How to align with a 1,5°C pathway?

Technical feasibility study on the scope and urgency of measures required to achieve alignment

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I. Introduction

This document aims to show in concrete terms what it means to be on a pathway compatible with 1,5°C. This means **a pathway which enables us to limit global warming to an average increase of 1,5°C of the temperature on the earth's surface** compared to preindustrial levels. This pathway is founded on the scientific data presented in the special 1,5°C report published by the Intergovernmental Panel on Climate Change (IPCC) in October 2018. It shows **the feasibility of this path & the efforts required,** based on easily understandable component factors and corresponding measures required to achieve the target.

This document is limited to an **overall feasibility study**, mainly from a technical point of view. **No socio economic analysis** has been carried out. The proposed measures could increase or decrease the budget deficit, improve or worsen inequalities. The aim is not to propose an economically realistic program, nor a socially desirable one, nor even a politically acceptable one, but simply present a set of pathways **which would enable France to align with the 1,5°C limit.** The difficulties inherent in this approach are commented on and it is accepted that the choices outlined are not exhaustive.

We are not trying to influence the reader to adhere to or be seduced by the described pathways. Our aim is to help the reader **comprehend the magnitude of change which needs to be made** and in so doing let her judge the feasibility or realism of this within the current context. The pathways presented here could allow France to comply with the « 1,5°C pathway », and, as such, serve to promote discussion of the difficulties and compromises needed. We have not tried to explain how they can be realised, rather they should be viewed as a series of objectives and constraints.

The first part of the study analyses the level of reduction of greenhouses gases (GHG) which France would need to achieve in order to remain on track with the « 1,5°C pathway». The study then lists a set of measures per sector, which would enable meeting the 1,5°C target. For some measures, the start year which is indicated is the latest date at which the action needs to be implemented to reach the target.

Each measure is obviously arguable if taken in isolation. It is therefore important to understand the **measures as a coherent whole**, as well as examining the balance between **C02 emissions** of each subset of measures, and the **constraints imposed** by the 1,5°C pathway. This study gives an idea of the scale of the task, and the reader is free to take ownership and/or suggest her own measures.

II. What level of reduction for France?

The IPCC 1,5° report adds weight to the fact that it is important for all to implement drastic measures to keep global warming to a +1,5°C limit compared to preindustrial levels.

In concrete terms what does that mean for a country like France, & is it really attainable?

In 2017, emissions in France increased by 3% compared to 2016, due in particular to a high growth rate. SUVs sold extremely well, in spite of their higher energy consumption, & imports of consumer goods– in particular textiles – are at a high. This proves that all previous actions have had very little effect on greenhouse gas emissions. The economy is still mainly based on raw materials extracted from the environment & energy consumption remains highly proportional to positive economic indicators. With the means currently at our disposal, aiming for more growth seems to be incompatible with the will to strongly reduce greenhouse gases.

The national inventory indicates that greenhouse gas emissions amount to 6,6 tons of CO2 per person. However, the carbon footprint of a French person, including imported emissions – mainly from goods produced abroad- amounts to 10,5 tons of CO2e per inhabitant.

In France what individual emission level would be compatible with a max 1,5°C rise in temperature? The answer to this question depends on assumptions about the imagined scenario (under or over the 1,5°C threshold, envisaged carbon capture capacity etc.) of the population in 2030 , and the way in which efforts are shared between countries.

This study is based on the following assumptions

- Temperature rise limited to 1,5°C with minimal overshoot
- No significant population limitation measures
- Proportional effort by other countries to meet climate goals

With these assumptions in mind French individual carbon footprint would need to come down to 3,7 tons by 2030 - ie to a third of its current level. This individual 3,7 t total is the sum of local emissions (about 2,3 t CO2e) and imported (1,4 t CO2e) greenhouse gas emissions. The local/imported split recognises the immutable nature of territorially anchored emissions (heating, agriculture and public/private transportation). Output related emissions are not shown differentiated between imported and local production, however it is obvious that the proportion of locally produced goods will have to increase. The 2,3 vs 1,4 split is a helpful approximation showing the effort required to stay within the 1,5°C limit.

II.1. Mainland France emissions: 157 Mt CO2e in 2030

Based upon the national low carbon strategy, we have set targets by main sector of activity.

To remain on a 1,5°C pathway, the levels per activity would be:

Sector	**Greenhouse gas emissions in 2030 (Mt CO2e)**	**Effort compared to 2017 (Mt CO2e)**
Transportation	31	- 101
Housing	13	- 38
Services	6	- 19
Industry	30	- 50
Energy Industry	35	- 20
Agriculture	38	- 48
Waste	6	- 12

Per sector national low carbon strategy targets have been doubled to reflect the effort required to stay within the 1,5°C limit. Values take into account the feasibility per sector.

In the rest of the study, emissions from domestic transportation, housing, services, domestic agriculture & the French energy industry are analysed independently, and account for 80% of domestic greenhouse gas emissions.

The remaining 20% (industry & waste) are grouped together with imported emissions in a consumption based approach. This acknowledges the fact that goods & services are mobile & travel, that they are imported but also exported, & it is therefore difficult to determine which goods or services should be produced domestically or imported.

II.2. Greenhouse gas emissions annual balance (import – export): 93 Mt CO2e in 2030

Measures taken in order to keep within the 1,5° pathway mean that certain activities need to be maintained. This applies in particular to new housing both public and private, property renovation programs, low emission vehicle manufacture

Greenhouse gas (GHG) linked to these items are induced by decisions taken in other sectors, and are therefore in a specific budget.

In the same way, the study of agriculture means that GHG emissions linked to domestic & overseas production are considered as a whole.

Once targets for housing, office buildings, transportation, agriculture, the energy industry, construction and renovation & vehicle assembly have been included a value for residual emissions (clothing, IT, distribution etc.) is considered. The residual emission target value reflects the 1,5°C pathway alignment goal, but a detailed item by item analysis for this sector is beyond the scope of the current study.

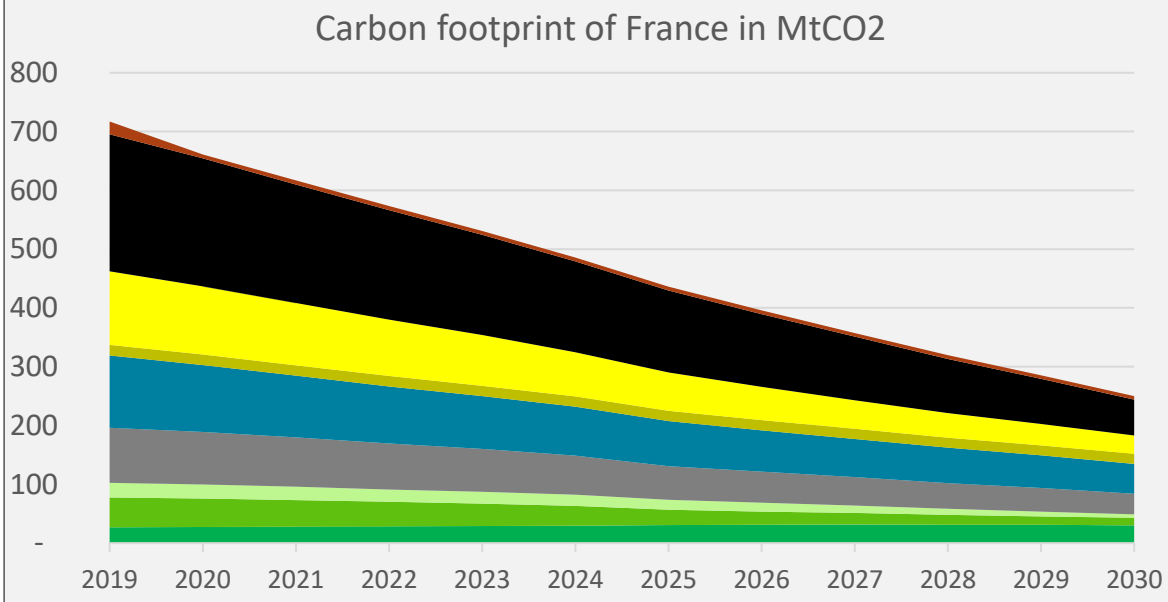
The approach can be summarised in the split per sector as showed below:

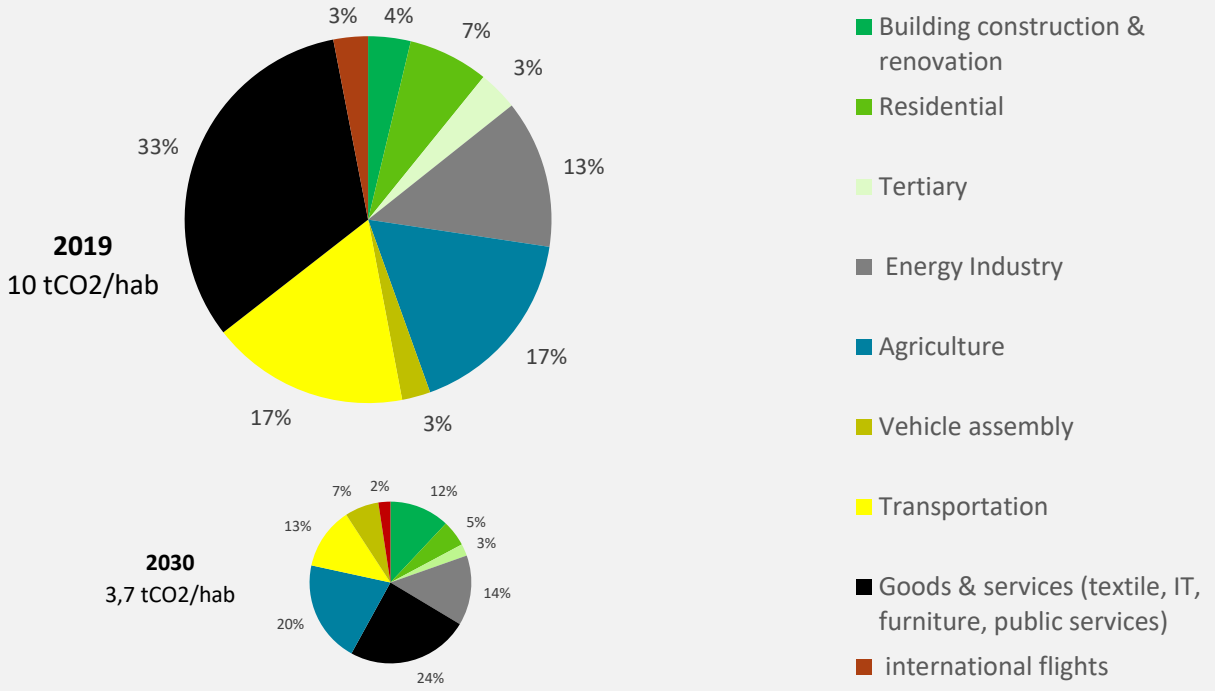
Sector	**GHG emissions in 2030 (Mt CO2e)**	**Effort compared to 2017 (Mt CO2e)**	
Transportation	31	- 101	-76%
Vehicle assembly	17	- 1	5%
Housing	13	- 38	-74%
Tertiary	6	- 19	-76%
Construction & renovation	30	+ 5	20%
Energy Industry	35	- 20	-36%
Agriculture	51	- 72	-58%
Clothing, IT, distribution, large household appliances, furniture, public service, service industry(excluding consumption from buildings in France)	61	- 170	-73%
International flights	6	- 16	-72%
TOTAL	**250**	**- 432**	**-63%**

February 2019 update:

The graph below shows the trend of emission reduction, according to the measures which are detailed in this study. As well as the value of emissions in 2030, the total of all emissions between 2019 & 2030 (the area below the trendline) must respect the CO2 budget as defined by the IPCC in its 1,5°C report.

This model is based on emission factors from the ADEME (French Agendy for Environment and Energy) database.





III. Types of measures needed per sector

III.1. Residential

Residential sector GHG emissions come from on site energy burning for heating, cooking and hot water.

GHG emissions from electricity production and/or energy used for urban heating networks must also be taken into account. These emissions are included in the national carbon budget in the «energy industry» chapter. Residential and energy sectors are interlinked since electricity conversion or the implementation of an urban heating network reduces residential emissions but increases emissions linked to energy production.

New construction work and building renovation have a significant impact. The renovation of a large part of the residential housing stock will increase GHG emissions; despite this it seems sensible to allocate a substantial part of the carbon budget to thermal renovation starting with the least heat efficient buildings. This would reduce energy consumption longterm yet maintain an acceptable level of heating into the future.

Adopting a frugal mindset and reducing consumption are the keys to lowered residential GHG. This study favours very ambitious renovation targets rather than the prohibition of heating in winter.

The goal of 1,000,000 homes renovated within ten years means that France's biggest ever training program must be implemented immediately. 50 000 new renovation professionals will be needed per year from 2020. This job sector should be incentivised with attractive pay and conditions, job openings distributed throughout the country but with particular emphasis on rural areas where fuel poverty is most common.

Of itself this will not be enough. Restrictions will be necessary, heating consumption reduced and lower room temperature norms accepted.

The table below is an example of the portfolio of measures which, if applied together, will enable a reduction of our GHG in order to meet the 1,5° objective for the residential sector.

Measures	Comments
Rapidly increase the yearly quantity of renovated homes, & enforce mandatory high environmental grade renovations. Systematically aim for the BBC (low energy building) norm. Step up from 200 000 renovations in 2019 to 1 000 000 yearly renovations by 2027 and stay at that level.	Creation of 50 000 jobs a year for 10 years, which requires adequate training programs, the associated structures and the applicants wanting to become renovation professionals The Dorémi (Negawatt) approach and the P2E skills learning (The Shift Project) are not considered in this study, only the scale of renovation required and the effort needed.

Increase heating renovation from 400 000 to 1 200 000 heating systems per year from now to 2026 and remain at that rate. Heating renovation can only be done in favour of solar, geothermal, air/water fuel pump, wood or biogas systems. Homes with fuel oil systems should be the priority for renovation. In 2026, fuel oil heating is prohibited. Natural gas & electric heaters such as convectors are progressively replaced.	There are several renovation branches, which need to adapt to the local context, network availability, sunshine & geothermal potential. The fact that this has to be right first time means that we need trained technicians all over the country who can give relevant advice plus increase the network of energy information centres. Biogas heating is either via a specific infrastructure, or by using the natural gas network with the same kind of certified origin as is the case for electricity.
Priority in terms of renovation of heating systems obviously goes to main residences and not secondary homes.	It is hard to quantify this measure, but it could mean that for a period of years, use of secondary homes in cold seasons would be prohibited
New buildings are increased to 300 000 units per year and maintained at this level. This is done without increasing the actual total amount of buildings, but by replacing the least energy efficient buildings.	One important aspect is the type of materials used. Biosourced local materials need to be used wherever possible. However, it is impossible for this to be quantified. Use of these materials means that all of the actors within the sector need to be appropriately informed & trained – architects, craftsmen, workers…
Construction of new individual housing is forbidden (except for non-permanent or “light” housing). New constructions must only be collective housing, with a maximum surface area of 30 m²per person.	Collective housing uses less fuel per m² and enables the implementation of urban heating networks, or waste collection for methanisation. Moreover it limits urban sprawl thus reducing mobility needs while increasing profitability of local shops, plus it conserves the carbon capture potential of the soil.
Immediate implementation of a 2°C reduction of average room temperature in homes (except for specific housing where a higher temperature could be necessary).	Reduce the average temperature in homes from 21° to 19°. Just such a law (decree n°2015-1823 of 30th December 2015) was enforced during the petrol crisis.
From 2025, implementation of a thermal curfew, in which all carbon based residential heating must be turned off between 10pm and 6am, limiting average room temperature to 17°C.	
Surface area per person must be reduced by 20% by 2030, down from the current 40m² to 32 m² per person.	Home sharing should be promoted, extended intra-generational occupation encouraged, inhabitant density increased.

Targeted electricity use: consumption must be more frugal, going down progressively from 4 to 2 kWh per day and per person. A progressive tax should be implemented designed to guarantee 1 kWh universal access for all and discourage consumption levels above 3 / 4 kWh of electricity a day.	The aim is to encourage users to choose between different allocations: more television consumption or more washing machine use, more air conditioning or more computers and information technology equipment … Efforts need to be made to reduce peak consumption at 7 pm (tax or cost incentives…).

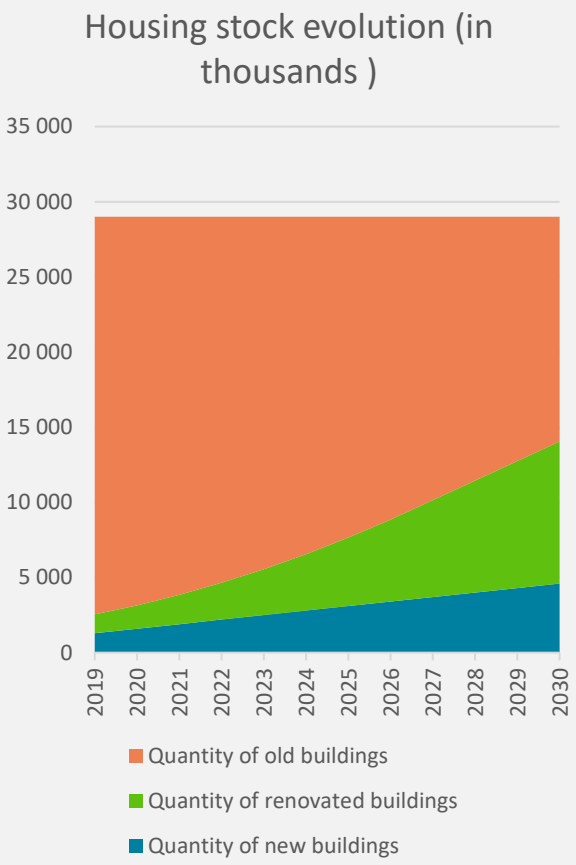
Effects:

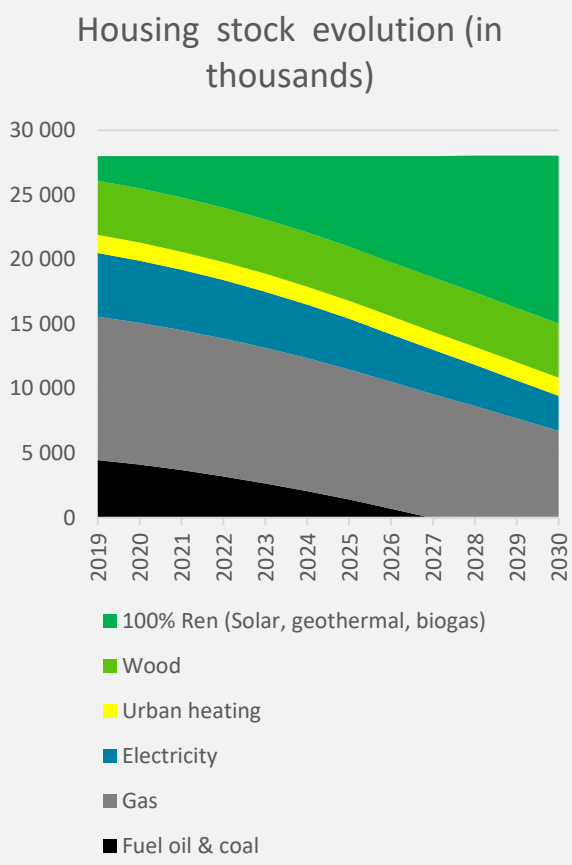
This portfolio of measures is for the transitional period, during which not all homes use renewable energy sources for heating. The community ensures a minimal production via centralised networks with top up coming from local networks and in situ production. Restrictions do not apply to in situ produced and consumed power.

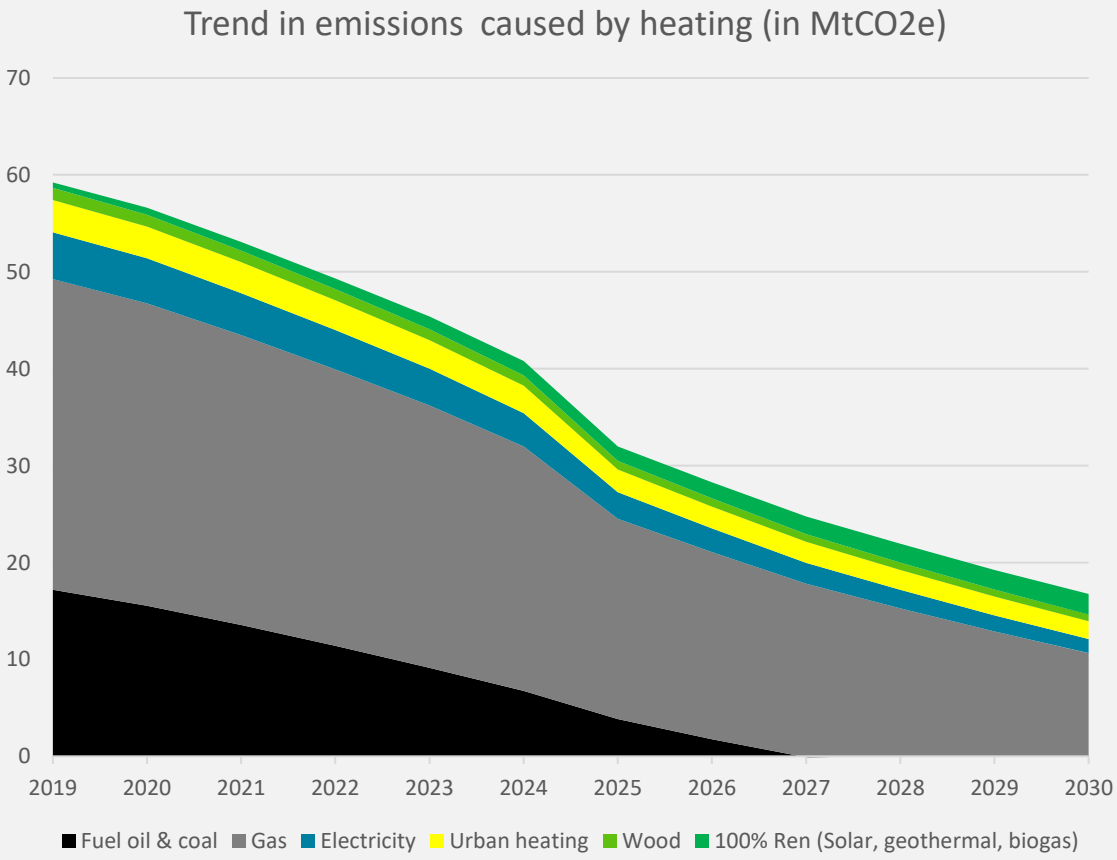
- Direct emissions from buildings decrease to 12,4 Mt CO2e in 2030, with 2,5 Mt CO2e added for upstream emissions (mainly for the extraction, transport and distribution of gas)
- Indirect emissions for heating (electricity & heating networks) decrease from 8,4 Mt CO2e to 4,3 Mt CO2e
- Indirect electricity emissions decrease from 7,7 Mt CO2e to 3,9 Mt CO2e, which reflects a 50% reduction in specific electricity consumption
- In 2030, 50% of buildings are still not renovated.

Febraury 2019 update :

The graphics below show the evolution of the housing stock with regards to proposed measures. The volume of homes remains the same. Half of the housing stock is renovated by 2030. Fuel oil heating systems are no longer in use by 2026.







III.2. Public and Commercial buildings

Public and commercial buildings, be they: shops, supermarkets, administrative buildings or office blocks with millions of employees, are an important source of energy consumption and producer of GHG emissions.

As is the case with the residential sector, significant efforts need to be undertaken to reduce the energy consumption of these buildings. This means renovation combined with frugality.

The tertiary sector typically consumes large quantities of task specific electricity which makes it difficult to enact savings without affecting productivity. Possible workarounds would be sunlight-synced working hours with load balanced electricity from solar panels. Moreover, numerous sites have significant surface areas (including building & car park) which make the massive installation of solar panels feasible.

The following table shows a portfolio of measures which, if applied over the whole of the public and commercial sector, would generate a sufficient decrease in GHG to meet the 1,5°C target.

Measures	Comments
Rapidly increase the yearly number of renovated buildings and enforce mandatory high level energy efficiency Systematically aim to comply with very low energy consumption building renovation norms. Renovate 50 000 000 m² a year in 2025 & maintain that level onwards.	As seen for residential construction, many jobs need to be created in renovation, with a probable lower emphasis on craftsmen.
Increase renewal of heating systems to get rid of all fuel oil heating by 2026, which currently represents 18% of total usage.	
No new public or commercial sector construction, meet growth by repurposing and renovating unoccupied and abandomed units, especially in city centres to reduce need for mobility.	As many jobs are redirected towards open air activities (labourers, craftsmen and agricultural workers) it is not necessary to increase surface area for the sector.
Temperature limited to 19°C in all communal walk-though areas (shops, reception halls…) and 22°C in areas where people sedentary.	The feeling of cold is much more pervasive when inactive.
Task specific electricity: strongly encourage use of solar panels in this sector	

III.3. Transportation

Total GHG emissions from transportation can be decomposed into : light vehicle GHG (private personal transportation), which makes up 58% of the total and represent roughly 76 Mt CO2e; light goods vehicles which account for 19% of total emissions and approximately 25 Mt CO2e; heavy goods vehicles (trucks and buses) which account for 23% of GHG emissions and around 30 Mt CO2e.

Light goods vehicles (LGV)

LGVs are put to different uses. Approximately 75% of distance covered by LGVs is by professionals, the remaining by private individuals.

LGV in a business context are at the heart of local economies : builders, commerce, urban logistics, removals, service vehicles – repair & breakdown services, ambulances, fire brigade, tractors and other small agriculture vehicles, public service – such as transportation of handicapped people, sometimes in lieu of school buses, waste removal, roads management…

De facto, this sector must be accorded permission to maintain distance covered.

Nonetheless, it is a sector which can be converted to all-electric vehicles. The current vehicles are heavy, and therefore the surplus weight of batteries will not make that much of a difference. Average fuel consumption is high – around 9,3 l / 100 km, with a lot of stopping and starting; acceleration and braking.

Use of LGVs by private individuals is however much more open to debate, especially given that they come primarily from the second hand market.

The following table shows a portfolio of measures which, if taken all together, could reduce LGV emissions of GHG sufficiently to meet the target of 1,5°.

Measures	Comments
New LGV with internal combustion engines are forbidden from 2022 onwards	3 years to orientate production of new LGVs towards electric power. Normal vehicle renewal rate will mean 70% of electric LGVs in 2030.
Maintain the level of new vehicles registrations to around 440 000 per year	Necessary for the existing vehicle replacement by majority of electric vehicles, but causes high emissions in the construction of the electric LGVs
Prohibit sales of new LGVs for personal use, with immediate effect.	LGVs for personal use are not seem as a priority, private purchasers directed towards second hand market. An exception may be considered for tourism vehicles, such as camping cars
Reduction of 2% per year of distance covered by LGVs for	This adds up to 20% less distance covered in 2030. A means to achieve this is relocalisating of the economy, bringing

professional use.	logistic hubs closer to the markets they serve, local food markets, local manufacture, recycling and repurposing … Transport linked to the massive building renovation renders this target all the more ambitious.
Reduction of distance covered by LGV for personal purposes by 5% per year. Private LGVs are forbidden from urban zones	This works out to just over 40% reduction in km covered 2030.

Effects:

- By 2030, GHG emissions caused by LGVs (combustion engines) decrease from 25 Mt CO2e to 5,5 Mt CO2e plus 1,4 Mt CO2e to be added from upstream fuel production
- GHG emissions from electricity production increase by 1,3 Mt CO2e
- Emissions from electric vehicle assembly will add up to 6 Mt CO2e per year

Passenger transport 

Passenger transport - excluding planes – accounts for just over 6 Mt CO2e, mainly from buses and coaches (90%) with the rest from rail transport.

The decrease in the use of private vehicles will generate an increased takeup of public transport. The assumption is that 20% of journeys previously done by car will be transferred to public road transport, 20% to rail and the remaining 60% either to soft transport modes or else not undertaken.

We also envisage that the occupancy rate of public transport will increase by about 50%.

In terms of motorisation, captive fleet transport such as bus networks can go electric, switch to hydrogen power or more likely adopt biogas fuel. For inter-city journeys by so-called « Macron buses » and longer distance coach travel, diesel remains the main fuel.

The following table shows a portfolio of measures which, if taken all together, could reduce passenger transport emissions of GHG sufficiently to meet the target of 1,5°.

Measure	Comments
From 2023 onwards, all new buses on the market are powered either by biogas or electricity	
The bus & coach fleet is doubled by 2030	
50% more trains are in service by 2030	Mainly for local service, as long distance routes already represent a very large part of total distance covered

Effects:

- Emissions from rail & road public transport increase by 50% to reach 9 Mt CO2e per year in 2030.

Domestic flights

Domestic flights emit over 5 Mt CO2e a year.

The following table shows a portfolio of measures which, if taken all together, could reduce national aviation emissions of GHG sufficiently to meet the target of 1,5°.

Measures	Comments
From 2022, domestic flight paths are closed wherever a road or rail alternative exists in under 4 hours	Short and medium distance air transport appears to be a luxury which cannot be justified in a context of radical GHG emission decrease. Only flight paths where no realistic alternative exists can continue to operate.
From 2020, no new aircraft brought into circulation.	

HGV (heavy goods vehicles transport)

It is of utmost importance to drastically reduce the road distance covered by HGV, but there are very few short term alternatives.

HGVs cover long distances with heavy loads, going electric doesn't seem feasible unless specific infrastructures such as electric motorways are built, however such investment would far exceed the permissible the carbon budget.

Alternative modes of goods transportation such as maritime, rail and by inland waterway are to be preferred. This will obviously have an impact on the speed of delivery.

To align with proposed pathway, the amount of ton-kilometres transported by road must be divided by 3.

The following table shows a portfolio of measures which, if taken all together, could reduce HGV emissions of GHG sufficiently to meet the target of 1,5°.

Measures	Comments
HGVs are forbidden from urban zones from 2022 onwards	Last mile logistic operations must be use electric LGVs. The fact that diesel/petrol powered home deliveries are no longer possible means that load transfers become necessary. This reduces the advantage of traditional road transport compared to freight.
Maximum speed reduced to 80 km/h	Fuel consumption decrease by 5 to 10%
No overtaking restriction for HGVs on 2 lane roads	Overtaking by HGVs create traffic backups which increase fuel consumption and driver frustration. This measure also has the intention of discouraging HGV use and promoting other transport modes.
HGVs transiting via French road networks is forbidden	An HGV which goes from Spain to Belgium can only do so if transited by rail.
Implementation of a pollution toll charge in 2020	

Private Transport

A complete renewal of the vehicle population is neither a feasible nor a desirable option, which means that we need to take action to reduce travel needs.

The proportion of green vehicles might continue to increase but given the preference for LGVs (as shown above) they are not expected to represent more than 20% of the 2020 total. The difficulties posed by a radical transformation of the car production lines, the short timeframe and the carbon costs of building electric vehicles support this view.

Car users will need to consider whether it makes sense to even have a car if distance driven falls significantly. We foresee a 30% to 70% drop in the new car market reflecting the shift towards other modes of transport and the increased use of car pooling.

The following table shows a portfolio of measures which, if taken all together, could reduce private transport emissions of GHG sufficiently to meet the target of 1,5.

Measures	Comments
No vehicle with fuel consumption over 4 l / 100 km put on the market in 2020; then max fuel consumption reduced to 3l / 100 km 2023, and 2l / 100 km in 2027.	No more SUVs, which will have to make room for more economical vehicles
Implementation in 2019 of a national eco driving license	Eco driving reduces vehicle GHG emissions by 10 to 15%. It is therefore mandatory for the whole population to switch to ecodriving, to avoid significant waste of energy. An acceleration control instead of a cruise control feature could be also be a means of obtaining the same result.
Motorway speed limited to 110 km / h	
All combustion engines are banned from central urban zones from 2024.	The norm in town has to become soft or public transport. Only professional vehicles will be allowed to circulate until 2030.
In 2024, all urban roads must have cycle paths. Safe cycling infrastructure must be progressively developed all over the country, & especially along main urban thoroughfares linking medium sized towns to villages & small towns in the countryside.	Encourage cycling
Gradual banning of cars depending on their	

Crit'Air (ecological score) from 2024, so that in 2030 no cars built before 2018 are on the road.	
Increase car occupation rate from 1,6 to 2,5 people per vehicle by 2028	This is made possible by the change in vehicle usage (higher carpooling). As a comparison, Negawatt association has a scenario of 1,9 occupancy rate in 2030.
Roll out fixed working hours so as to simplify public transport & carpooling.	One of the main barriers to carpooling is the fear of not finding a car to get back home. This is caused by a high flexibility of current working hours. Never-ending meetings & last minute tasks must not remain the norm. As is the case for schools, working hours must be more rigid, which will make organising & implementing shuttles & carpooling easier. End of day homeworking could be used a variable of adjustment.
People who live more than 10km away from their workplace must work from home- sector of activity permitting - 2 days a week, from 2025 onwards...	Living far from work becomes very complicated in a world where energy is restricted. The transition from a carbon way of life will cause the relocation of many jobs, which will also give the opportunity to reduce the distance between work & home, providing that people are willing to sometimes switch from a hyper specialised sector of activity to a more basic position.
Road planning must encourage soft transport modes	All new infrastructures must be accessible by bicycle. No more remote car-centric shopping districts or individual housing suburbs with no local services...
For small trips of less than 5km, soft transport has to be the norm.	This means that the infrastructure has to be adapted for the new modes of transport (lanes & secure parking for multimodal transport, repair services …). Products & services will also have to adapt (increased use of cargo bikes, widespread use of electric assistance for transport of heavy equipment, school runs, etc.). This measure also rests on significant cultural & behavioural changes, & an educational program (teaching how to ride a bicycle, choosing equipment, repair skills…) will have to be drawn up & deployed very quickly

Effects:

- 70% reduction by 2030 in distance covered by cars, compared to 2018.
- 20 million vehicles on the road in 2030 versus almost 40 million today
- 3,3 l / 100 km average fuel consumption of combustion powered cars in 2030
- 50 % reduction in mileage by car per person in 2030 compared to 2018.

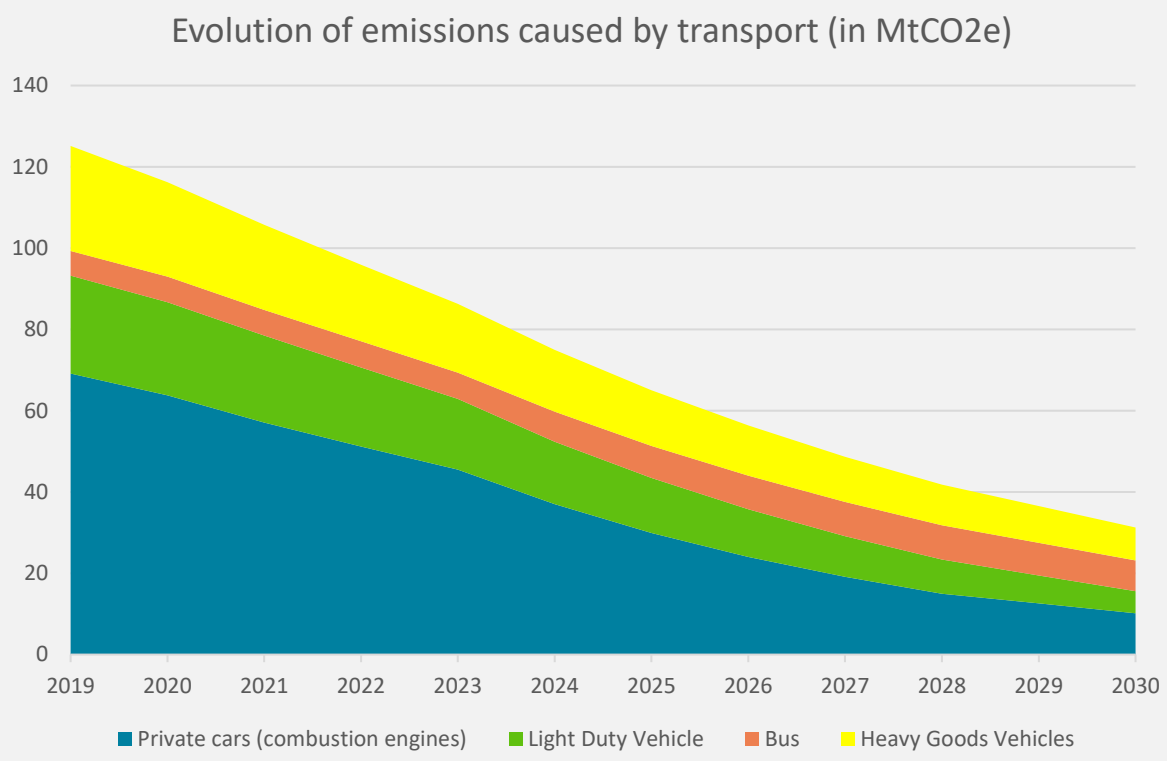
Changes to travel in kilometres per person per year

Vehicle type	**2018**	**2030**
Car	13 000	6 500
Private LGV	800	450
Public transport	1 000	2 300
Train	1 900	3 200
Bicycle	400	2 400
Extra walking		350
TOTAL	17 100	15 200

This equates to an overall reduction in travel of about 11% in 2030 compared to 2018 and posits a decrease in passive travel (car, train, bus) of 25%. This result is contrary to most current hypotheses, including the NégaWatt scenario, which are based on km. travelled staying the same or increasing

February 2019 update :

The graph below shows the modelised reduction in emissions of the transport sector, according to the measures detailed in this document



III.4. Agriculture

A large proportion of global agricultural GHG emissions come from meat and dairy farming. The picture is somewhat different for France where a third of the agricultural land surface is used for livestock farming, two thirds for arable farming

Domestic GHG emissions are divided equally (50/50) between cattle rearing and crop production. Emissions from cattle rearing are caused mainly by bovines - methane from rumination and end waste processing. Crop emissions come from: the production and use of nitrogenous products; fossil fuels used by agricultural machinery; greenhouse heating; changes in use of land (vegetation clearing, cultivation of grasslands …).

Emissions from imported produce need to be factored in. A part of these emissions is linked to meat products, but surprisingly, the main component comes from animal feed.

Estimations differ in various sources, but we can safely say that approximately 50 Mt CO2e come from cultivation (42 Mt CO2e domestic) & 75 Mt CO2e are from cattle breeding of which, 43 Mt CO2e are domestic.

Of the 85 Mt CO2e directly linked to national agriculture, only 60 Mt CO2e are actually consumed in France. There are therefore a high number of exchanges taking place, both in terms of importation & exportation.

The following table shows a portfolio of measures which, if taken all together, could reduce agriculture emissions of GHG sufficiently to meet the target of 1,5

Measures	Comments
All private gardens need to produce fruit and vegetables. This directive should be included in planning regulations. For new housing, gardening lots should favoured over parking spaces, if building permission is to be granted	Victory gardens during the world wars reconnected citizens with the land and thus contributed to the global war effort. Nowadays their role is to ensure a local source of basic products and hence reduce food side supply risks as agriculture transits towards sustainable farming
The conversion rate of agriculture lots to sustainable models (either organic or low carbon emission) must increase from 200 000 hectares a year to 1 000 000 hectares in 2028	Increasing carbon capture capacity means: reducing field size; increasing agroforestry; planting more hedgerows and trees. As a result, the number of farmers need to be doubled from 800,000 to 1,500,000 by 2030. To achieve this requires training and support services plus attracting a sufficient number of people back onto the land. A low emission patch of land produces 3 times less GHG emissions than does the equivalent conventional agriculture plot. We can use the term organic to characterise this transformation,

	but in reality, it is a whole set of sustainable agricultural practices which need to be implemented.
Deep ploughing is forbidden whenever possible. No lands are to be left bare between harvests.	By inverting the soil, deep ploughing prevents abundant life & reduces carbon capture.
All regions of France need to aim for self-sufficiency of food and building materials. To achieve this: crops need to be diversified throughout the region; cattle rearing married with land maintenance priorities, and timber extraction levels compatible with forest sustainability	
Meat consumption must go down by 10% a year from 2020 to reach 25 kg par per person per year in 2030, compared to roughly 90 kg today. Consumption of dairy products must follow the same trend.	Meat contained in processed food in particular must be reduced almost to zero. Household spending on meat remains about the same throughout the period since quantity is replaced by quality. The carbon impact of meat can be mitigated by favouring the sectors which emit fewer GHGs (poultry rather than cattle), but all externalities, both negative and positive, must be taken into account. Livestock remains relevant for land maintenance practices and the enhancement of land carbon capture capacity. Small herds of dairy cattle will be needed to meet dairy product demand.
Local consumption is encouraged. Meat & dairy must be sourced within a 100 km radius max.	
Substitutable processed products are banned over time and replaced by unprocessed foodstuffs.	This is a difficult measure to quantify, although the advantages of limiting processed food are quite obvious. It reduces: the amount of waste; the quantity of packaging; transport kilometres and the cold chain length. Learning how to cook again can be part of the cultural revolution, as this helps to slow down & appreciate things. Replaceable as some products only exist in a processed form: butter, bread, oil, wine …).
Quotas are drawn up to limit	

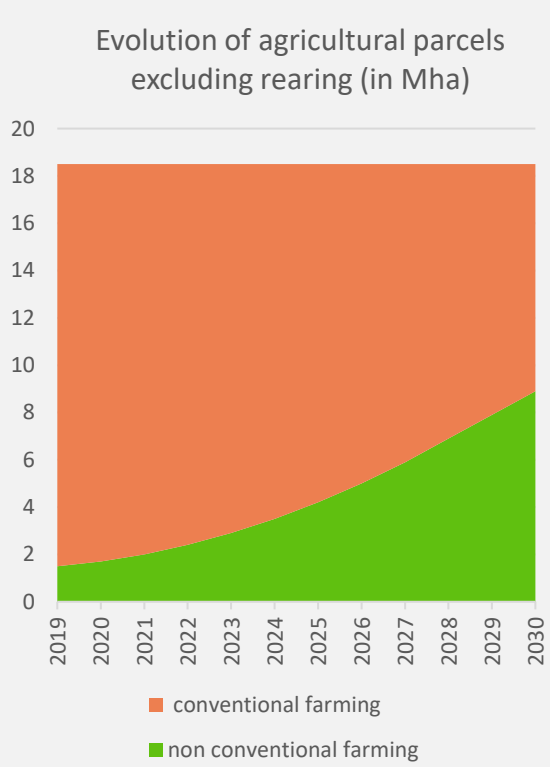
consumption of imported products, such as coffee, chocolate & exotic fruit.	
All farm operations carry out energy audits	Reduces energy waste, & decreases C02 emissions of farm operations. This entails generalising Clim'Agri or Cap'2ER type approaches to all farm operations.

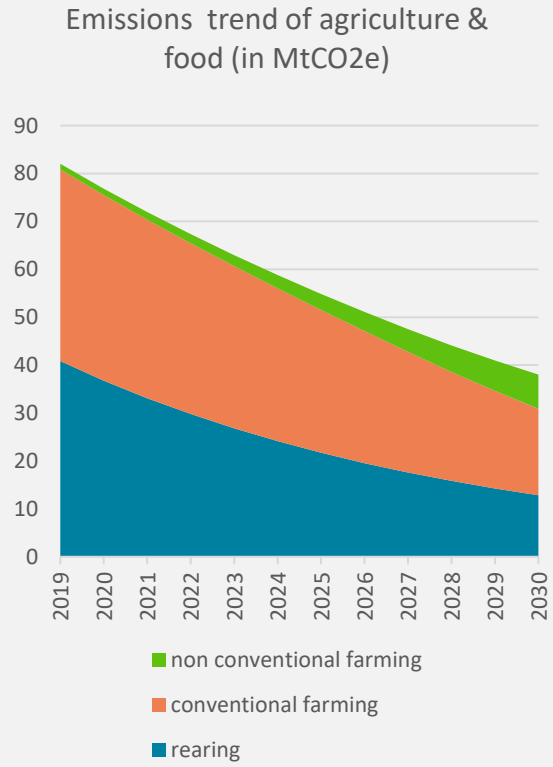
Effects:

- GHG emissions caused by cultivation are reduced to 28 Mt CO2e, of which 90% are domestic
- Low emission agriculture makes up for 50% of agricultural lands in 2030
- GHG emissions from meat products are reduced to 23 Mt CO2e in 2030.

February 2019 update :

The graph below shows the modelisation of the downward trend of emissions from the agricultural sector. The graph on the right shows the evolution of agricultural parcels in millions of hectares.





III.5. Energy industry

The energy industry takes into account all GHG emissions linked to the production and transportation of energy. The sector encompasses electricity production, the maintenance of the energy distribution grids, urban heating networks, petrol and gas refinery and distribution.

This item is very dependent upon the amount of energy necessary to cover all of the needs listed above.

As long as petrol is used, it will be necessary to produce it, and the growing electrification means it is difficult to envisage a significant reduction in GHG linked to use of electricity, in a French context where the electricity energy mix is already quite low carbon.

Needs analysis:

With a view to simplification, home based energy production is excluded from the calculations. We consider initiatives like solar panel rooftop installations as 'top up' consumption for those households who have them.

The proposed measures make a reduction in electricity consumption by the residential and tertiary sectors feasible. Despite rising demand from electric vehicles, we predict a net saving of 30% by 2030 with more than half the reduction coming from domestic energy savings.

The primary requirement is that the electric energy mix GHG emissions do not increase, this implies no new construction of coal, gas or oil-fired power plants.

From an emissions point of view, a mainly nuclear or renewable energy mix is quite similar. We could therefore limit ourselves to running current installations & continuing the current trend of renewable electricity generation.

However keeping existing nuclear plants in service, or thinking nuclear for the long term, in a context of major travel constraints, when the ability to maintain the level of scientific excellence required is in doubt and access to natural resources unsure, it is much safer to plan for a rapid diversification of our electricity generation mix.

French electricity generation is reasonably low carbon, the same cannot be said of Germany, for example, nor the rest of Europe in general. To remain below the 1,5°C threshold requires that all countries commit to ending fossil fuel power generation, an action which in the short term, is incompatible with a reduction of nuclear in the energy mix.

To be compatible with the 1,5°C pathway, it makes sense to develop as much renewable energy as possible, while at the same time maintainings global energy production levels. The energy surplus resulting from reduced consumption can be exported to facilitate the European electricity transition, and the move away from fossil fuel.

Electricity production from renewable sources essentially relies upon harnessing of solar and wind power.

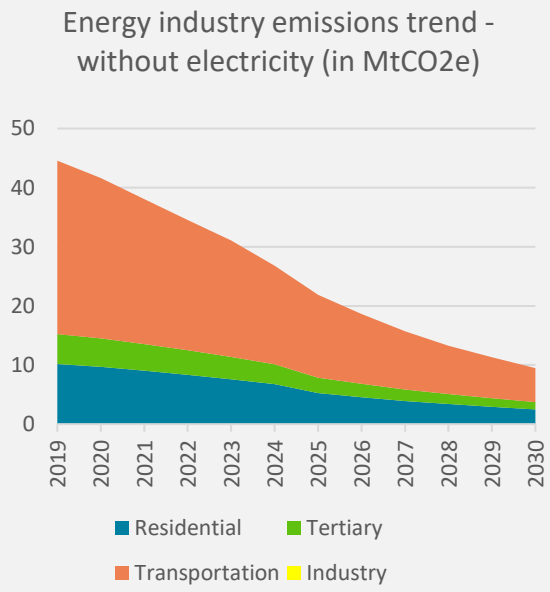
Today these projects are hindered by recourse to legal appeal procedures and complaints. A substantial and rapid increase over the next 10 years of installed capacity means that litigation resolution will have to be seriously fast tracked.

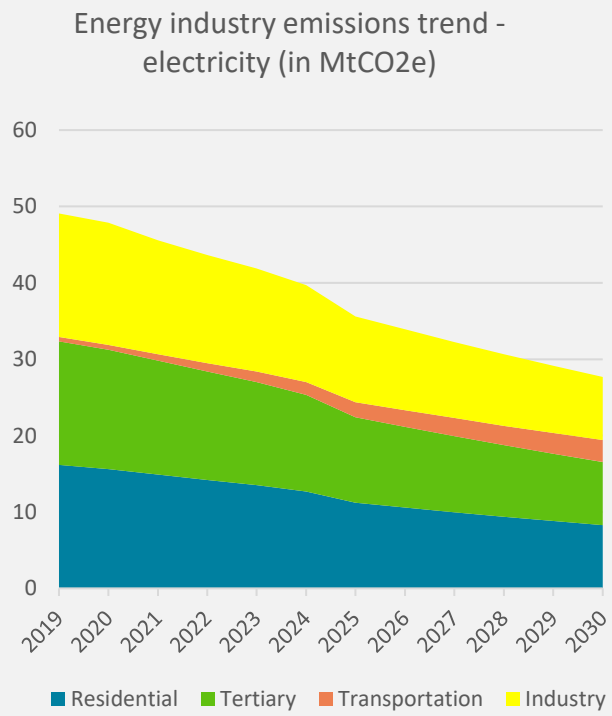
Based on renewable power increases in Germany over the last decade, we estimate that between 2 GW to 5 GW of wind power can be added each year. This equates to roughly 40 GW added by 2030 which makes a yearly production between 40 & 80 TWh possible by 2030. In terms of solar power, production will increase by 1 GWc to 5 GWc per year adding up to 40 GWc of solar energy by 2030 and giving a yearly total power output of 40 to 60 TWh.

We estimate that electric power from renewable sources will represent between 80 to 140 TWh by 2030 and make up 25% of total electric power output. This would allow a 20 GW of nuclear to be decommissioned by 2030, i.e. two 900 MW cuts a year.

February 2019 update :

Graphs below show the emission reduction trend of the energy industry (on the left excluding electricity, on the right including electricity).





III.6. Town and Country Planning

In addition to the sets of measures already presented, further measures are needed to address land use planning considerations. The table below presents the type of additional steps required.

Measures	Comments
All present & future new land development projects are frozen with effect in 2019.	As well as having a negative impact on biodiversity, further urbanisation runs contrary to measures described above – namely: increased housing density; reduced travel distances and a rollback to less intensive agriculture, all of which require urbanisation to be halted.
All new building projects must prove that GGH emissions are reduced throughout the whole project lifecycle.	The building or dismantling stages of projects can emit more than all of the reductions or emission savings during normal operation. All new development must have as a primary target the reduction of GHG, & it must be proven that this will be the case throughout the whole product lifecycle. Greater Paris subways are a good example. Building a single tunnel would emit more 40.000 tons of CO2 per kilometre, so the investment in terms of emissions saved would only be viable after 40 years.
Ecosystem regeneration to ramp up carbon capture	2030 is only an intermediate milestone. We very quickly need to attain carbon neutrality, which means that more CO2 can be stocked than is produced. This means that ecosystem conservation & revival projects need to be implemented immediately for wetlands, boglands, forests, prairies & cultivated lands to maximise carbon storage Agroforestry should become the norm wherever this makes sense.

III.7. Aviation related emissions

Not flying would be painfully hard to stomach for some, for others this is already the case. By way of a reminder, globally, only one person out of seven has ever taken a plane, and every year less than one in two of the French population travel more than 100 km, which, de facto, excludes flying.

Demonstrably, long distance tourism is not the norm today, not for humanity in general, not even for the French.

Having said that, it is not feasible to completely and immediately ban long-haul flights because our economy is strongly linked to this form of transportation. Business trips are still necessary; tourism cannot be instantaneously transformed to survive on the local market alone. Low-cost flights have played an important role in maintaining a relatively conflict free world by democratising travel and improving cross-cultural understanding.

Nonetheless, aviation GHG emissions need to be reduced by more than 70%, to meet the 2030 footprint of 6 Mt CO2e for international travel.

Despite great progress made recently in reducing aviation emission/passenger kilometre there are physical limits to how much further they can be reduced.

If the aviation carbon budget is strictly implemented it would equate to 5000 km/person (round trip quota) usable over the next 12 years. Obviously, this doesn't make sense in the real world as it penalises frequent fliers. Neither is it possible to ask everyone to reduce air travel by 70% as this would make flying impossible for a large part of the population while others could continue to fly regularly, albeit not quite as often as before.

Below is a set of measures which we believe to be more socially acceptable.

The following table shows a portfolio of measures which, if taken all together, could reduce aviation emissions of GHG sufficiently to meet the target of 1,5

Measure	Comments
All unjustified (see measures below) flights outside Europe are forbidden from 2020 onwards.	>"Don't fly" has to become the new norm. Restrictions can be implemented progressively: casual tourism targeted first; extended later to include all other unjustified (see criteria below) flights. An intermediate solution can be brokered for flights within Europe including French domestic flights.
A quota of 2 long distance return flights for young people aged between 18 to 30	These years are the time when people affirm their cultural identity, so it is of the utmost importance to maintain cultural exchanges during this period of self-discovery.

Setting up of a national lottery to hand out 500 000 flights a year.	This creates a level playing field for flight entitlement. Flying is not forbidden, nor is it the privilege of a happy few since the lottery is open to all
Business trips must be justified	Business trips must be limited to strict minimum, which means that they have to be justified to rule out all unnecessary comfort flights.

III.8. Goods and Services

Goods and services are considered as a balance variable. They are accredited with an emissions quota equal to the volume of emissions remaining once decent living conditions are assured and the basic the food, shelter and travel needs are satisfied. These residual emissions are to be shared between different consumption items and services, both public and private.

How should the residual be shared out? This is answered by reference to the objectives discussed in previous sections. There are two priorities: building construction/renovation and vehicle assembly.

For the rest, in broad strokes, the emissions are as follows:

Item	GHG emissions in Mt CO2e
Public services	75
Private services	30
Common goods including clothing	45
IT / Hifi	45
Home appliances, furniture etc.	30

Note that the total possible residual will be about 61 Mt CO2e, which is less than the current emissions of just the public service sector.

If significant energy efficiency and decarbonisation efforts are applied to the global energy mix, GHG emissions could be reduced by a third, down to 150 Mt CO2e. This output is still two and a half times over the allowance. Public services could be curtailed, consumer spending power squeezed, or overall consumption reduced in order to meet objectives.

NB: The multitude of goods and services makes carbon footprint analysis difficult and we have not been able to dress a balance sheet as in previous sections - especially given the paupacy of data pertaining to public services. Moreover, we believe that we can provide relevant information about reduction of GHG emissions for the sectors of housing, transport and agriculture, as this is a regular feature of our PCAET[1] client consultancy work and we understand the orders of magnitude. However, without precise carbon accounting data, it is all the more difficult for us to estimate the impact of a given measure towards a reduction in emissions of the service sector.

It hardly seems realistic to expect continued access to a high quality health service, to sophisticated medical equipment, to provide care for the disabled and dependent… with an education system in which most students achieve exam success, can pursue specialised studies, have access to quality research

[1] Voir http://bl-evolution.com/nos_prestations/climat/plan-climat-air-energie-territorial/

equipment… with infrastructure renewal, with rail network maintenance and possible expansion, with building cycle lanes and maintaining the road network… with a vibrant cultural service, with quality sports facilities… a wide range of state activities, a functioning justice department, internal and external security services… a healthy banking and insurance sector, a strong economy… with buying new clothes year in year out, a new smartphone every other year, upgrading computers every three or four years, acquiring ever more connected devices.

The picture painted above shows a runaway digital lifestyle which is incompatible with a 1,5°C pathway. One conclusion is that staying within the 1,5°C limit means we need to progressively disconnect, or at the very least, significantly cut back on connectivity. A further conclusion is that the current level of consumption of goods and services, clothing in particular, is unsustainable.

A few measures for digital sobriety

What is the impact of digital sector emissions? Building a smartphone generates 40 to 60 kg CO2e on average. This is but the tip of the iceberg, often forgotten is that phones require a powerful network to be useable, they need data storage equipment and infrastructure. Communication emissions (voice or data) are made up from three roughly equal parts: production of hardware (smartphones, computers…), network infrastructure (relay antennas, cables, routers…) and storage infrastructure (data centres).

Reducing emissions fourfold can't simply be done by keeping your smartphone for 8 years instead of 2, it also calls for restraint in data consumption (by strongly reducing video for example) and the creation of new infrastructure.

The following table shows a portfolio of measures which, if taken all together, could reduce digital industry emissions of GHG sufficiently to meet the target of 1,5.

Measures	Comments
Set a limit for to the volume of equipment in service at a given time. Make renting (leasing?) rather than purchase the norm for desktops and mobile computers. Increase minimum product life of terminals and smartphones to 4 years, 8 years for mobile computers and 12 years for screens.	These measures aim to restrict new product output. Making manufacturers extend product lifetime encourages better build quality and durability, both of which will help to grow the second hand equipment market. These measures can be directly applied to the professional sector first, then gradually implemented for private consumers.
Ban sales of TVs with screen sizes over 40 inches	TV manufacturing GHG emissions are, directly and proportionally, linked to screen size.
Building just one 5G network.	France has four principle mobile providers, building four propriety networks each generation. A single, shared by

	all, network would both reduce infrastructure and increase coverage.
A ban on website integrated online advertising	Advertising data makes up for a substantial part of internet traffic, and is of debatable use. Removing them would help to reduce flow of data
Video streaming needs to be divided by 3 by 2030 flux	Video streaming is the main factor in the increase in of data consumption, & it is increasing by 20% a year. If we follow that trend, it will increase fourfold by 2030, but we need to do the opposite, which means less time spent watching videos, no quality upgrade & an improvement in energy efficiency. .

The textile industry

In France, each person buys 10 kg of new clothing every year, which equates to 40 items per person per year, and almost the same quantity bought second hand. We could reasonably live for the next 10 years without any new clothes being sold, just by reusing existing materials. This sector symbolises the current predicament: an insatiable demand for raw materials which exacerbates water conflicts, offshoring of production to high GHG emission, poor energy mix, producer countries, a generalisation of shipping by air, ever more rapid obsolescence and all of this combined with a very low recycling rate…

Fast-fashion is not compatible with 1,5°C limit to global warming.

The following table shows a portfolio of measures which, if taken all together, could reduce the textile industry emissions of GHG sufficiently to meet the target of 1,5°

Measures	Comments
Relocalisation of part of production	A more local production prevents GHG emissions caused by transport & high carbon energy mix of current producing countries
Development of small scale clothing manufacturing & garment repair.	This should allow product average lifetime to increase from 1 to 4 years.
A 1kg limit per person per year for new clothes market, from 2022 onwards.	

These measures aim to reduce by 4 & by 8 respectively the emissions of the digital sector & the textile industry. For other consumer goods, principles such as the circular economy, reuse, an end to planned

obsolescence & adopting a more reasonable consumption are not remote possibilities but actual necessary prerequisites, although they will not suffice.

Relocation is a must of course, but a reorientation towards less carbon intensive sectors is also necessary. Behind these words & grand ideas is the fact that a significant proportion of jobs needs to change, & that we will need people to make & repair. We will have to make do with resources available in the country, and office jobs will no longer be the norm.

Thanks to all of these measures, we will bring down emissions from consumer goods from 120 Mt CO2e to roughly 25 Mt CO2e, which means that there remains just over 35 Mt CO2e for all public & private services, which therefore cannot be kept to current standards.

Maintaining a healthcare system for all, which enables the majority to be healthy doesn't seem to be compatible with sophisticated technology, which is greedy in energy & resources, to cover for more rare illnesses. This is the case even if we turn to a system which highlights prevention (healthy diet, outdoor sports rather than cures.

In the same way, a thorough education for all may not be compatible with scientific research equipment. In any case, if we are to remain below the 1,5°C threshold of global warming, we need to divide by 3 GHG emissions caused by public & private services. Although gains in energy efficiency may help for one third, the other two thirds will have to come from restrictions & discontinuation of certain services.

IV. Conclusion

All the above measures are presented with a managed transition in mind (no brutal change like stopping the production of fossil fuels from one day to the next) and imagine the ability to bring very substantial resources into action extremely quickly. **This ideal scenario is hardly realistic.** A 2-year delay or the failure to radically transform jobs would require even stricter economy measures to be implemented.

Waiting another 4 years until the next presidential election takes place, before implementing the described changes, means that France **will have to aim to be carbon neutral as early as 2030**. The necessary structural changes are too far-reaching for this to be feasible.

Are the proposed measures plausible? At an individual level some might be willing to accept the changes, **but the acid test is at the national level.**.. It means creating between 1 and 2 million (often very local) jobs over 5 years. Somewhere between 5% and 10% of the population has to trained and probably move house. Limited mobility due to travel restraints and the effects of economic restructuring could require a third more of the population to change jobs.

Without adequate support, the implementation of such measures seems quite unlikely, but they will be quite impossible if neighbouring countries do not implement the same changes.

A drop of water…

France doesn't even account for 2% of the world's GHG emissions. The implementation of a drastic reduction plan will not make a significant difference to global emissions. **The globalised economy makes it impossible to achieve the targets described in this document** through a consumer-based approach, **unless other countries, concurrently and rapidly, adopt the same radical action**.

Is it possible to get everybody on board with no global governance, with the current set of commercial regulations, and all this in a context where leaders of some major countries doubt the reality of climate change? The answer is a resounding no.

Can we embark on a drastic program to reduce national emissions by ourselves? History shows that human organisations which use the least energy can apply very little leverage on other, more energy intensive, organisations.[2]

For the time being, **it must be stated that a trend compatible with a 1,5° limit to global warming seems very unlikely**. Only an immediate (meaning before 2020) worldwide uprising which kickstarts the implementation of a comprehensive set of measures, such as described in this document, could make it possible to stay below the 1,5°C. ceiling.

The consequences of 1,5°C global warming are described in detail by the IPCC October 2018 special report. It shows that this will already cause significant changes and have important repercussions upon our societies. Therefore, as well as putting into place ambitious measures to minimise climate change, **it is incumbent upon us to implement strategies based upon resilience and adaptation**.

[2] See *Thermodynamique de l'évolution*, François Roddier or *De l'inégalité parmi les sociétés : Essai sur l'homme et l'environnement dans l'histoire,* Jared Diamond

Over the next decades the world we will live in will be one of profound change, **those countries and organisations which fare the best will be those which planned ahead and become resilient.**

Every tenth of a degree counts.

Does that mean that we should give up? Getting the public to accept such a set of ambitious measures is unlikely, and to get national political support seems unthinkable. **In spite of that, doing nothing would be even worse**. Waiting another 5 or 10 years before doing anything means that a similar set of measures will be necessary just to keep below the 2°C threshold of global warming, as compared to the preindustrial age. Adopting, right now, a set of less ambitious measures still makes remaining below 2°C unlikely, and above 2°C **climate change consequences mean we need to take into account other constraints:** significant decrease in crop yields, massive migration, rampant diseases…

We have waited too long, that is now an obvious fact, and a smooth transition is no longer possible. We are engaged in a real race against time. Every year counts. Every Gt CO2e emitted counts; every tenth of a degree of global warming will cause a cascade of negative impacts.

If we want to avoid having to cope with crop yields falling significantly, with a squeeze on food supply, with shortages, even famines; if we want to avoid having to manage migrations of several hundreds of millions of people, whose land will have become inhospitable; if we want to avoid having to confront the rise of diseases new to our latitudes such as chikungunya, malaria or dengue fever; **we must do everything we can to limit global warming as much as possible.**

Avoiding this worst-case scenario requires that we make **the carbon free economy a project for society**. We will need imagination, to tell stories, and get people dreaming about this subject for the majority to embrace it and come on board. But we should in no doubt about the difficulties lying ahead.

A real wartime economy needs to be set up, an economy based on rationing, an economy which demands tremendous efforts be made, an economy far removed from our comfortable world of today. **It requires that we knuckle down and pull together for the next decade or two.** This great transitioning and shift in paradigm will not be painless, it will not be without consequences on our lifestyles, it will clash with ingrained ways of thinking and will certainly provoke mass rejection.

Nonetheless, if we are to believe the IPCC 1,5° special report, safeguarding a decent way of life into the future, avoiding a fall into the unknown, make it an absolute necessity, because every extra tenth of a degree counts.

What is the responsability of France ?

The graphs on page 7 pose several questions.

On one hand, the scenario's aggregated emissions between 2019 and 2030 for France add up to 5,7 GtCO2e which is between 1% & 1,4% of the CO2 budget compatible with a 1,5°C threshold (420 à 580 GtCO2e [1]). However, France represents "only" 0,9% of world population. So even if the measures proposed are drastic, they would not totally redress, nor reverse, the inequalities caused by our lifestyles & GHG emissions. On the other hand, if we take into account energy sources, France "only" represents 1% of emissions (excluding emissions linked to imported produce and non-energy emissions). However, if we include past emissions, France represents almost 2% of total cumulated emissions (37GtCO2e [2] out of 2200 GtCO2e total [1]).

Actually, this imbalance would be even greater if historical data were to take into account the non energy processes such as agriculture and industry, as well as imported emissions. As an example, in 1990 and 2016, French energy emissions totaled 368 MtCO2e and 343 MtCO2e – quite similar amounts [3]). In the same way, the carbon footprint for the French population in 1990 is the same as in 2015 (roughly 10 tCO2e/hab including non-energy emissions plus the commercial import/export balance [4]). When we add imports and non-energy emissions, the carbon footprint for France is estimated to be around 700 MtCO2e, which is almost double the energy emissions. The estimated "cumulate carbon footprint for France" is equal to total cumulated energy emissions (37 x 2 ≈ 70 GtCO2e)).

This represents between 3% to 4% of total cumulated emissions (2200 GtCO2e) for a country which makes less than 1% of the world population.

As French citizens, it is therefore our responsability to take action.

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[1] Special Report : Global Warming of 1.5 ºC, IPCC 2018
[2] Our World in Data, WRI, consulté le 25/02/2019
[3] The Shift Project Data Portal, consulté le 25/02/2019
[4] Chiffres Clés du climat – France, Europe et Monde, Edition 2018

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