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CO_2 REDUCTION FOR URBAN GOODS MOVEMENT: IS IT POSSIBLE TO REACH THE FACTOR 4 BY 2050?

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ABSTRACT

In this paper, we propose an appraisal of combinations of several public policy measures that seem to be the most probable by 2050, for urban goods movement (UGM). The proposed scenarios follow the trends of transportation long-term issues in France and introduce the specificity of the urban geography in freight-related trips. The considered trips are those classical for freight distribution in urban areas plus those related the household purchasing behaviour. A simulation method that combines several land-use and transport interaction (LUTI) models is also proposed, in order to estimate the gains of each scenario respect to the current situation (the emissions calculated on 2006 surveyed data for the city of Lyon). Finally, we present a set of suggestions in order to reach the factor 4 for UGM and if it is realistic.

Keywords: urban goods movement, greenhouse gas, sustainability, factor 4.

INTRODUCTION

The main conclusion of the IPCC 2006 (Intergovernmental Panel on Climate Change) is that developed countries have to reduce their greenhouse gas emissions by 2050. In these countries, the industrial greenhouse gas emissions are stabilised and the one of the housing and the transport sectors are increasing. Some countries in Europe have already adopted long-term targets, like UK (60%), France (75%), Germany (80%) and the Netherlands (80%) (Kawase *et al.*, 2006). The green house gas reduction of 75%, i.e., the target imposed in France, takes the name of factor 4 (Lopez-Ruiz, 2008).

Although several studies deal with greenhouse gas reduction in transportation, they are related to interurban freight and people transportation (Enerdata, 1999; Crozet *et al.*, 2001; Banister and Hickman, 2005; Criqui and Allaire, 2007; Bristow *et al.*, 2008; Crozet *et al.*, 2008; Crozet and Lopez-Ruiz, 2009a, 2009b). The urban contribution of freight movement has not been taken into account. Following the definition of Ségalou *et al.* (2004), urban goods movement (UGM) are characterised by three components: trade between the establishments, trips for purchase and other goods movements (moving, public works supplying, waste collection, etc.). According to this definition, goods transport accounts for 25% of the greenhouse gas emission of the whole transport industry in the urban areas (Patier, 2002; Ségalou *et al.*, 2004).

On the basis of the results of different tools (policy-oriented model Freturb, review of the results from available evaluations of the impact of the innovations in France and in Europe), we propose an appraisal of the combination of those measures which seems to be the most probable by 2050. We conclude by some suggestions of leanings in order to reach the factor 4 for UGM and if it is realistic.

BACKGROUND ISSUES

It is important to look at the long-term future, particularly when dealing with policies related to reaching greenhouse gas reduction targets, as the actions may require long times to be efficient; impacts and breaks often take time to become identifiable and may have unexpected consequences. Moreover, combining policies to make them be more efficient because of their synergies has to be analysed and evaluated. To help the public deciders to understand these long-term future issues, a number of empirical research techniques are proposed in the scientific literature. Two main categories of techniques can be identified. The traditional forecasting approach, i.e. the prevision based on time series, is still dominant in many research studies looking over a short or medium term horizon (Armstrong, 2001), which consists on estimate future trends from current information and are also popular in long-term issues works. However, these approaches present many limits when dealing to highly complex, long-term problems where trend-breaking futures are required, like in topics as energy consumption and transportation.

Another category of techniques are the backcasting ones, first introduced by Robinson (1982) to analyse future energy options in terms of how desirable futures could be attained. The major characteristic that distinguishes these techniques from forecasting ones is that they don't simulate what futures are likely to happen, but with how desirable futures can be attained. In other words, the proposed situations are hypothetical ones and then the measures and actions to arrive to these situations are developed. There is an important literature on the methodology and technical issues relating to backcasting (Robinson, 1982; Dreborg, 1996; Crozet *et al.*, 2001; Bagard *et al.*, 2004; Geurs and van Wee, 2004; Akerman and Höjer, 2006; Kawase *et al.*, 2006; Banister *et al.*, 2007; Hickman and Banister 2007; Bristow *et al.*, 2007; Lopez-Ruiz, 2009; Lopez-Ruiz and Crozet, 2010). Moreover, these techniques are preferred to forecasting in long-term future analysis for greenhouse reduction policy making. In this way, several future situations of sustainable cities have been proposed, both realistic (Philibert, 2005; Criqui *et al.*, 2006; Criqui and Allaire, 2007) or extreme (Crozet *et al.*, 2001; Raux and Traisnel, 2007; Routhier *et al.*, 2009).

This state of the art is not supposed to be exhaustive. It only endeavours to present some recent methodological studies in order to meet greenhouse gas reduction targets by 2030 or 2050, towards a sustainable development. It is to be noted that these different studies do not address the specific issue of urban goods movement, which will constitute the core subject of our paper.

In France, the main long-term future scenarios (2030-2050) follow the guidelines of the "Group of Batz" (Crozet *et al.*, 2001), a group of long-term issues researchers who hypothesised four sets of extreme general scenario guidelines for greenhouse reduction situations in 2030. The authors think out five scenarios by 2020, to get a framework of intelligibility able to bring to light: - potential transformations of the constraints influencing the general mobility; - the levers the public policies could use to cope with a new deal. The authors assume that infrastructural and environmental issues will gain in importance by 2020, in such a way that it will not be possible to be satisfied with past trends: major reorientation will be necessary. In order to picture the broad outline of the future situation, the authors present the following table.

Table 1 – Basic structure of the four scenarios related to urban mobility politics and policies by 2020

Programmes (*policy*) Public choices (*politics*)	Preferential resort to organisations and collective regulating process.	Preferential resort to the markets and to individual incentives.
Passenger and freight mobility preservation (and even rise).	Scenario 1: "technological voluntarism" (*homo technicus*).	Scenario 2: "cost knowledge and fair pricing" (*homo oeconomicus*).
Cut down in passenger and freight mobility.	Scenario 4: "mobility control through urban transaction" (*homo politicus*).	Scenario 3: "mobility control through private transaction" (*homo contractor*).

Source: Crozet *et al.*, 2001

The different scenarios presented above are deliberately caricatured compared with real policies of the urban mobility. Neither forecasting nor backcasting study approach is implemented: these scenarios try to show alternative conceptions of public actions, comparing different potential choices associated with interactions between public and private actors, in order to control mobility.

Scenario 1 is roughly a business as usual scenario, favouring the development of technology, to solve the current economical, environmental and societal conflicts. In scenario 2, emphasis is on price signals in order to affect behaviours of the economic agents, by means of individual incentives. Strictly speaking however this scenario is not free-market-oriented, inasmuch as it requires not insignificant public intervention about pricing. Scenario 3 refers more to the right of property (according to Coase) than to pricing in order to reorient mobility patterns. To cope with the scarcity of energy sources, this scenario might move towards the implementation of a "right to move" market. In scenario 4, the main lever is the political way. In case of necessity to reduce general mobility, it is envisaged here that a collective regulation be implemented. In the end, the authors suggest a realistic scenario, which takes various components from the four scenarios described above.

From this framework, a realistic application has been developed (Lopez-Ruiz, 2008; Crozet *et al.*, 2008; Lopez-Ruiz, 2009), in order to propose three voluntaristic scenarios for 2050. The first (*Pegase*) follows the technologic voluntarism perspective, following the main trends on long-term behaviours for modal choice but introducing a strong usage of "environmental-friendly" motorised vehicles. The second (*Chronos*) and the third (*Hestia*) are based on mobility control by regulation and incentive policies (Crozet *et al.*, 2008; Lopez-Ruiz, 2009; Lopez-Ruiz and Crozet, 2010). In *Chronos*, the usage of lower speed but less polluting modes is increased by regulation but keeping the trends of extending the urban spaces. In *Hestia*, the distances are reduced because the expansion of the urban space is contained and sometime regressive. These studies are applied to both people and freight transportation following a macroeconomic analysis for the French long-term issues in transportation at a national scale. The three proposed scenarios are compared to a "do nothing" trend, all of them estimated using a technico-economic macroscopic model called TILT: Transportation Issues over long-term (Lopez-Ruiz, 2009). It has been designed to be a long-term equilibrium model by combining a macroeconomic and microeconomic structure in a backcasting approach that takes into account new motor technologies and facilitates sensitivity and impact assessments through five modules that work on three different geographical scales (urban, regional and interregional).

- A *macroeconomic module* based on a re-foundation of the energy-environment modelling structures in order to assess properly long-term modifications of demographics as well as social and cultural preferences in relation to transport needs.
- A *microeconomic module* based on a discrete choice and demand evolution that takes into account transport cost, infrastructure capacity and quality of service in order to asses changes in agents transport choices.
- A *vehicle fleet dynamic and technology evolution module* that analyses technological impact based on market penetration probabilities and vehicles' survival rates for different motor technologies and different transport services (road, rail, sea, air, inland waterways).
- A *public policy module* that joins a sensitivity analysis and multicriteria analysis in order to offer a detailed assessment of the effects of different measures on CO_2 emissions.
- An *impact assessment module* based on an input-output equilibrium analysis that details impacts on employment and production by sector.

This model is centred on defined behaviour types in order to determine demand estimations, from which the traffic flows are obtained using a macro-simulation approach. From the analysis of the different simulations, it is shown that the two mobility control scenarios are more effective than the first one (which does not meet the factor 4 target). Indeed, *Pegase* does not meet the factor 4 target although a small reduction of greenhouse gas emissions is shown. *Chronos* and *Hestia* simulate different behaviour trends to answer to different contexts, and rise the factor 4 target when people and freight flows are considered (for only freight, their results are about the 60% UK target, but for people mobility the 80% is reached in *Chronos*, whereas the reduction in *Hestia* is near 90%). From the results of the analysis, recommendations can be proposed to public deciders to think about policies and actions to be implemented in order to reach a similar situation (Crozet, 2008; Lopez-Ruiz and Crozet, 2010). Specific analysis are made for the inter-urban freight transportation (Lopez-Ruiz, 2008) and for the rail transportation (Crozet and Lopez-Ruiz, 2009a).

At the urban level, Criqui and Allaire (2007) propose also three scenarios. Two of them (the technological voluntarism and the mobility control by regulation) follow the “group of Batz” indications (Crozet *et al.*, 2001). The third one, called hybrid by the authors, is a combination of the other two. No simulations are proposed but the main elements to build the future environment for simulation is discussed. The research deals with the urban areas but only for people transportation, and the freight component is not directly included in the discussion.

Bristow *et al.* (2008) examine strategic pathways to low carbon passenger transport in Great Britain by 2050, compared with the current trajectory of transport policy. The 2003 UK Energy White Paper (Department of Trade and Industry, 2003) made indeed legally binding targets to reduce CO_2 emissions through domestic and international action by 60% by 2050 against a 1990 baseline. However according to the authors, this reduction looks increasingly inadequate and should be more important compared with other countries as France (75%), Germany and the Netherlands (80%). So the authors seek to identify pathways by which the personal land-based transport sector might be able to deliver the deep cuts in carbon emissions of 60-80% by 2050 that would be required in order to achieve stabilisation of atmospheric CO_2 at acceptable levels. The focus is on personal land-based travel as it was the largest source of transport emissions, 65% in 2001 (aviation is not included in the study). The paper shows a gap between aspirations for long-term reductions in CO_2 emissions and current government policies in the transport sector.

A 2050 baseline was established using trend information, forecasts and best evidence from the literature on response to policy intervention. It composed a do-nothing scenario, while a range of strategies was tested in comparison with it. These strategies were based on technological development, pricing, public transport and "soft measures". The authors use a definition of soft measures according to Cairns *et al.* (2004) including workplace travel plans, car sharing, teleworking, school travel plans, teleconferencing, on-line grocery shopping, local collection points, personalised travel planning, public transport information and marketing travel awareness campaigns and car clubs.

Six scenarios have been developed: - technological change and unrestrained demand; - technological change and demand restraint through pricing (carbon-based fuels taxation); - technological change and public transport service and fare levels (price reductions and improvements to service levels); - technological change, telecommunications and soft measures; - pricing which drives both technological change and demand restraint (incentives in technology change); - additional combinations of the above (in order to meet the target, a combination of measures is required to drive significant changes both in technology and behaviour).

The authors conclude that even dramatic technological advance cannot meet the more stringent targets for carbon reduction in the absence of considerable behavioural change. The most promising combinations of measures involve clear price signals to encourage both a reduction in the use of motorised transport and the development and purchase of more efficient vehicles; decarbonisation of public transport and facilitating measures to enhance access whilst reducing the need for motorised travel.

Independently Hickman and Banister (2007) have reported on a recently completed study (Banister *et al.*, 2007) for the UK government on the options available to meet a 60% CO_2 reduction target by 2030 in the UK transport sector, even if traffic levels continue to rise and all the projections suggest that more emissions rather than less are likely to arise by 2030 and beyond.

A backcasting (this term has been introduced by Robinson, 1982) study approach is implemented, developing a business as usual baseline for transport emissions, and two alternative scenarios to 2030. Different policy measures (techno-logical, behavioural and regulatory) are assessed and assembled into mutually supporting policy packages.
The Visioning and Backcasting for UK Transport Policy (VIBAT) study approach consists of three main stages. The first is to set targets for 2030 and to forecast the business as usual situation for all forms of transport, so that the scale of change can be assessed. The second is to describe the transport system in 2030 that will meet the 60% reduction target. This takes the form of two alternative visions of the future that will push both the technological and the behavioural options, separately and in combination. At last, the third stage is the backcasting process strictly speaking, where alternative policy packages are assembled to lead to the images of the future, together with their sequencing in terms of when implementation should take place. The backcasting approach designs images of the future representing "desirable solutions" to societal problems. The term "scenario" covers both the images of the future and the trajectory leading back to the present.

The business as usual baseline is based upon several projections, mainly from Transport Statistics Great Britain (TSGB). It clearly shows a projected increase of 35% of all transport emissions between 1990 and 2030. From then on, two alternative images of the future have been constructed to reflect some of the different alternatives in terms of achieving the 60% CO_2 reduction target. One (close to the business as usual) focuses on market forces with higher GDP growth and lower oil prices, suggesting more travel and greater input from technological innovation (called "New Market Economy"). The second focus on a social welfare and environmental perspective, with lower GDP growth and higher oil prices, suggesting less travel and a greater reliance on behavioural change (called "Smart Social Policy"). At last, considering the policy packages, a comprehensive review allowed identifying more than 120 individual policy measures that could contribute to carbon efficiency in transport and these policy measures were then assembled into packages that were mutually supporting. Eleven policy packages have been developed. Some of them (including freight movement) are technologically based (low emission vehicles, alternative fuels, information and communication technologies), some rely on pricing to drive them (pricing regimes, increased oil prices), while others depend more on regulation and control or behavioural change (liveable cities, smarter choices, ecological driving, long-distance travel substitution, freight transport, carbon rationing).

In the end for the authors, the critical policy conclusions are that the 60% target reduction under "New Market Economy" image is not possible over the timescale envisaged, even when pushing hard on all options. Technological innovation on its own cannot bridge the gap, even if there is a very strong push on efficient vehicles and alternative fuels. The 60% target reduction can be achieved under "Smart Social Policy" image (with a reduction of 10% in car travel), through a variety of policy packages, but major change is required that combines strong behavioural change with strong technological innovation (international air emissions not included).

The overall conclusion of the study is that the 60% CO_2 reduction target can be achieved only by a combination of strong behavioural change and strong technological innovation. It is in travel behaviour that the real change must take place, and this should be implemented from now on. Changes in the built environment will largely become effective in the medium term (10-15 years), while the major contribution of technological innovation will only be effective after 2020.

McKinnon (2007) focus on CO_2 emissions from freight transport in the UK, in a report prepared for the Climate Change Working Group of the Commission for Integrated Transport (CfIT). He first underline that freight sector has received less attention about CO_2 emissions than car traffic and aviation in the UK. The study highlights significant discrepancies between estimates derived in different ways, aiming at assessing the government statistics on CO_2 emissions from the freight sector. On these facts, using the most reliable estimation methods, it is suggested that domestic freight transport in the UK generated 33.7 Mt of CO_2 in 2004, roughly 21% of emissions from the transport sector and 6% of total emissions from all sectors. Road transport accounted for 92% of these freight-related CO_2 emissions. The movement of freight in vans, which represented only around of 35% of all van-km, was responsible for 13% of total freight emissions.

An interesting analytical framework is produced, incorporating all the factors which influence freight traffic levels and related energy consumption, and illustrating the links between freight transport and the economic activities. It appears that the relationship between freight tonnage and CO_2 emissions depends crucially on seven key ratios: - the handling factor (measuring the number of links in a supply chain); - the average length of haul (mean length of each link in the supply chain); the modal split; - the average payload on laden trips; - the proportion of kilometres run empty; - the fuel efficiency of the vehicles; - the ratio of fuel consumption to CO_2 emissions (fixed for a particular type of fuel / power source). It is noted that between 1990 and 2004, trends in most of these key ratios moved in a direction which reduced the carbon-intensity of the freight transport system per tonne of freight moved.

Then two illustrative (i.e. not base on detailed forecasts of likely changes in the key parameters up to 2015) scenarios are constructed to illustrate how changes in the key ratios collectively impact on total CO_2 emissions from the freight sector: - scenario 1 (this "aspirational" scenario could cut CO_2 emissions by around 28% compared with 2004); - scenario 2 (this "steady state" scenario (considered more realistic) generates a 2% rise of CO_2 emissions compared with 2004).

The key freight variables, listed above and pivotal to the two scenarios, can be influenced by a range of public policy measures (land-use planning controls, infrastructural investment and/or revenue-support for alternative modes, freight facilities grants, lorry routing schemes, road pricing, road telematics improvements, regulations relating to vehicle emissions, duty reductions for alternative fuels). All of them are affected by tax policy (fuel, vehicle excise). Behaviour at all levels in the freight sector, from logistics director to lorry driver, can also be modified by specialist advice and incentives (guidance on how to manage and operate freight transport systems more efficiently). For the time being, the author notes that government initiatives are targeted mainly on modal shift, improving the loading of road vehicles and raising fuel efficiency. However, within a tougher CO_2 regime, the UK government might have to consider measures which suppress the total demand for freight movement.

At last, concerning cost-effectiveness of CO_2 mitigation measures in the freight sector, the study concludes that attempts to assess the cost-effectiveness of these measures are still at an early stage. However preliminary analysis suggests that the cost effectiveness of several freight-related CO_2-mitigation measures compare favourably with measures targeted on personal movement.

Akerman and Höjer (2006) lead a backcasting approach study to outline an image of a sustainable transport system for Sweden in 2050. According to them, the backcasting approach consists of four steps: the first one is the setting of one or a few long-term targets. In the second step, each target is evaluated against the current situation, prevailing trends and expected developments. The third step generates images of the future that meet the target. At last, the fourth step allows the images of the future to be analysed in terms of feasibility and paths towards the images. The results are supposed to provide recommendations on what policies to start with as soon as possible, in order to link the development towards the targets and avoid detrimental lock-in situations.

The authors consider that a stabilisation of the concentration of CO_2 in the atmosphere at 450 ppm (parts per million) is defined as sustainable, in line with the target of 550 ppm (CO_2-equivalents) for all greenhouse gases, adopted by the EU (IPCC, 2001). On this basis, images of the future are generated to meet a 60% CO_2 reduction target by 2050, compared to the year 2000.

Concerning the energy efficiency of vehicles, even if substantial technological improvements are expected, the study shows that it will be insufficient, because transport volume are forecasted to double between 2000 and 2050, whereas a combination of much improved technology and transport volumes similar to the ones in 2000, would hardly reach the target level. So it is not possible to reach a sustainable transport system (as defined in the paper) if current transport trends prevail!

Beyond this statement of fact, the study then focuses on three segments of the transport demand, in order to bring to light the appropriate means of action to meet the target while maintaining or even increase welfare: - short-distance passenger travels; - long-distance passenger travels and -freight transport. For this purpose, two concepts are foregrounded: - the geographical accessibility and - the functional accessibility. The former refers to a market or service through physical mobility while the latter covers a wider concept including access via information technology for instance.

Concerning short-distance passenger travels, image of the future is built on the basis of a strong decrease of the distance to work. To meet this target, the authors recommend a combination of technological development, learning and change of habits. The most important of these changes may be the rise of a generation of "telecommunicators", i.e. people with high skill in using new information technology for telecommunicating over a distance. Simultaneously, as a consequence of a new direction in urban planning, the mixing of housing and workplaces should be increased, leading to shorten trip lengths, encouraging people to use public transport or "smart" modes.

As regards long-distance passenger travels, a sustainable image for the year 2050 requires a concerted EU action for a truly integrated rail system in Europe to curb air travel growth. Regarding business travel, an important increase in an extensive use of teleconferences is expected.

Freight transport per capita in the sustainable image is expected 27% lower than it was in 2000 in Sweden. One of the main reasons is shorter transport distances, caused by significant changes from the organisational point of view (location of the activity and logistical chains). Besides, long-distance lorry transport has been reduced by one-third, while rail transport has increased slightly compared to the year 2000. An overall dematerialization of society (e.g. through lighter and more durable products) has also contributed to the reduction in freight transport.

In the end, the study gives some recommendations to run a policy for sustainable transport, strongly emphasising the fact that decisions should be taken from now on regarding particularly the structure of urban areas and transport infrastructure, due to the high inertia of these sectors.

From all these approaches, we can deduce a group of important aspects that have been taken into account in the configuration of the proposed future situations. The most important parameters in the scenario construction for transportation long-term issues are the energy sources assumptions, the technologic acquisition, the organisational aspects, the urbanistic developments and the behaviours derived from them. However, in an urban context, it seems important to distinguish the public decisions, the city configuration decisions and the behaviours derived from them to set the different stages of the prevision process.

URBAN LOGISTICS AND ITS CORRESPONDENCE TO FACTOR 4 PROBLEMATICS

Since the early 1990's, several studies deal with logistics planning and policy issues (Ruske, 1994; Dablanc, 1998; Taniguchi *et al.*, 2001; Ambrosini and Routhier, 2004; Rosini, 2005; Patier *et al.*, 2007; Bestufs, 2009; Patier *et al.*, 2009; Dablanc *et al.*, 2010). From these studies, we can define the main elements that appear to be important in long-term issues related to urban logistics: the location of the different economic activities in an urban area, the commercial supply strategies and public policies, the logistics and organisational aspects of urban supply, and the role of the new technologies.

Urban goods transport has specific characteristics concerning urban logistics: a lot of operators, a specific management of the logistic chains: various delivery vehicles, different organisations (rounds, direct trips), a large part of own account transport, a large part of subcontracting, leading to an expansive last mile movement worsened by congestion, more and more constraints in road sharing, new orientations in regulation and planning by local authorities. We can precise what is taken into account in the urban goods movement:

- Delivery vehicles used for inter-establishments trade (commercial, industrial, services) and goods vehicles for business trips (craftsmen carrying goods from depot to site, …): about 40% of the total amount goods traffic in vehicle x km (in car unit);

- Home deliveries and private cars carrying goods (household purchasing): about 50%;

- Vehicles involved in the urban management (waste collection, postal service, removal, hospital, public works, building works): about 10%.

Overall goods traffic segments listed above amounts to 20% (in car unit) of the total urban motorised traffic, what accounts for 25% of CO_2 emissions. Later we take into consideration the two first segments seen above representing above 90% of the total urban motorised traffic, on which simulations will be implemented.

Ségalou *et al.* (2004) noted that heavy goods vehicle (HGV) represent only one part of the urban goods movement (UGM). In France, apart from shopping trips, HGV (>3.5 t) account for about 50% of the UGM vehicle-kilometres (Routhier *et al.*, 1996-99), whereas a third of light goods vehicles (LGV) with weights below 3.5 tonnes also carry goods on a regular basis (SES, 1999). It is thus essential to identify accurately the contribution of UGM in traffic generation, with the help of a relevant knowledge database. The method presented in this paper is an extension of the data acquisition process carried out in France for several years towards a complete environmental assessment of the UGM. It is a policy-oriented model which aims at helping local decision making to assess the contribution of the various actors within city logistics in relation to energy consumption, congestion and environmental concerns (pollution, greenhouse gas, noise).

Currently, in towns (Ambrosini and Routhier, 2004), activity is significantly linked to operating modes, organisational modes and vehicles size. The transport chain is connected with operating mode and type of activity. Own account trips reach almost the same share of pick-ups/deliveries as professional carriers, while 3/4 of pick-ups/deliveries are carried on rounds and 3/4 of tours consist of single trips. Over 5 % of pick-ups/deliveries are served by vehicles less than 3.5 tons. Moreover the distance travelled depends on operating mode and urban density.

So different levers can be used to result in changes relating to the many and various organisations of urban freight transport, including chiefly rounds (this type of organisation is currently the most usual one, but its efficiency can be still improved). Apart from that, changes in operating mode behaviours are expected towards a larger use of hire or reward transport, more efficient than own account one. In this way it should lead to a decrease in the number of vehicles used and the number of kilometres travelled, bringing an emission reduction about in turn.

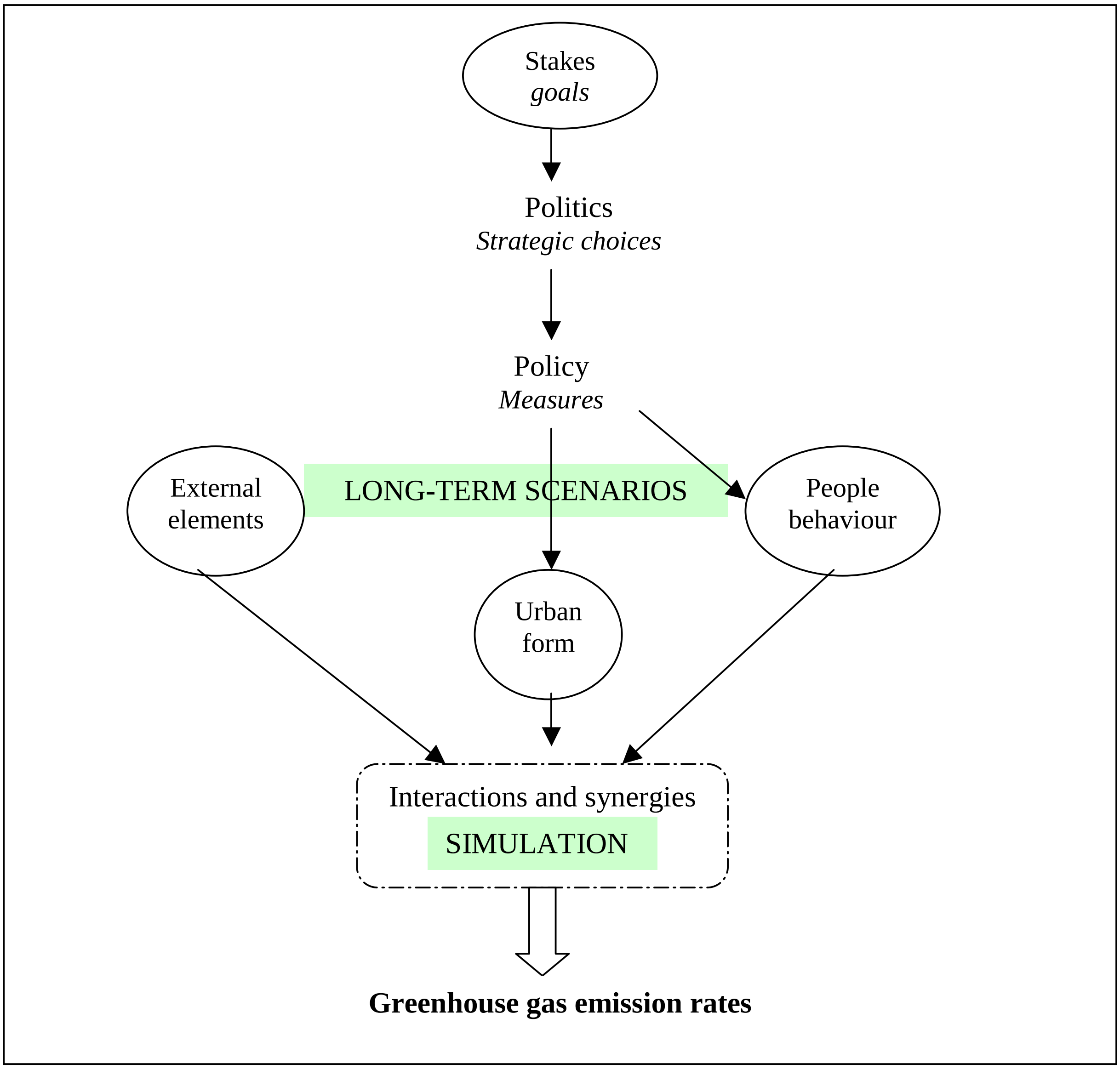
THE PROPOSED METHODOLOGY

In order to include the particularities of urban goods movement in a long-term analysis of greenhouse gas emissions, we propose a methodological framework for the scenario construction. This framework corresponds to the first phase of backcasting and will take into account the consequent actions to undertake at the politics and policy levels following the directions suggested by these scenarios. For this, Figure 1 sums up into a chart the main decision process in urban logistics long-term planning.

Conceptual UGM long-term issues framework

The stakes will define the main goals of the long-term analysis. In this study, we follow the French target to meet the Kyoto protocol. Therefore the factor 4 aims at an overall 75% greenhouse gas reduction. The main question here is to investigate about the importance of UGM respect to the other sources of emission. To meet the established target, several strategic choices are possible (Politics). These choices become the main expected objectives that can be implemented through the appropriate policies. The most usual policies are related to:

Figure 1 – Chart of the proposed long-term issue methodology



- the action on the land use (location of the warehouses, platforms, hyper and supermarkets and generally all type of industry), the effects of the high density;
- the optimisation of the goods management (co-operation and consolidation, bin packing, full trucks, routing etc.) including the new logistics places and with the help of the new technologies;
- the regulation by the public authorities (congestion charging and road pricing, incitements towards green behaviour);
- the development of the e-commerce, home deliveries and relay points deliveries;
- the development of clean vehicles with zero emission.

External elements are those that will interact with the policies and measures, of which the impact cannot be directly controlled by public authorities. The most important external elements are the economic and the social contexts, at all scales (world-range, continental, national, regional, local, urban, suburban, etc.) and their trends can be hypothesised but not always correctly estimated. In the economic context, the petrol price fluctuations (Tremeac and Raux, 2009), the economic crisis (Paché, 2009) and the new economies impacts have changed the established trends and have to be taken into account carefully because of this prediction difficulty. The social context and more precisely the reactions of the inhabitants and the professionals to the changes proposed by the new policies have also to be studied. In any case, these elements become important in the analysis phases than in the scenario construction, where they are taken as a fact. Moreover, the changes in the people behaviour have to be also taken into account.

The urban form is the configuration of the urban area as a result of the politics and policy phases, and consists of the following elements:

- energy sources and motorization technologies;
- demographic and socio-economic characteristics of the population;
- demographic and socio-economic characteristics of the economic activities;
- organisation and management of the city operations.

From the elements listed above, different scenarios can be implemented and have to be simulated. Obviously, interactions and synergies among the main elements of the urban form are expected. The simulation tools in long term issues for urban goods movement are in general mesoscopic models, that are more detailed than macroeconomic models and can be adapted to a urban area in order to estimate the main trends in a long-term horizon without long and difficult calculation processes. The simulation results can be progressively improved through an iterative feedback procedure.

We propose a backcasting approach, that consists in hypothesizing few future scenarios before simulating them and finding the best configuration among the proposed ones. Then, the possible actions resulting in this situation are expressed and discussed.

Scenarios and hypothesis

The proposed scenarios in this paper are the following:

S1: a trend scenario (business as usual (BAU), or “do nothing” situation), extending current trends (1999 and 2006) by 2050;

S2: a “locational” scenario based on the assumption that 1/3 of the household supply volumes is provided respectively by hypermarkets, supermarkets and small stores;

S3: a "store supply organisational" scenario based on the assumption that the share of hire or reward operating mode freight transport goes from 45% to 75% of the deliveries;

S4: a "household supply organisational" scenario based on the assumption that 50% of the household purchases are made through e-commerce and deliveries at home; Two sub-scenarios are proposed:

S4-1: having the activity distribution proposed in scenario 1;
S4-2: having the activity distribution proposed in scenario 2;

S5: a "mixed" scenario based on a combination of the previous assumptions.

BAU scenario

The following elements: demography and household-related trends, energy and technology, are exogenous.

The population is estimated using the forecasting data of Grand Lyon (2006) that estimates a 0.5 % annual population increase for the urban area of Lyon for the next decade. With a decreasing for the following decades, the overall population of this area passes from 2.0 Millions (M) inhabitants in 2006 to 2.3 M in 2050, while the number of households increases from 0.85 M to 1.0 M, assuming that the number of inhabitants per household remains the same for a given zone. The motorization rate of the households (i.e. number of cars per household) comes from Sytral (2006). The demographic evolution of the economic activities is forecasted from the results of Routhier et al. (2009). The number of small shops remains similar to that of 2006 (but the number of employees grows proportionally to the population), the number of other stores and their employment rates grow proportionally to the population (Routhier et al., 2009).

For the technology and energy consumption choices, we adapted the hypothesis proposed by Crozet et al. (2008) to urban goods movement simulation. In this context, three types of vehicles have to be considered:

- Cars for shopping trips, that are supposed to follow the same ratios than Crozet et al. (2008), that is 56 % of diesel-electric hybrid cars, 24 % of gasoline-electric hybrid cars and 20 % of pure electric cars.
- LGV, supposed to be 20% diesel-electric hybrid and 80% pure electric.
- HGV, supposed to be 100% diesel-electric hybrid.

In these hypothesis, it is assumed that the number of vehicles changes totally by a gradual disappearance of heat engine vehicles replaced with hybrid engine vehicles (Crozet et al., 2008).

S2: The locational scenario

The locational scenario is an urban commercial planning scenario. It is built by changing the number and location of the retailing activities using equivalence tables (Henriot and Routhier, 2010), in order to affect 1/3 of the freight demand (in tones) to each category of retailing (i.e. small shops, supermarkets and hypermarkets). In 2006, the supermarkets represented 14% of the total household supply (in tones), while the other 86% were almost equally shared between the other two categories. The number of small shops and hypermarkets decreasing rates and stores increasing rates are applied according to the ratios of Henriot and Routhier (2010). This new commercial supply configuration is supposed to meet the population's needs, so they are spatially distributed over the whole urban area.

S3: The retailing supply organisational scenario

The third scenario supposes that the share of for-hire or reward operating mode freight transport goes from 45% to 75%. Urban goods movements are carried out almost as much by for-hire carrier as by own account (carried out by the shipper with their own or rented trucks). The French UGM surveys show that for-hire operating mode is the most efficient : the rounds in third party have 19 deliveries in average against 13 in own account made by consignor and 5 in own account by consignee; the number of km per delivery is also the lowest (Patier, 2002). In this scenario, we assume that the distance of a trip per type of vehicle for each operating mode are similar from 2006 to 2050. This scenario is realistic because the trend is for the increasing of for-hire transport (express deliveries).

S4: The household supply-organisational scenario

The fourth scenario supposes that e-commerce and proximity delivery services are used by 50% of the population. That means that both people with and without a car will use these services. Based on the data of several experiments in Nantes, France (Durand et al., 2010), 60% of the people are delivered at home whereas the other 40% use delivery points. Assuming these ratios, we suppose that the small grocery stores are also used as delivery points to reduce motorised trips.

S5: The mixed scenario

The fifth scenario will be built by choosing the best combination of the other four, i.e. that which results on the best reduction of the total travelled distance.

Simulation tools

The simulation method is based on the combination of two modules, following the framework of Gonzalez-Feliu et al. (2009): a inter-establishment flow simulation model, FRETURB (Routhier and Toilier, 2007) and an end-consumers flow simulation procedure, STG (Gonzalez-Feliu et al., 2010). Both models give a mesoscopic estimation of the kilometres produced by these two components of urban goods movement.
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The results of these simulations are integrated into a procedure that estimates both the traffic impacts (number of Km. car equivalent units) and the greenhouse gas emissions (in

equivalent CO_2 tons). This procedure assigns the corresponding coefficients of traffic flows to each vehicle category, as well as the greenhouse gas emission ratios. We start from the methodology proposed by ADEME (2003) for the IMPACT software and we apply it to the reference scenario by 2050.

The following table 2 gives the assumptions we considered to get a share in the vehicle motorization (gasoline-electric, diesel-electric, pure electric), according to the vehicle type (car, LGV and HGV). The percentages are based on the works of A. Morchoine (2005) and P. Pinchon (2004).

Table 2 – Assumptions on vehicle motorization and expected CO_2 savings by 2050

	Diesel-electric	Gasoline-electric	Pure electric
Private cars (PC)	56 %	24 %	20 %
Light goods vehicles (LGV)	20 %	0 %	80 %
Heavy goods vehicles (HGV)	100 %	0 %	0 %
Expected CO_2 savings by 2050, compared to 2006			
PC and LGV	-44 %	-44 %	-66 %
HGV	-30 %		-66 %

MAIN RESULTS

The proposed scenarios have been simulated in order to estimate the reduction rates in greenhouse gas emissions for each of them. In table 3, we report the traffic impacts of each scenario, in terms of travelled distances. More precisely, we report the trends in millions km.PCU per year. In table 4, we report the trends in greenhouse gas emissions, more precisely in tones of CO_2 per year.

Table 3 – Traffic impacts (in millions Km.PCU/year compared with 2006 situation)

	Inter-establishment	End-consumer	Total
2006	**1088**	**1225**	**2313**
S1	8,4%	7,5%	7,9%
S2	6,1%	12,5%	9,5%
S3	-9,8%	7,5%	-0,6%
S4-1	8,4%	-26,9%	-10,3%
S4-2	6,1%	-27,1%	-11,5%
S5	-10,4%	-27,1%	-19,2%

We observe a 8% increase of the total km.PCU/year in the BAU scenario (S1), with similar trends in each components. The locational scenario presents an important increase of the travelled distances, mainly due to end-consumer movements. We observe in precedent works (Routhier et al., 2009) that the hypermarkets and commercial centres concentrate the private car movements, which is not the case of peripheral supermarkets. More precisely, in our simulation, the travelled distances decrease in the main urban area (due to a strong use of public transport and non-motorised modes) and increase in peripheral areas, where geographical distances are not so different than those of hypermarkets.

The retailing supply organizational scenario (S3) results are the following: The km average of a delivery trip decreases from 14 to 11 km. The total inter-establishment traffic (in Km.PCU) decreases of 10%.

The household supply organisational scenarios are respectively related to S1 and S2. The development of e-commerce distribution organizations and strategies results in a fair reduction of the total distance travelled by the end consumers and the new distribution systems to deliver the goods' final destination with respect to the situation in 2006, but if compared to the 2050 situation (respectively S1 and S2), this gain is significant; for S4-1, the gains respect to S1 are about 20%, and for S4-2, the gains respect to S2 are about 27%.

The best mixed scenario combines S3 and S4-1. The gains of this situation with respect to 2006 in terms of travelled distances are significant (about 20%). If we calculate the greenhouse gas emission rates, we obtain the following trends (table 4):

Table 4 – Greenhouse gas reduction (in tons CO2/year) in Lyons urban area

	Inter-establishment	End-consumer	Total	*Total only with organisational changes*
2006	476 118	250 214	726 332	*726 332*
S1	-35,1%	-44,3%	-38,2%	*2,1%*
S2	-35,5%	-43,5%	-38,3%	*2,0%*
S3	-44,1%	-48,7%	-45,7%	*-10,4%*
S4-1	-35,1%	-53,7%	-41,5%	*-4,2%*
S4-2	-35,5%	-54,3%	-42,0%	*-5,3%*
S5	-44,4%	-58,2%	-49,2%	*-17,3%*

We observe the importance of the technological changes, that leads to reach a 38% reduction of greenhouse gas emissions without other actions (S1).

These scenarios are not radical and more constraints to freight transportation in urban areas can be hypothesised. However, urban goods movement constitutes nowadays only 24 % of the total greenhouse gas emissions in urban areas (Routhier et al., 2009). For these reasons, a factor 2 is already a good result in order to reach a factor 4 in a global point of view, taking into account that transportation (freight and people) and household energy consumption are the two most important contributors to greenhouse gas emissions in urban areas.

CONCLUSION

This paper has proposed a methodology as well as several results for long term issues in urban goods movement. After a review of the last works in long term issues applied to transportation, mainly in urban areas, most of them dealing with people transportation, we have described the proposed methodology. Taking a French medium urban area as an example, we have applied our methodology in order to make a preliminary study of the effects of realistic and moderated actions to the total distance travelled by urban goods and the resulting greenhouse gas emissions.

We observe that the technologies allow a reduction about 40%, which is not enough to meet the British targets (60 %). The proposed scenarios improve the global efficiency of the urban goods movement flows but the factor 2 is just approached in the best scenario (S5). The later is the best scenario, and shows that a saving of 17% of CO2 is possible with only organizational actions. Combining locational and organizational actions should a priori reduce these emissions, and a further study should show where should we go in mixing the retailing location and freight distribution organization strategies in order to reach the French target (75 %).

The proposed changes are not extreme and can be implemented in a long-term horizon planning strategy. For example, a part of the own-account transport can be converted into for-hire transport if a concertation phase is well prepared. A clear example is that of Parma (Italy), the most representative case of fresh-food urban distribution system where own account transporters are the main customers of the service (Merella, 2009).

Finally, in our opinion it seems to be possible but difficult to reach the factor 4 but the translation of the global logistics performance in the urban context, as well as the links between supply chain management and urban logistics approaches, have to be taken into account to meet the target.

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