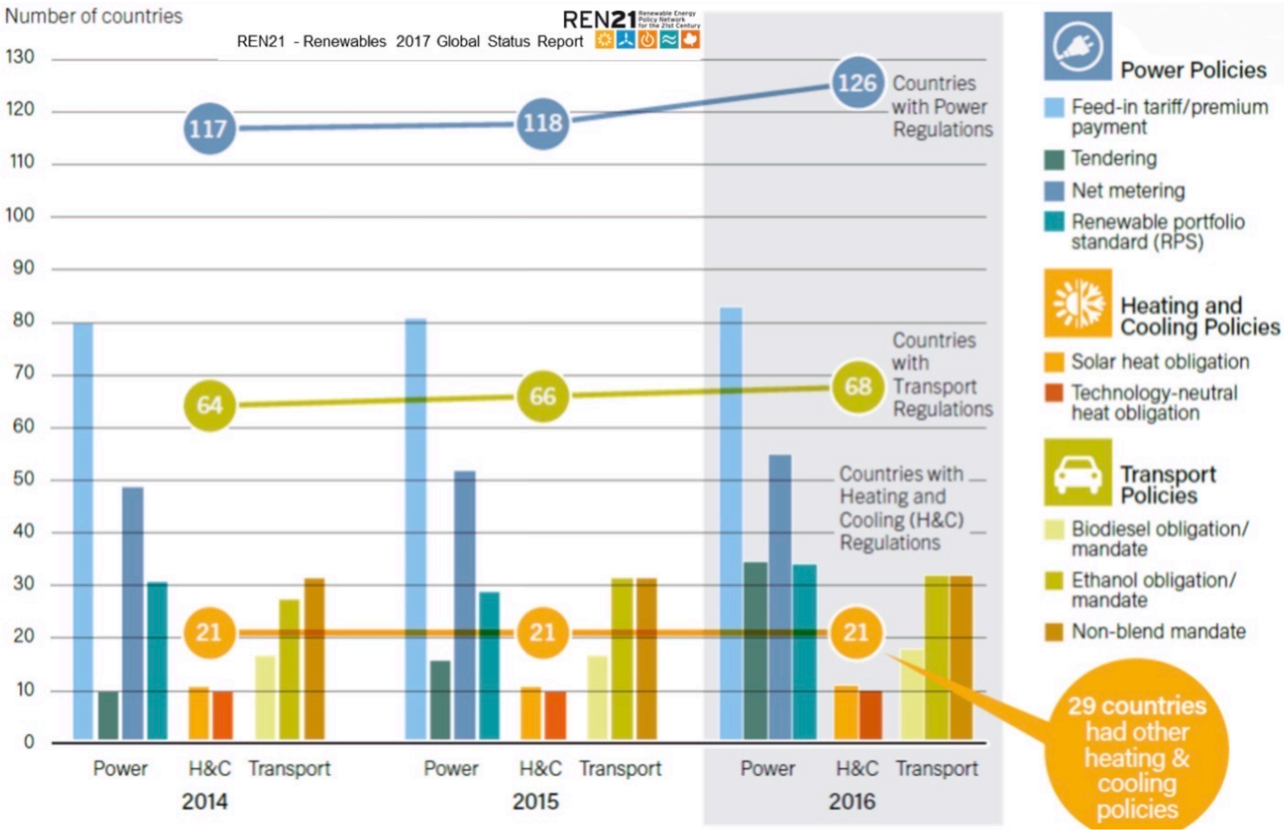
It's important to monitor constantly your target addressing, you can't just check the outcomes one you reach the deadline.
And you have to take actions if you realise there are significant deviations from the foreseen trend to achieve all the fixed goals.
EUobserver was set in order to monitor the status of advancement of the 20-20-20 Package, in the different sectors.

In 2012, there was another legislative act, the so-called Energy Efficiency Directive which establishes a **set of binding measures** to help the EU reach its 20% energy efficiency target by 2020. Under the Directive, all EU countries are required to use energy more efficiently at all stages of the energy chain, from production to final consumption.
This is a relevant example of a legislative move caused by the monitoring of the advancement of achieving targets, which led to EU bodies to emanate this directive, in order to drive the status toward a better direction, with a more aggressive policy, aiming to achieve the goals.



EU progress towards 2020 climate and energy targets (issued in 2015)

Number of Renewable Energy Regulatory Incentives and Mandates world wide (2014-2016)



In 2011, the **Global BioEnergy Partenership** (GBEP) formalised the concept of **sustainability indicators.**
The focus in the previous FQD (Fuel Quality Directive) was in setting a threshold in CO2 emissions, and for industrial operators this was the main concern.
However, the concept of sustainability is far beyond the idea of only GHG emissions.
They put next to environmental aspects, also social and economic key parameters, in order to assess the sustainability of a process or a technology.

Environmental	Social	Economic
1. Life-cycle GHG emissions	9. Allocation and tenure of land for new bioenergy production	17. Productivity
2. Soil quality	10. Price and supply of a national food basket	18. Net energy balance
3. Harvest levels of wood resources	11. Change in income	19. Gross value added
4. Emissions of non-GHG air pollutants, including air toxics	12. Jobs in the bioenergy sector	20. Change in consumption of fossil fuels and traditional use of biomass
5. Water use and efficiency	13. Change in unpaid time spent by women and children collecting biomass	21. Training and re-qualification of the workforce
6. Water quality	14. Bioenergy used to expand access to modern energy services	22. Energy diversity
7. Biological diversity in the landscape	15. Change in mortality and burden of disease attributable to indoor smoke	23. Infrastructure and logistics for distribution of bioenergy
8. Land use and land-use change related to bioenergy feedstock production	16. Incidence of occupational injury, illness and fatalities	24. Capacity and flexibility of use of bioenergy

This kind of idea was already discussed, but not yet formalised by an international body.
It was a very important step ahead.
This makes you understand, why as engineers, we have to coordinate multiple competences, related to various fields.

The main goal is the **reduction of global increasing temperature limit**, < plus 2°C from pre-industrialised period.
And a new point introduced was the relevance of the the **carbon-negative actions**, that are needed in order to achieve our goals.
We are usually more familiar with the carbon-neutral concept (no carbon consumed), but given the situation, we have to think in a more ambitious way, we can't only rely on c-neutral concepts.
Carbon is not the enemy: we need it, but in the right place (e.g. soil)

…I will refocus our European Semester to make sure we stay on track with our Sustainable Development Goals. (Ursula van der Leyen, 16 July 2019, Strasbourg)

REDII Directive (2018/1999)

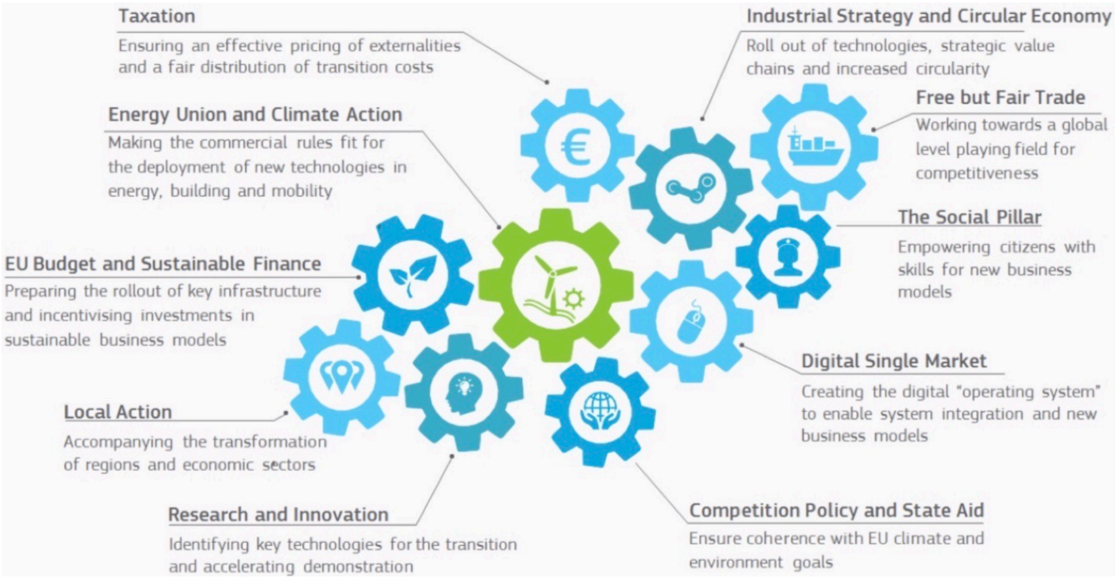
- New 2030 targets
- New Annex IX Part A, with reference to agronomic models
- Recycled C Fuels (definition)
- Introduced (RFNBO, PtX, flue gas ferm., waste gasif)

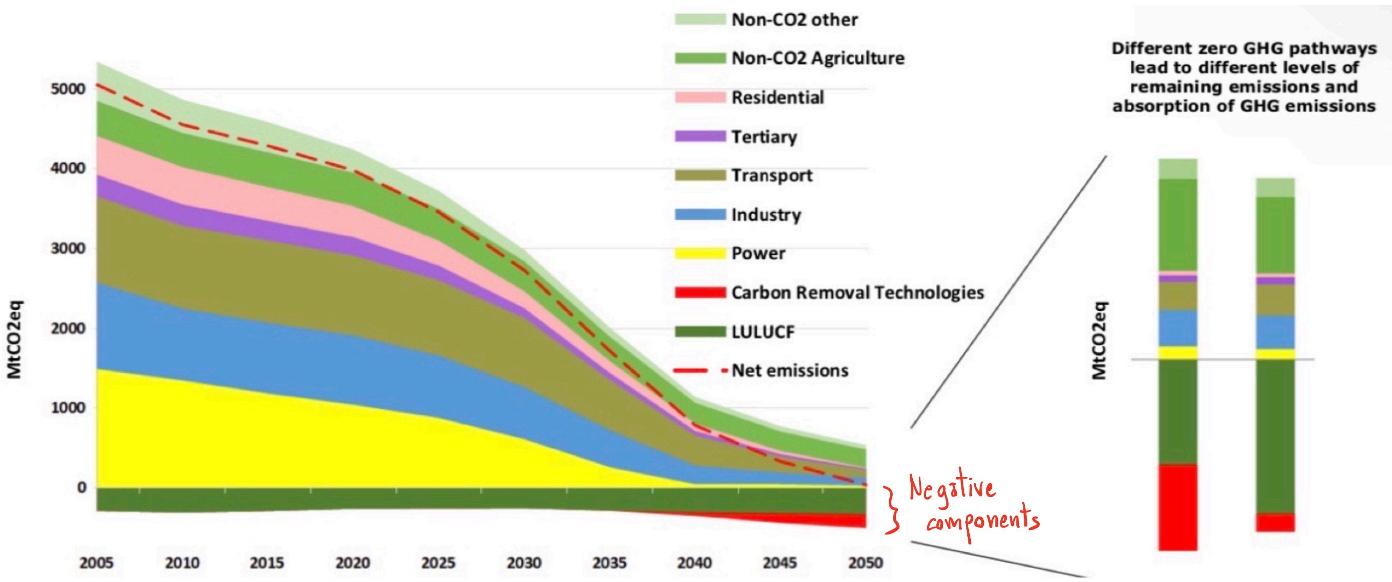
Insight: PtX
Power-to-X (also P2X and P2Y) is a number of electricity conversion, energy storage, and reconversion pathways that use surplus electric power, typically during periods where fluctuating renewable energy generation exceeds load. Power-to-X conversion technologies allow for the decoupling of power from the electricity sector for use in other sectors (such as transport or chemicals), possibly using power that has been provided by additional investments in generation. "X" can mean liquid or gas, depending on the fluid which is produced and stored from the power.

Clean Planet for all (communication)

This was done ahead of the directive (not a directive itself)
A European strategic long-term vision for a prosperous, modern, competitive and climate neutral economy

• Policy analysis: reformed EU ETS, national GHG emission reduction targets, legislation to maintain the EU land and forests sink, the agreed 2030 targets on energy efficiency and RE, as well as the proposed legislation to improve the CO2 efficiency of cars and trucks.
• These policies and targets are projected to reach reductions of greenhouse gas emissions of around -45% by 2030 and around -60% by 2050. This is **not sufficient for the EU to contribute to the long-term temperature goals set in Paris Agreement.**
A range of scenarios were developed, in which we can see the role of various energy sources



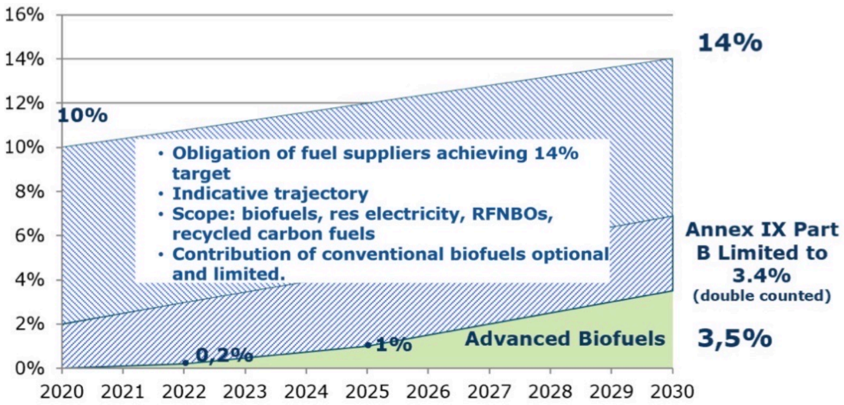


From the "Clean Planet for all" communication, the REDII was released, which revisited the previous RED.
The new directive establishes a **new** binding renewable energy **target** for the EU for 2030 of at least **32%**, with a clause for a possible upwards revision by 2023.
Under the new Governance regulation, which is also part of the Clean energy for all Europeans package, EU countries are required to draft 10-year **National Energy & Climate Plans** (NECPs) for 2021-2030, outlining how they will meet the new 2030 targets for renewable energy and for energy efficiency.
Member States needed to submit a draft NECP by 31 December 2018 and should be ready to submit the final plans to the European Commission by 31 December 2019.
Most of the other **new elements** in the new directive need to be **transposed into national law** by Member States by 30 June 2021.

What is REDII about?

This Directive establishes a **common framework** for the *promotion of energy from renewable sources*. It sets a binding Union target for the overall share of energy from renewable sources in

35. Exercise of the delegation
36. Transposition
37. Repeal
38. Entry into force
39. Addressees



REDII main provisions on biofuels
What are the consequences for transport fuel?

14% is the target of share biofuels in transport fixed by REDII by 2030, with **3,5%** of **advanced biofuels.**

RFNBO means Renewable Fuel of Non-Biological Origin
If I produce hydrogen exploiting power from a PV power plant (for example), through an electrolyser, and I convert this hydrogen, combining it with CO_2 into a new energy product like bio methane (CH_4) and steam (H20)….that is not a biological origin, but renewable.
That's why this fuel are called RFNBO.

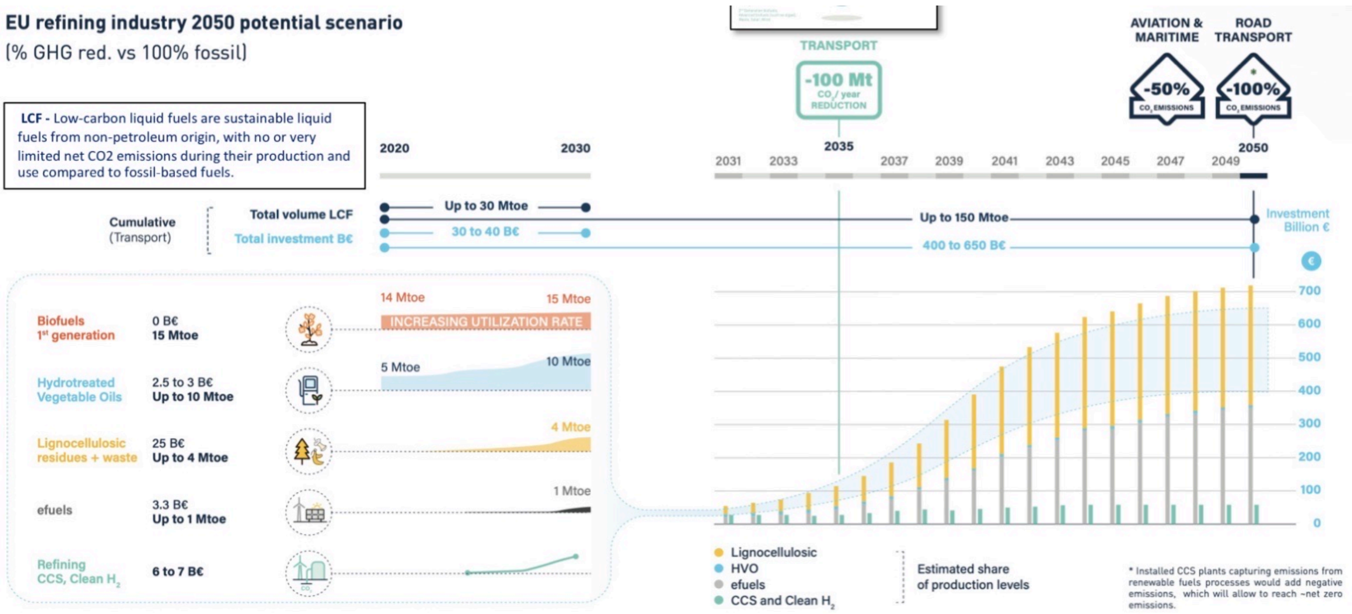
Recycled carbon fuel has a good example in *LanzaTech* technologies.
If you have a steel making plant which emits gas at the outlet, and you take the gases and bring those in a fermenter , where selected microorganisms will convert the CO_2 and the hydrogen that is in the gas into ethanol (for example), you'll obtain a recycled carbon fuel.
Carbon has no renewable origin, but it's a fossil carbon, and it's converted into a recycled fuel.
The advanced biofuels and the waste lipid fuels dealt in the Annex IX Part B are multiplied twice, so that their actual amount is double counted.
There are specific specific multiplier used in the counting of the amount of biofuels used, for each transports sector.

Looking at the demand of oil products, it's clear that we consume 291 million TOE of diesel fuel, for truck and cars.
This is a feature of the European terrestrial transport sector, which is characterised by a huge usage of Diesel engine. In the rest of the world gasoline is much more spread.

IVA).
Only 0,56 euro/litre was the actual price of the product!

What is the pathway chosen by fuel producers in order to reach net zero emissions (in road transport) by 2050?

On one hand there's the European policy aiming to -55% by 2030 and -100% by 2050, and then what the producers say, showing that they can implant seriously a shift in fuel types, but they are able to introduce them in the **large-scale market only by 2035.**
We must be realistic in our scenario then.



Circular Economy Package (2015)

In addition to REDII, the CEP was published, and like the 20-20-20 by 2020 package, it means it is a **set of several directives** which co-work in order to aim a certain common goal.
This set of directives is structured like this:

- **Waste** Framework Directive (2008/98/EC),
- **Landfilling** Directive (1999/31/EC),
- **Packaging Waste** Directive (94/62/EC),
- Directives on **end-of-life** vehicles (2000/53/EC), on **batteries & accumulators** and **waste batteries** & accumulators (2006/66/EC), **waste electrical and electronic equipment** (2012/19/EU)

The concept of circular is based on the idea of recovering all what you waste.
You regard your waste as resource it's no longer something you have to get rid of.
Critical raw materials are those feedstock that are difficult to take off the market, because we depend on them for a lot of products, a typical example is given by lithium for batteries.
In the circular economy view, these materials MUST be recovered, and we need to improve our process production in order to ease to recovery of these materials form the waste.

scappamento) emissions.
And maybe, your goal is to reduce to -30% of CO2 emissions, but that is not like carbon monoxide or other local pollutants, because CO2 emissions represent a grade of efficiency of your combustion process. Then to achieve that kind of goal, you have to reach a level of 30% improvement in efficiency, and that's something over our possibility technologically speaking.
This is the reason why we shift to electric.
But if you apply the Well-To-Wheel approach, considering the whole system, the situation is different. Comparing electrical transport and hybrid vehicles with cleaner fuel (like is done in Brasil, exploiting ethanol in hybrid cars), then the latter solution is much more efficient from a GHG emissions point of view than an electrical car.
The reason is connected to the fact that the **energy density** of the sustainable fuel is much higher than the battery in electrical cars (that are pretty heavy).
The CO2 regulation is the directive that is forcing the electrification of transport.
E-fuel are RFNBO (Renewable fuel of non-biological origin): PV energy —-> produce hydrogen and compound with CO2, react giving liquid fuel (example).
If I put an e-fuel in the Tank-To-Wheel approach instead of a dirtier fuel, it doesn't change anything, whilst it's a totally different situation according to the Well-To-Wheel.
On the industrial and economic point of view, if you switch to purely electrical transport you will have a big impact on the whole industrial sector.
If you keep an hybrid engines approach exploiting a bigger amount of e-fuels, you will keep the industrial sector running, since you still have all the traditional components in your combustion engine to work out. Furthermore, still there are a lot of social impacts.
Another consideration is that the **dependence of critical materials** for the production of batteries will be reduced, because in hybrid vehicles you have a smaller battery, typically.
All these aspects have not been considered sufficiently in the view given by the CO2 regulations.

The two sectors most critical to decarbonise are the **Maritime** and **Aviation**.
It' not realistic having electrical airplanes in the foreseeable future.
So, one necessary move is to switch to a **cleaner fuel**.
Another logistical improvement might be to **reorganise the flights routes**
We are talking about two very different products though.
JETfuel is one of the most sophisticated you can produce, they need to pass some very strict regulations about contaminants. In a plane the fuel has also other specifics to comply with, such as refrigeration, so it has to be stable regardless the wide range of temperature it can be exposed during the flight compared to the on-ground condition.
The large part of aviation is international, and the regulations of this sector is done by different bodies: one of them is European, this controls aviation and maritime emissions, and the other is ICAO (International Civil Aviation Organisation) and IMO (International Maritime Organisation), and both of them have programs aiming to decarbonise.
But our problem is the harmonise the international directives with the European (domestic) ones.
In EU the target -65% in GHG emissions from fuel, on the other hand in the ICAO the goal is about -10%. The two legislations must work together, harmonised.
On the other hand, the Maritime fuel is one of the heaviest and dirties fuel used in transport. At ambient condition, it's a solid, so they have to inject steam in the tank in order to extract the fuel.

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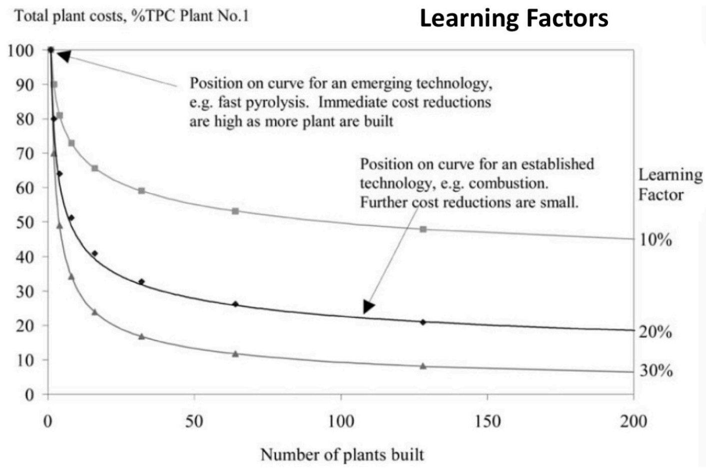
That's why policy sometimes doesn't take in account the actual time needed to realise a certain technological process.

There are two important phenomena that occur when you have to **scale-up the technologies:**

Learning Factors

If you want to reduce the cost of a technology, you have two aspects to work on: you must increase your production, in order to reduce the actual production cost; otherwise, rather then make many units, you can make bigger one.

But there's another factor, which the "learning factor".



It means that, if you build something for the very first time, it would likely not be optimise and efficient.

After much more units produced, the process and the technologies will start gain a higher level of optimisation, due to the learning process.

The more innovative the technology is, the more big will be the learning factors.

And the pace at which the technology will improve is larger during the first period of its life.

There are many aspect related that can gradually improve (not strictly related on the technology), for instance the logistics of the feedstock and the materials that are supplied to the industry can be optimised over time.

The story of the introduction of industrial ethanol production in Brasil followed the same kind of pattern.

This successful extending process was possible thanks to the well-designed and **smart policies** that the government published.

First of all it was a steady policy, which lasted some time. And secondly they actually acted on the price of gasoline, artificially increasing its price, in order to make ethanol competitive on the market.

How do we measure the introduction of a new technology?

Through a scheme that is called the "**Mountain of Death**".

The most critical part during the development of a new technology is reached at the building of the **First-of-a-kind-plant.**

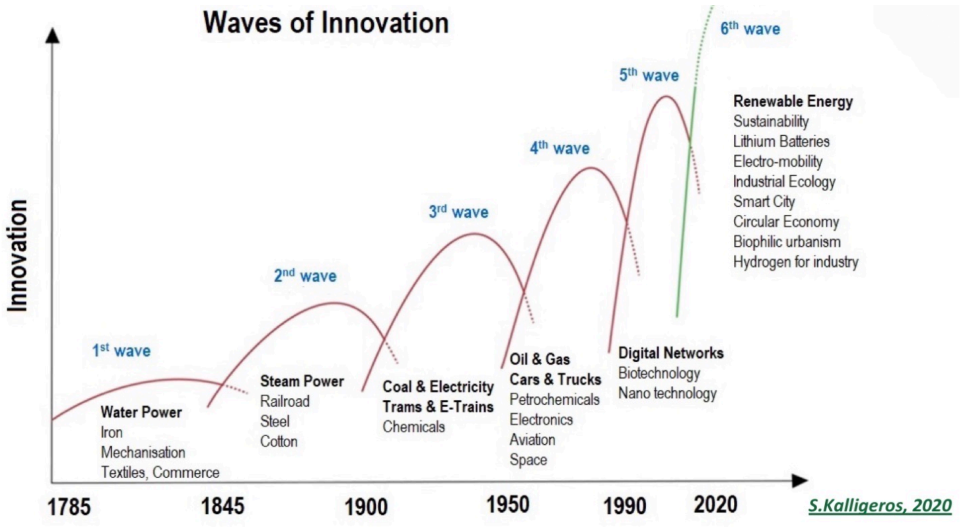
This phenomena is related to the concept of the risks evaluation in an investment, namely the concept of "**bankability**".

If a project is bankable you have the certainty that the investment will pay you back, and that the project will actually have a healthy process, leading to a reward in the long run.

It means that not only the technology is actually working, but you can also produce the products at a competitive price.

When you' re still in the **lab phase** of the development, the cost are still moderate, quite cheap. But the production cost will gradually increase, and ever more rapidly going thorough the **pilot phase** and the **demo phase** (quite expensive).

But then, when you reach the point of the FOAK, which is located near after the demo, and this I will be the actual first industrial-scale plant.



Because on one side, from the **policy** making side, it's hard to keep up with these innovations, since it's quite a slow process and swayed by many other factors. It's likely that when political bodies actually take actions in a certain direction, another ground-breaking innovations might occur. On the other side, the **industry** also needs a certain time in order to adapt and modernise its production chain, its machineries, train people on new processes.

CAF: Conventional Aviation Fuel (e.g. fossil kerosene)

SAF:Sustainable Aviation Fuel (e.g. recycled carbon fuel)

Lanzatech: very important emerging start-up in the field of recycled carbon fuel

In order to reach a 100% CAF substitution (MAX scenario) —> 170 new biorefineries will must be built each year from 2020 to 2050 (15-60 $B/y).

And this process would reduce (MAX) CO2 emission by 63%

Source: UN-ICAO

It's a really challenging changing process.

The Fit-for-55 proposal

It's the most ambitious package released by the European Commission during the past years.

The summary of **topics** is the following:

- CARBON BORDER ADJUSTMENT MECHANISM
- FUEL EU MARITIME
- LULUCF REVISION
- NEW EU FOREST STRATEGY
- NOTIFICATION ON INTERNATIONAL AVIATION CARBON OFFSETTING AND REDUCTION SCHEME (ICAO CORSIA program)
- REDUCING METHANE EMISSIONS IN THE ENERGY SECTOR
- REFUEL EU AVIATION
- REVIEW OF THE EFFORT-SHARING REGULATION
- REVISED CO2 EMISSION STANDARDS FOR CARS AND VANS
- REVISED REGULATORY FRAMEWORK FOR COMPETITIVE DECARBONISED GAS MARKETS
- I REVISION OF THE DIRECTIVE ON DEPLOYMENT OF ALTERNATIVE FUELS INFRASTRUCTURE
- REVISION OF THE ENERGY EFFICIENCY DIRECTIVE
- REVISION OF THE ENERGY PERFORMANCE OF BUILDINGS DIRECTIVE
- REVISION OF THE ENERGY TAXATION DIRECTIVE
- REVISION OF THE EU EMISSION TRADING SYSTEM (ETS)
- REVISION OF THE EU EMISSIONS TRADING SYSTEM FOR AVIATION

Conclusions

POLITECNICO DI TORINO

- **ENERGY** is a **POLICY-DRIVEN** sector
- The Bio and Circular Economy, the EU targets on GHG reduction, the Green Deal by the EU Commission will all boost **R&D, Industrial demo, and Industrial scale-up (FOAK)** in the coming years in a variety or biomass and waste sectors
- **New process routes** will be brought to **commercialization**
- **Integration** between different renewables, fossil, and a large number of scientific and technological disciplines will be unavoidable to compete on a global and local in the pathway towards Net Zero
- **Education and training** will have to support this tremendous effort with ad-hoc programmes, interdisciplinary and International
- **Policy is in continuous update and revision**

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Energy demand

Many governments are wondering “can we actually reduce our demand for Russian natural gas?”.
That’s a big geopolitical question.
Over the last two years we have been looking carefully at the energy demand during the pandemic.
In the very beginning of 2020, when China was first hit by the virus, its energy demand also plummeted.
Power is needed to produce, just if there’s an economy is functioning .
Many factors can affect your energy demand, obviously a virus that forced us to be stuck at home for a few months strongly influenced it.
Depending on the technologies you have to convert energy into any service you need (light for example), energy demand can be influenced.
If you manage to come up with a new revolutionary clothing textile that is able to keep you very warm naturally, without the necessity to use heating systems, probably our energy demand would go down.
For instance, LED lights have been a very big technological improvement in the our lighting system.
However, not everybody has switched to LED lights, even if there is a clear energy saving in the long run, given that their price is actually slightly higher than traditional lighting bulbs.

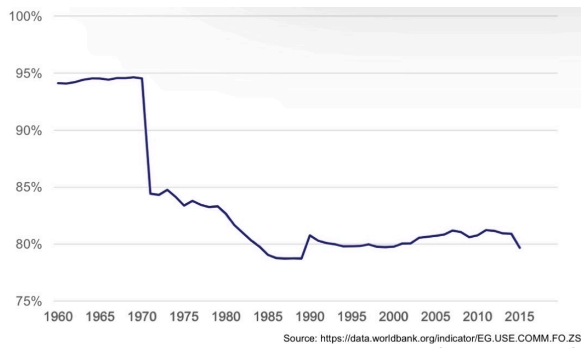
Demand and consumption are not the same thing

Practical example: many publications have been discussing how renewables lead to a world of **peak energy** (consumption).
We’re talking about the maximum historical consumption and production. Afterwards a sort of decline is forecasted. Similar to “peak oil”.
We will consume less fossil fuel energy, but it’s not completely clear if we will demand less energy in total.

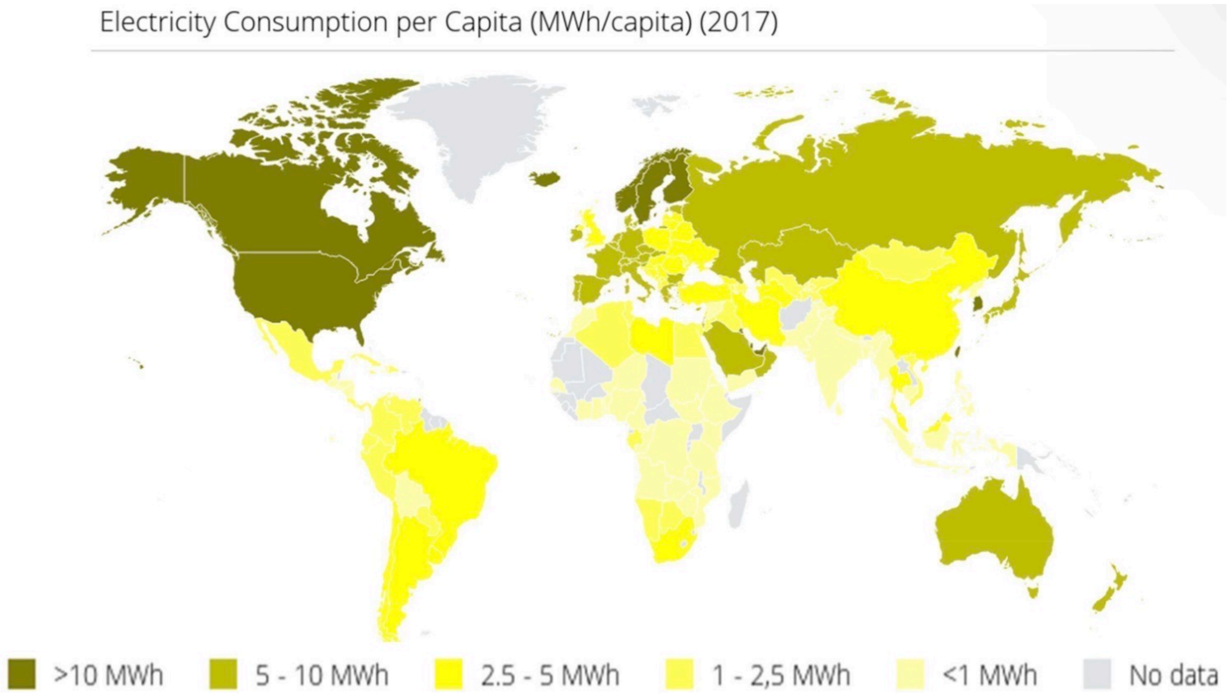
Outline

1. What is the difference between energy consumption and demand?
2. Demand functions, derived demand
3. Elasticities
4. Long run demand for energy
5. How do we estimate ED?
6. Energy efficiency gap, rebound effects
7. Behavioural economics to cut energy demand?

It’s very important, first of all, to understand that the usage of energy and its impact, depends on what kind of energy we actually use.
The biggest thing we are mostly concerned about is the fossil fuel consumption.
Nowadays, we are around a 75-80% of **fossil fuel** energy consumption compared to the total



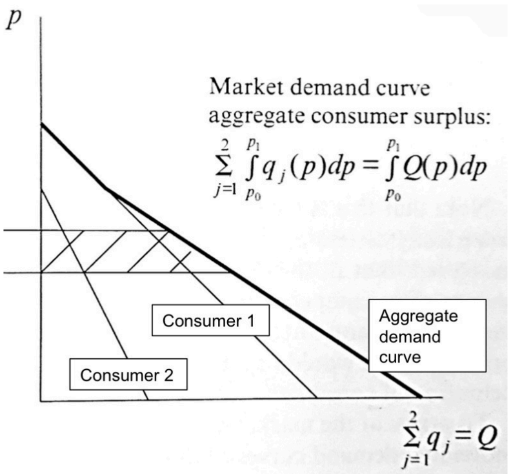
Fossil fuel energy consumption (% of total)



The average amount of energy that is consumed by an average American is many order of magnitude higher than the one of an African guy.
So far, we've been talking about namely **consumption**, which is something directly measurable and it's something specific organisation constantly keep track of.
In economic terms, consumption is the equilibrium outcome, given all the circumstances (amount produced, prices, markets, etc..).
A supply needs a demand, so there is production of energy and there are consumers (common users, industries, hospital, etc.), and we can empirically observe that a certain amount of energy has been used in a given year.

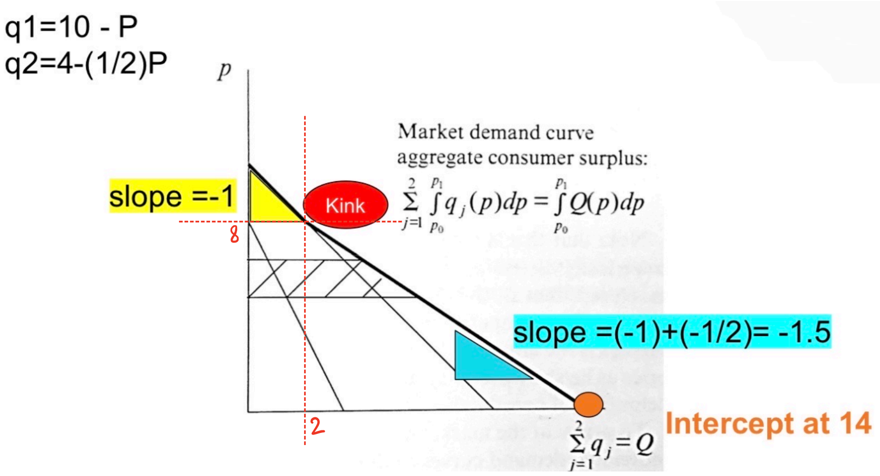
However, **demand** is a bit more of tricky concept, because it's like a theoretical construct that we have independently of the specific given circumstances.
At the moment, we are experiencing a huge increasing in the gasoline price, but regardless this actual factor, we have a certain demand of gasoline as a fuel, because it's a kind of a necessity for us anyway.
In a way, it's a sort of the *abstract desire* that you have for a certain good.
It tells us the willingness of the consumers to pay a certain price for a given quantity of commodity or service.
We also consider the "effective demand": we all would love spend an entire week in a luxury hotel in Bali, but if you are not within the range of being able to purchase that kind of service, then the hotels in Bali aren't going to consider your demand given your interest in that kind of service.

What deals a typical (but simple) demand function look like?
This is a linear demand function.
It's like a small algorithm that answers the question "how much quantity would you consume for each prices", or vice versa "what price are you willing to pay for a given quantity".
Of course, it's not just a function of the price, there are a lot of other things that affect our



the decrease in price and the extra quantities you are going to buy then.
This can be also carried out with a certain group people. Of course, each of us has a different demand function for a given good, some of us can be really responsive to change in prices, in terms of their consumptions, others could be quite unaware.
Here there are two demand functions associated with two different consumers, and then their **aggregate demand curve,** just adding horizontally their curves. So you can also compute the consumer surplus related to this little group a consumers.

Example:
Let's say a consumer has this demand function: $Q_1 = 10 - P$
When the price is zero, he consumes 10 units, and then for each units of increase in the price, his quantity consumption decreases of one unit.
And then we have another consumer which is a little less responsive: $Q_2 = 4 - \left(\frac{1}{2}\right) P$
We want to calculate a big aggregate function that can put together this two relationships.
The **horizontal axis intercept** is when the price is equal to zero: in this case, we just need to substitute zero in both the demand function and compute the sum of their quantities demanded. Consumer 1 demands 10, while consumer 2 demands 4, and this leads to a total of 14, which is the horizontal intercept.
Regarding the vertical intercept, instead, this tells us at what price does the quantity collapse to zero.
For the consumer 2, when the price is equal 8, he will demand zero (for any prices higher than 8, this person can be considered out of the market).
Whilst, for consumer 1, when the price is slightly over 8, he's still consuming units, then at higher prices there is only one consumer left in this market, however when the price reach 10, the consumer 1 will stop demand too.
What we obtain then is a slope with a **kink**, and this is framed by the price at which one consumer goes out of the market.
So we have to sum also their slopes.



The answer is:

Aggregate Q= 14-1,5 P (if P<8); 10-P (if P>=8)

$$\varepsilon = \frac{\%\ change\ in\ y}{\%\ change\ in\ x} = \frac{\Delta y}{y} \Big/ \frac{\Delta x}{x}$$

Elasticity
It's defined as % change in a variable resulting from a 1% change in another variable.
These are percentage changes (unit free!)

In this reasoning we holding other things constant, steady (other factors).
And this is a tough assumption given that things adjust over time (technologies, regulations, policies, preferences, etc..), but this usually take a bit of time.
So, in the short run, if you're thinking to a big price shock of a good, you can study the responsiveness of the market using the elasticity.
Since it's a **unit free parameter**, it's very easy also to make comparisons with other kinds of markets.
We can have many **types** of elasticities:

- Own **price** elasticity: if the energy price P rises by 1%, how much does energy demand change (in terms of percentages)?
- **Income** elasticity: if income Y raises by 1%, how much energy demand change (as a %)?
- **Cross-price** elasticities: if the gas price raises by 1%, how much the demand for renewable change (as a %)?

If not specified, when we talk about price elasticity, we refer to own price one.
Definition: UNIT elastic : elasticity =1
The two variables change at the same rate, proportionally.
Price Elasticity
How do you calculate own price elasticity of demand?
You need the slope element, so the change in one thing in with respect the change in another.
But be careful to not confuse the elasticity with the slope, they're not the same thing.

$$\varepsilon_p = \frac{\%\ change\ in\ energy\ demand}{\%\ change\ in\ energy\ price} = \frac{\Delta Q}{Q} \Big/ \frac{\Delta P}{P}$$

$$\varepsilon_p = \underbrace{\frac{\Delta Q}{\Delta P}}_{\text{slope}} \cdot \frac{P}{Q}$$

Example:

- Demand for Lumen/hours of lightning (service). How much does it change with cost of each Lumen/hour?

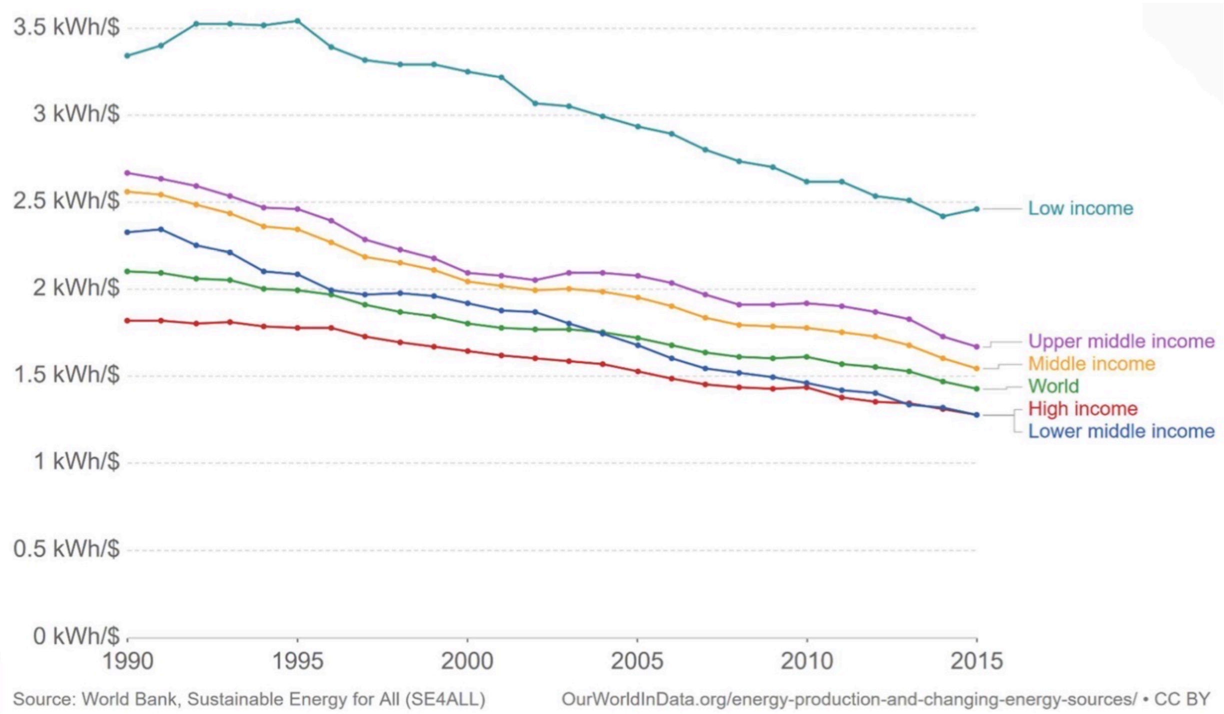
$$\varepsilon = \underbrace{\frac{\Delta\ \text{Lumen/hour demanded}}{\Delta\ \text{cost L}}}_{\text{Slope}} \times \left[\frac{\text{cost L}}{\text{Lumen/hour demanded}}\right]$$

→ depends on the starting point along the curve

1. Durables' **investments** (fridge, car, house, factory…) - assets'life is long, these things are changed rarely. But if electricity is very expensive, maybe buy a more energy-efficient fridge.
2. Changes in `**tastes**' habits, behaviours, etc. (e.g. social awareness of climate change after Fridays for the Future)
3. **Technology** (electric scooter)
4. **Policies** (incentives, subsidies)

Do you expect long run elasticities to be smaller or greater than short run ones?
Long run elasticity should typically be **greater** than short run ones, because more things can adjust/respond .
Example: if the price of energy↑ , in the short run you can only **switch off the lights** and try to consume a bit less. Your quantity demanded ↓ , but not so much. But in the long run, you can **install a solar panel** on your roof and make your own energy. So, your demand for external energy ↓ ↓ a lot. You "respond" more to the price change in the long run.

As we saw in the initial graphs, we keep using ever more energy, the total **energy consumption** is continuously **growing** (due to the increases in demographics and economic activities). However, we're getting better at exploiting our sources, and this leads to an actual decrease in energy used per unit of output.



Energy intensity of economics

Energy intensity level of primary energy is the ratio between energy supply and gross domestic product (GDP) measured at purchasing power parity. Energy intensity is an indication of how much energy is used to produce one unit of economic output. Lower ratio output indicates that less energy is used to produce one unit of output.

Moving back to energy demand function, how we actually **estimate** it empirically (from the data)?
Let' say we suspect that the demand function follow the mathematical form of : $Q = aP^{\beta}$
If you check the **elasticity** of that demand function, we can easily see that it's constant and specifically equals *beta.*

$$\varepsilon = \frac{dQ}{dP} \cdot \frac{P}{Q} = \beta\left(aP^{\beta-1}\right) \cdot \frac{P}{aP^{\beta}} = \beta a P^{\beta-1} \cdot \frac{1}{a} P^{1-\beta} = \beta$$

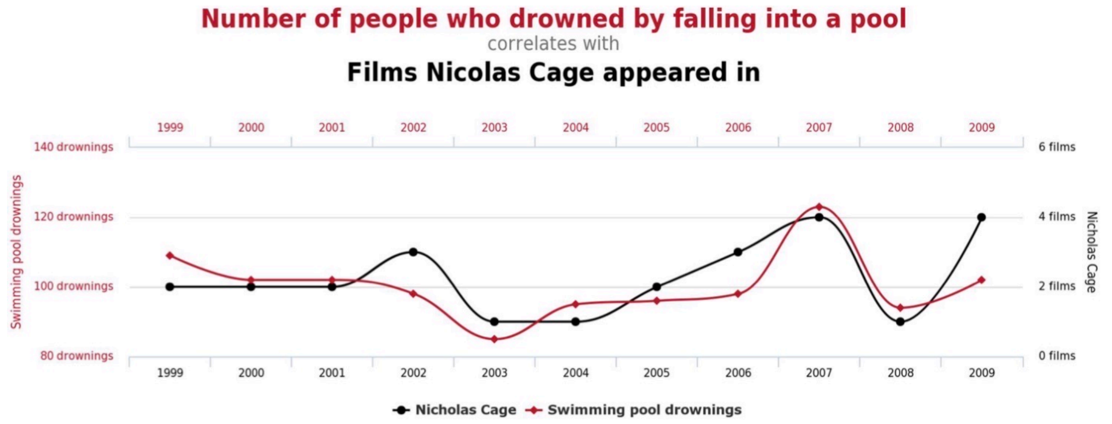
What we typically do is trying to linearise it, applying natural logarithms on both sides: $\ln Q = \ln a + \beta \ln P$

Then, to estimate empirically a function that has more or less that form, it would mean to **get some data**, some observations over time, of different prices and different quantities.

1) Get data from markets with some variation in P and Q
2) Estimate a model of the demand function "econometrically" (statistical methods for economic analysis).

$$\ln E_{it} = a_0 + \beta_1 \ln Y_{it} + \beta_2 \ln p_{it} + \beta_3 X_{it} + \varepsilon_{it}$$

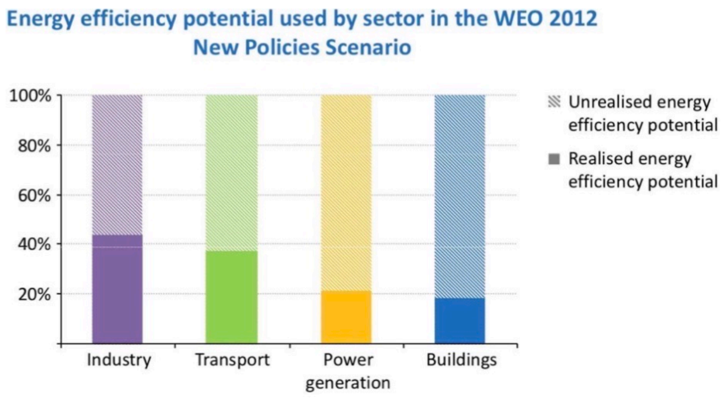
subscript t indicates **time**, i is the **unit of observation** (*individual, province*, etc.) and βs are the **parameters** of interest to be estimated.
E is the consumption of a type of energy, α the intercept, Y is income/GDP, p the price of energy and **X a vector of controls** (anything that could significantly affect the energy demand, depending on the unit of observation).
• For instance, if i is variation across individuals, controls would include things like *age, political orientation*, etc. If i is a province, we should control for *population, capital stock, weather, price of other fuels*, etc.
The βs are the elasticities to be estimated (there are various techniques). The *epsilon* embeds all the various errors, and everything else not taken into account by the other terms
In this formulation, I have to be very careful at not to say that the price we see from the data is CAUSING a different quantity, so the two things are fairly determined at the same time.
I cannot really say if the increasing price is causing the quantities to drop, for example.
An important concept is that: correlation does not imply causation!



more of these commodities, caused by some specific phenomena. This led to the shifting of the demand curve, but in the meantime there were no significant changes in the technology or other factors, that could lead to important changes in the supply curve. The result is that the several equilibrium points were obtained by the gradually shifting demand curve and basically steady supply curve. So they were kind of tracing a supply curve.
On the other hand, if we want the demand curve, we should <u>find shifters of the supply curve</u> (e.g. natural disasters, technologies of production, etc.).
Let's say we have a period when the demand is quite stable (no disincentives or advertisement movement that affect people's behaviour and preferences), but there are lots of shocks to the supply (that lead to significant changes in prices of commodities, for example a long period of drought that might affect agriculture, reducing the amount of cereals produced).
If we consider various interception of the demand (stable over a period) and a supply curve which experience various changes, we would obtain a cloud of equilibrium points that are actually displaced along a downward-sloped curve.
<u>What we observe from the real market data are just the equilibrium points</u>, we don't know the actual form of the specific curves that lead to that outcome.
Estimating a demand curve is not easy, obviously, since it's a theoretical concept.

Energy efficiency gap

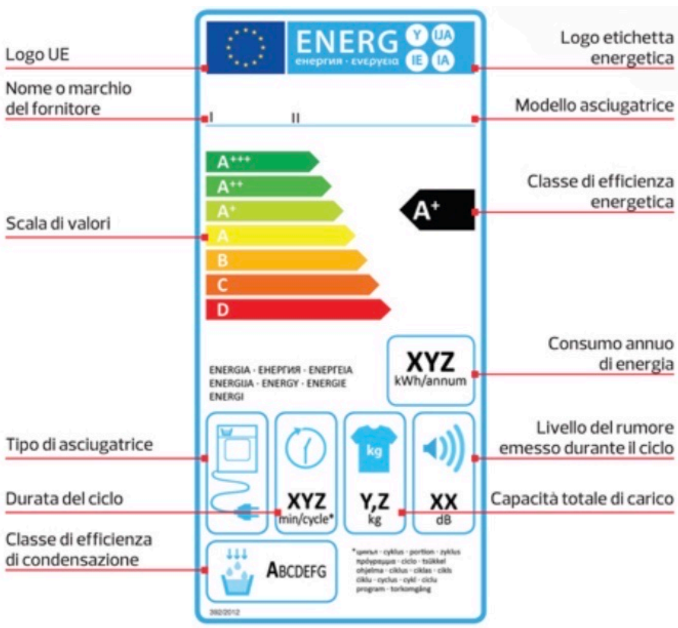
We also want to talk about energy efficiency, and why its improvement doesn't actually enhance the general economic condition as we wish (from a simply engineering perspective).
When we get a new technology that improve our energy consumption, we implement it but the actual results are not the ones we could forecast.



Two-thirds of the economic potential to improve energy efficiency remains untapped in the period to 2035

What is clear form this diagram is that there's an evident **energy efficiency gap**, that means a large share of technologies have not been adopted yet, and it's not perfectly clear why.
Since would energy cost less, wouldn't you implement these kinds of disruptive solutions?
We might say that these new technologies pay for themselves, in the long run.
In fact you invest on it, and then after a few years you're a way back into your investments, because you pay less in your bills.
Then **why** wouldn't households or companies make energy saving investments that should "pay for themselves"?
1. **Discount rates** (<u>how people evaluate time</u>): maybe do not place enough weight on the future, and upfront costs seem too big. When things are going to happen in the future, we sort of tend to attach a bit less value to them, because future is more uncertain.
2. **Limited access to finance** (the classic way to smooth expenditures over time). But is it the same for large companies?
3. Too much **uncertainty** about the future (prices, regulations, etc.)
4. **Behavioural aspects**

2. **Anchoring/default effects, inertia:** we apply rules of thumb (a method of procedure based on experience and common sense), usually based on what we already know, and resort to the default option rather than enact complex changes.
The default effect is when you are given a certain default option, and then you are less likely to move towards alternative solutions (e.g. changing internet providers).
An anchor effect occurs when you're a told a certain price for a commodity, and so, you are likely to move around that value. You are not going to push towards prices too far from that initial propose.
3. **Framing, salience/signpost effects**: we note more things that are salient and with the right framing (exploited by advertisement companies).
4. **Peer effects, social norms**, and so on



Policy makers might then ask themselves "can we kindly nudge people into a bit more energy savings"?
For example, this kind of label that have been appearing over all the electrical appliances are making very evident and clear in which energy efficiency category you are.
The aim is to nudge more people buying the most efficient product, even if it costs more, making them more aware of energy costs.

It's not very clear yet if these kinds of technique about behavioural interventions are effectively able to promote household action on climate change, for example.

They might work if…
• not alone but when combined with other policies
• for frequently occurring behaviours
• for specific contextual factors
BUT evidence is not so clear. For example, very few studies have integrated nudging and financial incentives

Exercise

Energy services are what we actually, what benefit us. We like being able to drive from a place to another, we like having a bath with warm water…but we don't like energy for the sake of energy. We don't like buying kW of electricity just for enjoying the flow of electrons in our appliances.
And what is the problem associated with these decoupling of interests? The fact that we don't actually know what is the price of the energy service we need, in a clear way.
If you go to the gas station and ask "how much is it to drive for 10 km?", you won't probably receive any answers.
In fact, what we can basically know is how much a litre of gasoline is, but that is the price for

Let's look at the **supply function**:
We have a fixed transformation factor in the formula, that takes energy and converts it into an energy service. So, this could be our car: how many kilometres it travels with a liter of fuel. It's basically a conversion technological parameter.

$$S_s = eE$$

This parameter is also a measure of **energy efficiency**! (How well we transform energy into services) .
Furthermore, e>0 always!
Then, wrapping up, *e* is basically a conversion factor

e = energy services/energy = S_s/ E

Is this parameter reliable in the short of long run?
If you think about a certain vehicle, it can do a certain amount of distance using a litre of fuel, and that's pretty it, so the conversion factor is fixed by the type of technology you're using
But in the long run, in order to improve the factor, you can actually buy a new car, with an updated technology, capable to drive you for longer distances using the same amount of fuel.
In the short run generally few things can adjust, whilst in the long run this is no longer true.

The answer is: given that the parameter *e* is fixed, this must be a **short run** parameter.
Conversely, in the long run, this factor might be a function of other variables, like your capital stock, or your income, so depending on if you can afford to but a new vehicle.
The short term matters a lot, and that's the period of time in which people cannot adjust much, and that's a very important thing to examine.
Wages are usually very sticky, and when you get a shocking bounce of inflation, the prices of the things you buy go up rather quickly, because people in the market can easily adjust the price tags, while your income is less likely to be renegotiated that quickly, in order to embed promptly inflation.

So, the parameter *e* is fundamental to get what we actually want (the cost of energy service).
It can bring us from the units of energy to the units of energy service.

Cars $S_s\,[km] = e\left[\frac{km}{litre}\right]\cdot E\,[litre]$:

We know the unit price *p* of energy (1$/kwh, 2£/litre, etc.) from eq. (3).
Combine with the efficiency conversion factor *e* (e.g. 6km/litre) from eq. (2), we can now derive the unit cost of an energy service:

$\frac{p}{e}$ = *unit cost of energy* divided by *efficiency* of converting energy into services

$$\left(\frac{P}{Energy}\right) / \left(\frac{Service}{Energy}\right) = \frac{P}{Service} = \frac{p}{e} \qquad \left[\frac{\$}{km}\right], \left[\frac{€}{lumen}\right]$$

That is namely a very extreme case that we can hardly experience in the real world; an improvement of energy efficiency that might lead to an actual increase of energy consumption. But theoretically this is expressed mathematically by the previous condition about the eleasticity, and so the price responsiveness.

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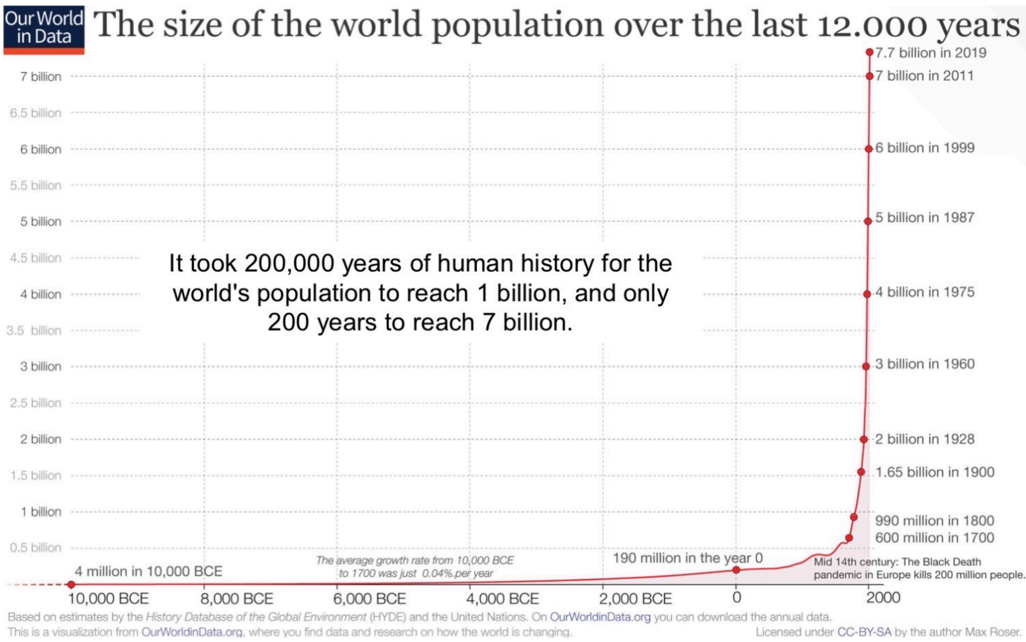
What market tries to do is matching the supply and demand of these services and goods.
In most cases, the best conditions and then the equilibrium point in a market is obtained by itself.
The majority of markets self-regulate.
We usually converge automatically to an equilibrium price.

Of course, markets can't function and operate without human beings, they are completely human constructions.
Human economies has always needed **energy** resources for production, exchange and consumption of goods and services. The more concentrate, the better (because easier to transport and trade).
In **Agrarian** system, we exploited animal power, the human power itself, water mills or wind mills, and pretty anything that was organic.
All those things were immediately converted and consumed into something, such as labour for cultivating crops, and so on.
Energy was exactly were it was needed the related services, and couldn't be transported.
The problem with this system, is that the constraint factor is actually the land.
When the population increases, the pressure on land increases, and then people may start starving. This was the actual reason for the limited demographic growth as long as the agrarian system was the only one known. Conversely, what we have experienced during the past few centuries is an exponential explosion in world population. And this has been possible only because we had actually changed our main way to survive and civilise the world.



The big leap was taken in Britain across the 17th and 18th century, when the first industrial revolution took over.
At the first time, the price of coal was relatively low.
Initially, we needed to develop technologies just to be able to extract coal from the mine in a cheap enough way in order to make it available.
And originally the supply of energy from coal were much bigger than its demand, given that we didn't know what to do with it, expect of burning it and releasing thermal energy.
But since when new technologies were developed in order to extract more and more of it, also new uses were found.
Firstly **urbanisation**, and then also the exploiting for **power** and **transport**.
Next we reached a larger demand than the supply, which led to expand extraction areas and techniques.

price pretty high, but in that situation given that high revenues, producers might be tempted to produce and sell more.
But if they all start selling a lot, then the prices will fall down, leading to a detrimental point for them.
However, there's a problem in this attempt to establish a global regulated cartel for oil, due to the presence of the biggest oil producer worldwide which is USA, that is not part of OPEC.
In **2018**, there was the actual take over by USA in terms of monthly crude oil production, overcoming Russia.
This phenomena was mostly due to the **shale revolution**: they came up with a new technology (a pure supply-side shock for the market), which has allowed to drill for gas and oil horizontally as well (fracking and horizontally drilling). Besides, this technique involves the usage of pretty light infrastructure, easy to deploy.

Given that in the USA there are **mineral rights for property owners**, different from most other countries, so you can profit from what you can extract out of your soil (they don't belong to the State). Then, there was a big incentive for land owner when these fracking instruments came out.
Already in 2014-16 there was a previous price war with OPEC, leading to a price fall as their production increased. However, the US producers managed to do so much technological upgrading and cost cutting that even though the price of oil was low, they could remain in business.
This was price, combined with the pandemic crisis, during when the majority of all the oil produced wasn't being demanded, and the western Texas (WTI, a type of oil) index future went negative (never happened), given that people were kind of paying in order to get rid of their oil.
Stocking oil is a neither easy nor cheap solution.
Definitions:
Spot price: The spot price is the **current price** in the marketplace at which a given asset—such as a security, commodity, or currency—can be bought or sold for immediate delivery. While spot prices are specific to both time and place, in a global economy the spot price of most securities or commodities tends to be fairly uniform worldwide when accounting for exchange rates.
Futures: Futures are **derivative financial contracts** that **obligate** the parties to transact an asset at a predetermined future date and price. The buyer must purchase or the seller must sell the underlying asset at the set price, regardless of the current market price at the expiration date.

Electricity markets

It's a pretty different world because electricity is much harder to trade, you need expensive infrastructures. What we get in reality is an actual discontinuity in prices, and this is a big issue in demand management, trying have people's demand for energy in those moments when we actually produce more, especially considering renewable energy sources (intermittent).
At the moment, we have to face to big technological problem of storage, because if you have intermittency of the supply.

There's a profit function:

$\pi = \mathbf{R} - \mathbf{C}$

Profits — Revenues — Costs (incl. capital costs)

Most private firms maximise profits by **choosing** how much to produce/sell (quantity), but depending on the degree of competition, they might control prices, as well (less common in the reality).

Given that total revenues and total costs are both functions of quantity, we can study mathematically at which quantity produced we reach the profit's maximisation.

$$Max_Q \pi = R - C$$

$$\frac{d\pi}{dQ} = \frac{dR}{dQ} - \frac{dC}{dQ} = 0$$

First order conditions (Fermat's theorem) →

$$\frac{dR}{dQ} = \frac{dC}{dQ}$$

Marginal revenues of an extra unit Q equals **marginal cost**

Everything "marginal" is referred to an extra unit.
A marginal revenue, is the revenue obtained by selling an extra unit of product (kWh, litre of fuel, etc..)
Why is this true, in economic terms?
• Imagine we are producing an amount Q1 such that one extra unit of Q gives more revenues than costs, so MR(Q1)>MC (Q1): would you call that an equilibrium? Would you produce that extra unit?
• No, in that case you need to produce more than Q1, and get the higher revenues above costs!
• Conversely, if at Q2 one extra unit costs more than it produces in revenues, then cut output.
• The firm finds the optimal Q* (equilibrium) when increasing or decreasing production of one unit does not create more revenues than costs or more costs than revenues.

But of course, you also have to check that you are actually at the top of the hill of the profit function, and not at the bottom of the valley, then you need to make sure the second derivative is negative.

Second order condition

$$\frac{d^2\pi}{dQ^2} = \frac{d^2R}{dQ^2} - \frac{d^2C}{dQ^2} < 0$$

→

$$\frac{d^2R}{dQ^2} < \frac{d^2C}{dQ^2}$$

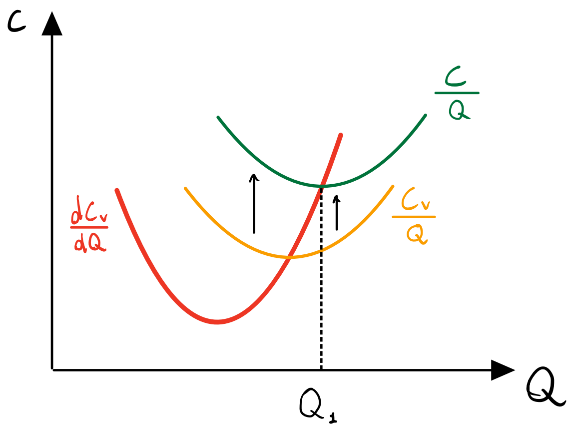
First study case: **Perfect competition**

1. **Homogeneous goods**:
• Consumers do not perceive differences among same products made by different firms (no brands, quality differences, etc.) ; this is the case of crude oil production in the real world.
• Products thus have the same price (e.g. Brent crude oil price)
• Firms are price-takers, cannot influence the price (this condition is not so comparable to the actual oil market, since main producers can significantly affect oil prices)
• Consumers' demand is **infinitely elastic** (for a single firm, there is no concern about producing too much, whatever Q they make will be absorbed by the market)

$$|\varepsilon|_p \rightarrow \infty$$

This variable cost per unit (average cost) function usually have a U-shape curve, with a clear trough/valley.
For instance, to produce one unit of solar energy, at the beginning is quite expensive, but then if you expand and you produce more and more of them, chances are that you're going to end up into an **economy of scale**.
At first, every extra unit produced reduces average costs (economies of scale) and costs less compared to the previous unit made.
When average costs start rising, the firm faces dis- economies of scale (too big to manage properly)
In the long run, we can include in total costs also those costs that don't vary with the Q (e.g. the cost of capital)=**fixed costs**, and this will lead to a vertical shift of the average cost curve, like if we added an offset.

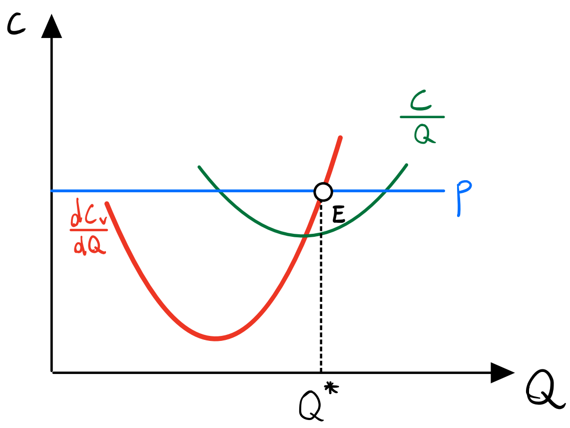
Marginal costs (dCv/dQ) crosses the average cost curve at its minimum (both in long and short run costs).
Until you reach Q1, your marginal cost is still lower than the average cost.
Because to the left, MC<AC, so adding an extra unit costs less than the average/mean cost of a unit of Q.
Adding that extra unit will reduce average costs. To the right, we'll have the opposite.



Let's say now, that there's a demand out there that gives us a price, and given that we are in perfect competition, this price is fixed (it falls from the sky), and you're not able to manipulate it. So, in this case, we can characterise the revenues of my firm just looking at price curve, which gives the unit revenue.
Then we can compute the total revenue as:

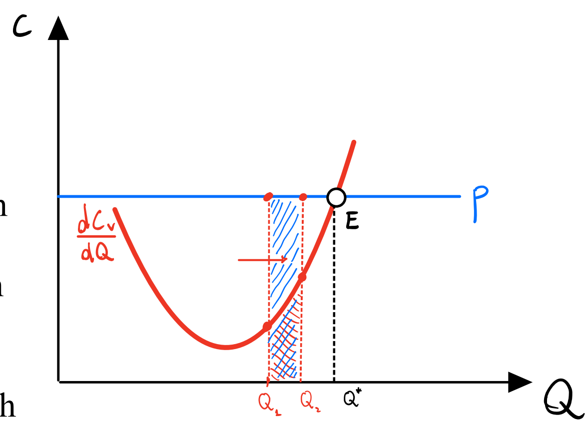
$$R=p*Q$$

Eventually, we will choose a Q such that the total profit is maximised, which implies that marginal revenue is equal to marginal cost.
We can easily infer from the previous relationship that the **marginal revenue** is:

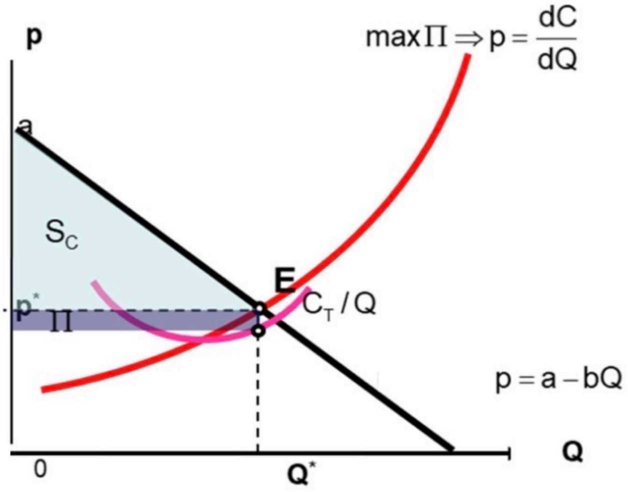


$$\frac{dR}{dQ} = \frac{d}{dQ}(pQ) = p$$

Marginal cost curve is already plotted, so the equilibrium will be set where our MC curve and MR curve intersect.
If you are producing Q1, then you will have benefits from enlarge the units until Q1, which will bring more cost for adding an extra unit (area below the marginal cost curve), but much more revenue (area below the price curve, which the marginal revenue is quite bigger).



How does the market clear? (Va in equilibrio)
If supply > demand (right of E), producers are asking for too high a price and consumers at that price want to buy a lot less. The lower demand induces producers to sell less. They converge to Q*. Conversely, if demand > supply, consumer want more of the scarce good, and they are willing to pay for it more than what suppliers need to cover marginal costs. Production increases to meet the extra-demand.

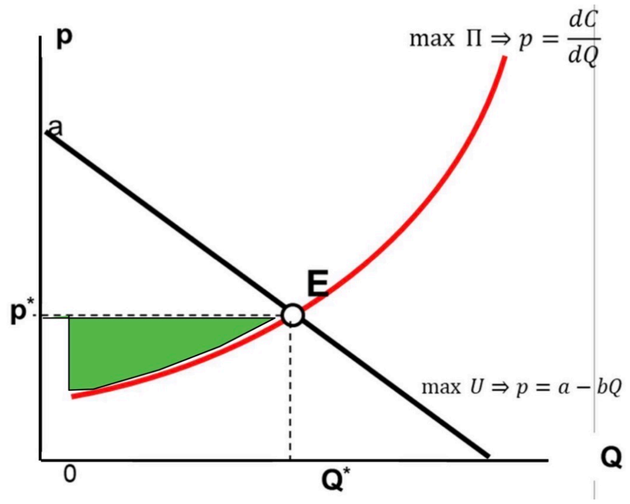


Of course, particularly if we are in perfect competition, there will be many firms competing with each other, and so the **extra profits** area we have seen when we were talking about a single firm **won't actually last a long time.**
If you're selling at p*, and making profits, there can be companies that enter the market start selling the same quantity Q*, even at a lower price, since they can still afford it, having a certain margin with respect of average cost.
In perfect competition, profits can only exist in the short run. In the long run, new entries reduces them to zero, and price equals average costs.

p=C/Q

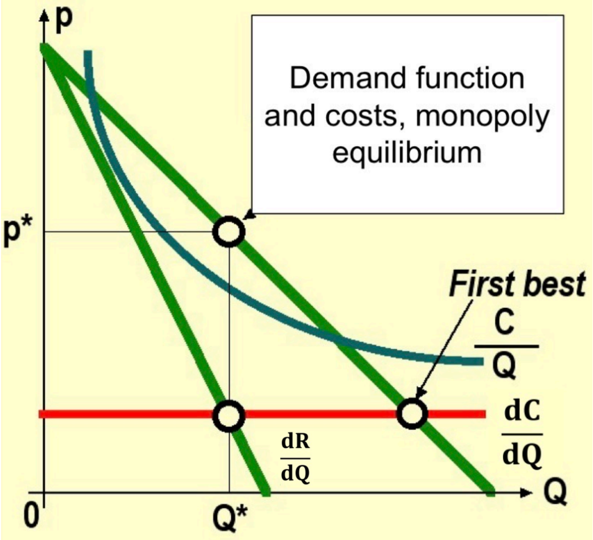
So, all you have in a perfectly competitive market is **producer surplus**.
Producer surplus is the area under the price and above the supply curve (marginal costs), for the units sold

$$P_s = \int_{Q_0}^{Q^*} (\overline{p} - S(Q))\, dx$$

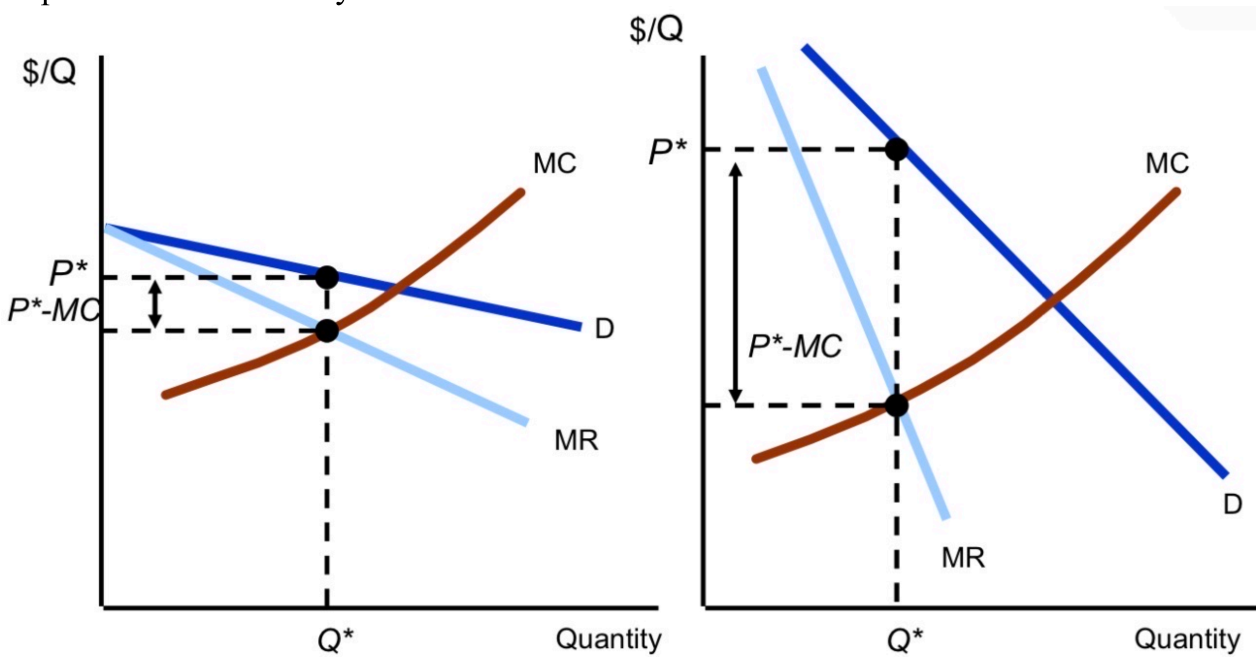


What happens at market equilibrium p* and Q*?

Consumers are willing to pay for commodity Q the range of prices captured by the demand curve. At the p* equilibrium, the consumers who were ready to pay a higher price get a "bonus" (surplus) because the single price p* is applied to all units Q*. In the same way, suppliers get a bonus because they were willing to sell at lower prices



For simplicity, let's assume a constant (flat) marginal costs, but of course they could be increasing, decreasing, U shaped, etc..
Monopoly is obviously going to maximise the profits, and due to the first order condition, we want MR=MC.
And this is the condition we reached even in perfect competition, BUT in a **monopoly**, this leads to a completely different outcome.
The firm can find the Q* at the equilibrium, at which corresponds a price p* (from the demand curve) far higher than the MC (due to the mark-up we mentioned before).
If we were in a **perfect competition** (if many firms existed), the market will clear at **MC=p** from the demand curve. And that's the "first best" outcome for society, where there would be much more units sold, and also at lower price.
That's why we usually try to regulate potential monopoly markets.
But how high the price and how low the quantities produced by the firm can be?
It depends on the elasticity of the demand:



The more elastic the demand function, the smaller the mark-up above costs
In a perfect competitive market, we end up against a perfectly flat demand curve, which means the elasticity of price is infinite, and this leads to a marginal revenue curve that overlap perfectly on it; as a result there can't be a mark-up above the marginal cost.

Let's take a look at *consumer* and *producer* **surplus**.
CS is as usual the area under the demand curve and above the price.
PS is the area under price and above the supply curve (marginal costs).

Supply of fossil and renewable energy

Outlook

- Supply of fossil
- Why do we need Renewable Energies?
- Recap on RES technologies
- Balancing the energy system with Renewables

Fossil

We need to understand deeply the characteristics of fossil supply, because it's our first reference, also when we are talking about renewables.
Coal, oil and natural gas are the main fossil energy carriers.
Oil refinery and transport is a complex and long-chain process.
The entire path crude oil go through starting from the extraction, to the final consumer (your car) is pretty challenging.
Between the brown and viscous liquid extracted from earth, practically unusable in that state, and the fuel feeding the engine of a car, we find the refining operation.
It's a transformation operation allowing us to obtain the many finish products that the market demands.
The refinement depends on four types of treatment:

- Separation
- Conversion
- Upgrading
- Mixing

These treatments vary according to the quality of crude to be treated, and the particularities of the market to be supplied.
The crude oil, taken at high temperature, is first introduced into a distillation oven; the petroleum compounds have different boiling temperatures, which allowed the different ones to be taken off: the lightest from the head of the column, to the heaviest from the bottom.
At the top, **LPG** (liquefied petroleum gas): butane and propane are recovered.
Under them, **petrol** for automobiles and **naphtha**.
At the bottom, the **kerosenes** are recovered (aircraft fuels, and domestic heating fuels), then **diesel** for engines, and then a series of heavier and heavier products.
These latter products are the lubricating oils, heavy fuels for production and industrial heat.
The refinery process, therefore, takes out barrels from certain regions of the world, every production area produce similar but not the exact same composition and quality of the barrel of crude oil.
How is the barrel of oil composed?
Below are showed the products obtained from a barrel of oil.
A barrel is about 159 litres.
The heaviest compounds are used to obtain the maritime fuels, which are basically solid at ambient condition. The staff has has to be inject steam in order to extract that fuel from the tank, to make it liquid and then extract.
The majority of products from the barrel are supposed to be exploited in transport purposes

from **BP** and **ENI**, with net-zero carbon footprint by 2040.
Energy and investments: across 2015-2019 (before pandemic) energy demand and emission growth was actually bigger than 2011-2015; in 2018 only **one-third** of 1800 billion $ global energy investments on **low-carbon**
Investment decline expected, due to bad economics (lower profits and cash flows, higher debts, reduced demand):

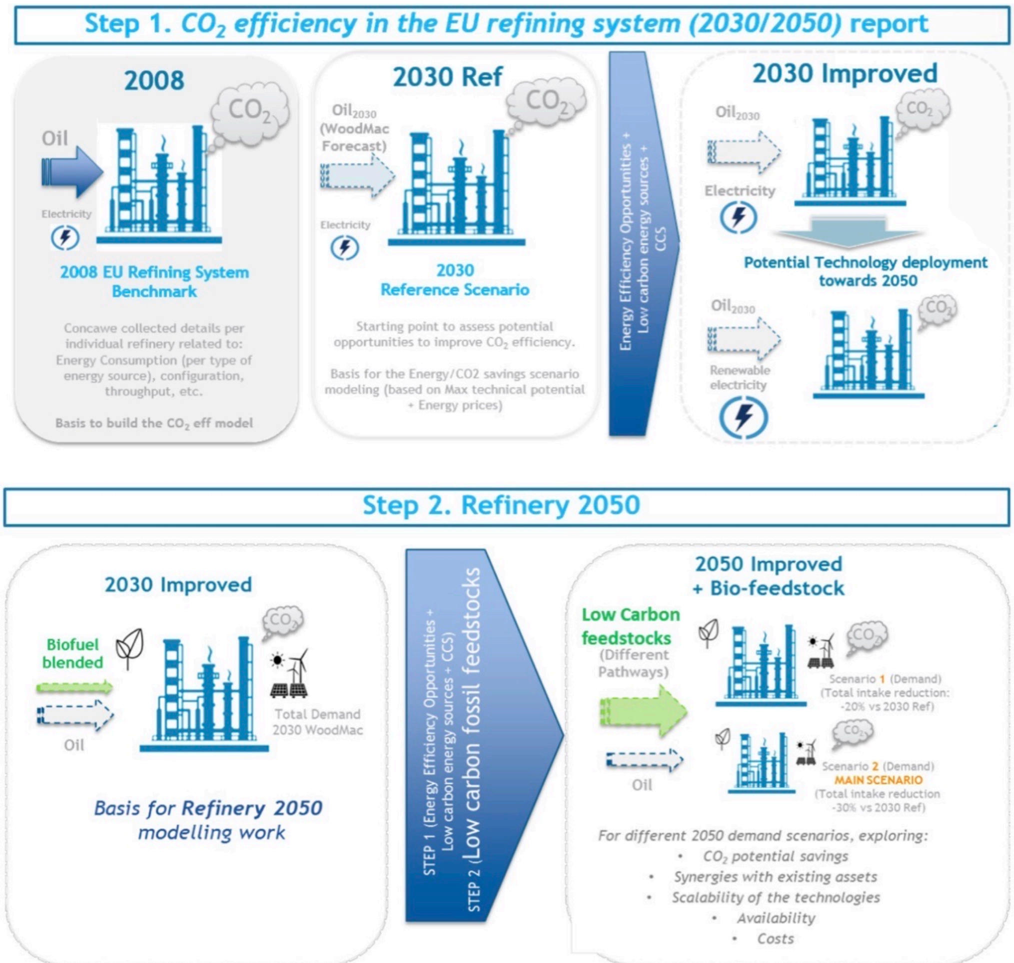
- HC -30%, RES -10%, Electricity Infrastructures -8% (necessary along RES development)
- Compared to investment levels needed for the Energy-Climate transition the reduction is even more significant

Under-investing in the energy sector could cause production /demand unbalances and increased energy prices when demand will recover

- reduced investments now will lead to 9 MMBD (million barrels per day) reduced production in 2021
- Rebound effects?

Biofuel production expected fall by 13% in 2020 due to lower demand

In 2020, the largest American oil association was calling and supporting for a carbon tax, which might seem something controversial, but it has a certain sense, above all because of the necessity of a stable system in which operate.
Big firms always have to make own forecast, because it's necessary to plan their investments. If they actually know what they have to pay for their polluting contribution and GHG emission, they can carry out a more effective and accurate planning and strategy (that can be different).



energy."

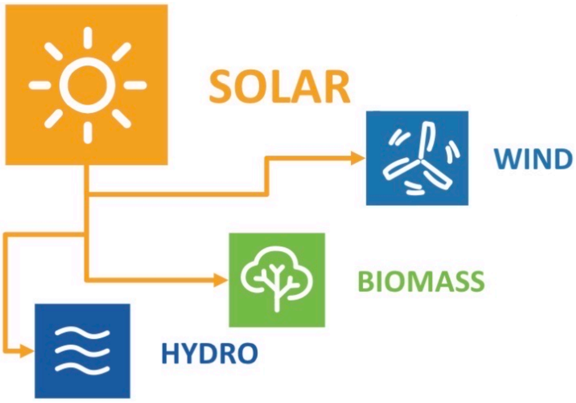
The International Energy Agency (**IEA**) defines renewable energy resources as those "derived from natural processes" and "replenished at a faster rate than they are consumed". The IEA definition of renewable energy includes the following sources: "electricity and heat derived from solar, wind, ocean, hydropower, biomass, geothermal resources, and biofuels and hydrogen derived from renewable resources".

Renewable energies (Renewables, RES) can help covering the increasing demand of energy at global (world) level without increasing the CO2 emissions;
Renewables **can** presently **already substitute fossil** energy sources in almost all their fields of utilisation. Renewables may, if implemented properly, contribute to social and economic development, energy access, a secure energy supply, and reducing negative impacts on the environment and health.
Last but not least, in fossil fuels producing countries, renewables can **decrease the internal fossils utilisation** and set fossil energy sources **free for export**.

Key Benefits

• **Environmental Benefits**
– Renewable energy technologies are clean sources of energy that have a much lower environmental impact than conventional energy technologies.
• **Energy for our children's children's children**
– Renewable energy will not run out. Ever. Other sources of energy are finite and will some day be depleted.
• **Energy Security**
– After the oil supply disruptions of the early 1970s, most of the nations that do not have enough fossil resources have increased their dependence on foreign oil supplies instead of decreasing it.
• **Jobs and the Economy**
– Most renewable energy investments are spent on materials and workmanship to build and maintain the facilities, rather than on costly energy imports. Renewable energy investments are usually spent within the nation, most of the time **locally**. This means that money remains in the Country **creating jobs** and supporting fuel local economies, rather than going overseas.
– Meanwhile, renewable energy technologies locally developed and **built** are being **sold abroad**, providing a **boost to the state trade deficit**.

Quick **overview** on the various **renewable** technologies



Some of the typical renewable resources are actually derived from the main one, which is solar energy.
The crop we cultivate and then the organic material (photosynthesis process) we can exploit to extract biomass and so energy, are a product of solar energy; same for wind and hydro power.

and potential energy stored in the rivers and lakes of the earth.
Humans have been harnessing water to perform work for thousands of years.
Greeks used water wheels for grinding wheat into flour more than 2,000 years ago; earliest innovations in using water power in China from 202 BC.
The evolution of the modern hydropower turbine began in the mid-1700s. The world's first hydroelectric project to power a single lamp in Northumberland, England, in 1878.
Presently it's the best assessed and implemented RES.

Geothermal

Energy flowing from the interior of the earth to its surface is fed by three different sources:

- energy stored in the interior of the earth resulting from the gravitational energy generated during the formation of the earth;
- primordial heat that had even existed before that time;
- heat released by the process of decay of radioactive isotopes in the earth (crust).

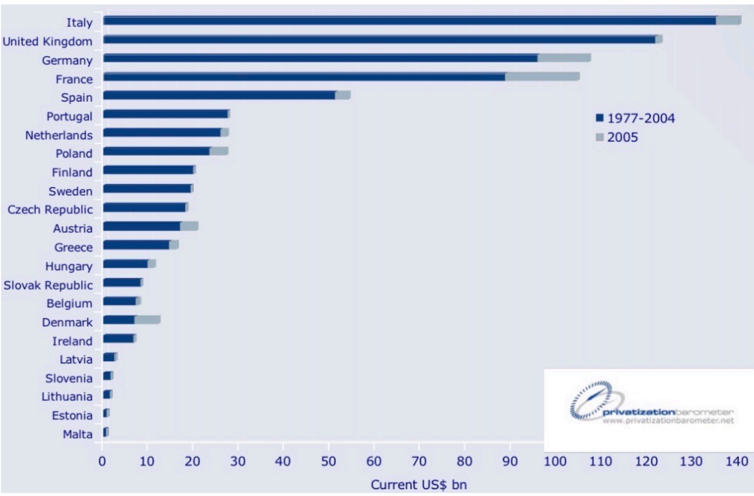
Due to the generally low heat conductivity of rocks, this heat resulting from these three sources is to a large extent still stored in the earth.
Geothermal energy has been used for thousands of years in some countries for cooking and heating. Thermal energy is contained in the rock and fluids beneath Earth's crust. Prince Piero Ginori Conti tested the first geothermal power generator on 4 July 1904 in Larderello, Italy. It successfully lit four light bulbs. Later, in 1911, the world's first commercial geothermal power plant was built there.

The **governments** are no longer who manage and own the firm, but the one who **set the rules** that should be followed by all the market players in order to operate inside the energy industry. We are going to focus mainly on prices regulations, but there are also other forms, such as policy, conditions for using infrastructure (electrical grid, pipeline, etc..), and so on.
These types of industries (public utilities) are key for national economies in terms of aggregate **investments** (around 18% of GDP), and **market capitalisation** (10 of the top 39 companies in terms of market capitalisation within the European Industrial Sector).
Insight: market capitalisation refers to the total dollar market value of a company's outstanding shares of stock. Commonly referred to as "market cap," it's calculated by multiplying the total number of a company's outstanding shares by the current market price of one share.
Market capitalization refers to how much a company is worth as determined by the stock market. It is defined as the total market value of all outstanding shares.
Companies can be sold, inside the market. Privatisation is the process which involves governments (not only central government, but also local ones, like municipal), owning shares of a specific company, that decide to sell them to private owners (even a part of them).

Privatisation history

- 1961, Federal Republic of **Germany**. Adenauer, who was the first chancellor (CDU, Christian Democratic Union) sold shares in Volkswagen and VEBA. Government balls out.
- 1973, **Chile**. Pinochet attempts to privatise companies nationalised under Allende (former socialist president)
- 1979-97, **UK**. Margaret Tatcher was in charge. Still the most important. SOE value added/ GDP from 10% to 0. They did it for two main reasons: the state needed money from the selling of the companies, and because the state-controlled companies at that time were very inefficient in the market, they were called "*white elephants*" (slowly moving, not suitable to adapt to the market).
- 1987-88 **Japan**. Nippon Telephone and Telegraph (NTT) the largest share offering in history (US$40bn).
- 1990s, Europe, **Italy**, Germany, **France**, **Spain**.
- 1992-1996, Mass privatisation in Russia and Czech Rep.
- Mid 1990s CEES and FSU

Speaking about who sold and obtained the most during this process of privatisation, **Italy** was the biggest value seller.



Country ranking by revenues

We sold big monopolistic companies (Enel, ENI, Telecom, etc..)
We are the first in terms of absolute values, but not the same in regards of revenues relative to GDP.
We privatised a value around the 8% of the GDP.

Perché privatizzare?

Formalmente, la privatizzazione è un processo con il quale lo Stato vende delle **azioni** di alcune aziende.
Perciò non si fa altro che creare delle azioni a partire da un'azienda e gettarle nel mercato finanziario.
Tutto questo ha un impatto molto positivo sui questi mercati (borsa), perché funzionano e quindi si dice che il mercato è **liquido**, tante più azioni sono vendute e circolano all'interno del mercato.
Ed un mercato finanziario efficiente è una risorsa economica per il Paese.
Le imprese prendono **risorse** dal mercato finanziario; se un'impresa ha bisogno di soldi, può andare in banca a chiedere un prestito, oppure può emettere azioni.
Un terzo elemento che ha portato storicamente alla sviluppo della privatizzazione delle imprese, ma un pò più delicato, è stato l'intento di **migliorare l'efficienza economica.**
Ci sono stati molti studi che hanno dimostrato come, nel passato, le imprese pubbliche fossero effettivamente poco efficienti di quelle private; questo vuol dire che erano in grado di fornire un certo servizio, MA ad un costo molto elevato, perché spendevano troppo (lavoro, materia prime..), portando ad un prezzo finale più elevato.
Ma recentemente, questa evidenza è venuta meno, visto che ci sono imprese pubbliche (cioè in buona parte controllate dello Stato) molto ben gestite e che funzionano molto bene.
Due delle **imprese leader** nel mercato energetico dell'elettricità nel panorama europeo, sono proprio la francese EDF (80% delle azioni sono statali), e l'italiana ENEL (30%).

Tipologie di privatizzazione

Ci sono prevalentemente 3 metodi:

- Questa tipologia di approccio è stata utilizzata in Italia: vendita diretta (**direct sales**). In questo metodo, lo stato che vuole vendere un'azienda va fa sul mercato e negozia direttamente con dei privati interessati all'acquisto. Lo Stato sa bene a chi sta vendendo le azioni, ma potrebbe farlo a condizioni economiche non così vantaggiose, perché sta di per sè limitando la competizione;
- Emissione di azioni (**share issue privatisation, SIPs)**, utilizzato in UK: in questo caso lo Stato crea azioni e le mette nel mercato finanziario (borsa), e il proprietario dell'azienda diventerà chiunque acquista la maggioranza delle azioni sul mercato. Perciò non si sa a priori chi saranno gli acquirenti, ma il mercato stesso andrà a decidere il valore di quella azienda, se l'azienda vale tanto, avrà tanti potenziali acquirenti ed il suo valore salirà molto;
- Privatizzazione tramite voucher (**voucher privatisation):** applicato nei Paesi ex-URSS, compresa la Russia. Storicamente erano paesi comunisti, e il proprietario delle aziende era lo Stato, ma lo era per nome e per conto del popolo, perciò seppur controllate dallo stato, le aziende sono teoricamente del popolo. Quando nel 1989 cadde il muro di Berlino, i rubli si svalutarono enormemente, i Paesi versavano nella povertà, gran parte della popolazione erano contadini e senza istruzione. Quindi, il governo di allora prese le aziende statali, impose un certo valore ad ognuna, lo divise in tanti equivalenti "voucher" (foglio, assegno), e lo mandarono a tutti i cittadini, che diventarono così proprietari diretti di una certa piccola percentuale di quella certa azienda. Quello che successe dopo, è che tante persone andarono a casa di molti di questi cittadini privi di formazione, scambiando la proprietà di questi voucher con un quantitativo immediato di denaro (ben al di sotto del reale valore), accumulando un

altri.
4. **Mercati mancati**, che non esistono, come il mercato della CO2: stiamo cercando di individuare un prezzo per le emissioni di CO2, per capire quanto costa emetterne.
Oppure, beni pubblici, non forniti da alcun mercato (difesa, illuminazione stradale, le rete, etc..).

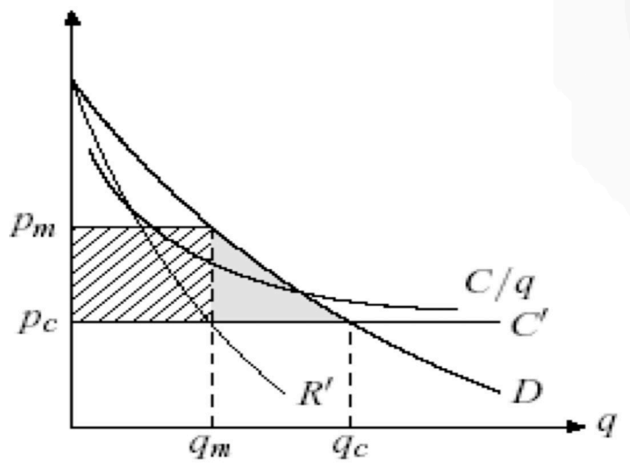
Come è cambiato perciò il **ruolo dello Stato** in tutto ciò?

Queste grandi riforme hanno avuto la finalità di rendere lo Stato non più produttore diretto dei servizi e dei beni, e di:
- portare a migliorare il più possibile la concorrenza in tutti mercati e i settori in cui è possibile; aumentare il numero di imprese
- dove la concorrenza non è possibile, deve intervenire e regolare il mercato

I governi europei hanno deciso di intervenire in questi settori non direttamente, ma istituendo degli organi pubblici *ad hoc,* come le **autorità di regolazione indipendenti** (come ARERA).
L'ottica per cui si è voluto creare una terza parte più imparziale, è il fatto che lo stato ha privatizzato le aziende, ma ne detiene spesso una parte di proprietà, per evitare quindi un conflitto di interesse.
Su cosa interviene tipicamente questo tipo di autorità:
1. Prezzi
2. Condizioni di entrata sul mercato
3. Standard di qualità
4. Condizioni d'accesso all'uso delle infrastrutture (stoccaggio/trasmissione gas, energia elettrica)

Ricapitolando:
In Europa, in genere esisteva un'unica impresa che dominava l'intero settore (e.g. Enel), e il mercato era molto concentrato, praticamente un monopolio.
C'erano quindi delle enormi barriere nell'entrare nel mercato/settore.
Il prezzo era fissato dal monopolio stesso, e questo ha portato a prezzi per le imprese molto alti, e il mercato era quindi molto poco trasparente.

Grazie all'emissione di diversi pacchetti di direttive europee (1996, 2003, 2009), ovvero i 3 Energy packages della comissione Europea, si sono attuate varie riforme che hanno rivoluzionato il mercato:
- **apertura del mercato** alla concorrenza, nei segmenti in cui la concorrenza è possibile: la produzione ad esempio è libera, chiunque munito di un PV plant può produrre energia elettrica (*prosumer*), mentre la trasmissione dell'energia elettrica ad alta tensione è gestita da un unico ente (TERNA) a livello nazionale, poiché non avrebbe senso costruire delle reti in parallelo per svolgere la stessa funzione. Anche per la distribuzione si ha un unico ente (monopolio9, in questo caso locale (distributore energia elettrica a Torino è IREN). Infine poi, da quella rete, noi finali consumatori acquistiamo energia da tante varie imprese, in diretta competizione tra di loro, su un mercato aperto e libero.
- per aprire però questo mercato, è stato quindi necessario aver suddiviso il settore in varie *business units,* secondo il processo di **unbundling**: il settore di produzione, trasmissione, distribuzione e vendita al consumatore finale sono tutte separate tra di loro.

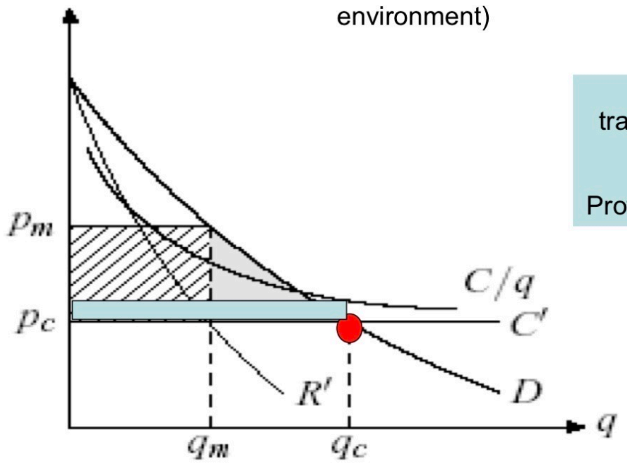


L'area tratteggiata è data dal prezzo di vendita del monopolio *Pm* meno il costo marginale *C' (guadagno marginale)*, per la quantità venduta *Qm*, e il tutto rappresenta quindi il guadagno complessivo, il profitto.
Ma, il fatto di aumentare i prezzi, ha con effetto sul mercato di ridurre la quantità di conseguenza, e quindi molti consumatori che in condizioni di concorrenza avrebbero comprato quel bene, sono ora fuori dal mercato, **perdendo** così un certo numero di **potenziali transazioni**.
Perciò, l'area di "triangolo" a destra, rappresenta tutto ciò che viene perso (come valore), dal passaggio al mercato monopolistico.
Monopolio crea una inefficienza, alcune persone che avrebbero comprato, non lo fanno più.
In particolare, questo fenomeno viene detto **inefficienza allocativa** (allocative efficiency)
Ci sono anche altri fattori di "perdita":

- un'impresa monopolistica non ha incentivi a minimizzare costi, poichè il mio surplus lo spedisco all'invio al consumatore finale, con un prezzo molto elevato, e non c'è altra concorrenza che offre lo stesso servizio. **Mancanza di efficienza produttiva e gestionale**
- le imprese monopolistiche vendendo beni essenziali, che tutti vogliono comprare, non hanno problemi di magazzino e di stoccaggio, e molti dei soldi ricavati potrebbero essere mal spesi. Si può avere quindi peculiari comportamento di trattamento tra imprese e governi/legislatori in base alle esigenze dell'uno e dell'altro, come le ***lobby***. Questi comportamenti sonno chiamati ***rent seeking behaviour***, che portano quindi ad uno spreco di risorse (economicamente parlando):è un concetto economico che si verifica quando un'entità cerca di ottenere ricchezza aggiuntiva senza alcun contributo reciproco di produttività. In genere, ruota attorno ai servizi sociali finanziati dal governo e ai programmi di servizi sociali. Questo tipo di fenomeno è legale, purché i vari fondi e finanziamenti a partiti politici siano resi trasparenti al pubblico.

Cosa si può fare quindi?

Affrontiamo ora un prima battuta aspetti totalmente <u>teorici</u> su come si può intervenire
Una volta si decide di regolare un mercato, **qual'è la tariffa migliore da implementare**?
In principio, questa dovrebbe essere quella che somiglia al prezzo in condizione di concorrenza massima, poiché mi garantisce la condizione migliore per l'economia.



E questa condizione è individuata da *p=MC,* obbligando l'impresa a vendere *Qc.*
MA c'è un problema. In questo caso il costo marginale è sotto il costo medio!
E si dimostra che questo è sempre vero quando il costo medio è decrescente, ipotesi verosimile visto che in questo tipo di settore esistono **economie di scala**.
Quando più unità di un bene o servizio possono essere prodotte su larga scala, ma con (in media)

Questa valutazione può ad esempio essere fatta in base al bilancio annuale.
Da questa formula, possiamo ricavarne l'inversa per calcolare la tariffa (prezzo) finale.
Ovviamente, i prezzi e le regolazioni si fanno "oggi", per poi essere applicate e promulgate ufficialmente "domani". Questo comporta delle leggere **incertezze**, legate ad esempio al **volume di vendita.** Immaginando di poter stimare "Q" tramite un dettagliata previsione, si può quindi calcolare il prezzo regolamentato da imporre.

$$TR = \rho \cdot K + Opex \qquad\qquad P = TR/Q$$

Può capitare però che si sbaglino le previsioni: se la quantità di servizio richiesta è maggiore di quella prevista, l'azienda guadagnerà di più rispetto a quanto previsto, e quindi il prezzo imposto risulterà troppo basso!
Perciò, ogni anno avviene un processo di revisione detto ***hearing process***, in cui si va a vedere se il guadagno che era previsto per l'anno è stato effettivamente conseguito oppure no.
Se si è guadagnato effettivamente di più, si andrà di conseguenza a riabbassare ulteriormente i prezzi, per rientrare nel livello limite di guadagno percentuale, e viceversa se si è guadagnato meno del previsto.
Come risultato, un anno risulterà guadagnare un pò di più, mentre un altro un pò di meno, ma in media negli anni risulterà pari al valore sperato.

Se il regolatore impone una tariffa derivante da una tale formula, l'impresa è portata a ridurre i propri costi operativi (Opex), diventando più efficiente?
NO, perché se il manager riduce i costi, a parità di ricavi, si ottiene un rendimento (rate of return) che sale, e quindi il regolatore l'anno successivo avendo riscontrato un ROR maggiore del livello imposto, imporrà un prezzo minore.
Perciò, questo metodo non induce al miglioramento del miglioramento dell'**efficienza** produttiva.
Un atro aspetto fondamentale, sta nell' imporre un valore ρ che sia maggiore del tasso di rendimento medio *r* che otterrei investendo i soldi in borsa, perché se non così non fosse nessuno si prederebbe in carico la gestione di un'impresa.
Di conseguenza, però, si può raggiungere la condizione in cui si hanno **sovra-investimenti** (over-investments) nella impresa, poiché il rendimento sarà maggiore del mercato, e il rischio è nullo dato che l'attività è regolamentata.
Infine, per quanto riguarda la **qualità**, si hanno incentivi a mantenerla alta, spendendo anche di più, dato che in questa formula si hanno ripercussioni ripercussioni positive.
Nel settore elettrico, la qualità può essere identificata con l'indice SAIDI (System Average Interruption Duration Index), che misura la numerosità delle interruzioni superiori a 3 minuti.

☺
- Financial integrity of regulated firm is always guaranteed
- Monitoring of profits
- No incentive to reduce service quality

☹
- No incentive to reduce costs (no «productive» efficiency)
- Incentive to overinvest if $\rho > r$
- No incentive for innovation
- Risk of accounting manipulation
- Information demanding method, high administrative costs

Pro e Contro

(*regulatory lag*). Quindi, i prezzi si fissano ad esempio per i prossimi 5 anni.
Dato che l'impresa sa che il prezzo avrà un certo andamento, avrà incentivo ad abbassare i costi operativi, dato che questo riduzione si tradurrà in un diretto guadagno per l'azienda.
Un'impresa è libera di imporre dei singoli prezzi specifici di un certo servizio, MA deve adempiere al vincolo sul livello di prezzo mediato imposto del *price cap.*

Per la **qualità**?

Avendo questa formula come naturale incentivo quello di abbassare i costi, si potrebbe impattare negativamente sulla qualità, che invece comporta costi più elevati.

Investimenti?

Compiere alcuni tipo di investimenti, come in automazione, che comporta un aumento di *capex,* ma diminuendo gli *opex,* sarà ben visto in questo contesto! Questo è possibile dato che il periodo regolatorio è sufficientemente lungo da ottenere i benefici.

Profitti stabili?

NO. Avendo incentivi ad abbassare i costi, se si è sufficientemente bravi si aumenta il proprio rendimento, altrimenti si può anche abbassare.
Perciò, questo meccanismo ha un rendimento potenzialmente più elevato, ma potrebbe essere **instabile**.

Pro e Contro

- Incentive to reduce operative costs ⇒ increase in productive efficiency
- Regulated firms freely set their prices.
- Less administrative burdens on regulator

- No cap on profits
- Incentive to reduce quality of services
- Prices may diverge significantly from realized costs
- Risk shifts to the regulated firm
- Unclear incentives for innovation
- Complex to implement – uncertainty about costs, X, regulatory lag.

Priced based mechanisms	Rate of Return	Price Cap
Prevent exercise of market power	Yes	Yes
Productive efficiency (short run variable costs)	No	Yes
Dynamic efficiency (long run innovation)	No	Maybe
Ensures high quality of service	Yes	No

aziende del settore, non può essere giustificata da differenza nelle tecnologie, dato che si sta parlando dello stesso business.
Perciò, si potrebbe imporre alle aziende un prezzo che rispetti NON il costo medio di una specifica azienda, ma il costo medio su tutte quante.
Nel caso di un'impresa molto efficiente, che ha un costo medio inferiore al prezzo, questo meccanismo permette di avere un guadagno, si avrà perciò lo stimolo a raggiungere un'efficienza maggiore alla media.
Nel caso di un'impresa che ha costi medi inferiori, ci sarà anche lì un incentivo di aumentare l'efficienza.
Si **stimola** perciò le imprese ad intraprendere un **comportamento competitivo**, anche nei mercati in cui una vera competizione sarebbe ostacolata.
Il piano di confronto può coprire:

- compagnie operanti nello stesso settore all'interno del singolo Paese (**national** benchmarking)
- compagnie operanti nello stesso settore MA in Paesi diversi (**international** benchmarking)

Si è comunque di fronte ad altri problemi tipici:

- Le autorità devono comunque raccogliere tutti i **dati** necessari all'analisi comparativa, e serve tempo per creare tali *database;*
- Rimane il potenziale di connivenza tra le imprese regolate, al fine di mentire concordemente sui costi medi di produzione, ma questo si definisce **processo di collusione**, che però è illegale e pesantemente sanzionabile;

- Define industry's **best practices** and target regulation against it
- Potential application to all sectors
- Reduce information rents (profits based on lack of transparency)

☺

- Different firms, heterogeneity
- Lack of data
- Potential collusion among regulated firms;

☹

- Il confronto va eseguito su imprese, in parte diverse tra di loro, dovendo quindi ignorare un problema di eterogeneità;

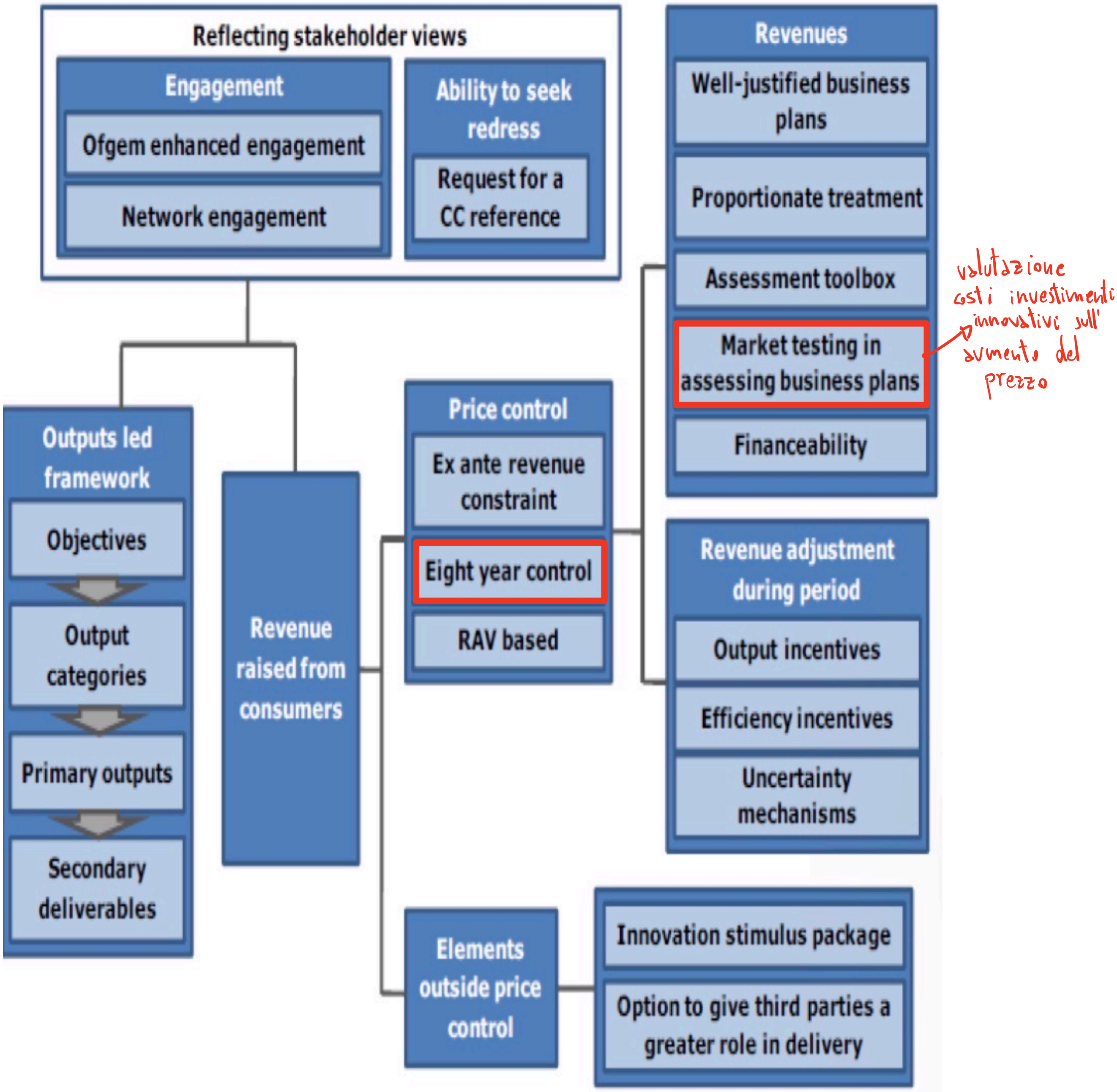
Nuovi obiettivi di regolazione

RPI (Retail Price Index) non è altro che inflazione.
Price cap puntava tutto sulla riduzione dei costi per il consumatore finale, ma al giorno d'oggi non è l'unico obiettivo che si può avere.
Ci sono molti altri obiettivi importanti:

1. Affidabilità della rete (sicurezza nell'approvvigionamento energetico)
2. Impatto ambientale
3. Soddisfazione della clientela
4. Capacità di adempiere obblighi sociali
5. Investimenti a lungo termini e innovazione

Si passa quindi da un controllo dei prezzi e delle efficienza, prettamente concentrato sugli **inputs** (costi operativi, etc..) a nuovi incentivi che guardano anche al miglioramento del benessere sociale e ad una varietà di **outputs.**
L'innovazione è un processo di per sé rischioso, perché si investe in cose che non si sa ancora

investimenti di innovazione impattano troppo sulle tariffe dei consumatori, bisogna spostare o eliminare gli investimenti.



Ogni azienda andrà a negoziare le gli investimenti da fare, per sé.
E' una regolazione più "targettizzata".