

## **A tentative post-COP 21 macro-roadmap to decarbonizing the Transport sector by 2060.**

*(A vision of how to structure a ~40 year transformation and an invitation to all other sectors to do the same!)*

The most disruptive outcome of the Paris decisions is that the horizon at which we need to envisage decarbonizing our economies has suddenly moved much closer to us. While, a few years back, the shared vision was to cut GHG emissions by half (vs 1990) in 2050, the objective is now “zero net emission” as early as possible in the second half of the century. For the advanced economies it means that most of the transformation must be achieved by 2050/2060, and certainly no later than 2070/2080 for the developing world. This suddenly puts a hugely stronger pressure on all human activity sectors. The future does not lie in an acceleration of incremental progress anymore; we are facing the necessity for a transformation of quasi-seismic magnitude where changes in behaviors, technologies and economic schemes will be key. In this transformation process, there will obviously be economic winners and losers, but overall we can be confident that the huge investments required in innovative products and services will create jobs and growth, thereby helping reach the Sustainable Development Goals.

If each sector was to lay out a tentative macro-roadmap of how to push de-carbonization in the next ~40 years to the most ambitious levels realistically possible (i.e. without jeopardizing the economy), both state and non-state actors could benefit from an incredibly rich information upon which build a positive, structured, timely coordinated transformation of our economy and Society.

Representing numerous Transport stakeholders, both private and public, the PPMC platform (Paris Process for Mobility and Climate) is happy to share a good faith vision (all targets are technically and economically achievable) vision of what the sectorial transformation of Transport - which represents a growing 15% of all GHG production and a fourth of energy-related CO<sub>2</sub> emissions- could look like. If complete well-to-wheel (w2w) de-carbonization seems out of reach in the coming four decades or so, Transport can get to extremely low fossil fuel dependency. And it can do it in a way which would meet the social aspirations for healthier ways of living, more inclusiveness, greater service reliability and digital modernity.

Avoiding un-necessary travel, shifting to the most carbon-efficient modes, improving existing solutions and opening up our minds to completely new practices are musts. The following macro-plan of action highlights eight disruptive transformations which have to be conducted jointly, in a concerted and timely manner, without procrastination. The positives will fast outweigh the negatives in everybody's life.

We were all dreaming of a new frontier: here it is!

## **1/ Move synergistically to ULEZs/ULECs in the 2020-2035 period, before doing the same towards ZEZs/ZECs.**

As outlined in the MCB “Chengdu Green Paper on Urban Mobility”, it is very clear that cities (almost three fourths of global CO<sub>2</sub> emissions) must become the natural cradle of de-polluted, modern, inclusive mobility of people and de-polluted last-mile freight delivery. In densely populated areas, the reduction of hydrocarbon-combustion-induced GHG emissions must be driven by the growing aspiration of people to breathe clean air. How? The way forward is clearly towards more walking, more cycling and riding local-emission-free electrically-driven means of transportation. Initial steps in this direction have been made through LEZ-style initiatives (Low Emission Zones), targeting both air quality improvements and congestion reduction in selected areas. This has been done by local road charging, regulation (access restriction for most polluting vehicles, based on emission standards), improvement in mass transit systems, promotion of pedestrian areas and cycling lanes. First publicized LEZ was in Tokyo (2003), with very visible results today. Several European cities and others followed suite. But fossil fuels and internal combustion engines continue ruling buses, trucks and passenger cars in such cities. Moving ultimately towards Zero Emission Zones and Cities require a bolder intermediate step with Ultra Low Emission Zones (to be extended to ULEZs, to include suburbs) in which soft mobility, e-mobility and seamlessly connected (ITS/ICT) inter-modality are greatly enhanced, with only little-pollution ICE vehicles allowed to circulate. This also requires that 1/ land use (shops, schools...) be somewhat re-organized to minimize unwanted travel and 2/ safe, reliable, innovative mass-transit systems be expanded to guarantee inclusiveness. London announced in 2014, after reviewing the benefits of the LEZ it introduced in 2008, the decision to move to a ULEZ in 2020.

We are suggesting that - while deciding to move massively to LEZs in the next couple of years for cities above 100 000 citizens would be a quick win - joining London in its effort to create ULEZs would not only spark a sizeable and positive transformation of life in cities but would create the scaling-up conditions to develop huge business opportunities and trim down the cost of change. Ideally, deciding to make the change in 10, maximum 15 years, would pave the way to easier standardization, synergism in best practice exchanges and favorable joint procurement conditions. Moving to ULEZs means also revitalizing city centers through “life-in-the-city” policies (tourism, shops, social events...). Managing such a transformation across countries would not only require municipal government decisions but also national coordination and intergovernmental harmonization.

To pursue the goal of 100% transport-related-emission-free cities by 2060, front-running cities would have to turn to Zero Emission Zones (which implies electric or plug-in hybrid systems only, smart door-to door solutions, asset sharing) by 2030.

## **2/ Improve modal and system efficiencies**

### **2-a/ Continue driving down energy consumption of new light passenger vehicles and cut their GHG emissions down to 50 g CO<sub>2</sub> /km as soon as possible before 2040. Post-2020 efficiency trajectories are needed.**

Today, in real world driving conditions, the fleet-average “well-to-wheel” emissions of PC/LTs world-wide are around 200 gCO<sub>2</sub>/km (closer to 170 in Europe). Could we go down to 50? Yes! Could we go down to 25? Yes again! Technology allows it, let's do it!

For a population above 9 billion in 2050, one third of which (at least) will not leave in cities, and with the emergence of a much broader middle-class, longing for freedom to move, it does not seem unrealistic to envision that around 2 billion light vehicles might be on the road by mid-century. Drastic energy consumption reductions are therefore necessary and we know they are feasible. “2 liter” (~50 gCO<sub>2</sub>/km, tailpipe) and even “1 liter” (~25 gCO<sub>2</sub>/km, tailpipe) prototypes are already publicized by car manufacturers. Reaching 50 w2w on average for new vehicles in 2040 in real world conditions is technically achievable (almost achievable with conventional technologies - provided that vehicles become lighter, with crash avoidance systems – and clearly achievable with hybrid/electric solutions and biofuels). For the entire fleet to be at 50 around five years later would require that retrofit regulations be enacted and/or fast rotation scenarios (sharing...) become routine by that time. Moving further down to 25 w2w on average will require a massive development of electric drive systems [plug-in hybrids, battery vehicles with or without range extenders (ICEs or FCs), very light ICE vehicles with energy recovery and biofuels, FC vehicles]. Generalization can be obtained after 2050 (in most advanced areas) with the proper infrastructure investments and the right experience curve [starting with substantial volumes in (or before) 2030 is imperative in areas where electricity and/or hydrogen are low carbon]. Moving down to 15 w2w will require an almost complete shift to e-mobility in areas where electricity and hydrogen are obtained through

almost zero carbon techniques. Scaling up should be heavily incentivized today wherever possible in order to get a sizeable market by 2040 and ensure market shift by 2060.

Let us note that, to foster ULEC/ZEC development, EVs and HEVs must develop on due time. It is also very important to pay attention to developing low-energy-consumption EVs (below 15 kWh/100 km in real world conditions), with common standards.

## **2-b/ Limit the effects of road freight dynamism by curbing down GHG emissions of heavy duty vehicles.**

Heavy trucks are a central tool in regional freight transport and, despite necessary encouragements to partial shifts toward waterborne and rail transport of goods, it is foreseeable that roads are bound to continue playing a vigorous and increasing (in net numbers, if not in proportions) role tomorrow. As trade is expected to grow quite rapidly in the coming decades because of, and as a reason for, new populations becoming hopefully richer, a drastic effort must be geared at reducing the pollutions and energy consumptions of trucks.

Assuming that thanks to all possible technical improvements [drag reduction, weight decrease, engine efficiency, lower carbon fuels (CH<sub>4</sub>, biofuels), hybridization.....] the emissions per t.km would decrease by a rate of progress close to the one observed for cars, but integrating the necessity of a longer timeframe, we could guess that by 2050, on average, a heavy truck (now emitting around 850) could emit on average around 300 gCO<sub>2</sub>/km. Scaling up will take time and this gradual transformation should therefore start by 2030. Moving down below 100 on average could be post-2060 and would in particular require clean hydrogen, second/third generation biofuels, and e-motorways.

ITS and connected infrastructure will also be key in “greening” road freight transport.

## **2w-b/ Continue electrifying rail and foster modal shift**

Because of their capacity to move people massively and rapidly, railways are essential in urban areas to provide the backbone of inclusive mobility. And electric traction is mandatory in the journey to ULEZs/ULECs and ZEZs/ZECs.

For long distances also, modal shift from road to train to limit GHG emissions in the coming decades is to be favored wherever appropriate. Improving railway effectiveness, reducing down time for freight, facilitating border crossing, successfully competing with airlines on mid-distance regional travel, using clean electricity... are also key in the search for carbon-positive modal shift.

In this optimization process the priority has to go to transit corridors.

## **2-c/ For aviation, manage the two key technical transitions: bio-kerosene and hybrids.**

ICAO/ITAG ambitions to reach carbon neutral growth by 2020 is a remarkable short term objective, which (if confirmed) would set an example for other modes. Then, aiming at reducing net CO<sub>2</sub> emissions to 50% of what they were in 2005 by 2050 [through technology, improved operations, better infrastructure management and global market-based measures (primarily offsetting)] is also pretty unique in the transport arena today. But this may not prove to be enough (particularly if the enhanced harmfulness of high altitude emissions was to be confirmed)

Sustainable bio-kerosene, complemented by fuel cells for on-board operations, therefore seem to be two solutions to be favored and actively developed, in parallel to the advancement of all energy efficiency tools in aircraft operations and traffic. By 2035, this transition should be done, worldwide. Technology should then be advanced enough to embark on the second transition: hybrids.

Also, as airports develop as mobility hubs, let us strive to make them “clean mobility hubs”.

## **2-d/ Convert river and coastal shipping to electric engines and battery/fuel cell systems? Make wind and biofuels play a role in long-haul shipping, after LNG**

Because shipping operates at low speed it does not require, comparatively to other transport means, huge power. For relatively short distances fuel cells and locally produced hydrogen appear to be promising solutions, all the more so as space availability, weight and hydrogen leak fear are not issues for such open air applications.

The use of wind, through ingenious sail designs, is also a part of the solution for long-distance, heavy-weight shipping. Second/third generation biofuels must complement the current solution package (LNG primarily). *(The IMO strategy is vividly expected)*

## **2-e/ Improve the system efficiency.**

Beyond modal optimization, smart co-modality will bring the highest benefits. ITS and ITC development must be accelerated to ensure efficient, seamless travel for people and transport of goods.

## **3/ Decarbonize power generation and hydrogen production, ensure a sustainable bio-fuel supply to make all the above achievable.**

While countries relying substantially on hydro-electricity or nuclear energy are already there, or close, it is crucial that most other countries head towards 20g CO<sub>2</sub>/kWh in their electricity production thanks to rapid conversion to renewable energies. The IEA says that it is possible by 2050 for the OECD countries, by 2070 in others. To initiate the right momentum to low-carbon power generation, it would be necessary that a sizeable number of countries which are above 400-600g CO<sub>2</sub>/kWh embrace the transition right away.

Launching clean hydrogen production (with a fully established global industry by 2035) is also a must to start pushing fuel cell use in non-stationary applications and ensure the development of e-mobility to the fullest extent. Latest studies show that to be economically and ecologically pertinent, hydrogen must be produced from renewable sources and made available locally. As a reminder, e-mobility will not develop appropriately without 1/ low-carbon electricity and low carbon hydrogen as energy carriers, 2/ storage and local generation systems (batteries, supercaps, fuel cells), 3/ the infrastructure to recharge/refill and the smart grids to optimize energy needs and flows.

Similarly, a fully established industry of sustainable bio-fuels is an absolute must by 2030-2035.

## **4/ De-fragment and shorten supply chains.**

Trends for trade increase and subsequent long-distance freight transport evolution are impressive. Therefore, above and beyond promoting lower-carbon transport means, more fundamental steps are to be taken towards rationalizing supply chains, and reducing overall transport distances. For business it means

1/ re-localizing and/or optimizing purchasing choices; redefining supplying schemes

2/ de-fragmenting certain operations (e.g. semi-finished products manufactured in different places and then assembled)

3/ simplifying and streamlining distribution circuits.

The current economy and the world trade have been built in particular on the “given” that externality costs were nearly none, and that transport was relatively inexpensive. A lot of national regulations, based on protectionist grounds or others, also hinder an optimized use of transport assets; in the world more than a third of trucks move empty! We are now at a stage where new environmentally-led paradigms must prevail and lead to new economic ways of functioning. The “fourth industrial revolution” and “factory 4.0” developments must address this critical topic.

Certain objectives on modal shift and overall reduction of mileage must be set.

## **5/ Transform work practices; now is the time, in particular, to accelerate unwanted commuting reduction**

Do we all have to continue commuting every day, mostly at the same time, to go to work together, with the associated congestion, lost time and cost this practice entails?

Do we have to continue increasing the volume of business executives' and civil servants' travels at the time of Skype, Facetime, virtual reality video-conferencing.....?

Today, the answer to both questions is obviously no... for a lot of activities! Time, individual energy and money can be used in better ways. Work-at-home, telework, telecommuting, remote office centers .... exist and have proved their pertinence, at least for a certain percentage of time, but are still representing, worldwide, a tiny proportion of human work.

As commuting represents a sizeable share of an individual's use of mobility means, a sizeable amount of time and a significant budget, we believe that now is the time to move more decisively into innovative ways of working, thereby deriving several dividends: environmental benefits, better health, time saved for family and/or individual activities, better availability for work, cash savings for more gratifying expenditures. Another huge benefit would be in terms of land use and better balanced population of territories; less justification for megapoles.

Combining car-pooling .... and new work practices could reduce VMTs very significantly.

## **6/ Taylor solutions for the rural (non urban) populations**

Even though the key transformations will be driven by cities, a successful transition will necessarily involve the countryside. In particular, decentralized generation of electricity through sun or wind makes e-mobility a solution of choice for rural populations. Reaching a high level of access to e-mobility, leveraged by vehicle-sharing and vehicle-pooling, is feasible in a limited amount of time. In the same vein, local generation and use of sustainable bio-fuels (including hydrogen) can be fostered.

Associating the rural world to modern decarbonization tools is also of extreme importance to gain wider public support to transformation.

## **7/ Invest in adaptation and offsetting.**

In all cases temperature is going to rise and extreme weather events will increase in frequency. The adaptation effort today is far from sufficient and a wise strategy calls for enhanced investments in adaptation. State and non-state actors must plan more pro-active actions and invest accordingly.

It is also quite clear that, in order to reach "zero net emission" by 2060 or so, offsetting is going to be of the essence. Investing in offsetting solutions (R&D and implementation of proven solutions) must start now. Peaking as soon as possible in GHG emissions is key and, while a lot of people still think of offsetting as a (primarily) post-2050 tool, offsetting must therefore be widely deployed without delay.

## **8/ Speed up the advent of economic instruments giving a value to carbon, de-risking long term investment in low-carbon solutions, and helping society at large embrace new behaviors/technologies**

During COP 21, one could hear throughout Le Bourget that pricing CO<sub>2</sub> at around 50 €/ton could give a strong push to alternative energies and that pricing it at around 100 €/ton would make certain technologies like carbon capture and sequestration economically viable. Discussions continue, both on price levels/trajectories and ways to keep a level playing field.

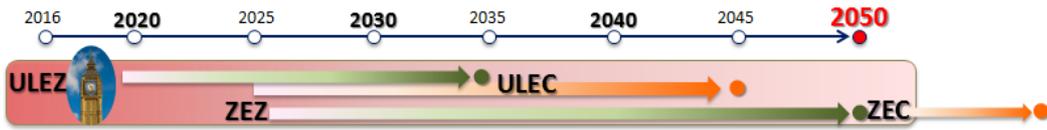
Also, as investments in new infrastructure, new technologies and mass transit systems will have to be substantially increased, private money will have to be injected in areas traditionally managed by the public sector. Business models will have to evolve accordingly.

More broadly, tools to de-risk long-term investments in low-carbon solutions have to be designed and deployed (shorter period amortization.....) without procrastination.

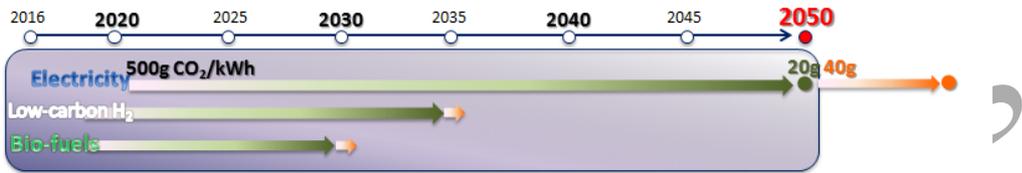
***NB: this tentative roadmap must be regarded as work in progress. It has already been presented and discussed in various state and non-state arenas. It needs to be further confronted to the views of experts from various sectors that it touches on. Thanks in advance to all those who, with the same "common good + economic realism" mindset, will contribute to make this roadmap a better one!***

# In a nutshell...

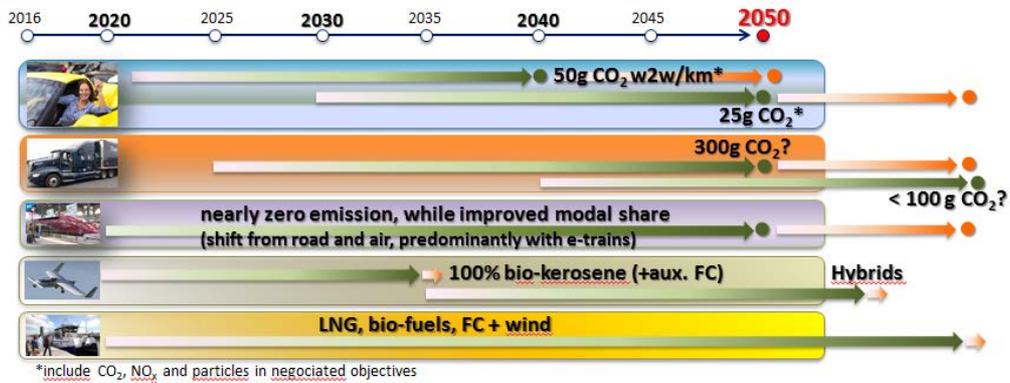
## Focus on synergistic urban transformation



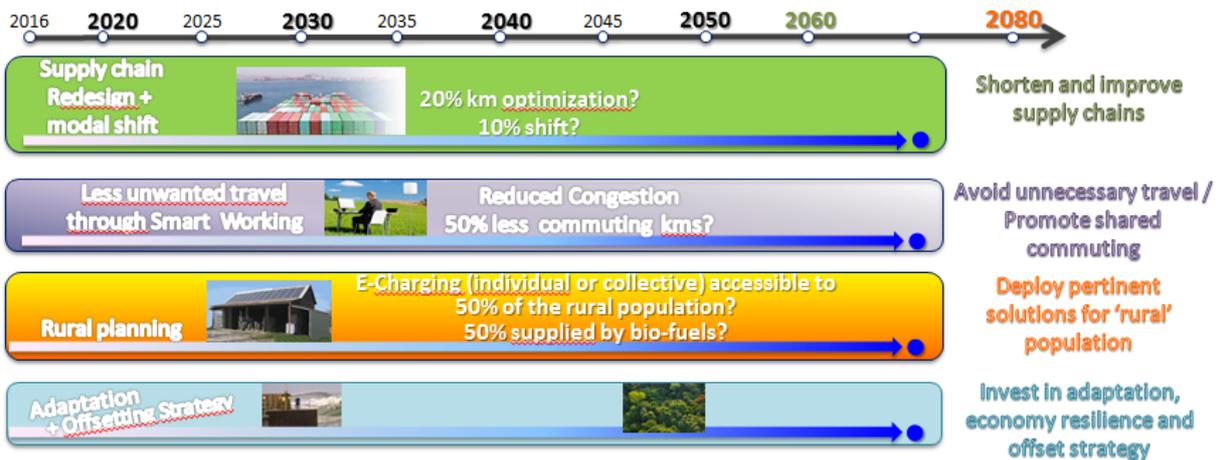
## Foster a three-pronged low-carbon energy strategy



## Orchestrate modal and system efficiency improvement



## Work out complementary systemic strategies



## Engineer financial & regulatory tools to support low-carbon solutions

