Energy transition: ZEN objective

Booklet CEPREMAP

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The climate clock

The carbon budget

- Almost linear relation between the cumulative CO_2 emissions and the temperature increase ΔT.
- $\Longrightarrow$ to any limit target of ΔT (eg: ≤ 1.5 or 2° C) is associated maximum cumulative emissions. This is the global carbon budget.
- Taking into account the cumulative emissions between 1870 and 2018, the IPCC (special report 1.5, 2018) estimates the remaining carbon budget for a target $\Delta T = 2^\circ$ C (resp. 1.5° C) to 1170 (resp. 420) Gt CO_2.
- Global emissions of CO_2 in 2018: 42.1 Gt. At this rate, carbon budget remaining exhausted in around 28 years (resp. 10 years).
- The climate clock is running very fast.

How to reach the ZEN goal?

- Whatever the temperature objective, in the future it will be necessary to achieve carbon neutrality. This is the goal of zero net emissions (ZEN).
- IPCC: carbon neutrality must be reached in 2075 for $\Delta T \leq 2^\circ$ C (resp. 2050 for 1.5° C).
- The options: the identity of Kaya.

$$\text{CO}_2 \text{ emissions} =$$

$$\underbrace{\text{population}}_{\text{demography}} \times \underbrace{\frac{\text{GDP}}{\text{population}}}_{\text{economic growth}} \times \underbrace{\frac{\text{energy}}{\text{GDP}}}_{\text{energy intensity of GDP}} \times \underbrace{\frac{\text{CO emissions}_2}{\text{energy}}}_{\text{carbon intensity of energy}}$$

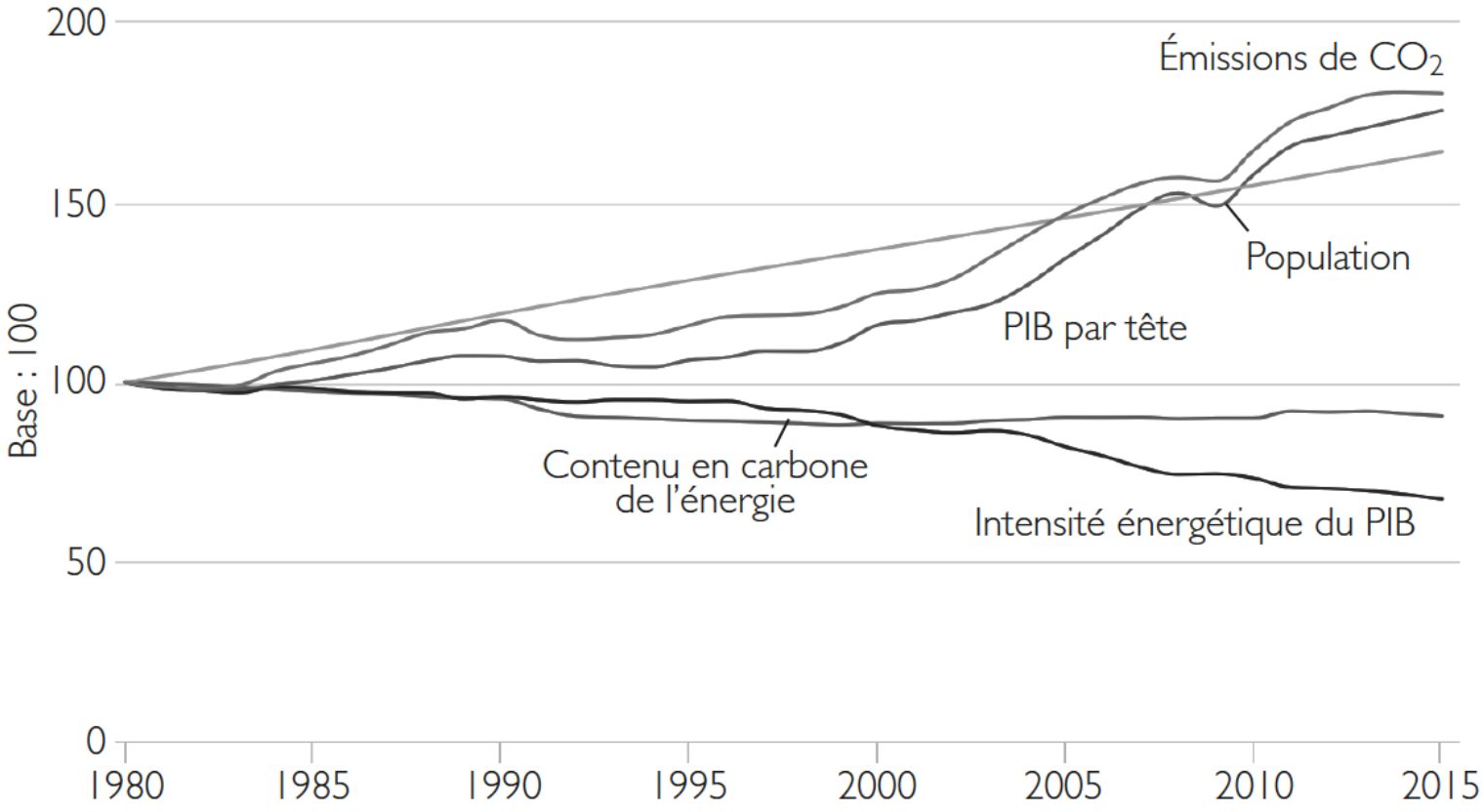


Figure 3 – L'identité de Kaya au niveau mondial (1980-2015).

Source : The Shift Project Database.

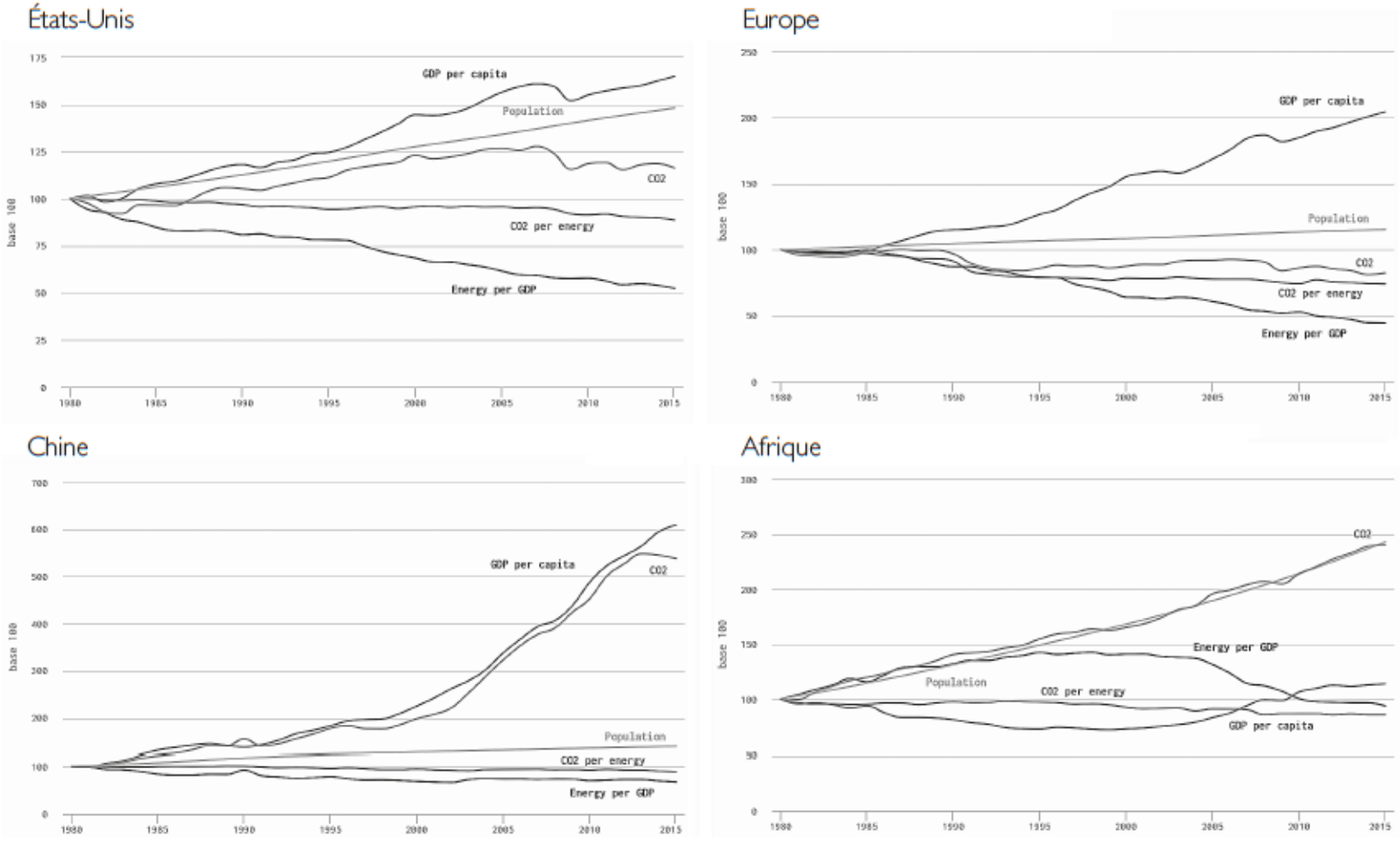


Figure 4 – L'identité de Kaya : États-Unis, Europe, Chine et Afrique (1980-2015).

Source : The Shift Project Database.

Options:

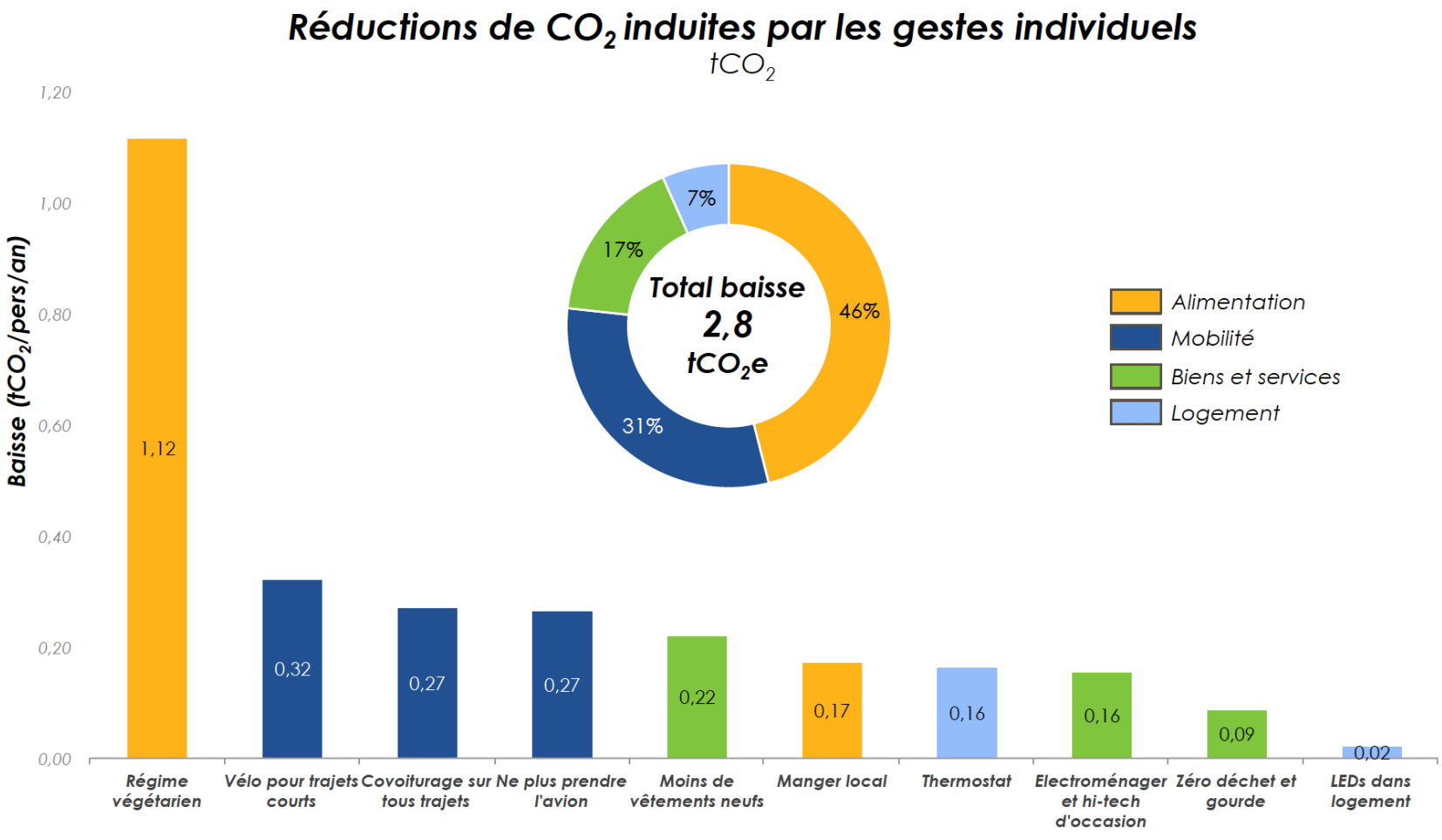
- reduce population growth
  - Has population a value in itself ?
- reduce economic growth
  - it works: see the drop in emissions following the Covid-19 pandemic
  - option “ degrowth ”: unacceptable for poor countries, very low social support in rich countries
  - what goal, GDP growth or welfare growth? $\rightarrow$ is GDP a good metric?
- reduce the energy intensity of GDP
  - changes in behavior (“ small gestures ”, remote working)
  - recycling, circular economy
  - technical progress saving energy
- reduce the carbon content of energy
  - decarbonize electricity production
  - switch to electricity in transport, residential, tertiary and industry.

How to reach the ZEN goal?

Households: changing behavior

- What would be the impact on greenhouse gas emissions of a more virtuous behavior of households?
- Definition of small gestures:

  Vegetarian diet Bike for short journeys Carpooling on all journeys (2.2 people per car) Don't fly anymore Buy three times less new clothes Eat local Lower the temperature of your home Used household appliances and high-tech Zero waste and gourd LEDs in its housing



The impact of the small gestures of a heroic Frenchman

Source: Carbone 4 (Dugast and Soyeux, 2019)

- Impact of changing the behavior of a “ heroic ” Frenchman: reduction in emissions of 2.8 tCO2eq, i.e. reduction of the carbon footprint of 26 %.
- How to trigger these changes in behavior?
  - science, education, information
  - change of social norms (the “ shame of the plane ” Swedish)
  - climatic disasters
  - climate policy
- Accepting small gestures does not necessarily mean accepting more fundamental changes and a consequent climate policy.
- Extrinsic motivation vs intrinsic motivation.
- Change of demand structure $\Leftrightarrow$ change of structure of the supply.

The decarbonisation of energy

Fossil fuels are not rare

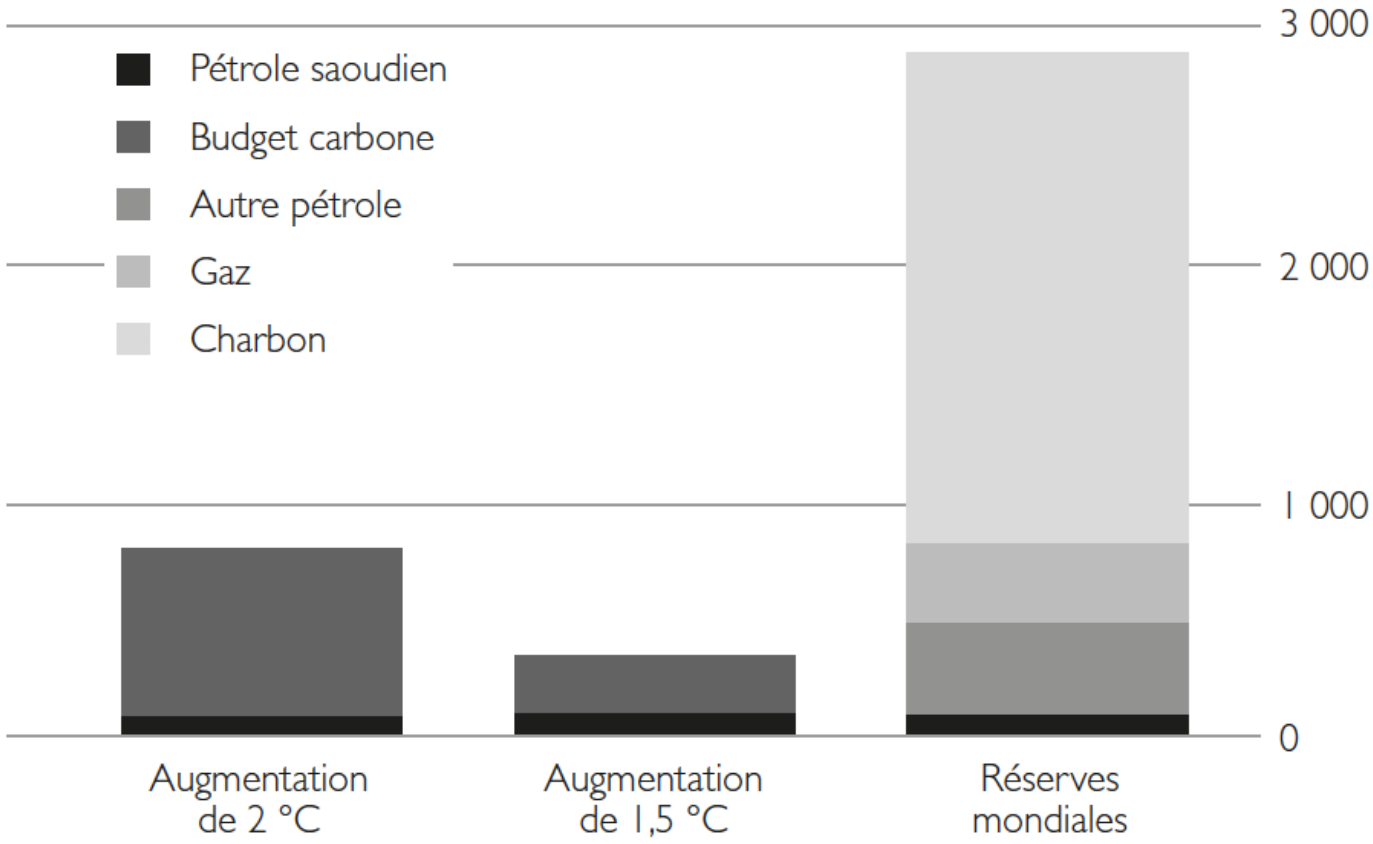


Figure 6 – Estimations des réserves et ressources d'énergies fossiles du contenu en carbone (Gt CO_2e).

Source : *Financial Times,* 2019 (d'après Rystad Energy, GIEC, IEA, World Energy Council).

- Since fossil resources are too abundant, some will need stay underground.
- These are stranded assets.
- Identification of potential stranded fossil resources and their geographic distribution: McGlade and Ekins (2015).
- Coal and a good part of oil are stranded fossil resources in the ZEN 2050 target scenario.
- But exploration and investment continues.
  - Lack of credibility of the climate objective and policy
  - Myopia leading to think that the stranded assets will be those of others

What about natural gas ?

Tableau 2 – Coefficients d'émission de CO_2

	Coefficient d'émission (kg de CO_2 par million de Btu)
Lignite	97,7
Charbon sub-bitumineux	97,2
Charbon bitumineux	93,3
Gazole	73,16
Kérosène	72,3
Carburant pour l'aviation	70,9
Gaz naturel	53,07

Source : Energy Information Administration (*http://www.eia.gov/environment/emissions/co2_vol_mass.cfm*)

- Less polluting than coal
- But methane leakage ?
- carbon leakage ?
- Technological lock-in

The decarbonisation of energy

From fossil fuels to renewable energies

Renewable energies: no more problem of cost.

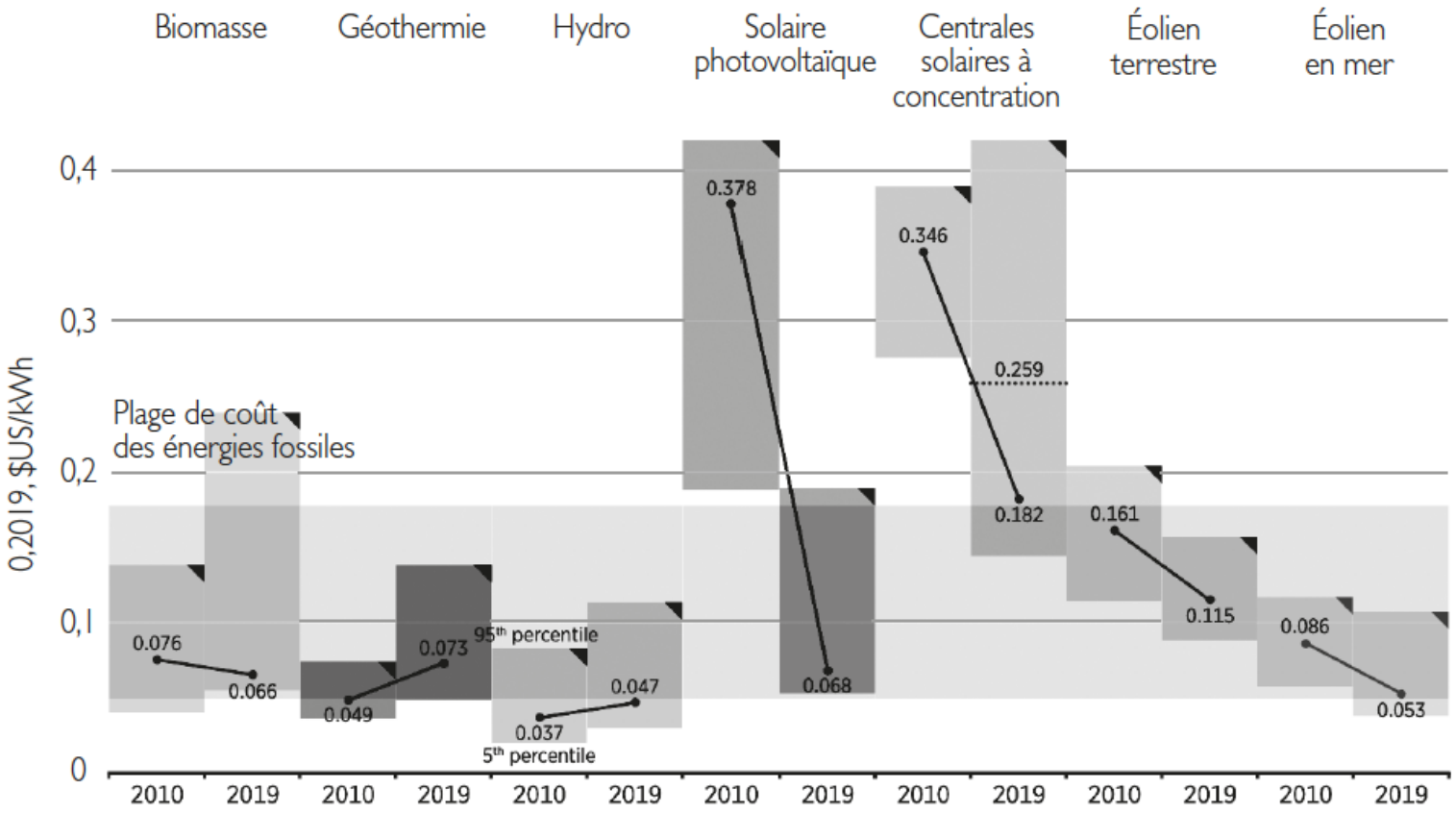


Figure 9 – LCOE des énergies renouvelables (2010 et 2019).

Source : IRENA, 2020.

- Problem: renewable energies are not available continuously and on demand - they are not are not controllable.
- Characteristic of " modern " RE: their production is
  - variable, unrelated to demand ($\Rightarrow$ potentially negative electricity price)
  - uncertain
  - constrained by geographic location
  - with low variable costs.
- Solutions to handle intermittence:
  - backup by thermal power stations (Germany)
  - geographic diversification
  - storage
  - demand management.
  - redundancy

The decarbonisation of energy

Carbon sinks and negative emissions

- The vast majority of scenarios for $\Delta T \leq 2^\circ$ C include significant negative emissions.
- Reforestation: according to the IPCC an increase of 1 billion hectares of forest will be necessary for $\Delta T \leq 1.5^\circ$ C by 2050 Debate in progress. Land use conflict problem.
- Bioenergy (biomass absorbs carbon as it grows) combined with CSC. Again, land use conflict.
- Geoengineering, option of last resort?

Climate policy

Give a price to carbon

- Elementary economics course: we know since Pigou 1921 that the carbon tax is efficient.
  - It gives a price to a good which, having none, is over-consumed.
  - It reduces carbon emissions at a lower cost.
  - It guides investments by providing a "business model" for green activities
- A carbon tax may not be enough. There are other imperfections and externalities:
  - sub-supply of "green" R& D
  - behavioral bias of households behavior $\rightarrow$ equipment subsidy
  - credit constraints
  - externalities of network
  - etc.

- In reality, many instruments: technical standards (vehicles and buildings), subsidies clean technologies and RE, public investments green, bonus-malus, negotiable emission allowance markets, carbon taxes, ...
- Efficiency of the different instruments, and real cost in terms of tonnes of carbon avoided uncertain.
- Evaluation essential, but rare.
- Properly calibrating alternative instruments to the carbon tax and avoiding the rebound effect can prove difficult (eg: 2008 automobile bonus-malus in France).
- But the carbon tax arouses very strong opposition. The grants and even standards are much more popular. Is this because their cost is hidden? Or because the standards are considered more "fair"?

Climate policy

Counteract the regressive effect of climate policies

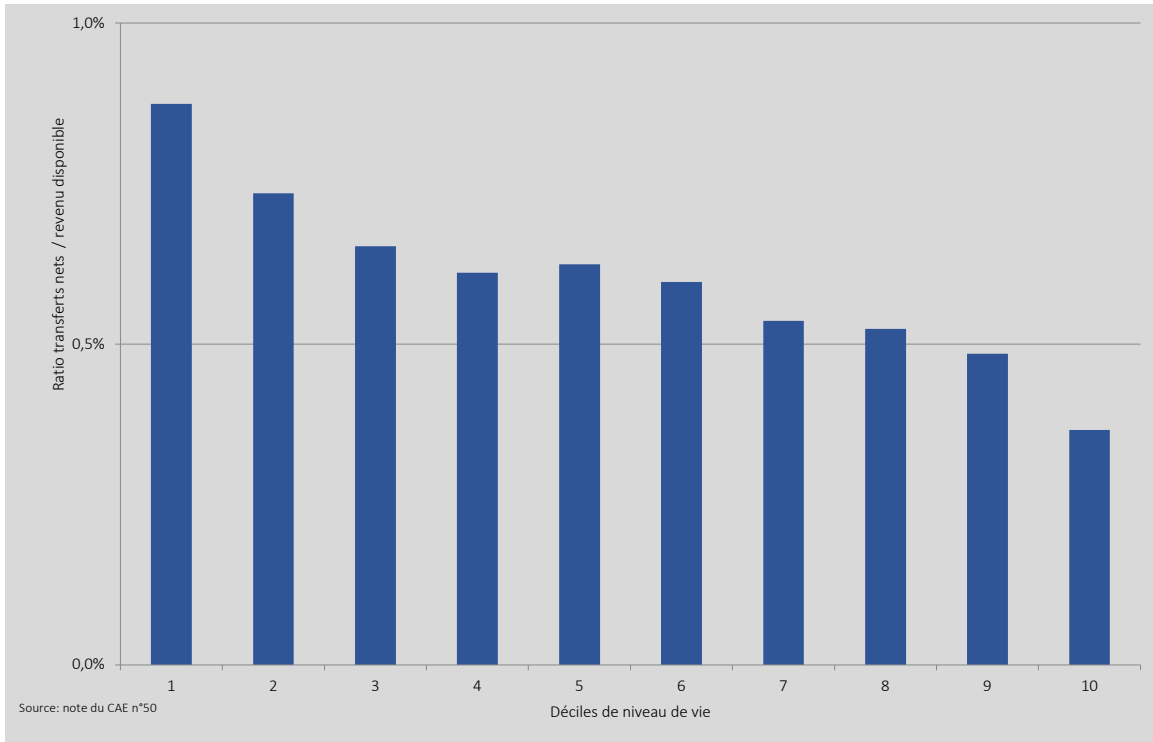
- The carbon tax is regressive.
- The horizontal heterogeneity, explained by the differences in location and equipment, is important.
- However, we can compensate for the regressive effects.
- E.g .: the policy proposal “ tax and dividend ” in the USA.
- Possible to target transfers so that more vulnerable are not the losers.
- Standards and regulations are often just as regressive as the carbon tax and the subsidies mainly benefit wealthy households (eg vehicle and housing standards in the US).

Example of the French carbon tax

- Concerns emissions from diffuse sources = 3/4 of emissions French, stable since 1990.
- Existing instruments, standards, subsidies, bonus-malus etc. did not lower emissions from transport and housing.
- After several failed attempts, implementation in 2015 of a carbon tax, Climate-Energy Contribution (CCE).
- CCE: excise applied to the CO_2 content of energies. Introduced at a very low rate, with a government commitment to increase this rate regularly over time. Reached end 2018 a level of 44.6 €/ tCO $_2$.
- Change to 55 € and continuation of alignment of diesel taxation on that of super frozen by the government in November 2018 continued at the Yellow Vests demonstrations.
- CCE paid 2/3 by households, 1/3 by companies.

Bureau et al. (2019) analyze the impacts on power purchase an increase in the ECA from its current level to the level planned for 2022 (86.2 €/ tCO_2), accompanied by the planned catching up of taxation on diesel.

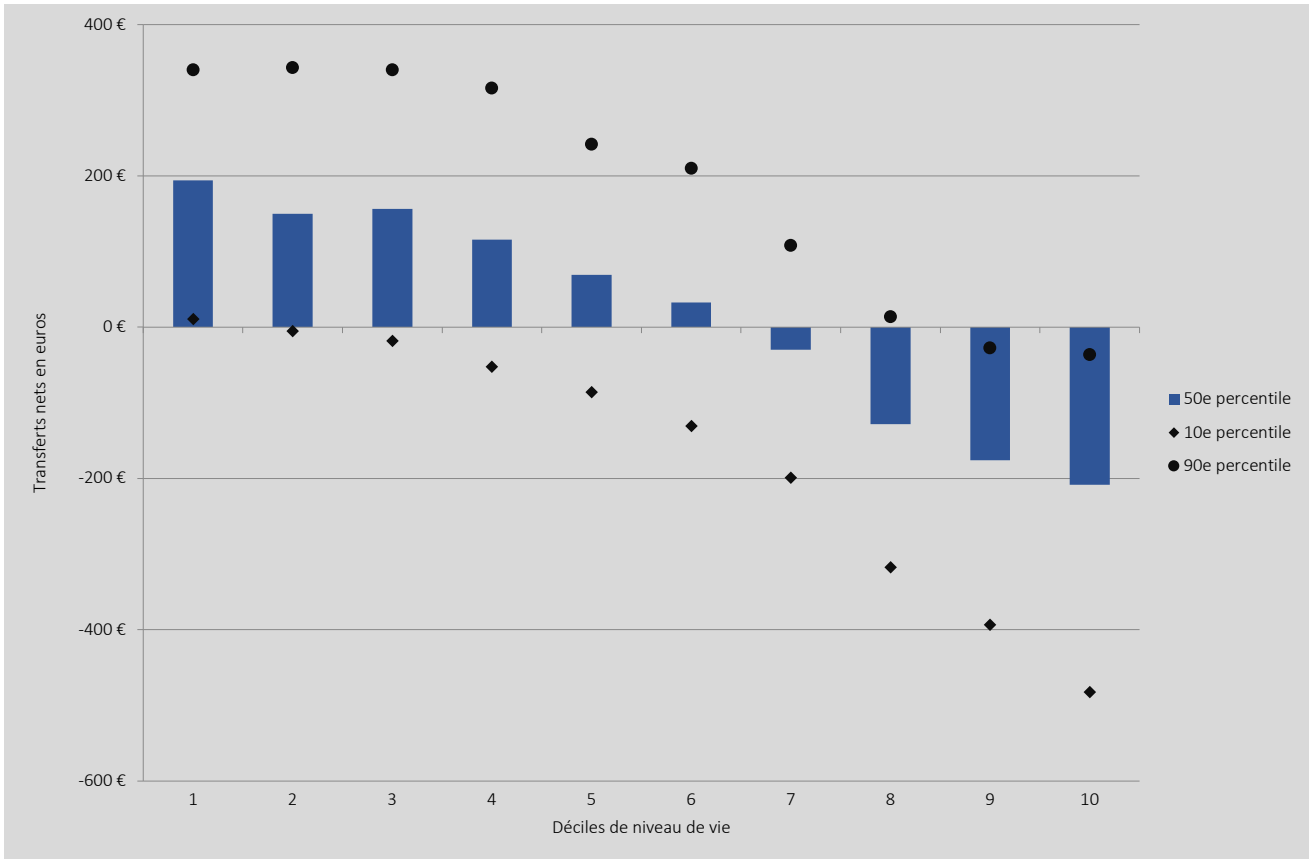
Rate of household effort associated with the reform, before use of revenues, in %



- Within each income decile, the heterogeneity of the impacts of the purchasing power tax is important.
- Example: among the households of the first decile, 10 % lose more than 220 € of purchasing power per year and per uc, 10 % are not at all affected by the reform.
- Heterogeneity of the impacts at given income linked to the location of households, through the differences in equipment between rural households and urban: all things being equal,
  - a household running on diesel loses 230 € per unit of consumption of more than a household without a car,
  - a household heating with domestic fuel loses 157 € more than one household heating with electricity.

Bureau et al. study several scenarios of revenue redistribution. Example: redistribution calibrated so that the fewest households possible only lose when the tax is introduced in the first 6 deciles.

Distribution of net transfers, by living standard decile, in euros



- Douenne and Fabre (2020): survey on a representative sample of 3002 people just after the yellow vests movement.
- The French are concerned about climate change and ready to make an effort.
- Tax and dividend policy rejected at 70 % (only 10 % of yes).
- Factors that could explain this rejection:
  - proximity to the movement of yellow vests
  - erroneous perception of the effect of politics on one's own power purchase
  - questioning the environmental effectiveness of the policy
  - lack of confidence in government in general, and in fact that the dividend will be paid in particular.
  - people do not want to live in a world in which, in fine, only rich people use their car ? (same as for the health markets, "repugnant market" Alvin Roth)
- On the other hand, the French are mostly in favor of standards stricter environmental policies, a tax on kerosene and green investments.

Attempt to build a democratic consensus around politics climate: the Citizen's Convention for the Climate

- October 2019. 150 citizens drawn at random.
- Mandate: define a series of measures to achieve a reduction of at least 40 % of emissions of greenhouse gases by 2030 (compared to 1990), in a spirit of justice social.
- 7 sessions of 3 days with expert hearings and debates.

- Suggested measures:
  - Everything except the carbon tax.
  - Main price incentives: VAT reduction on train tickets from 10 % to 5.5 %, exit tax advantages on diesel, modulation of VAT to promote transport of goods on short circuits, strengthening of automobile bonus-malus, strengthening of the kilometric eco-contribution of aircraft, implementation of a carbon adjustment at the borders of the EU.
  - Constraints: prohibit city centers from the most emitting vehicles, ban from 2025 on the sale of new vehicles with high emissions, force owners to renovate comprehensively, prohibit oil and coal-fired boilers by 2030 in new buildings and renovated, stop the development of peri-urban shopping areas.
  - Public green investments to modernize infrastructure, rolling stock and stations, and in the energy renovation of housing.
- $\rightarrow$ Climate bill

Climate policy

Finance: integrating new risks

- Paris Agreement (December 2015): financing flows must be oriented according to the climate objective.
- They can be done by classical climate policies giving a carbon price, provided they are sufficiently credible to long term to be correctly anticipated by the markets financial.
- In their absence, how to “ green ” the financial markets?
- This greening would protect against the risks associated with global warming and energy transition (Mark Carney, 2015) :
  - physical risk,
  - legal risk,
  - risk of transition.

- Transition risk: comes from stranded assets.
- Typical examples: unburnt carbon reserves, and infrastructure associated with fossil fuels; at least 20 % of existing thermal power plants would be stranded assets (Pfeiffer et al. 2018).
- More broadly, financing and investment activities of financial institutions in assets incompatible with the transition.
- Contrasting empirical results on the taking into account of this risk by investors. Since 2015, this risk seems to be present, somewhat, in the price of assets.

- Because of these new risks, climate change and energy transition is a growing concern for banks central and supervisory authorities.
- Multiplication of climatic resistance tests carried out by regulatory authorities.
- More global movement for transparency in climate information; development of a classification tool to determine what is to be considered a "green" or "sustainable" activity (taxonomy).
- But these exercises only have risk awareness objectives climate and vulnerability measures, in addition to their methodological. No binding implication for financial institutions. In particular, these exercises do not focus on the solvency of institutions.
- Some economists argue that capital requirement should depend on whether capital is green or brown. It is the amount of capital a bank or other financial institution has to have as required by its financial regulator. Capital requirements govern the ratio of equity to debt.

The macroeconomic consequences of the fight against global warming

The direct benefits of the fight against global warming

- Primary motivation for climate policy.
- Highly dependent on the scope of climate policy. France or Europe alone: little effect.
- Main benefit: the damage avoided.
  - gradual damage (migration of cultivation areas, desertification, new diseases, water rationing),
  - catastrophic damage caused by extreme weather events (floods, hurricanes etc.), which can cause
  - social crises and population movements, when certain areas of the planet will become uninhabitable.

- Very uncertain damage estimates. But we know that the Earth has not known $+4^\circ$ C for 10 million years, and that in the Ice Age, with - 4° C, humanity has almost disappeared.
- Geographical distribution of damage just as important as its size. Probable worsening of inequalities because of greater initial vulnerability and reduced possibilities for adaptation of the poor populations.
- Other benefit: adaptation costs avoided (relocation of many activities, particularly agricultural, protection against rising sea levels, fight against new diseases, installation of air systems packaged on a large scale ...).
- Finally, co-benefits in terms of health and well-being due to the decrease in local air pollution.

The macroeconomic consequences of the fight against global warming

Effects on consumption and investment

- Increase in the price of carbon $\Longrightarrow$ negative shock, similar to an oil shock.
- Important difference with oil shock: here the state can obtain tax revenues which can be recycled down other taxes (look for a double dividend), or other.
- Additional public or private " green " investments allowing the necessary structural transformations: in RE, clean transport infrastructure, housing renovation, carbon sinks ... $\Longrightarrow$ positive demand shock , Keynesian type.
- Combination of previous shocks $\Longrightarrow$ ambiguous result, depending on the power of the multiplier effect of green investments (cf. stimulus plans).

The macroeconomic consequences of the fight against global warming

Review of failed assets

- Abandonment of the extraction of fossil resources = negative wealth shock for producing countries, companies in the energy sector, and investors holding their assets.
- Premature downgrading of " brown " capital = negative wealth shock for the agents, companies or households, who hold this capital, and negative supply shock for the economies considered.
- $\Longrightarrow$ strong resistance to climate policy, with the argument of associated job losses $\Longrightarrow$ anticipate sectoral reallocations caused by the transition and support the training and retraining of workers in the companies concerned .
- Still rare empirical evaluations.

Long term effects

From growth to green growth

- Change in growth regime, based on the dynamic effects triggered by the transition:
  - learning, scale and network effects leading to lower costs of green technologies,
  - increase in the size of the markets to which they are addressed,
  - redirection of innovation at Acemoglu et al. (2012).
- But:
  - technical progress in RE or electric vehicles does not a priori increase labor productivity
  - $\Longrightarrow$ Directing technical progress in this direction would have a price in terms of growth, by crowding out innovations that increase labor productivity.
  - Explanation of the stagnation of productivity?

Conclusion

Despite the difficulties, decarbonization of energy is possible.

There are many levers: R D prompting the necessary drastic innovations, education, information prompting changes in individual preferences and social norms, fiscal and regulatory policies redesigned for greater efficiency and fairness in the sharing of efforts, additional public investments at the price of carbon, green finance ...

Some are more effective, others easier to set up, but none are sufficient on their own.

The challenge is to design a coherent set of measures structured around a carbon price reflecting the reduction in the carbon budget that we still have to consume.