Workshop: The Energy Transition in Land Transportation

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Session 1 chaired by Yannick Perez, Assistant Professor, CentraleSupélec & Univ Paris Sud (RTIM) Paris-Saclay, Research Scientist at the chair Armand Peugeot

Comparison of leading electric vehicle policy and deployment in Europe.

Uwe Tietge, Research Scientist, the International Council for Clean Transportation Europe team, Berlin.

The study presents some data on electric vehicle (EV) market shares, the availability of charging infrastructure, and the impact of incentives on EV uptakes in Europe. It encompasses the 5 key European leaders (Netherlands, Norway, UK, Germany, France), including 2 case studies for each country.

Two kinds of subsidies are complementary for EV uptake:

- ✓ Supply-side incentives, including the EU CO_2 standards (130 g/km in 2015, 95 g/km in 2021), and "super credits" or "multipliers" for vehicles with ≤50 g/km;
- ✓ Demand-side incentives, such as direct consumer incentives (vehicle subsidies, tax exemptions), indirect consumer incentives (preferential access), charging infrastructure support, and complementary incentives (sales targets, R&D support, consumer outreach and education, etc.)

The analysis of the effectiveness of EV incentives shows that fiscal incentives are effective, charging infrastructure a prerequisite (as people awareness), and that socioeconomic and

geographic contexts matter. In order to be effective, the policy design needs to be simple, substantial and sustainable.
Although the 2015 target of 130 g/km for type-approval new European passenger cars was surpassed (120 g/km in 2015), there is a growing gap between this data and real-world emissions (170 g/km in 2015). This gap increased from 9% in 2001 to 42% in 2015.

Heterogeneous Users, Endogenous Congestion and the Cost of Pollution.
Marc Ivaldi Professor, Toulouse School of Economics (TSE) and Ecole des Hautes Etudes en Sciences Sociales
The motivation of the developed transport model is twofold: equilibrium models of congestion in network are both too complicated and too crude; there is no structural relation between trip generation and mode choice in the demand for transport, and nonlinear prices are not taken into account.
The model aims at better taking into account the effects of congestion, to incorporate preference heterogeneity and optimal nonlinear prices, and to provide a bridge between the theoretical and econometric models. The model is applied to data from the Origin and Destination Travel Survey of Santiago, conducted in 2002.
The estimation delivers realistic demand elasticities. The model is also used to assess the welfare effects of a congestion policy. For instance, it is shown that a policy of congestion pricing may have a negative effect: an increment of fuel taxes by 10% leads to a total welfare loss of $ 63,500 per day. The model also suggests that only pricing the modes is not sufficient, an overall consistent policy of transport is needed.

Corrective Policy and Goodhart's Law: The case of carbon emissions from Automobiles
Mathias Reynaert Assistant Professor of Economics, Toulouse School of Economics, joint work with James Sallee.
Cars are becoming much more efficient over time. But, as seen in the first presentation, this progress is largely illusion, because the performance gap between official and on-road fuel consumption has grown from around 10 to 50% since the late 1990s.
The paper develops a theoretical model in order to evaluate how gaming affects consumer surplus (CS). In the case of absent policy, gaming harms consumers through price effect and choice distortion. Policy flips the sign of price effect, as gaming lowers firm cost and then creates lower prices for consumers. In this way, consumers may benefit from gaming.
The descriptive analysis confirms the industry-wide rise in gaming for CO_2 in EU, which is coincident with policy changes.
These elements are consistent with Goodhart's Law ("When a measure becomes a target, it ceases to be a good measure"). Indeed, policy erodes accuracy of fuel-consumption measures; the fuel-economy standard disrupts market self-regulation and then creates gaming.
Finally, the structural estimation allows calculating the delta CS in EU market with and without gaming and policy. The results validate the theoretical model, consumers do benefit from gaming.

Overlapping Strategies for Reducing Carbon Emissions from the Personal Transportation Sector

Carolyn Fischer, Senior Research Fellow, Resources For the Future, Washington DC, joint work with Soren Anderson and Alex Egorenkov

The transportation sector accounts for 26% of US GHG emissions, of which 61% for LDVs (light duty vehicles). The causes are the number of miles travelled, the fuel consumption of cars and the carbon content of fuel. The solutions appear to be: drive less; less emitting cars (with smaller cars, miles per gallon technologies); and switch to renewable fuels.

Different economic tools exist and are evaluated in regards to these 4 kinds of solutions (see table below): CO_2 tax, BTU tax, Renewable fuel standards (RFS, with minimum quantity or percentage targets), Low Carbon Fuel Standard (LCFS), and traditional or size-based Fuel Economy Standards (CAFE).

MARGIN	CO2 tax	BTU tax	RFS (Q)	RFS (%)	LCFS	CAFE traditional	CAFE size-based
Drive less	+	+	–	~	~	–	–
Smaller cars	+	+	–	~	~	+	
MPG tech	+	+	–	~	~	+	+
Switch fuels	+		+	+	+		

A model is used to assess the impacts of the current policy mix, the optimal policy and the single policies mentioned above, on different components of the transport system: carbon savings, cost-effectiveness ($/t$CO_2$), changes in private surplus, and other damages (on pollution, congestion and accident externalities).

A no policy scenario is compared to a baseline scenario (combining BTU tax, RFS % and size-based CAFE) and an optimal scenario (combining CO_2 tax, RFS quantity and traditional CAFE). Both scenarios lead to a 9% total cumulative emissions reduction for the 2015-2040 period, but with a much lower cost for the optimal scenario ($15/t$CO_2$) compared to the baseline ($44/t$CO_2$). Accounting for other damages further improve the benefits of the optimal scenario, CO_2 and BTU taxes, which end up with large negative costs (-$21/t$CO_2$).

Finally, the current policy seems to be too focused on technology, and is missing low-tech and low-cost options (miles & size).

From weak signals to mobility scenarios: A prospective study of France in 2050.

Vincent Kaufmann, Professor, Ecole polytechnique fédérale de Lausanne, Director of LaSUR, joint work with Emmanuel Ravalet.

The presented work is about the construction of mobility scenarios for France in 2050, by the identification of current trends and especially weak signals in mobility patterns. The study was conducted through an interdisciplinary group with SNCF, and built on a survey conducted among 1.800 French households.

For these scenarios, three new phenomena have been considered:

- ✓ The changing role of car, such as the changes among the younger generations, and the fact that car use began to decline for many urban agglomerations in 2005.

- ✓ The development of poly-topic habitats and intensive mobility linked to family, work or leisure reasons, like bi-residence or long-distance commuting.
- ✓ The increase in daily travel time budget throughout Europe since the 1990s, after a long period of stability (known as the "Zahavi Conjecture").

The survey also identifies a great diversity in mobility practices, with the following typology of logics of action: "Exclusive drivers" (8.7%), "Open drivers" (16.9%), "Exclusive alternative mode users" (4.4%), "Thwarted drivers" (16.6%), "Prone to alternative modes users" (12.6%), "Multimodal comparers" (22.6%), "Civic environmentalists" (9.9%), and "Locally rooted" individuals (8.3%).

Three prospective mobility scenarios have been constructed and then quantified:

- ✓ Ultra-mobility, "faster and further", for which the car will remain a key mode of transport in France in 2050.
- ✓ Alter-mobility, "A different way of travelling", characterized by the development of alternative modes.
- ✓ Proxi-mobility, "The quality of local living", encouraged by a fatigue due to high mobility / fast-paced daily life and by aspirations for a better quality of life.

Session 2 chaired by Dominique Bureau, Délégué Général du Conseil économique pour le Développement Durable (CEDD), Président du Comité pour l'économie verte au Ministère de l'écologie, du développement durable et de l'énergie

The Carbon Footprint of Suburbanization: Evidence from French Household Data

Miren Lafourcade Professor, University Paris Sud (RITM) Paris Saclay & Paris School of Economics, joint work with Camille Blaudin de Thé

The suburbanization is a long-standing trend from the 1950s, but urban sprawl has come at many costs (market failures), in particular the growth in GHG emissions from transport. A large body of literature already exists about the negative relation between density and transport-related energy, but this paper aims at taking into account self-selection (people who like driving prefer living in areas of low density) and endogeneity issues (density correlated with unobserved variables affecting driving) which are absent in the literature. This study alos analyzes the impact of the design and diversity characteristics of urban sprawl.

Based on 2006 household data on fuel consumption associated with personal driving, family expenditures and other socioeconomic and dwelling characteristics, the main econometric specifications test the regression of fuel consumption on densities. The estimation allows evaluating the average impact of individual characteristics on fuel consumption, as well as the distance to CBD, or population and train station densities in the residence.

The CO_2 predictions on the French Metropolitan Areas (MAs) reveal a greater CO_2 "car-print" in the SW part of France, and for the medium-sized MAs. The paper thus suggests a new bell-shaped relation between driving emissions and population size.

The specific anti-sprawl policies should include public transportation networks (metro/train stations), collective denser housing and price signal.

Mobility Choices and Climate Change: Assessing the Effects of Social Norms and Economic Incentives through Discrete Choice Experiments

Charles Raux, Professor, Université de Lyon, Director of Laboratoire Aménagement Economie Transports.

Reaching ambitious targets of transport emissions reduction need both technology and behavioral changes. The study evaluate and compare the impacts of social norms and economic incentives (carbon tax, personal quotas and bonus-malus) when encouraging pro-environmental mobility behavior. The social norms refer to injunctive norm (IN; encourage people on the basis of scientific explanation), and descriptive norm (DN, 60% of French people…).

An experiment is conducted through a discrete choice experiment, in a hypothetical context of a long distance leisure travel of one week stay at 1000 km for 2 people. The proposed alternatives are air, car, coach, train, or no travel at all. There is a trade-off between travel price and travel time under various framing conditions (social norms and economic incentives): no CO_2 information, information for each mode, and 5 other situations with information and injunctive norm, that are info+IN alone, or with DN, tax, quotas or bonus-malus. It appears that the framing effects differently affect the travel modes. Psycho-social norms are effective on their own in influencing (stated) travel choices, thus this study makes a case for using psychologically positive framing effects in promoting pro-environmental behavior. Moreover, only providing basic information on CO_2 emissions for each alternative has a significant (strong) effect, and can be reinforced by an injunctive norm. Additionally, normative messages through benchmarking (bonus-malus) or carbon budgeting (quotas) are stronger than a pure tax. Finally, the amount of the financial (dis)incentive in itself might not matter, the framing itself does.

Application of E3ME to assess the economic effects of low-carbon transport in France

Sophie Billington, Project manager, Cambridge Econometrics (UK)

The study aims at evaluating how can low-emission vehicles contribute to the French energy transition and the improvement of air quality, and the related impacts for the consumer, the macroeconomic and energy system impacts in 2030 and 2050, as well as the technology requirements and uptake.

A Hybrid Modelling Approach is used, combining bottom-up modelling for the market penetration of electric vehicles in the French vehicle stock, and top-down approach to model the macroeconomic effects, using E3ME. This gives a model of Energy-Economy-Environment interactions, which contains a series of empirical equations to estimate the effects of policy scenarios on consumption, investment, trade, employment and prices.

The main impacts for 2030 include an average avoided spending on fuel of 591 € annually per motorist, 66,000 to 71,000 net additional jobs, and reductions in pollutant emissions of 72% for NOx, 92% for PM, and 40% for CO_2 emissions.

As a result, the transition to low carbon mobility in France will create opportunities and challenges. Indeed, an overall net positive macroeconomic impact is modelled for the low carbon vehicle scenarios, even if the results are highly sensitive to input assumptions, for example the technology cost, oil price and Motor Vehicle supply chain assumptions.

Defining Abatement Costs in Presence of Learning-by-Doing: Application to the Fuel Cell Electric Vehicle

Guy Meunier (INRA and Ecole Polytechnique), joint work with Anna Creti, Alena Kotelnikova and Jean-Pierre Ponssard

Two technologies are competing to decarbonize the transport sector: Battery Electric Vehicle (BEV) and Fuel Cell Electric Vehicle (FCEV). The second one has much lower energy efficiency, but hydrogen has the benefit of a larger range. The requirements for its uptake are the decreasing in manufacturing cost, the need of clean and cheap H_2 production and the deployment of a H_2 distribution network.

Marginal abatement cost (MAC) curves are a standard tool to assess the economic efficiency of these new technologies, but practical assessment in a dynamic setting is not straightforward. The paper then introduce learning-by-doing together with cost convexity to conduct a dynamic MAC analysis applied to the deployment of FCEV in substitution to internal combustion engines (ICE). The optimal trajectory is a smooth transition, where the main characteristics to be assessed are: the design of the deployment schedule and the choice of the optimal launching date. In the application for the FCEV case study. The dynamic abatement cost which would justify launching hydrogen car deployment in 2015 is 53 €/tCO_2.

The possible extensions of this work deal with the analysis of policy options, the coordination of the deployment of complementary capital intensive goods (networks, production plants), and the competing green options as the possible complementarity or substitutability of the FCEV and BEV technologies.

Round Table

"How does the energy transition materialize in your sector of activities: main challenges and potential breakthroughs?"
chaired by Anna Creti

Sylvain Hercberg, Directeur du Pôle Prospective EDF-Direction Prospective et Relations Internationales

Transport is essential for development, and the transport demand is expected to grow rapidly in the coming decades, notably due to demographic growth, economic growth and urbanization. This creates a huge challenge in regards to oil consumption, which represents more than 90% of the energy used in transportation.

It is necessary to act at all levels, from the local scale of transport organization to the State level, in order to support economic development in a sustainable way. Beyond the political framework, action is also needed on technologies, in order to be the most effective and the cheapest for the collectivity.
The electric vehicles share is projected to increase rapidly in the future, and the benefits for France are important due to its low-carbon electricity generation. Some challenges are still on the way, as the density and the cost of battery storage, the range of electric vehicles, or the infrastructure deployment and the interconnections with the electric system, but these technologies seem to be close to maturity.

Grégoire Marlot, SNCF / Directeur de la Stratégie

Energy transition in the transport sector, and especially reaching the "Factor 4" French target by 2050, need public policy and behavioral changes in addition to technology, that at best could achieve a factor 2 if deployed alone. Similarly, a massive deployment of the autonomous vehicle (as studied for Lisbon) would not present benefits for the collectivity if not combined to mass public transport.
Mass transportation thus appears necessary to obtain sustainable mobility: the rail transport represents 10% of the national transport, for only 0.4% of its emissions; its CO_2 emissions per passenger * kilometer are within 3 to 10 g, while they are around 200 g for a private car.
Nevertheless, the relevance area of massive transports needs to be respected. They also have to be connected to the other transport modes, especially in terms of infrastructure adaptation and digital information, in order to facilitate the "door to door" travels.
Finally, the competition among these modes needs to be fair. The social costs of road transportation are not supported by its users, so there is a gap between the cost for the collectivity and what the users pay. Public policies have to better take into account these externalities and provide incentives and constraints to encourage shifting from car to efficient modes.

Erwin Performis, Air Liquide, VP Hydrogen Energy Market

Hydrogen is an energy carrier that Air Liquide studies for about twenty years. It can be applied to all transport vehicles, from cars to trains including also maritime and air transport. It could in particular participate in the ambitious target of 95% abatement in road transport emissions by 2050 planned in the EU roadmap. Hydrogen also represents an opportunity to develop the storage requirements associated with a massive deployment of intermittent renewable energy as wind and solar PV. In the world, the first deployment of hydrogen is related to mobility, with four car manufacturers (Toyota, Honda, Hyundai and Daimler) already selling FCEV. Today, around 300 stations and 150,000 hydrogen-fueled vehicles exist in the world.
The main challenges and tools to accelerate this transition are the evolution of incentives and regulation, the financing needs in particular for the infrastructure deployment, and a global awareness and confidence in this technology.

Yann Tréméac, Chef de service adjoint, Service Transports et Mobilité, ADEME, Paris

The transport sector deals with various high stakes, with economic, social issues (for instance the car dependency in low-density zones), and several environmental issues such as CO_2 emissions and air quality. The ADEME (Environment and Energy Management Agency) service on transport and mobility deals with 3 axes: to accompany mobility behavioral changes, such as the development of carpooling, or walking and bike which are rapidly increasing; to help the freight transport to lower its emissions through CO_2 targets and logistic chain improvements; and to support territories for an integrated policy in transport.

The approach is also technology-neutral, with the promotion of complementary technologies, such as electric vehicles, hydrogen, gas, and diesel for the fuel. The electric vehicle is more relevant when used intensively. The prospective vision also emphasizes the greater importance of intermodal services; the using of the car as a service allowed by the ICTs, eventually by the autonomous car; but also the modification of the vehicles to tend towards smaller and less resource intensive cars. Finally, the development of these modes has to be coherent with the other parts of the energy transition, especially the convergence with the renewable energies and the needs for energy storage.

Jean Guy Devezeaux de Lavergne, CEA, Directeur de l'i-tésé

The ANCRE (National Alliance of Coordination of the Research on Energy) gathers research and industrial actors to work on energy scenarios and the prospects for current and future technologies. The transport sector appears to be difficult to decarbonize. A lot of technologies exist, and some of them will certainly experience a strong growth by 2030. This is an opportunity for France and Europe to develop these technologies for taking part in global competition.

Many developments are on track for the electric and hydrogen (for mobility and electricity storage) technologies, and they present wide benefits for flexibility and electric renewable energy integration, as long as the storage challenge has to be resolved. In particular, they are different battery families in development, together with some research on the intelligence within the batteries to optimize their operation, and even research on the electrification of airplanes. The biomass stock is also very important in France but its operational access is not maximized yet. Finally, many challenges for the uptake of these technologies are non-technical ones: the need to transform the French success stories into real and sustainable deployments; the need to align research and public policy with the time horizon maturities of the technologies; the difficult exercise of anticipating an uncertain future; and the necessary dialog between all stakeholders.