INTERNATIONAL CONFERENCE ON MOBILITY CHALLENGES

Location: CentraleSupélec (Université Paris Saclay), December 9-10, 2021

Summary of the first day sessions

Annual conference of the Armand Peugeot Chair (CentraleSupélec & ESSEC Business school), Energy & Prosperity Chair (Louis Bachelier Institute), and the Climate Economics Chair (Université Dauphine - PSL).

Coordinators: Marc Baudry (Paris Nanterre University), Anna Creti (Paris Dauphine University, PSL), Jan Lepoutre (ESSEC), Guy Meunier (INRAE), Marc Petit (CentraleSupélec), Yannick Perez (CentraleSupélec), Jean-Pierre Ponssard (CNRS& Ecole Polytechnique).

Authors of the summary: Sadighi Maryam, Ariane Bousquet and Kasser Albin (Chair Energy & Prosperity, Fondation du Risque) and Wale Arowolo (Armand Peugeot Chair, CentraleSupelec).

Table of the sessions and invited speakers

International conference on mobility challenges

Scope of the conference

There has never been more finance available for innovative green mobility in the transport sector than now for the energy transition. But where is it going? and how is the funding of the energy transition made available to the different actors in the transport sector? How are the actors utilizing the funds? Is the amount invested in green mobility finance sufficient to achieve the set local, national, and international climate change mitigation objectives?

This conference provides the latest perspectives from industry and academia on green mobility financing in the automotive industry. It brings together researchers, industry experts and policy makers' views and analyses of the current potentials, opportunities, and the policy options to facilitate green innovation financing in the transport sector.

1. Infrastructure and electric mobility

Chairman : Damien-Pierre Sainflou (Stellantis)

Bassem Haidar (CentraleSupélec & Armand Peugeot Chair)

More public charging stations or more powerful batteries in vehicles?

Electrification is a key element to mitigate climate change issues and to achieve carbon neutrality in the world by 2050. There are many public policy interventions to lower emissions in cities such as penalties for not meeting emission reduction targets for Internal Combustion Engine Vehicles (ICEV) OEMs, ban of ICEV sales etc. Nonetheless, the actual situation of electrification with Electric vehicle (EV) shows large heterogeneity among countries. The main differences between the ICEV and EV business cases are related to the charging infrastructure (charging/refuelling duration, charging stations availability) and the vehicle capital cost (CAPEX).

For the EV, there is also the chicken and egg dilemma between the charging infrastructure availability and the EV market growth - no *massive adoption of EVs* without the *charging infrastructure* and vice versa. Therefore, should public authorities invest in bigger EV battery capacities or in the deployment of more public charging infrastructure? Furthermore, about half of the French population do not have access to private parking lot, making home charging

challenging for them. This raises another fundamental question, what is the optimal charging power to encourage the shift to EVs and to facilitate public charging?

Our research focuses on the French urban and rural laggards. Laggards are those willing to buy a Battery Electric Vehicle (BEV) but do not have a home charging point. Identifying a solution for laggards could accelerate the energy transition since about 50% of French households are not equipped with private charging. To understand the need of laggards for public charging infrastructure, we simulated 5,000 BEV profiles considering the daily driving and charging infrastructure needs for both the urban and rural areas in France. In addition, we explored the cost-efficient combination of battery capacity and charging power that minimises the EAC (Equivalent Annual Cost - i.e., the amortized investment +OPEX – Revenues) of the EVs. This is important to achieve a win-win situation for EV owners and Charging Point Operators (CPO) when EAC>0 in the rural and urban areas.

Our results show that 35-50 kWh BEV with 22-50 kW chargers are the most cost-efficient solution for urban needs and 55 kWh BEV with 50 kW chargers for rural needs. Moreover, policy makers could further incentivize the purchase of BEV by increasing the capital costs and the charging infrastructure deployment subsidies.

François Detroux (ENGIE)

Complementarity and competition between technologies

ENGIE supports the development of low-carbon mobility. We operate along the entire value chain - energy production and supply, clean fuel infrastructure deployment, retailing and related services such as biogas, hydrogen and gas mobility. The technologies encompass a variety of production and transport pathways: for example, hydrogen can be delivered through infrastructure in compressed (350 or 700 bars) or liquid form. It is noteworthy that there is no zero-emission vehicle, we have to consider the lifecycle of the energy use and the source. The Life Cycle Analysis should be performed to holistically measure the greenhouse gas and local pollutants, through the well-to-wheels life cycle and the equipment life cycle.

Light vehicles

EVs are increasingly gaining competitive edge in the light-duty mobility segment. By 2025, EVs are expected to have a lower Total Cost of Ownership (TCO) compared to diesel fuelled vehicles, according to our ‘IMPACT’ study. There seems to be a consensus among different stakeholders that gas technology may no longer be needed in this segment. Vehicle Original Equipment Manufacturers (OEMs) have committed €300billion worth of investments for

electrification by 2030 and no longer propose new vehicle models powered by gas technology. Nonetheless, can we secure a 100% shift towards green BEV? What are the key bottlenecks to overcome to facilitate the shift towards green BEV?

The bottlenecks are the availability of raw materials, green electricity, deployment of public charging infrastructure in dense urban areas and highways and how to secure rural connections. We are positioned in the light-duty mobility segment with the acquisition of EVBOX – a leading electric vehicle charging infrastructure market player.

Heavy-duty Vehicles

Today, biogas is the only low-carbon alternative available for the heavy-duty vehicles (truck mobility) sector. There will be no 44 ton BEV or FCEV available for sale before 2024 and there is a significant lack of infrastructure for these technologies. In the long term, there is no one-size-fits-all solution in this segment.

Conventional fuels are omnipresent in this 'hard-to-decarbonize' segment, and it is likely that different low-carbon technology solutions will coexist and complement one another in this segment. Each low-carbon technology has its strengths and weaknesses. Biogas, battery electric and green hydrogen have limited resources. Biogas vehicles are the only low-carbon mature technology with low TCO but emit local pollutants. Electric and green-hydrogen vehicles do not emit local pollutants but have a significant TCO challenge that needs to be resolved. Also, operational constraints, such as the charging time and travel range, play against electric mobility in this segment. It is necessary to consider the complementarity among these technologies to rapidly decarbonize the heavy-duty vehicles sector.

We support the development of these three low-carbon technologies through public biogas and hydrogen stations. We also partner with major OEMs and are involved in some initiatives such as the 'Zero Emission Valley' (a renewable hydrogen mobility project in France for captive professional fleets) and 'Hynomed' (a new green hydrogen production and distribution company).

In conclusion, there is a range of alternative fuels and related technologies for decarbonizing the transport sector. Moreover, there is an urgent need to secure the business models to accelerate the investments in low-carbon mobility such as improving the maturity of hydrogen and battery technologies and securing long term public support for biogas. The three alternative fuels should also incentivize end user behavioural change, for example, it should encourage people to commute in smarter and more efficient ways (with smaller vehicles,

smaller range, public transport etc). Finding the right solution for every type of mobility requires more public policy debate since different technologies can meet different mobility needs.

Pierre de Firmas (ENEDIS)

Charging infrastructure deployment: theory and practice

ENEDIS is the electricity Distribution System Operator (DSO) responsible for about 95% of the French territory and is committed to energy transition with electric mobility as one of the most important enablers. Since the charging points are connected to the distribution grid, we are responsible for controlling and managing the load demand. We believe that France is out of the chicken and egg dilemma with the ongoing massive investment in the charging infrastructure. The year 2020 witnessed a turning point for the electric mobility market in France. In the year, about 200,000 EVs were sold in France representing more than 10% of the light vehicle sales. Moreover, the sales have been increasing in the first 10 months of 2021. We initially forecast that 15 million EVs will be sold in France by 2035. Now, we have revised our forecast to 17 million EVs after the announcement of the ban on the sale of new petrol and diesel vehicles in 2035 by the EU.

In France, around 30% of the CO_2 emissions is from the transport sector, we address the deployment of electric mobility at the industrial scale and are involved in more than 200 projects. For example, we work with cities to change their bus fleet to electric, with ship harbours to connect to the network (to electrify the ports) etc. We also work with other stakeholders such as policy makers, local authorities, vehicle OEMs, building professionals, electricity suppliers etc. We believe there is a need for companies to change to electric fleet, we are moving in this direction with a fleet of 18,000 light EVs representing 20% of our total vehicle fleet. We are currently addressing three main challenges to integrate the distribution grid with electric mobility.

Connecting shared houses/buildings to charging points: Home charging is the cheapest and requires the lowest infrastructure investment. Therefore, the most economical solution is to maximize the charging points at home. We are involved in different projects to equip buildings with charging infrastructure. The challenge is that 44% of people live in collective buildings. We are working to change the law to ease the installation of charging points in collective/shared buildings and expect the decree to be finalized in few weeks. If people connect to the infrastructure, they will have to pay for their part.

Access to public charging infrastructure: We have developed a unique expertise to help the public authorities to design their master plan. We are also working with the local authorities to

provide the network capacity and the EV penetration markets forecast to establish the masterplan.

Fast charging on highways: There is the highway plan to equip the highways with fast charging options before the end of next year (2022). We are undertaking network studies for the highways to access the power demand and fast charging requirements.

In conclusion, we are preparing for the future by studying and experimenting with innovative solutions. We are involved in ongoing R&D to optimize the integration of electric mobility with the distribution network on vehicle-to-grid, metering, charge management and the synchronization between EVs and renewable energy sources. We have published some studies in 2019, 2020 and 2021. Finally, we believe that electric mobility charging is manageable for the distribution system, even at the peak demand periods (around 8pm) in winter months.

2. Panel on financing the transition towards a greener mobility

Chairman: Pierre SEDZE (Journalist and media consultant)

Introduction

According to the Institute for Climate Economics (I4CE), French households, businesses and public administrations made €45 billion worth of climate investment in 2020. Venture Capital (VC) investment in French start-ups in all sectors increased from €1.8 billion in 2015 to €5.4 billion in 2020. Furthermore, the national hydrogen plan hopes to invest €2 billion from 2022 and increasing to €7.2 billion by 2030, notably on heavy-duty mobility.

How is the financing of the energy transition in the transport sector made available to the different players in the economy? How are the actors utilizing the funds? Is the amount invested in green mobility finance sufficient to achieve the set objectives? Is the electric mobility investment alloation sound? Let our invited **experts introduce themselves and** address these questions.

Raphaël LANCE is the head of renewable energy funds (dedicated to the energy transition sector in Europe) at Mirova. Mirova is a €25billion investment fund manager and an affiliate of BPCE-Natixis group specialized in sustainable investment finance in the last 10 years. Since 2018, Mirova's investment funds have been extended to mobility infrastructure and operations.

Augustin DERVILLE is the co-founder of Electra, a French start-up specialising in the deployment of fast charging stations for EVs. Electra raised €15 million from VC and angel investors in June 2021.

Maxime LEDEZ is a climate investment researcher at I4CE. I4CE was founded by the French National Promotional Bank (Caisse des Dépôts) and the French Development Agency. He works on the identification of climate investments and the comparison between the identified needs and the realized low-carbon transition investments.

Guillaume KOSMAN is the head of Consulting dpt for Mobilize Power solutions, a brand of the Renault group. Mobilize Power help companies to establish or expand their EV fleet by providing tailor-made, turnkey charging solutions and overseeing operations and maintenance.

Pierre-Etienne FRANC was formerly the Vice President of Air Liquide's Hydrogen Energy World Business Unit. He is currently the CEO of FiveT Hydrogen, a global hydrogen infrastructure investment fund.

Discussions

An overview of climate investment published by the French Environment and Energy Management Agency (ADEME) mentioned that the public and private sector invested €45 billion on climate change mitigation clean technologies projects in 2020 (hereinafter – 'climate investment').This amount of climate investment is 10% higher than that of the year 2019. The electric mobility market has been particularly successful, how do we explain this success? Is this amount of climate investment sufficient to meet the requirement in the climate change mitigation plans?

Maxime LEDEZ (I4CE)

To define the scope of climate investments, the study is based on the French National Low Carbon Strategy (SNBC), the French Multiannual Energy Program (PPE) and the EU Taxonomy (the EU classification system of environmentally sustainable economic activities). The study mainly considers the infrastructure deployed to directly reduce the greenhouse gas emissions in France. For mobility, the study does not consider investments in R&D, upstream industrial infrastructure or marine transport.

About half of the €45 billion of the climate investment is dedicated to the transport sector: €8 billion for low-carbon vehicles (based on battery, natural gas vehicle or hydrogen technology). €10.6 billion for infrastructure deployment such as charging stations, alternative fuels refuelling stations and rail infrastructure and €10 billion for soft mobility (such as bicycle cycling paths).

The increase in investments in the year 2020 compared to the year 2019 is mainly concentrated on the electric and hybrid vehicles (it tripled between 2019 and 2020). This increase is due to the European regulation that obligates vehicle OEMs to offer low-carbon alternatives that came into effect.

To determine whether the investment is sufficient, the study considers the investment needs relative to the PPE and the SNBC with the goal to reduce greenhouse gas emissions by around 40% by 2030. For the transport sector, the investment deficit is estimated at about €6.5 billion for the coming years.

Pierre SEDZE How are the investors making market entry decisions? What solutions have investment funds already invested in? Are the new market entrants moving the lines through the disruption?

Raphael LANCE (Mirova)

We support the low-carbon transition in the transport sector by considering different technologies such as battery for light-duty vehicles and hydrogen for heavy-duty vehicles. Our strategy is to build a diversified portfolio, giving investors access to a sector in full formation. We have invested in the cab company 'Hype', that operates a hydrogen-powered fleet of about 600 taxis in Paris. We financed the vehicles and the charging stations.

For the EVs, the business model for charging stations is mature for urban areas but still uncertain along highways for long distance trips. Our investment in DRIVECO illustrates our current strategy. DRIVECO is a B2B station installer for large-scale retailers and car dealerships. This allows us to benefit from market growth, without being impacted by the 'traffic risks'. We have also invested in Clem' (that offers low-carbon electric carsharing and smart charging solutions).

Pierre-Etienne FRANC (FiveT)

The transport sector represents a form of substitution economy. The value created is not immediately perceptible to individuals and only makes sense with collective choice. Public policies to assist the deployment are essential. In the past, regulations and subsidies such as feed-in tariffs have allowed renewable energies to develop. With respect to hydrogen mobility, there is a very ambitious European policy for the upstream production of green hydrogen, but the downstream infrastructures financing policy is not clear (with the notable exception of Switzerland for the deployment of trucks). It is imperative to develop policies, such as support for the charging rate at stations, to allow investors like Mirova or FiveT to make important long-

term investments. An amount of 50% of FiveT's funds could be invested in the downstream infrastructure: this represents €800 million over the next 6 years, and €3-5 billion with other investors and public supports. This amount will be invested where the policy makers have proposed the right support mechanisms.

Raphael LANCE (Mirova)

In a substitution economy, new entrants, such as Tesla, are making innovations that allow a switch to a completely new model. Similarly, there are many new entrants in the electrochemicals market, such as McPhy (a manufacturer of electrolysers), and some battery manufacturers. They are moving the lines and forcing the legacy market players to adapt. Also, oil and gas companies are involved through mergers and acquisitions to consolidate their position notably by buying smaller innovative players. There is an innovation premium for early entrants into these new markets, as there are significant entry barriers. Moreover, scaling in these markets require significant resources.

Pierre SEDZE The start-up Electra is one year old and has managed to raise €15 million thanks to some Venture Capital and angel investors. How did you manage to convince investors? How will the funds support your development?

Augustin DERVILLE (Electra)

First, there was a significant market opportunity for fast charging systems in cities, which made it possible to interest investors. Second, our product addresses the important need for electric mobility owners to plan their recharge. With flow management tools to avoid queuing problems, our application allows different vehicles that wants to recharge concurrently to be distributed among the different ultra-fast charging points. The charging time is currently 30 minutes and could be reduced to 20 minutes.

Electra is financed by buying electricity from suppliers and selling this electricity with charges, on stations that start at 200 kWh up to 2000 kWh. Electra purchases infrastructure from OEMs of fast charging stations and offers the installation to landowners on a long-term basis. We managed to convince the financiers thanks to the experience of our founding team in business development and EV charging infrastructure. To develop our business, we have some equity that will be complemented with debt from financial institutions to deploy the first stations to proof our value proposition.

Pierre SEDZE The mobility sector has given rise to new business models. How do you see the different business models in the charging infrastructure market?

Guillaume KOSMAN (Mobilize Power Solutions)

We must distinguish the business model of fast charging from the classic charging, that is really very different in terms of roadways and urban landscape. Despite the existence of a traffic risk, the existence of a business model around fast charging is becoming feasible. First, the user is aware of paying for a different service, so he is willing to pay between 0.45-0.70€/kWh (versus 0.15€/kWh at home), which leaves the opportunity to make a significant margin. For slower charging on the street, the user is less willing to pay more per kWh. Secondly, fast charging station have a relatively high turnover (2 charges per hour), so the business can be profitable.

Pierre SEDZE How do investors behave when faced with the risks of new business models for fast charging or hydrogen? To what extent can investors expect to make a return on their investment?

Guillaume KOSMAN (Mobilize Power solutions)

The internal rate of return (IRR) on investment for fast charging projects remain very uncertain, depending on your hypothesis it can be between 10-30%. Despite the uncertainties, many investors are positioning themselves, such as BlackRock that has invested $500 million in Ionity (a company that builds high-power charging network for electric vehicles along major highways in Europe). Today, there seems to be no lack of investors for projects. As far as I know, the calls for tender for motorway concessions has been successful even though a charging station on a freeway costs about €1 million.

Raphaël LANCE (Mirova)

There is indeed considerable uncertainty about the profitability of the investments. This reflects the uncertainties in the construction of the business model. Mirova has adopted a diversified approach, by setting up funds not only dedicated to transport and mobility but also offering a broader investment on energy transition. Today, the expected IRR over 10 years is 8-9% in new mobility projects, as there is always a risk premium. Once the projects are more mature and de-risked, the IRR will tend towards 4-5%, like other renewable energy projects.

Pierre-Etienne FRANC (FiveT)

We need to look at the hydrogen mobility business in the same way we looked at renewable energy fifteen years ago. In the face of uncertainty, we must bet that the dynamics will scale up these assets. By choosing the right partners and the right investments, the underlying dynamics will make these assets extremely valuable. Today, for example, investors are

reluctant to invest in (blue) hydrogen production from natural gas because there is a belief that regulation, public policy and the market will align in favour of renewable (green) hydrogen.

Pierre SEDZE Public and private climate investments represent about €45 billion according to the ADEME study. Who invests more - the private or public sector? and is there competition between the public and private sector investments?

Maxime LEDEZ (I4CE)

In the entire transport sector, including rail, 60% of the investments are public (managed by local authorities or network managers), while 40% are private, for example companies and households investing in EVs and charging stations. The public and private investments are interlinked. Public project leaders can mobilize private funds, just as private project leaders can mobilize public funds. For example, the SNCF network (a public sector investor) borrows from the private markets while an individual (private investor) can apply for an ecological bonus for his new EV.

Most investments are financed on the financial markets. For example, the Grand Paris Express company issued green bonds. It will rely on operating revenues to repay this debt in the very long term, up to around 2070. For private actors, investments can be made from their own funds, loan from commercial banks or subsidies. Moreover, there are also regional initiatives, combining local (public) authorities and private companies with hybrid financing, such as the 'Zero Emission Valley' in the Auvergne-Rhône Alpes region.

Pierre SEDZE There are many corporate venture capital (VC) investors in mobility, such as Bridgestone, Ford, RATP, Hyundai, SNCF etc. What makes Mirova's investment funds different from these entities? Do you invest in the same type of solution(s)?

Raphael LANCE (Mirova)

These corporate VCs are willing to invest in new technologies by financing start-ups. Mirova is a company with a mission to impact and to transform the society. We do not invest directly in technologies, but we support the development of new business models that makes traditional investors profitable.

Pierre SEDZE With a four-and-a-half-fold increase in EV sales between 2017 and 2020, EVs are a success. However, with 54,000 charging stations installed in France by 2021, the goal of 100,000 charging stations in 2022 appears out of reach. How should electric charging stations be deployed on a large scale to not hinder the relative success of the EV sales? Is the regulatory leverage sufficient?

Guillaume KOSMAN (Mobilize Power solutions)

By 2025, according to the French Mobility Orientation Law ('LOM Law'), all car parks of over 20 spaces in non-residential buildings will need to equip 5% of their space with charging stations for EVs. Therefore, the medium and large-scale retail outlets must adapt. In addition, motorway concession companies will have to equip their service areas with charging stations by 2023. The 'LOM Law' also provides for the installation of charging stations in condominium parking lots. Despite these obligations, the work to connect the electric network to the charging stations takes an average of nine months and is holding back the development of electric mobility in France.

Augustin DERVILLE (Electra)

For retailers who own parking lots, players like Electra are ready to finance the infrastructure on their parking, and to share the generated revenue with them. The retailers are open to the installation of charging stations in their parking lots. Moreover, the 100,000 charging stations target for France in 2022 is not necessarily a satisfactory indicator to measure the deployment of charging stations, given the difference between slow and fast charging stations. It may be more relevant to observe the deployment in terms of the installed capacity per parking lot. It is also necessary to strike a balance between the charging time and the customer needs. For example, a thirty-minute parking at a food chain parking lot versus a two-hour parking at a cinema parking lot.

Pierre-Etienne FRANC (FiveT)

Hydrogen mobility requires fewer charging points compared to electric mobility. Hydrogen refining stations are an essential part of regional clusters. It's an easy and profitable model to deploy in an area like Paris in which Hype already provides a substantial demand for hydrogen. For a complete deployment between regional clusters, that is all along major traffic roads in Europe, the European directive indicates that about 900 stations would be necessary, about 100 in France. For the coming years, it is especially important to build stations where a fleet need has been clearly identified.

3. Analysis of regional initiatives

Chairwoman : **Elodie Lecadre Loret** (ENGIE)

Philippe Boucly (France Hydrogène)

A roadmap for an ambitious hydrogen strategy

France Hydrogène brings together the hydrogen players in France (400 members at beginning of 2022). The national hydrogen strategy is based on three pillars. 1. Decarbonization of industry 2. Development of professional and heavy-duty mobility and 3. R&D and innovation. The government has allocated about €10 billion to develop hydrogen for the period of 2020-2030. This should contribute to develop 6,500MW of electrolysers – to produce 680,000 tons of hydrogen and create between 50,000 and 150,000 jobs.
The French government's support consists in different ways. First, through "calls for projects" managed by ADEME. Second, through IPCEI (Important Project of Common European Interest) within the European Framework with €3.2billion to develop 'gigafactories' for components manufacturing and some regional projects. Third, through support mechanisms to supplement the difference between the costs of low carbon/renewable hydrogen and gray hydrogen (derived from natural gas/produced from fossil fuels) as well as a mechanism for refineries i.e an incentive tax for the use of renewable energies in refineries (TIRUERT).

The use of hydrogen will be mainly concentrated within seven large industrial clusters (basins) for industry and mobility. France Hydrogen has considered two scenarios: 1. A reference Scenario (based on the national goals) - 6.5 GW of electrolysers, 1,000 hydrogen refuelling stations. 2. A more Ambitious scenario – 10 GW of electrolysers, 1,700 hydrogen refuelling stations. Currently, France has only 25 hydrogen buses and 63 buses are under manufacturing. 360-400 buses are also planned to be deployed in the near future. Regarding hydrogen trucks, there is only one in France today, however, many more trucks are going to be deployed. The Occitanie regional project ('Hydrogen Corridor' project) targets two production units of renewable hydrogen, eight refuelling stations, forty hydrogen trucks, forty refrigerated trailers, and fifteen hydrogen retrofitted coaches.

It is noteworthy that hydrogen production cost is a function of the electricity price, electrolyser capital cost and other operational costs. For example, with an electricity cost of €50/MWh, an electrolyser cost (CAPEX) of €1000/kW, a discount rate of 5%, a lifetime of 20 years and OPEX of 2% of CAPEX, the hydrogen production cost will be around €5,5/kg.

Challenges for the French hydrogen sector

1. The need for cost reduction: Cost reduction is possible through the scaling up of production, developing the transport of hydrogen (pipes) and distribution (Hydrogen Refuelling Stations) infrastructure, and the downstream sectors (mobility, industry and energy) demands. To reduce the cost, building territorial ecosystems and scaling up the production are very important. The European hydrogen backbone project in 21 countries through twenty-three Transmission System Operators (TSOs) to develop 40,000 km of hydrogen pipelines will be a key enabler for scaling up. The R&D efforts and fostering innovation should also be maintained.

2. The need to promote technology neutrality: There is a need for technology neutrality that is enabled through investing in other methods of low carbon hydrogen production apart from electrolysis. These methods include Steam Methane Reforming (SMR) with Carbon Capture, Utilization and Storage (CCUS), Thermolysis of biomass (Hynoca process for instance), Methane Pyrolysis, native hydrogen etc. Technology neutrality is required to strike a balance between supply and demand of renewable hydrogen.

3. Contribution to re-industrialisation: There is a need to maximize the local content (for instance when using public procurement) and to develop competences and training while reinforcing all the components of the value chain. This is key to recover technological sovereignty.

In conclusion, hydrogen is a key energy vector in the energy transition that requires a holistic and systemic approach.

Markus Kaufmann (Roland Berger)

Hydrogen Valleys: Insights into the emerging hydrogen economies around the world

In recent years, many hydrogen projects have been announced. Over the past twelve months, the announced green hydrogen projects have tripled. There is a clear trend of increased project announcement and larger scale (in GW). However, in the absence of regulatory enablers, the actual Final Investment Decisions (FIDs) are still largely pending. Within the projects, a strong integration and cooperation along the entire value chain of hydrogen is still needed.

The “Hydrogen Valleys” project is seen as a local market maker for clean hydrogen. The main mission of “Hydrogen Valleys” project is to create a project that encompasses the entire value chain to ensure that all the players move together in a coordinated manner to avoid stranded assets. This is in response to the need for integration of a large-scale project in the entire value chain to justify the investment in a coordinated fashion in one cluster. The drivers of the project are economic, environmental, and social (showcasing hydrogen) considerations. While the European countries are pioneers in the hydrogen integration projects, it has now expanded globally. There are now many international projects with at least a partial focus on hydrogen for mobility. More than 85% of the announced projects have mobility end-uses (buses, trucks, and cars) and more than 95% of the projects will rely on green hydrogen production. The mobility end-use case is a strong application area with willingness to pay, it is also an area to showcase rather than for example, building an electrolyser in a refinery. Largely, the commercial structure is increasing although there is still funding gaps to be closed.

There are three common project archetypes:

- Local, small-scale and mobility focused projects that is mostly led by Public-Private Partnership (PPP) initiatives often with long-term experience and mostly located in Europe. The challenge here is the accessibility of public funds not so much the availability.
- Local, medium-scale and industry-focused projects that is centred around one or two large industrial off-takers (refinery or fertilizer manufacturers) with mobility off-takers as a potential add-on. These projects are mostly led by the private sector. The challenge here is compliance with regulatory requirements.
- Large-scale, international and export focused projects that aim to connect supply and demand globally. The project develops in phases to mitigate investment risks and can be private sector or large sovereign investors led. The challenge here is putting long term commercial off-take arrangements in place to de-risk the investment.

Based on the lessons learnt, the “Hydrogen Valleys” have identified six key success factors for mobility-driven projects:

- To prepare the business case, a big enough and captive fleet size is needed.
- With secure long-term contracts (H2 supply, refuelling, off-take), holistic project de-risking is possible.
- In the operation phase, be aware of the availabilities (the bus actually running is key) and an effective service by the OEM.
- In the execution phase, for the HRS engineering and permitting, identify the key barriers that needs a collaborative approach.
- In the execution phase, for the EPC and O&M of HRS, be aware that the partners are different and there is a need for tailor-made business models (finding the right purpose and choosing it rightly).
- Finally, in the funding and financing phase, there is a strong potential in the short term through public supports.

In conclusion, there is a need to maintain the momentum on hydrogen projects and to identify the priorities, needs and the key steps for short-term deliverables. The next steps for the ‘Hydrogen Valleys’ project are to have the right regulatory enablers in the market. Others are to connect multiple valleys by the middle of the decade, connect demand and supply points, have more FIDs for projects across all archetypes, focus on early commercial off-take routes, expand to new markets, and have a continued dialogue among policy makers and project developers.

Benjamin Wolff (Element Energy, UK)

Review of pilot projects in Europe and the role of public funding

Element Energy provides consultancy and management services in the entire value chain of hydrogen and is involved in the development of flagship hydrogen mobility projects in Europe. Element Energy supports R&D and demonstration projects to enable a significant acceleration of the hydrogen market.

The European Union Fuel Cells and Hydrogen Joint Undertaking (FCH JU) has funded most of the R&D and demonstration projects so far. These projects are key to enable the development of the market. The first support schemes were designed to support complete hydrogen ecosystems. As the hydrogen industry matures, European funding bodies are adapting their support schemes, with a greater focus on production and HRS (Hydrogen Refuelling Stations). Recently released European calls for projects suggest a greater focus on developing green hydrogen production and the infrastructure network.

Public support is required in the EU countries for the first vehicles in the ecosystem. France has one of the most ambitious strategies at the European level regarding the development of renewable hydrogen. Many projects have been supported by ADEME (the French national agency for ecological transition) through the Call for Proposals “Ecosystèmes territoriaux hydrogène”. ADEME supports the development of complete hydrogen ecosystem (production, distribution, dispensing and end-applications) and aims to connect the different projects for large scale deployment in the medium term.

One of the flagship projects supported by Element Energy for light-duty vehicles is ‘ZEFER’ (Zero Emission Fleet Vehicles for European Roll-out) that targets the deployment of 180 vehicle fleet in Paris, London, and Copenhagen. The project has been successful with over 99% availability of the vehicles, and has also inspired subsequent projects. Nonetheless, we found that despite decreasing vehicle costs, national and regional grants are still needed to further reduce the cost premium of FCEVs (Fuel Cell Electric Vehicles) and accelerate the market. In the year 2021, the TCO (Total Cost of Ownership) is still high, with a premium to pay over other applications.

The ‘Hype Project’ in France has successfully mobilized European and national funding to accelerate the deployment of the biggest FCEVs taxi fleet in Paris. Also, large scale follow-on projects are emerging across Europe in taxi applications (for instance in Madrid). Another key project is the ‘Corridor H_2’ in the Occitanie Region. It aims to decarbonize heavy-duty mobility in the region and on major European corridors. The project has received funding from the EU

to develop the ecosystem, and the Occitanie Region will also provide grants to local fleet-operators in order to support the demand-side of the project.

Sophie Legras (INRAE Dijon)

Taxation with inter-jurisdictional commuting and pollution

The study aims to focus on fiscality among the determinants of interjurisdictional commuting. Around 64% of workers commuted out of their municipality of residence in 2013 in France and 75% in the 'Ile-de-France' region. The consequent air pollution has impact on the respiratory and cardiovascular systems and road transport is responsible for 53% of NO_X emissions. Local fiscality (residential taxes, business taxes, traffic related charges and taxes) represents around 17% of tax receipts in the EU28 and the US.

We modelled a tax competition between two asymmetric jurisdictions with respect to productivity (a low-productivity jurisdiction and a high-productivity one). We introduced the environmental costs of commuting in our model and considered an incentive for the high-productivity jurisdiction to attract workers to export its tax burden by the induced pollution import.

We found that for a high-productivity jurisdiction there are three types of impacts: a negative impact on utility, a positive impact on pollution load effect (because as the incentives reduce, there will be less pollution), and a head tax effect. Therefore, there is a trade-off between the fiscal burden export and pollution import. For a low productivity jurisdiction, there are four types of impacts on the wage, pollution, head tax effects as well as a negative commuting cost effect. Therefore, there is a trade-off between cross-commuting and resident-workers welfare. Finally, we compared the wage and commuting tax and found that higher welfare levels exist with commuting tax, and that it increases the incentive for cross commuting.

4. Mitigating GHG Emissions and fairness issues

Yves Crozet (IEP LAETS Lyon)

Decarbonise Transport: "Whatever it takes"

Decarbonizing transport is a huge challenge and makes it difficult to achieve the 2050 climate goals. The cost of reducing carbon emissions is not consistent among decarbonizing instruments, countries and public/private sectors and the ambition to align public and private carbon taxes faces several hurdles. For example, in Norway, the government spends about €1,370 per ton of CO_2 to electrify vehicles while the EU price is about €390 per ton of CO_2.

In France, the carbon tax is €44.6 per ton, while the carbon market (EU-ETS)'s price has varied between 2-80€. Some sectors are still not covered at all by the EU-ETS, such as aviation and marine transport. Today, the current French fuel tax is equivalent to a €250 per tonne of CO_2 carbon tax for private drivers, while companies and professionals are taxed much less. Therefore, it is challenging to further increase the carbon tax if it is not implemented in other sectors (aviation, marine transport) and if revenues from the tax are not clearly directed towards specific investments for the energy transition.

Discussion

Two participants The figures for Norway could be much lower if we account for the positive externalities (such as the reduction in local pollution) when switching to EVs, especially in cities.

Yves Crozet The overall costs would still be very high.

Corinne Bach (Carbometrix)

Emission in Transport: how to measure them?

Carbometrix comprises a team of certified carbon consultants. We explored what it would mean to really have a zero-emission business and found that although automobile OEMs publish their carbon footprints, ~~but t~~hey do not measure it correctly. Our study is based on research with automakers worldwide and identified gaps in what the OEMs published, and recomputed actuals to avoid misleading information.

Our study attempted to answer the following questions: how do we assess the carbon performance of automakers and rank them? and why are the OEM's communication misleading/'greenwashing'?

To accurately compute the emissions from cars, we accounted for both the well-to-tank (fuel/electricity production and distribution) and the tank-to-wheel (energy consumption) emissions. We used the specific emissions of new cars (in gCO_2/km) as an indicator to rank the automakers based on their carbon intensity. Also, we computed the carbon emissions for each car sold by each automaker and aggregated the data to find the average performance of the automaker's sales. This framework enabled us to have a carbon intensity ranking for the automakers from the lowest to the highest. We found the top 10 OEMs are - Tesla (100% EVs),Toyota (numerous sales of hybrid cars), Suzuki, Renault, Hyundai, BYD, Honda, Mazda, Saic and Volkswagen. Some limitations of our study include the possibility of underestimating the hybrid models carbon emissions, the non-consideration of the well-to-tank emissions, the

challenge of matching the models and brands with their OEMs, the driving behaviour of users and differentiating the EVs, hybrid and PHEV for certain brands such as Hyundai.

Discussion

A participant The results could only be a lower bound of real emissions.

A participant It would have been more accurate to take into account the carbon intensity of the electricity used to manufacture the vehicles, and more specifically batteries. This could affect the result of Asian manufacturers that do not produce vehicles with decarbonized electricity. Depending on the battery size, it could also change Tesla's rank.

Corinne Bach The bulk of the emissions would still be in the value/supply chain upstream and downstream of the OEM, so it would not radically change their results. However, the main issue with batteries is not their production carbon intensity but rather the materials used to build them.

A participant Adding battery recycling would be a game changer for the ranking. For example, for Toyota.

Corinne Bach Toyota's result was surprising, it could be explained by the limitation of the WLTP (World harmonized Light-duty vehicles Test Procedure) standard to assess the real carbon emissions from hybrid cars.

A participant It was interesting to compare the OEMs that have different strategies with the same metric.

Mathilde Niay & Bruno Quille (Ministère de la Transition Ecologique, CGDD)

Bonuses for the conversion of private vehicles in 2019: A socio-economic analysis

Bruno Quille and Mathilde Niay are both statisticians and economists at the General Commission for Sustainable development at the Ministry of energy and solidarity transition office of (Economy and evaluation, Green and Solidarity Economy Service).

Our study is on the ex-post socio-economics analysis of the bonus (premium) for the conversion of private vehicles. Ex-post impact studies are rather new and becoming increasingly popular. They emerged from growing public demand to justify the efficiency of public policies (and taxes), new data and empirical methods and democratic requirements.

The policy objective is to accelerate the energy transition of the auto fleet by providing a financial incentive for households and companies. It has both environmental (CO_2, fine

particles, NOx) and social (including taxes) costs reduction goals. The premium was created in 2015 and has gone through changes, such as an expansion of the allocation terms in the year 2018. Since the year 2019, it has focused on the better targeting of low-income household beneficiaries. Recently, the conversion premium has become a tool in the post COVID recovery plan.

We performed a cost-benefit analysis of the measure with data from different sources and assumed that drivers replaced their oldest vehicles earlier, and that they bought more efficient and relatively more expensive vehicles (premium excluded). We found that, in 2019, non-taxable households represented 90% of beneficiaries and 85% of the scrapped vehicles were diesel vehicles. Regarding the purchased vehicles, 70% were second-hand vehicles, 46% gasoline and 53% diesel vehicles. EVs were still too expensive for the beneficiaries.

In conclusion, although the assessments are sensitive to assumptions, the total gains of the policy are positive. The main gains are for fine particles, making the policy an “air pollution” measure more than a carbon-reducing measure. Improving households’ targeting in 2019 has led to environmental gains. Indeed, all the environmental gains were more than twice better compared to 2018. For the buyer, the social impact is negative without the premium and becomes positive with the premium. The main gains for consumers are the consumption and *reduction in extra costs.*

Discussion

A participant What is your CO_2 price reference?

Mathilde Niay & Bruno Quille Our reference is from the report of the commission chaired by Alain Quinet i.e ‘the Quinet report’ (The Value for Climate Action - A shadow price of carbon for evaluation of investments and public policies).

A participant Did you take into account the territorial density to compute the benefits?

Mathilde Niay & Bruno Quille Yes, using the circulation zones.

Emmanuelle Taugourdeau (CNRS, CREST)

Multi-tier tax competition on Gasoline (with Marie Laure Breuillé)

Our paper analyses the fiscal interactions arising from gasoline taxation in France. Today, there are huge disparities in gasoline prices among countries but also regions and

departments. The price disparities could make people move to other regions for cheaper prices.

There is no consensus in the literature on how consumer react to price changes: the only consensus is that the elasticity is low in the short time, and in the long term, consumers change their consumption pattern. For example, In France, between Creuse and Indre, a full tank refuelling leads to a 10€ difference. The fuelling decision seems to be mostly based on the fuel price, while the refuelling location appears secondary. The decomposition of fuel prices shows that taxes represent more than 60%. This includes two very different taxes: VAT (on manufactured products) and excise tax (on quantities). These taxes amount to €35billion shared among the central government and the regions and departments. From 2011 to 2016, the central government allowed regions to develop their own taxes and, as a result, all regions set the highest possible tax level (€0.025/litre of gasoline). The current system is regressive because low-income earners living far from work pay more for gasoline.

Our research questions are: Is gasoline tax a good instrument for the local governments? and should local governments be involved in setting the gasoline tax rate?

We applied a theoretical model to study the simultaneous vertical and horizontal gasoline tax competition. Horizontal standard competition happens between regions that set different tax rates while vertical interactions are considered between regions and the central government. Our model considers two regions with uniformly distributed agents that consume two goods in a quasi-linear utility function under budget constraint (gasoline purchase, transport costs etc).

We found that local and national fiscal tools are interdependent. However, it is not clear whether local excise tax is a good instrument or not. The optimal solution found in our research suggests that low local tax rates instrument could be left to the local government but with a very low room for manoeuvre. With unchanged Value Added Tax (VAT), an increase in excise taxes (for quantity purchased) reduces the demand for gasoline. Therefore, price elasticity of demand also plays a crucial role.

END of DAY ONE