A1 - For diverse, fair and peaceful sufficiency-efficiency trajectories in

Transportation, Housing and Food

Version 2.3

This document proposes scientific arguments to feed articles in the specialized and generalist press and challenges people involved in public policy.

It *demonstrates that any energy consumption for personal transportation or housing or food needs is the product of a personal footprint and an energy performance of a technical system. It proposes a map to conceive and pilot the energy transition valid for any scale of territory and any scale of social groups. It explains that a floor (light blue) and a ceiling (orange) to our needs are necessary for justice and peace. It proposes to continue this work with a 3D map to conceive and pilot the fight against global warming.*

This document invites scientific publications. If you are a researcher, you are invited to enrich it with publications in your scientific journals.

The following A2 document illustrates these lessons in the case of the housing sector in France

Summary

Taking for each need, the energy consumption[kWh] per person [p] as a key **I**ndicator (I [kWh/p]) for the energy transition, I is written as the product of an energy **P**erformance of a technical system (P) by the **F**ootprint of the user[1] (F) $\mathbf{I = F \times P}$.

For each need, the equation to make a successful energy transition is then written $\mathbf{I/d = P/e \times F/s}$ such that $d = e \times s$. The transition consists in **d**ividing by '**d**' the indicator I, by acting on '**e**' the **efficiency** and on '**s**' the **sufficiency**.

Experience seems to show that a policy that focuses only on efficiency risks failing by a rebound effect ('d' lower than the objective) by allowing non-sufficiency to develop (s<1). Symmetrically, a policy that focuses only on the footprint would fail by the other rebound effect, that of inefficiency (e<1). Moreover, these policies are more restrictive for the underprivileged classes, whereas a policy that takes into account both efficiency and sufficiency would allow differentiated trajectories for actors with all possible values of 'e' and 's' as long as $d = e \times s$ reaches the threshold value that allows us to reach our objectives.

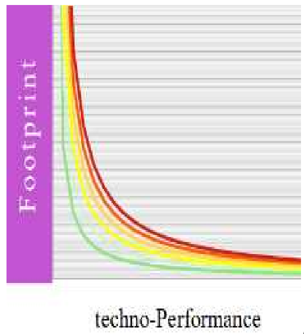

Fig 1: Map of the energy transition for a need

For each need, a graphical (fig.1) representation of the function F= I/P with the Performance (P) on the x-axis and the Footprint (F) on the y-axis allows to represent as many curves as there are values of I. The range from dark red (very high I of high-consuming individuals) to dark green (I well above the target) curves draws the space for transition. The yellow curve represents the country's target in 2050. All individual's indicator inside the area between green and light-red curves so that the national mean indicators will be on the target curve. Transition's policy at each scale (individual, groups, country) is going from a curve to an other, and can be pilot on this map. A vector allows to visualize various possible trajectories between these two curves. Each vector can be broken down into two vectors, the efficiency's vector and the sufficiency's one (fig. 2). Freedom of choice for personal trajectory for housing, transport and food, with the possibility of changing trajectories at different ages of life, if we keep reaching our common country's target

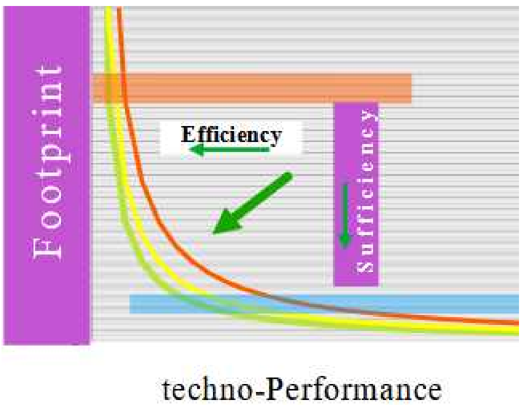

Fig 2: Efficiency-sufficiency vector, floor (light blue) and ceiling (orange) on the map of the transition of one need

The fact that the curves have no limits neither on the x-axis nor on the y-axis, shows that the energy transition may well achieve its 2050 objectives by having groups located at both ends. An accentuation of social inequalities would generate social conflicts. The Donut theory becomes then relevant. By setting a floor and a ceiling on one's footprint. It leaves freedom of choice and inequality in a finite area (green/orange/ light-red/bleu).

If the adherence of citizens to a floor seems popular in some countries, that of the richest to the idea of a ceiling requires arguments in favor of ecology and future generations, and would mark a strong political turning point. But the transition will also require a renewal of economic thinking, changes in behaviour and the removal of actors' brakes of economical sectors impacted.

1 Like km for transport, m2 for housing and calories for food

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0 – The two objectives of COP 21

Developed countries must reduce their primary energy consumption by 2050 in order to comply with COP 21 (in France it is necessary to divide by 2). They must also reduce their CO_2 emissions by 2050 (in France , carbon neutrality).

In this article, we will discuss the first objective and conclude with perspectives for work that include both objectives.

1 - Individual consumption as a key indicator

To satisfy some of our needs such as transportation, food, housing, communications, clothing we consume energy. The collective consumption for this need can be written as the sum of the individual consumptions.

Let's take the energy consumption per person as our key indicator I [kWh/p].

This indicator can be integrated at the scale of country :

$I_{Country} = \Sigma\, I_{individuals}$ [kWh]

By representing consumption by sector to measure their relative weight

$I_{country} = I_{transport} + I_{dwelling} + I_{Feeding} + I_{communication} + I_{other}$ [kWh]

By representing the population by income deciles to anticipate social movements

$I_{Decile} = \Sigma\, I_{individuals}$ [kWh] so that $I_{Pays} = \Sigma\, I_{décile\ j}$ [kWh]

(j from decile 1 the poorest 10% to decile 10 the richest 10%)

2 - The energy footprint-performance equation

Considering a given period of time, the characteristic parameter of the sector concerned I is written :

$$I = P \times F \tag{2.0}$$

where P is the energy performance of the technical system used (the energy required by the media to provide one unit of the need during the time period)
and F the personal footprint related to the satisfaction of the need (the quantity of units of the need consumed by the person during the time period).

Transport Case

The unit of need is the number of kilometres travelled.
The sectoral equation is obtained as the product of two factors:

2.a $I_{transport} = P_{transport} \times F_{transport}$ with $P_{transport}$ [kWh/km] and $F_{transport}$ [km/p]

Here is an example of the calculation:

A person who 300 days in the year takes his car (5l /100 km = 0,5 kWh/km[2]) alone to travel 10 km and once in the year takes the plane (300 l/100 km = 30 kWh/km) to travel 1000 km with 100 people on board. His footprint is 4000 km (300*10 + 1000), his performance is 0,45 kWh/km (= 0,5 *3000 + 30 *1000/100)/4000. Whereas if he takes the bike every day, it is only 0.08 kWh/km.
We can handle this equation at an individual level, or by groups of individuals, or for the whole country's population (cf.1).
To reduce our impact I, we have three ways of doing so:
- Reducing the first factor, which is to improve the energy performance of motors, which is to act on their efficiency P,
- Reducing the second factor is to act on the footprint of our travel, a more sober lifestyle by reducing F
- or reducing both.

Housing case

The unit of need is the heated and/or cooled m².
Unlike other sectors such as food, where the logic applies directly to the individual, heating and cooling consumption is proportional to the surface area of the building, almost regardless of the number of occupants (taking into consideration here the houses for main use). These energy expenses represent more than 70% of the consumption at the dwelling level.
2.b $I_{Dwelling} = P_{Dwelling\ welling} \times F_{Dwelling}$ with $P_{Dwelling}$ [kWh/m²] and $F_{Dwelling}$ [m²/p]

The kilowatt-hour of primary energy [kWhep] is commonly used in the building sector. It allows to qualify the non-renewable energy content of the energy source used in the building, in order to classify them on a common scale. In the present analysis, P is expressed in kWh/m² without considering the energy source.

Reducing the first factor (P) means improving the energy class of the dwelling (notably through renovation). Reducing the second factor (F) is to act on what we call the surface footprint.

Food case

The unit of need is the calorie consumed[3].
2.c $I_{Feeding} = P_{Feeding} \times F_{Feeding}$ with $P_{Feeding}$ [kWh/cal] and $F_{Feeding}$ [cal/p]

$P_{Feeding}$ is the sum of all the energy needed "from farm to fork", including the energy consumed for: the manufacture of chemical fertilizers and pesticides, ploughing, transport, storage, processing, cooling, cooking, packaging, marketing, etc. $P_{Feeding}$ varies a lot, from the case of wild fruits eaten on the spot which are produced only with direct solar energy, to the meal served at home by a cold link requiring a lot of primary energy often fossil. The $P_{Feeding}$ of our food is a data still insufficiently studied[4].

2 The kWh/km is more generally expressed in liters per 100 km. The conversion for gasoline or kerosene is about 10 kWh/l.

3 Whether it is of animal or vegetable origin. The energetic performance to provide calories from meat is much less than that to provide calories from plants since it takes on average 10 kg of plants to provide 1 kg of meat.

4 In the 70's, the $P_{Feeding}$ in the agriculture and agri-supply sector was well studied by the agronomist. Since the 80's, the bibliography is scarce, you have to go to the USA to find the work of Pimentel (Food Energy and Society) and recently the work of a Spanish researcher. Often scenario for Feeding transition places a lot of emphasis on the upstream agriculture and agri-supply sector. However, it seems that in Europe from 1920 to 1980, it was the upstream sector that saw a decrease in the energy performance of the calorie

Reducing the first factor is to improve the energy performance of the production system of our food. To reduce the second factor, it is to act on the reduction of its consumption of calories.1 week of consumption of a family in Bolivia and the USA


High energy performance diet


Low performance diet

It may seem counter-intuitive, but a "technologized" power supply is very inefficient. In contrast to the two previous cases where the energy performance is linked to a greater technology. The calories that we consume being energy, we can conclude that the conversion efficiency of solar energy into consumed calories has been deteriorating since the beginning of the XX century with our "modernization".

3 - The two types of rebound effects and consequences on our policies

The energy transition to be made consists in dividing by 'd' our global energy consumption (I), or $I = P \times F$, so acting on P and/or F is to be considered.

Reducing the product of two factors does not necessarily mean reducing both factors. There can be an increase of one of them, provided that we reduce the other one as much.

To properly separate the effects of differentiated policies on performance (P) or footprint (F), let's set the coefficients d, e and s as follows:

3.0 $I / d = P / e \times F / s$

where $d = e \times s$

with 'd' the impact divisor, efficiency (e) the performance divisor and sufficiency (s) the footprint divisor

Recall that we want P/e and F/s to be as small as possible to limit I/d.

- e > 1, means the energy consumed per unit of consuming action decreases.
- s > 1, means the amount of consuming action per person decreases.
- 0<e<1, means the "in-efficiency", i.e. the inverse of the efficiency, increases.
- 0<s<1, means the footprint increases. One can also say that the "non-sufficiency" (excess) , i.e. the inverse of sufficiency, increases.

<u>Transport case</u>

To reduce our consumption by 2, we can :

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production system, and that since 1980, it is the food industry, distribution and catering that have sharply decreased the performance.

a) buy a new vehicle that improves the efficiency of the engine by two (e = 2). Without changing trips s = 1, we have d = 2.
b) or, without changing our old vehicle (e = 1), we reduce the trips by two (s = 2), we then have d = 2. Our consumption is reduced by half.

But, in case a), if because of the awareness of the low energy consumption per kilometer, we increase the trips and drive 4 times more kilometers (s = 0.25), we have d = 2 x 0.25=0.5.
In total, our consumption doubles. This is what we call the **rebound effect**[5].

And if in case b), for example for fashion reasons, we move with a new vehicle which weighs more and consumes 4 times more than the old one (s = 1/4), we have d = 1/2. Our consumption doubles, it is another rebound effect.

Mathematically, we understand that there are two rebound effects.

	e > 1	**e < 1**
s > 1	**d > 1** **I decrease**	**d ? 1** Risk I increases too much on the Performance (P) side Rebound type "in-efficiency
s < 1	**d ? 1** Risk I increases too much on the Footprint (F) side rebound type non-sufficiency	**d < 1** **I increases**

As a consequence for our policies, it is possible to make the energy transition in a differentiated way by playing on ‘e’ and on ‘s’ with even the possibility that ‘e’ or ‘s’ are lower than 1 if and only if d= e . s >1.

But to make the transition by focusing only on performance (or only sufficiency), is to risk a rebound effect on the other factor thus risking to lessen, to cancel or even to reverse the reductions of consumption desired.

Housing case

In Europe housing energy policy has only been concerned with the energy performance of buildings, which means that thermal regulations and public aid only act on efficiency. However, our surface footprint is constantly increasing (the action on sufficiency is less than 1)[6]. This rebound effect is one of the causes of the low efficiency of our policy.
It is quite possible that this is the explanation of the phenomenon observed in Germany: despite their advance in housing renovation, their consumption does not decrease because of the rebound effect of the surface area non-sufficiency type[7].
The second rebound effect would be to degrade the performance of the envelope of one's home (e less than 1) and to reduce its inhabited surface (s large). It can be a question of desired sufficiency

5 This rebound effect has been observed for 50 years, in western countries since the first oil shock.

6 In France, the average surface area per inhabitant was 20 m² before the oil crisis. It is currently 40 m² and the trend, if we follow the Swiss path, will be 47 m²... https://www.bfs.admin.ch/bfs/fr/home/statistiken/bau-wohnungswesen/wohnungen/wohnverhaeltnisse/flaechenverbrauch.html

7 On October 4, 2020, french Daily Le Monde published an article entitled "In Germany, energy renovations in buildings have not reduced consumption".

often not considered in public policies or even widely discouraged: in the case of light and/or mobile habitats (van fitted out, yurt little insulated, old mobile home, hut ...). Or it can be a question of subdued sufficiency linked to the weakness of the resources of the person and to the prices of rents locally.

Conclusion: if it is possible to make the energy transition in a differentiated way, this may accentuate inequalities. This will be a source of social conflict.

What would it mean to consider the footprint in our housing scenarios?

This would mean more flexibility in our transition scenarios, as it would open up alternatives to the one way, "performance buildings”. It would also mean lower renovation costs, both for the population and for renovation support budgets.
It would in a way take into account the cry of indignation of the poorest. "You decision makers live in your big boxes and in your scenarios for transition, you only consider performance while my sufficiency effort is despised!"

This could reduce the need for new housing construction and save on the gray energy of construction.

Food case

The new European policy 'Farm to Fork' of agriculture and food acts on ‘e’ (relocation of production and development of short circuits, production of plant calories more energy efficient than animal calories, zero packaging, reduction of chemical fertilizers and plant protection products, reduction of tillage, less energy-consuming methods of processing agricultural products ...). It rightly integrates waste, because it is the calories produced and consumed that count for the calculation of $F_{feeding}$ those wasted in the field, during the chain of transformation and transport, in store, at the consumers only increase the value of $P_{feeding}$. According to the countries or social groups in caloric overconsumption (junk food) or in caloric underconsumption (undernourishment, famine) the policies on ‘s’ are different.

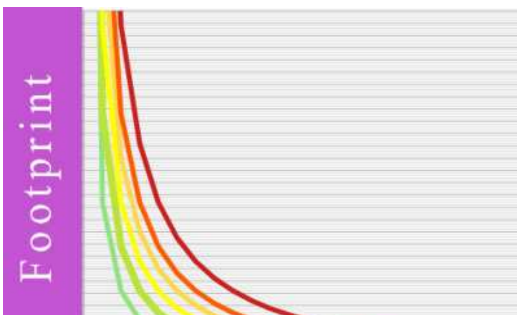
4 - Map of trajectories and social risks

I = P x F (see 2.0) can be written F = I / P

For a given value of I, the footprint is an inverse function of the performance.

4. 0	F = fn (1/ P)

It is then possible to draw personal iso-consumption curves by varying the value of I, with the Performance on the abscissa and the Footprint on the ordinate. By coloring these curves dark red (I very high) yellow (I objective of the COP 21) dark green (I well beyond the objective) we obtain a map of the transition.



Interpretation of the graph "map of possible trajectories

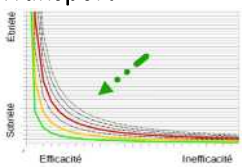
Each curve represents the group of people with the same kWh/p value. On this curve, the consumption of an individual 'i' corresponds to a point (x_i=P_i, y_i=F_i) characterized by its energy techno-performance and its footprint.

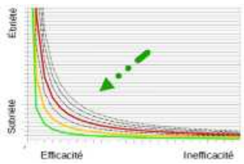
The red curve represents the country's situation in 2020.
The green curve represents the world situation in 2020.
The yellow curve represents the country's COP21 objective situation in 2050.

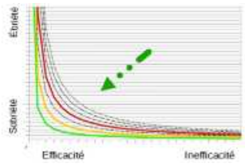
With this two-dimensional view of performance and footprint, this graph could serve as a map representing the trajectories of collective and individual changes by 2050?

To succeed in the transition is to collectively move the scatter plot of our personal consumption along the green arrow from right to left (more efficiency) and from top to bottom (more sufficiency). There are as many graphs as there are sectors consuming energy.

Transport Feeding Housing







Freedom of choice of trajectories for a sector

Consider the case of a person above the isocurve of the national average for a sector.

It can reach the yellow curve (the national objective) by the trajectory of the blue arrow (= gain in efficiency) or by the trajectory of the purple arrow (= gain in sufficiency).

It can reach the green curve(exceeding the national target) by the trajectory of the dotted green arrow (= gaining in sufficiency and efficiency).

But it can also reach only the red curve by the trajectory of the dotted blue arrow (=gain in efficiency but have a rebound effect towards non-sufficiency).

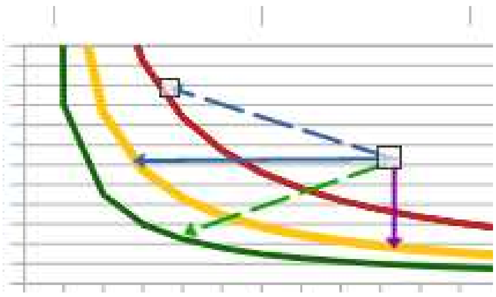


Figure 4: Trajectory vectors

The transition can be done in a differentiated way according to the sectors provided that in 2050 the yellow curve for all sectors is reached. For developing countries, the reasoning is that of increasing energy consumption without exceeding a yellow curve.

Illustration of extremes by sector

Let's try to understand what it means in today's world for consumers to move further and further towards the two limits of these curves.

The further to the right on the x-axis, the weaker the performance.

- For transportation, we can illustrate this with the image of Jeff Bezos' rocket (very few km/p and very energy consuming/km).

- For housing, it is the image of "the little match girl" in a thin cardboard hut with a quickly dissipated energy (very few m² /p and very energy consuming/m²).

- For food, it is the image of a gastronomic restaurant in Paris that imports beef from Kobe in Japan, frozen and transported by plane (very energy consuming/Cal, few Cal/p).

The further up the y-axis we go, the more intoxicated we become.

- For transportation, we can illustrate this with the image of the round-the-world trip in a solar airplane (many km/p and very energy-efficient/km).

- For housing, we can illustrate this with the image of the "green billionaire" living alone in a 300 m2 passivhouse (a lot of m² /p and very energy efficient /m²).

- For food, we can illustrate this with the image of Gargantua crudivore eating huge quantities of products from his organic permaculture farm (many Cal /p and very energy efficient/Cal).

We then understand that the transition can be achieved by increasing inequality. The extreme inequality would be to be collectively at the COP 21 targets and have only two groups left at either end of the yellow curve. **Inequalities generate feelings of injustice that lead to social conflicts.**

The temptation would then be for the public authorities to legislate. This would also be a source of social conflict.

Considering that it is not desirable to lead the transition in a context of authoritarian legislation, the Donut theory becomes relevant. By limiting by a floor and a ceiling the individual footprint (see orange and blue bands), it leaves a freedom of choice (of restricted inequality).

Kate Raworth has developed a theory in her book Donut Economics: Seven Ways to Think Like a 21st-Century Economist that sees the economy as thriving when the social foundations are met without exceeding any ecological ceiling. The donut is represented by an area between the two boundaries, namely the safe and just space for humanity.

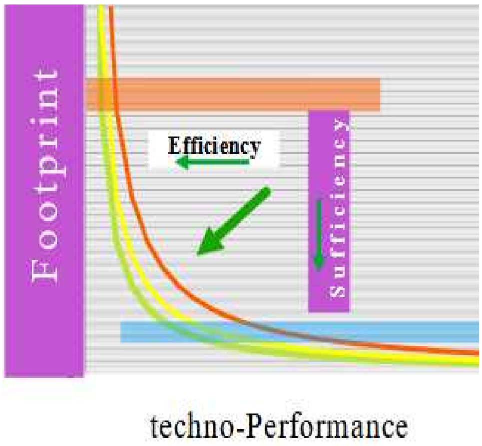


Figure 5: Directions and limits for successful transition

Bounding this map would be a tool to conduct social and inter-generational peace policies.

Country’s citizens should to decide collectively on minimum (minimum footprint of decency) and maximum (maximum excess of decency) acceptable values for their housing, their transport, their Feeding: $F_{Dwelling, min}$, $F_{Feeding, min}$ and $F_{Transport, min}$ as well as $F_{Dwelling, max}$, $F_{Feeding, miax}$ and $F_{Transport, max}$.

For Dasho Karma Ura[8], the floor and the ceiling of a need (food, housing, transport...) are a necessity if we consider that an individual is body and mind. The floor is the minimum for the body not to suffer, the space between the floor and the ceiling is that of the body-mind balance. And the ceiling is the limit beyond which the spirit suffers, because the individual becomes dependent on exessive need. This last one having taken too much place in one’s existence, the individual develops psychic sufferings, which causes behaviors unfavorable to the good harmony of the society.

8 Director of the Center for Bhutan Studies, a center that works on Bhutan's gross national happiness

5- Designing Peaceful Transition Policies

To define the ceilings and floors for each sector, only negotiations between stakeholders and democratic debates that differ from country to country (region to region?) can avoid the risk of authoritarianism and popular uprising.

The map now limited, policies are then to be conducted on segments of curves.

Two singular zones can then be identified: the zone of the ceiling footprint in orange and the blue zone. From the floor footprint

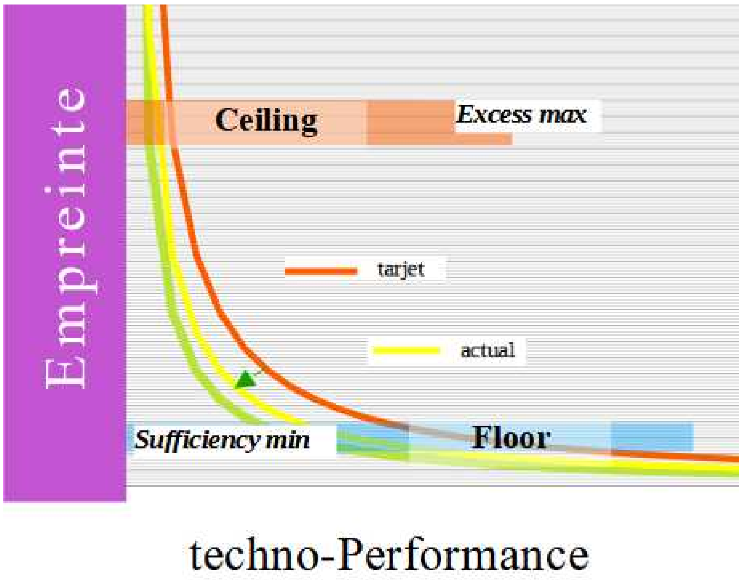


Figure 6: Bounded map of the energy transition

Blue zones are a priority to avoid social conflict. And action on the orange zones and beyond are also important for community cohesion through more evenly distributed efforts.

The economy of functionality that is developing in the housing and transportation sectors is understood on the map as a win-win interaction between individuals from different zones, for example:

- for transportation, carpooling allows a person who would make a long trip alone to reduce his in-efficiency (the kWh/km is reduced by half for this person if he is accompanied by a passenger) and the passenger without a vehicle to travel (increase his footprint transportation).

- for housing, co-location allows a person in an orange zone to reduce his or her surface and an under-housed person ("submissive sufficiency") to be housed at the surface floor.

Freedom of choice of trajectory between sectors and at different ages of life

Achieving the transition collectively would then mean shifting the scatter plot of individual consumption towards more performance and more sufficiency. This would leave a lot of freedom of trajectories in each sector, with each person having the possibility to change trajectories at different ages of his life.

Example of a country "over-consumer". The reasoning is easily transposed for a country "under-consumer"

<table>
<tr>
<td>2022 Transition Map</td>
<td>2050 Transition Map</td>
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<tr>
<td>In red iso-curve average 2022[9] of 95% of the population
in light green iso-curve of the minimum personal consumption 2022 of the 95% [10]of the population
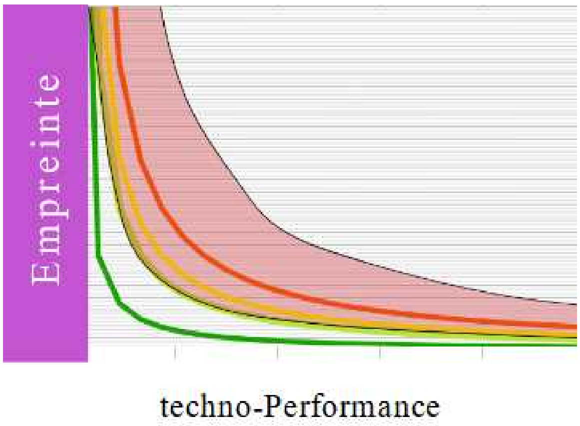
Figure 7: Unlimited distribution of 95% of the population in 2050</td>
<td>in yellow iso-curve target 2050 of 95% of the population
in dark green iso-curve of the minimum personal consumption 2050 of the 95% of the population
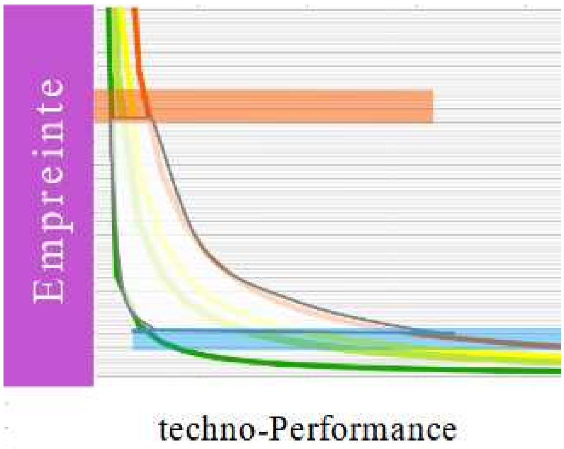
Figure 8: Limited distribution of 95% of the population in 2050</td>
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Incentive policy ?

Individuals' choices and behaviour are largely driven by economics rules.

Thus, sectoral pricing policies could initiate the movement.

Bonus-malus systems are also possible.

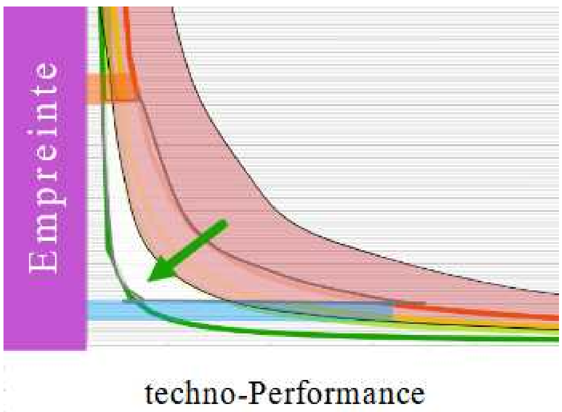

Figure 9: Map of the energy transition policy

9 It represents a non-linear regression (based on the inverse function) of the cloud of points of 100% of the population

10 Assuming that the exclusion of 5 % of extreme cases is valid: of the 2.5 % least and 2.5 % most consumers. See otherwise 99% or other values.

6- Perspectives

Towards a three-dimensional map of the low carbon trajectory?

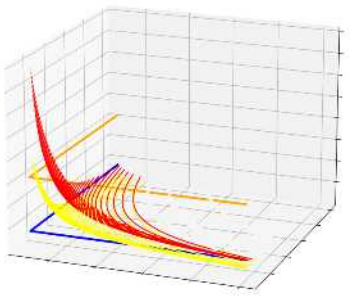

Figure 10: 3D map of the low carbon trajectory

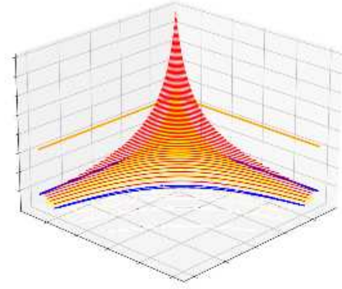

Figure 11: 3D map of the low carbon trajectory

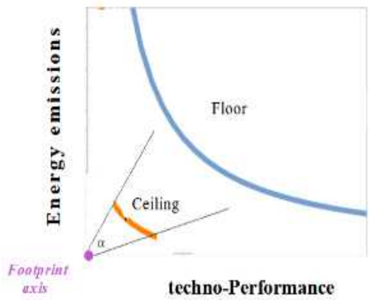

Figure 12: blue floor and orange ceiling

This 3D map represents the path to carbon neutrality in 2050. The 2D map of the energy transition is included.

The formula is kg_{CO2}/person = kg_{CO2}/kWh x kWh/un x un/person

(un = unit of need: km, calories, m2 ..)

This formula is directly related to the Kaya identity. [11]

This can be written by toggling the variable P to the left in the equation

F/ P = F/ E x E /G x G / P

F/P is the carbon footprint per capita

G/P is the GDP per capita

E/G is the energy intensity of the GDP

F/E is the carbon footprint of energy

Where:

- *F* is global CO2 emissions from human sources
- *P* is global population
- *G* is world GDP
- *E* is global energy consumption

11 https://en.wikipedia.org/wiki/Kaya_identity

Here the need is expressed in its sectoral unit and not in currency.

The third axis could be called the carbon pollution of energy. The area at iso-kg_{CO2}/p looks like a spinnaker sail.

For developed countries The objective for réduction of carbon emission is therefore to move from the red sail to the yellow sail of 2050. To do this, the vector's trajectory is the efficiency-sufficiency with a third dimension - decarbonization[12]. These three directions are mathematically of equal importance and can all have a rebound effect in one (or now two) dimensions. But the costs and implementations are different; this is the challenge of the political reflection to be conducted.

The cutting of a sail with the horizontal plane of the blue social floor and that of the orange ceiling draw two segments (fig 9) of an inverse function on a two axes energy performance -energy pollution's map.

Note that the blue segment of the floor has a larger opening angle(α) than the orange's one and is further away from the point (0,0) that represents the footprint axis. This means that two people on the same veil the one on the floor uses low energy-performance and more polluting energies than the person on the ceiling while having the same impact on the climatic heating (even kgCO2)[13]

International level?

In the same way that there are possible differentiated trajectories between individuals, this map would make it possible to conceive different trajectories between countries, by openly addressing at the international level the norms and directions of the efficiency-sufficiency vectors, the costs generated, the different floors and ceilings, the gaps by deciles within the countries, etc.

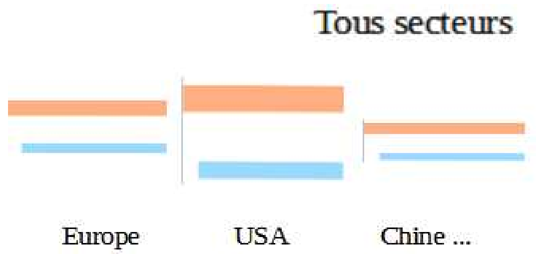

Figure 13: International comparison of energy transition maps for all needs

12 it is important not to confuse sufficiency (which is based on our relationship to our needs and lifestyle choices) with "carbon sufficiency" (which consists of replacing carbon-based energy sources with non-carbon-based sources without questioning needs or performance

13 If we look for a trivial example, such as the simple case of a single means of transport, it can be explained as follows: "the person on the floor with an old, low-performance car and a high-polluting diesel is to be compared, from the point of view of the 2050 carbon objective, with a person on the ceiling with a high-performance, less polluting hybrid car .