Case studies evaluation report

Summary report on case studies of pilot projects including documentation and comprehensive assessment

A report compiled within the European research project

Deriving effective least-cost policy strategies for alternative automotive concepts and alternative fuels - ALTER-MOTIVE

Intelligent Energy – Europe (IEE), STEER

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(Work Package 4 – Deliverable D12)

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THE ALTER-MOTIVE PROJECT

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1 Introduction

1.1 Project aims

The core objective of the project ALTER-MOTIVE is to derive effective least-cost policy strategies to achieve a significant increase in innovative alternative fuels and corresponding alternative more efficient automotive technologies heading towards a more sustainable individual & public transport system. Specifically by analysing cases, ALTER-MOTIVE shall also detect least costly solutions. This includes avoiding stranded costs funding refuelling infrastructure but also start-up-funding for obsolete propulsion technologies. This way costly dead-end developments may be avoided. But in terms of an overall optimisation of the economy establishment of inferior solutions (kept alive by market power or regulations) shall also be avoided. This related to propulsion technologies creating huge indirect costs.

Work Package four (WP4) of the ALTER-MOTIVE project aims at analysing cases from the past,- some times recent past - in order to distil information which could be useful for future decision taking regarding alternative fuels (AF) and alternative automotive technologies (AAMT).

WP4 consists of the following tasks:

- 4.1: Definition of criteria for case studies of pilot projects
- 4.2: Analysis of past case studies
- 4.3: Identification and documentation of case studies recently launched or currently under implementation
- 4.4: Analysis of pilot projects from an economic, ecological, technical/energetic and dissemination point of view

The cases documented cover various **kinds of alternative fuels**, but also alternative automotive technologies. The cases were/are usually launched by municipalities, local NGOs, local companies. They do not mainly deal with the production of AF (e.g. biodiesel or bioethanol), but rather have a dissemination focus **using fleets, e.g. on municipal level creating visibility for AF/AAMT**. But the more than cases ho o the ALTER-MOTIVE web site are holding a variety of different measures as for example:

- New innovative ways of the **marketing** and use of alternative fuels;
- **Local implementation** of alternative automotive concepts;
- Initiatives focusing on an overall reduction of individual traffic;
- Examples for infrastructure construction for AF & AAMT

A major focus in the WP4 work had to be put on recently developed case studies according to the description of work of the project (Annex I of the contract). Also new projects to be further developed in the next years had to be included to show new tendencies like battery exchange - avoiding white patches or a focus on things of the past only. This wider sample allows a forward looking construction of a least cost alternative fuel policy targeting an efficient reduction of the dependency on oil and efficient reduction of the global warming potential of transport. The number of cases concentrating on individual (private) transport was smaller and many cases focused on CNG only, so cases for commercial and public transport were added; knowing that the private procurement is very different from the corporate procurement in terms of sensitivity to cost. The focus of the survey targeting cases was not on fleets only but also on policies and on fuel supply chains in order to cover individual transport. However the recent collapse of European biodiesel industry delivered a void sample for retailer’s initiatives.

1.2 Objective and structure of this report

This report provides an **economic, technical (applicability and efficiency) and environmental evaluation** of these cases as well as a summary of the **lessons learned** from them.

Setting up an action plan - which is available on www.alter-motive.org requires knowledge about practical experience revealing deviations of planned technical performance as well as human deviation from desired or optimal behaviour. This deliverable shows the main results from WP4. We are revealing findings from the cases collected and from an additional survey and are deducting rules for setting up policy action plans in the conclusions at the end of the report.

In **chapter 2** the method of approach is shortly described depicting the collection of questionnaires. So this deliverable features **quantitative results from a survey** which was deepening our knowledge about the cases in **chapter 3**, authored by FGM. The questionnaire revealed the main motivation of the stakeholders as well as background information. The in depth survey was set up because self evaluation seen in the case descriptions showed trivial findings in many cases like “cost are prohibitive”, “technology not mature”, ”acceptance was high”...). The in depth survey targeted to reveal information covering the gaps. In **chapter 4** which was authored by EEG an in-depth energetic, economic and ecological evaluation is conducted - based mainly on the corresponding characteristics of each fuel and power train.

The summary and conclusions - compiled by FGM - are also giving results from an Internet survey evaluating potential approaches constructing alternative fuels policies. In the Annex you may find an example for an questionnaire used.

The description of the most successful cases is done separately in Deliverable 11 which is available as CD. All cases and their evaluation may be accessed on-line via www.alter-motive.org. The CD also links towards the on-line database which is updated till the end of the project.

2 Method of approach

In order to cover most knowledge available with stakeholders the approach applied in this report is based on the following three issues:

1. Collecting information about cases via comprehensive questionnaires in a standardised way ;
2. Quantify case implementations asking interviewees from cases about the number of cars switched, energy switched (e.g. diesel to CNG), energy conserved and CO_2-emissions reduced;
3. In addition an internet survey has been compiled gathering opinions from stakeholders.

In parallel supported by the partners having men hours in the work package, the number and information in the case database was challenged and an evaluating summary added. Finally more than 120 cases are now documented including also valuable cases collected by former projects like SUGRE and BIOSIRE. All of the cases are residing in one database used by ELTIS in order to guarantee a long term support for the data quality. The following table shows the contribution of the partners to the collection of the questionnaires – the number of the related case as documented in the on-line database is also given:

Table 1 Questionnaires collected and their connection to the Alter-Motive (on-line) case database

FLEET QUESTIONNAIRES	AREA COVERED	Case No. Alter Motive
TNT, delivery vehicles running on bio-methane	Whole federal territory of Germany except islands of North Sea and Baltic Sea	3
Cooking oil usage in trucks in La Rochelle	Communauté Agglomération de La Rochelle 18 local authorities and 147 000 inhabitants	62
Car sharing La Rochelle using clean vehicles	Communauté Agglomération de La Rochelle	104
Biogas buses Lille	Communauté Urbaine de Lille (Lille Metropolis) 85 local authorities and 1.1 million inhabitants	103
CNG buses in Burgas	City of Burgas, Bulgaria	61
CNG buses in Sofia	City of Sofia	60
Compactors in Seville running on Biodiesel and hybrid	City of Seville	64
Gdynia buses	Municipalities: Gdynia, Sopot, Rumia, Kosakowo	70
Slupsk buses on Ethanol	Slupsk agglomeration	68
Cities of Ede and Wageningen, biodiesel and PPO usage	Cities of Ede and Wageningen	46
Fuel cell busses Amsterdam	City of Amsterdam	40
TPG post Amsterdam	City of Amsterdam	47
PPO buses Eindhoven	Region of Eindhoven	41
“Green Post” electric and hybrid delivery vehicles	Four EU countries – Italy, Belgium, Hungary, Bulgaria (the tests have been carried out in Perugia, Bruges, Szentendre, Russe)	15
CNG buses Augsburg	Stadt Augsburg	76
HyFLEET:CUTE	Public transport operators of 10 aeras	21
Natural gas usage in Porto	Part of Porto Metropolitan Area	100

FLEET QUESTIONNAIRES	AREA COVERED	Case No. Alter Motive
Urban buses Vitoria-Gasteiz	City of Vitoria-Gasteiz	116
Biodiesel usage Breda	City of Breda	45
"The Whisper" hybrid electric bus Apeldoorn	City of Apeldoorn	48
Hydrogen bus Connexxion	Province of South Holland	51
City of Rotterdam, battery electric logistics	City of Rotterdam	42
Hydrogen buses Dunkerque	Communauté Urbaine de Dunkerque 18 local authorities and 210 000 inhabitants. European project « Althytude »	37
Hyfleet Berlin Hydrogen Fleet	The hydrogen fleet covers Berlin's urban districts "Spandau" and "Charlottenburg-Wilmersdorf".	21
CNG buses in Frankfurt/Oder – Germany	City of Frankfurt/Oder	2
CNG-Vehicles for parcel delivery used by DHL in Germany	19 German cities (Augsburg, Berlin, Bonn, Bremen, Dortmund, Düsseldorf, Duisburg, Dresden, Essen, Frankfurt am Main, Hamburg, Hannover, Leipzig, Mainz, Munich, Nuremberg, Regensburg, Stuttgart, Würzburg).	71
Hamburg Wasser transitions its gasoline-powered fleet to CNG	City of Hamburg	29
CWS-Boco Germany introduces CNG-powered vehicles to its fleet	The whole of Germany	27
Gas driven Buses – Skopje	Whole city of Skopje – Republic of Macedonia.	25
Biofuel Donostia – San Sebastian	San Sebastian	13
15 Hybrid Compactors (refuse trucks)	City of Gothenburg and surrounding – 11municipalities	6
50 RME Garbage trucks in Gothenburg	City of Gothenburg and surroundings – 11 municipalities	101
Ethanol Buses in Stockholm	Stockholm city and surroundings	10
1100 vehicles – Gothenburg City	City of Gothenburg	109
Hythane – Malmö	City of Malmoe (third biggest city in Sweden)	8
TOTAL 36		
POLICY QUESTIONNAIRES	**AREA COVERED**	
Goryahovitsa	City of Gorna Oryahovitsa, Bulgaria	12
Sofia	City of Sofia, Public Transport	60
Debrecen	City of Debrecen, Hungary	28
Gdynia	Gdynia city	
Lublin	Lublin city	
Slupsk	Whole Poland	
Gothenburg	City of Gothenburg	109
Sweden	Sweden (primarily the three biggest cities: Stockholm, Gothenburg, Malmoe)	111
TOTAL 8		

The more than 120 investigated cases were also taken as background information when writing this report, but it is clear that the standardised survey with 44 questionnaires gave more information to be exploited statistically. As additional input for writing the findings, publications were used but also a small internet survey about policy preferences for the different alternative fuel options was exploited validating the findings.

3 Quantitative results from the analysis of questionnaires

3.1 Introduction

Since it was felt that the self description of the cases by the authors who in most cases were also responsible for the (funded) projects was not sufficient to get all answers, we opted for an in-depth analysis. At an early stage it turned out that there are different type of projects - some bottom-up initiated by fleets and other initiated by policy makers. So we split up the questionnaire in to two versions. A third questionnaire mutation was done for projects/policies implemented by the fuel industry since they are private, but not fleet owners. By the end of the project the information learned when interviewing stakeholder was transferred to the case description.

The survey targeted acquiring more information for elaborating the show cases on the one hand and acquiring some empiric data on the other hand for compiling an economic and environmental analysis. There were three mutations of the questionnaire targeting the different types of actions:

- Fleet measures originating from decision of private or public entities
- Policy measures having a wider focus in terms of fleets/vehicles/fuels
- Supply chain measures initiated by fuel retailers

The Alter-Motive partners collected 42 questionnaires - 36 fleet types and 8 policy type questionnaires. Therefore only the fleet answers can be further analysed for sub samples. This part of the report deals only with the general analysis of the cases, the economical and ecological analysis is done separately in chapter 4.

Since the basis (number of respondents) of the analysis varies with the questions – some got more answers, some less - the term “case”, “initiative” or “project” is used there synonymously with “answer”. Finally we might issue a warning since there were a few case incorporated which tested innovative technologies only and therefore are not usable to analyse effects anticipating a broad transition to alternative fuels. The terms “refuelling infrastructure for liquid fuels”, “filling stations for gas”, “charging facilities for battery electric” and “overhead wires for catenary electric” had to be used to make clear what infrastructure means. This makes questions more complicated but on the other hand the term “infrastructure” alone is not specific enough.

3.2 Results fleets

3.1.1 Description of the sample of the analysis

The 44 initiatives investigated in the in-depth case analysis using questionnaires **started** in most cases with fossil diesel and were **transiting to alternative fuels** as follows - category other is equal to hydrogen in most cases. The share of target fuels is **not** representing the stated preferences for alternative fuels but was targeted in order to retrieve information about most alternative fuels.

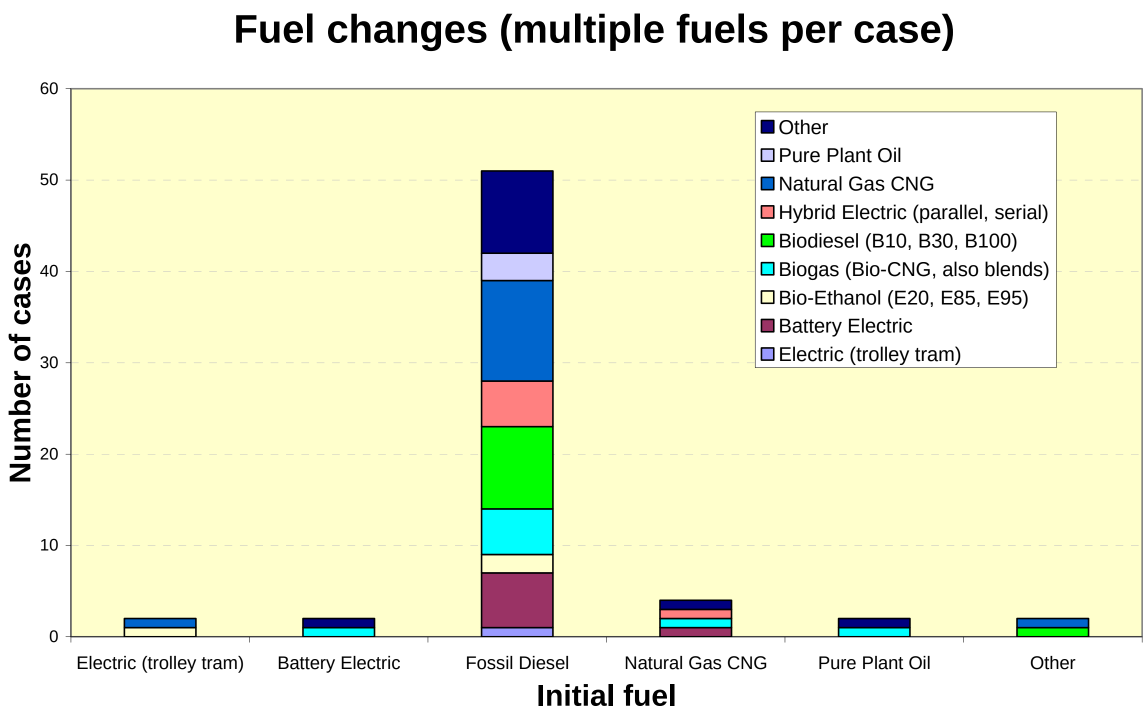

Figure 1 Fuel shifts seen in the sample of fleet cases covered via questionnaire

Of course most of the fleets started from fossil diesel but also few from other fuels, second being CNG. Looking at the fuel chosen we may see some preference for transiting to methane (compressed natural gas CNG and biogas), further emphasised by the following figure presenting the **area covered** - more than 20 cases mentioned CNG as their fuel of choice. Although the market share of hybrid passenger vehicles in Europe is higher than for alternative fuel vehicles, this category is not easily accessible for interviews since those vehicles are bought after decisions of individual buyers and excluded since one private car forms no fleet. With public and commercial transport the financial hurdle is still there when transiting to most alternative solutions so we have more cases with biodiesel as fuel than hybrid or battery electric propulsion. It is obvious that catenary electric propulsion (or ground propulsion) are not seen as alternative by the new member states – even if some cities of the old member states opt for building new systems. But we managed to have this mature and proven technology included in the survey sample.

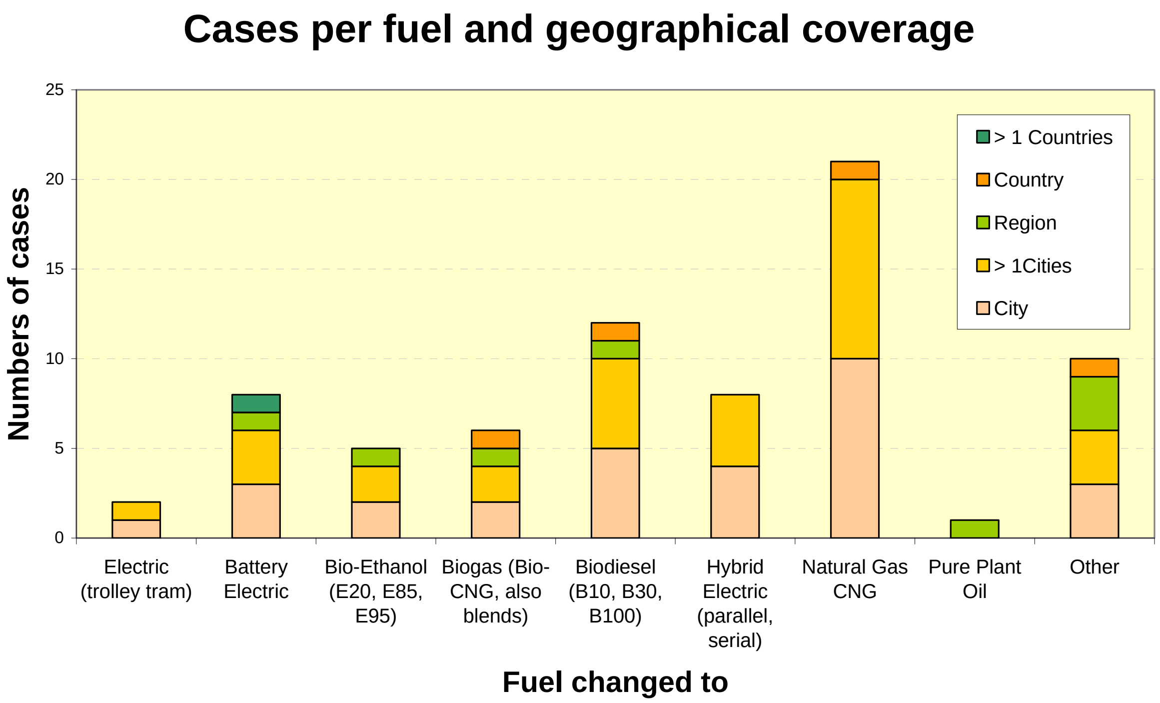

Figure 2 Area covered per fuel as seen in the sample

On overall approximately half of the cases were located in cities (54% in total), 17% of the cases covered more than one city and 20% of the cases covered one whole region. The small number of cases for the fuels and the biased case selection does not allow validating the hypothesis that hybrids and electric propulsions are city-based and pure plant oil is countryside-based – but still it's very logical considering the characteristics of those power trains.

The following figure gives an overview about **the type of fleets** present in the survey as stated by the respondents. On overall most of the fleets (83%) were public, 11% of them logistics companies, 3% of them smaller private fleets and the same amount other types of fleets.

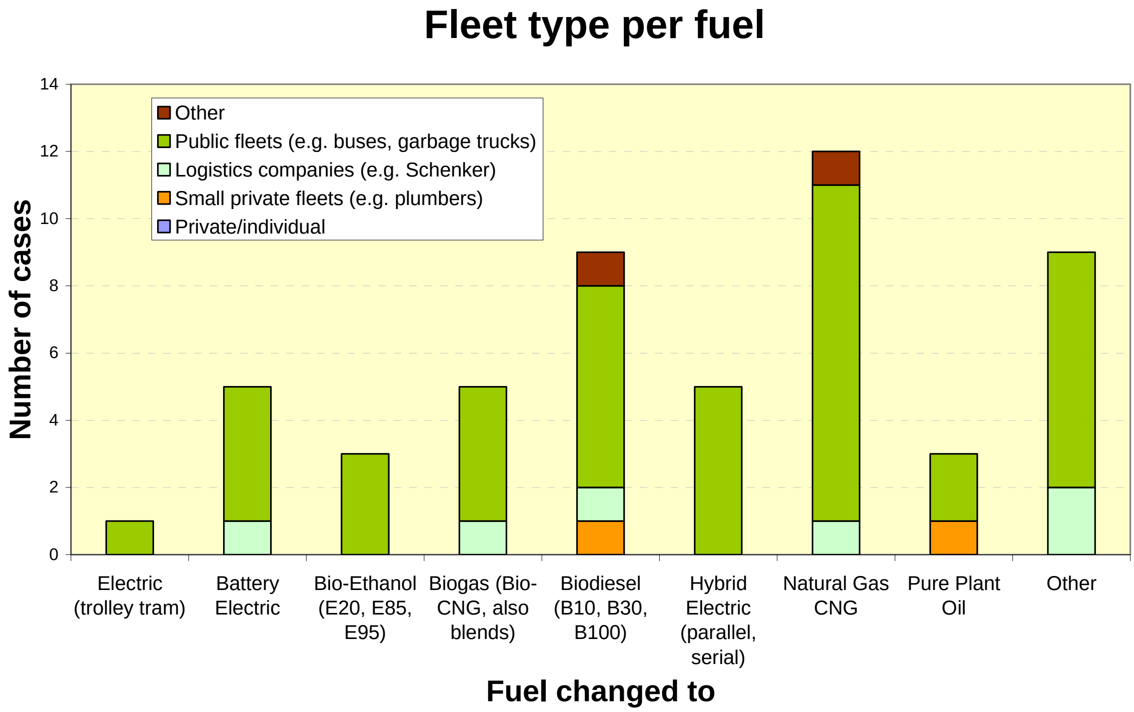

Figure 3 Preference for fuels depending on the fleet type

The second largest group of fleets, logistics companies did not change to ethanol nor plant oil. This fact is, of course only applicable to the interviewed companies.

The most important **motivation** for the initiatives was "improvement of the local air quality" (32% of the total), followed closely by "preventing climate change" (26%) and "other" (26%). The category "other" summarise various issues, starting with noise reduction, ordered actions from an upper administrative level, comprising test of technology (in most cases), cost issues or a bundle of topics.

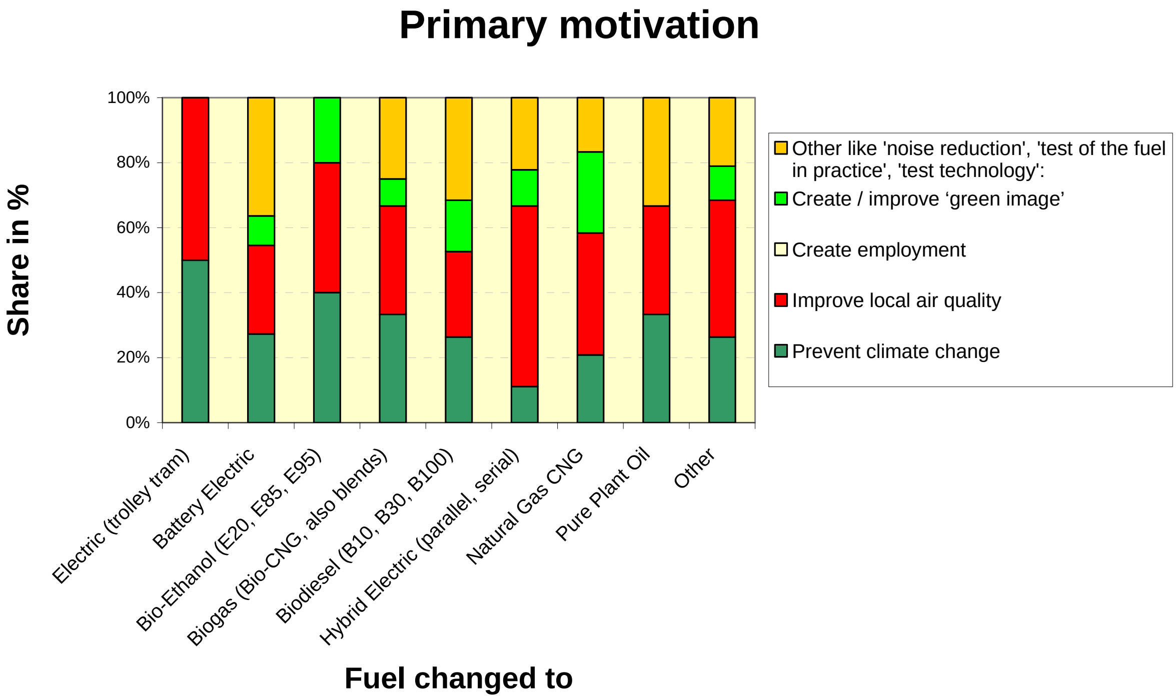

Figure 4 Share of motivation changing fuel/propulsion depending on the fuel type (in relative figures)

With catenary electric and bio-ethanol the **climate change issue** was most prominent as primary motivation. A green image was the main motivation for cases focusing on CNG, but also applied in case of ethanol as target fuel.

Local air quality improvements dominate as motivation when using hybrid electric propulsion, catenary electric follows in the ranking.

In most cases the **incentives considered** by the initiatives were subsidies (all in all 43% mentioned subsidies for vehicles and 13% subsidies for erecting refuelling facilities). Other incentives comprise “fuel price” and “EU-projects” as well as the possibility to use one owns fuel produced in the backyard.

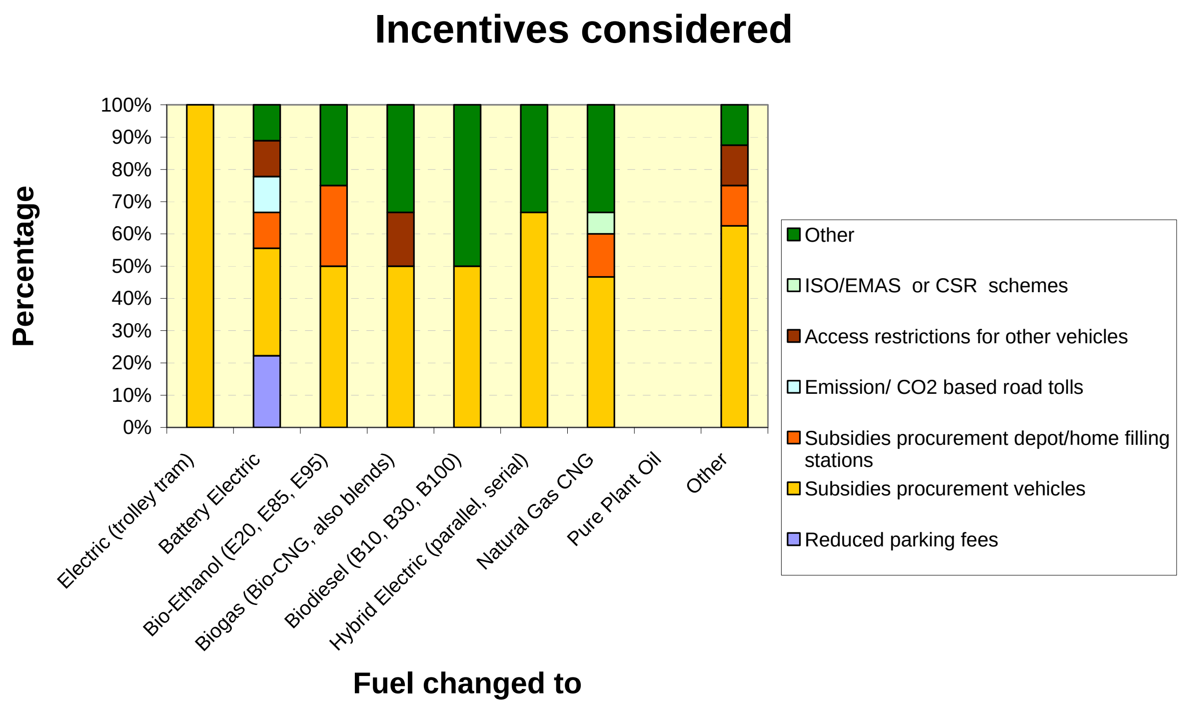

Figure 5 Incentives considered by the initiatives depending on the fuel type

When changing to pure plant oil interviewees claimed that no incentives were considered (although may be existing in practice). Reduced parking fees were an issue for initiatives targeting battery electric vehicles only. Access restrictions and emission-based road tolls as incentives were only considered for cases targeting BEV use.

A ranking of the **drivers** for the fleets to start their initiatives featured “image” as top ranked (3.11 points on a scale of 0-5 points), followed by “saving money” (2.47) and “external forces” (2.06). “Risk reduction” targeting independency on fuel imports from politically instable regions seemed to be less popular (0.85). This backs the hypothesis that **corporate buyers** have **economic reasons** to head for alternative fuels – even if some times economy is achieved only indirectly via the public image of the company.

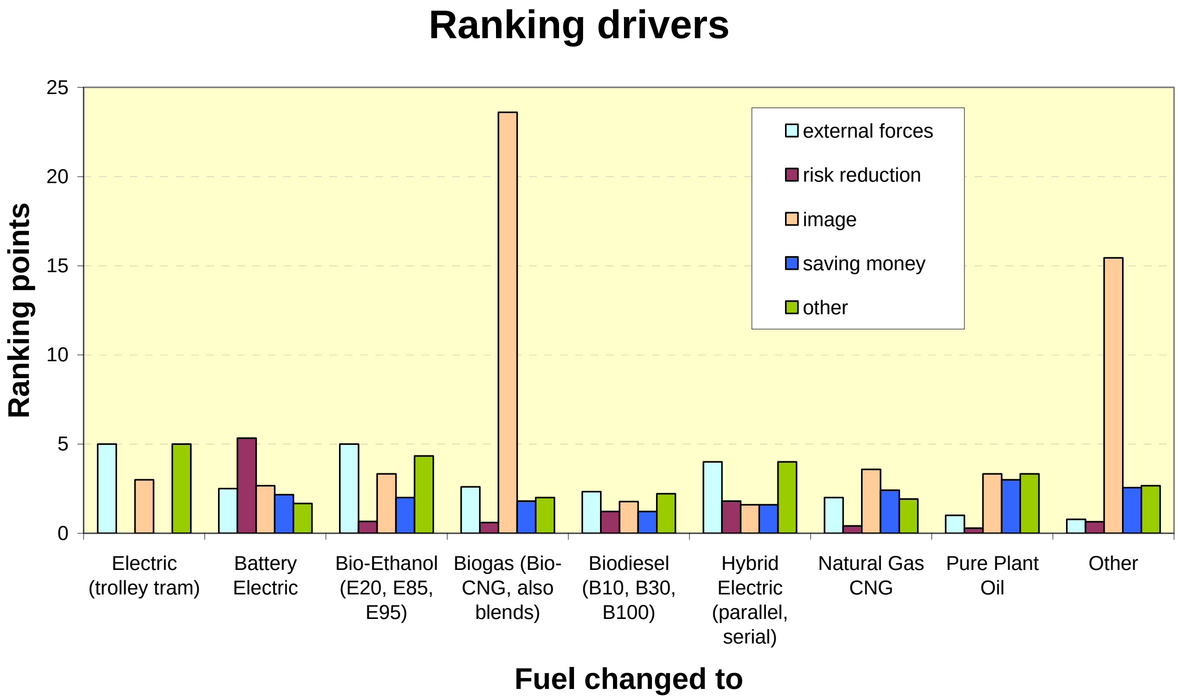

Figure 6 Main drivers for the initiatives depending on the fuel type

Especially in connection with biogas "**image**" was mentioned as very important driver.

There were not enough answers to look at the varying project **duration** for the different target fuels, but the median for the set-up **preparing** the ground for the project was **5 months**, the **decision phase and the testing 12 months**, the small scale implementation 6 months, the big roll-out 18 months and the evaluation 24 months. With a shared usage, of course the time for local preparation is reduced, allowing a swifter implementation of such tests of borrowed vehicles.

3.1.2 Measures/Actions

Looking at the **implementing actions** of the initiatives, in one third of the cases new refuelling facilities were built (36%), followed by the erection of own maintenance workshops (23%) and the procurements of new vehicles (21%).

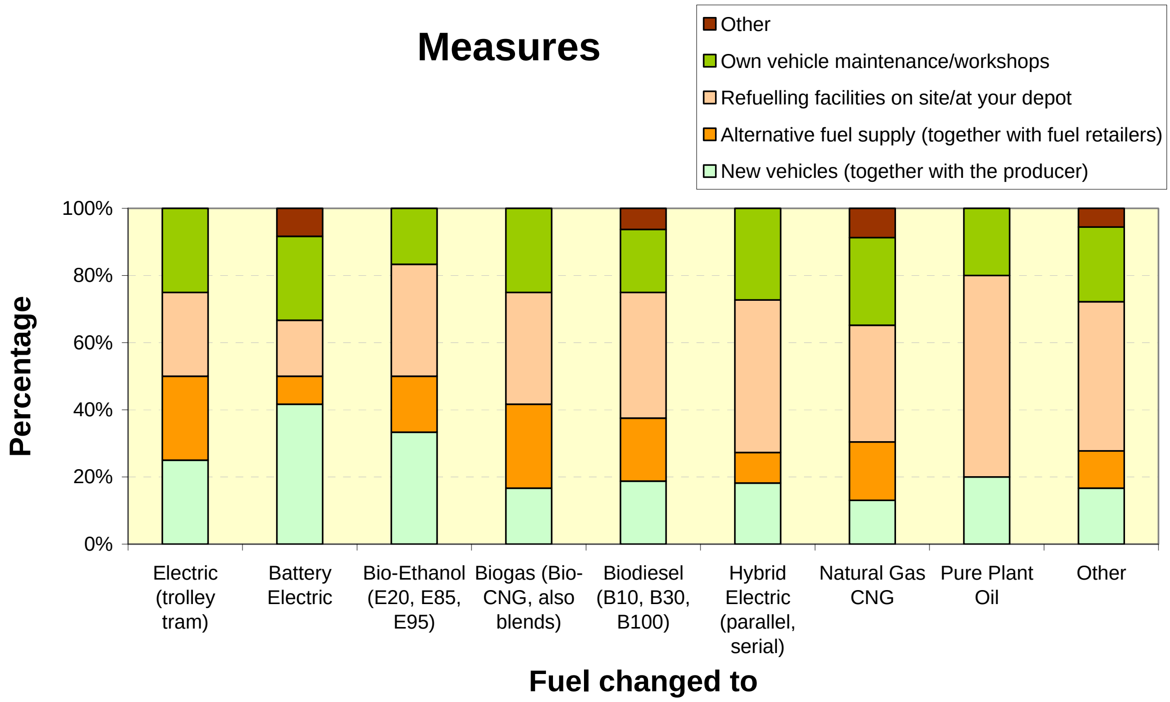

Figure 7 Type of measures depending on the fuel type

Alternative fuel supply - to be interpreted as alternative power sources - was less necessary for battery electric vehicles, but alternative fuel supply was important for biogas since not existing and catenary electric vehicles too having the same meaning as with BEV. New vehicles were used predominantly with BEVs, but also with ethanol (flexible fuel vehicles). Refuelling facilities as measure are dominating with pure plant oil.

Looking at the **number of vehicles** equipped with alternative fuels or propulsion in the course of the projects, newly procured vehicles came first (47%), second frequent was fuel blending (29%). 14% of the initiatives tested vehicle in operation without purchasing them, reducing their financial risk.

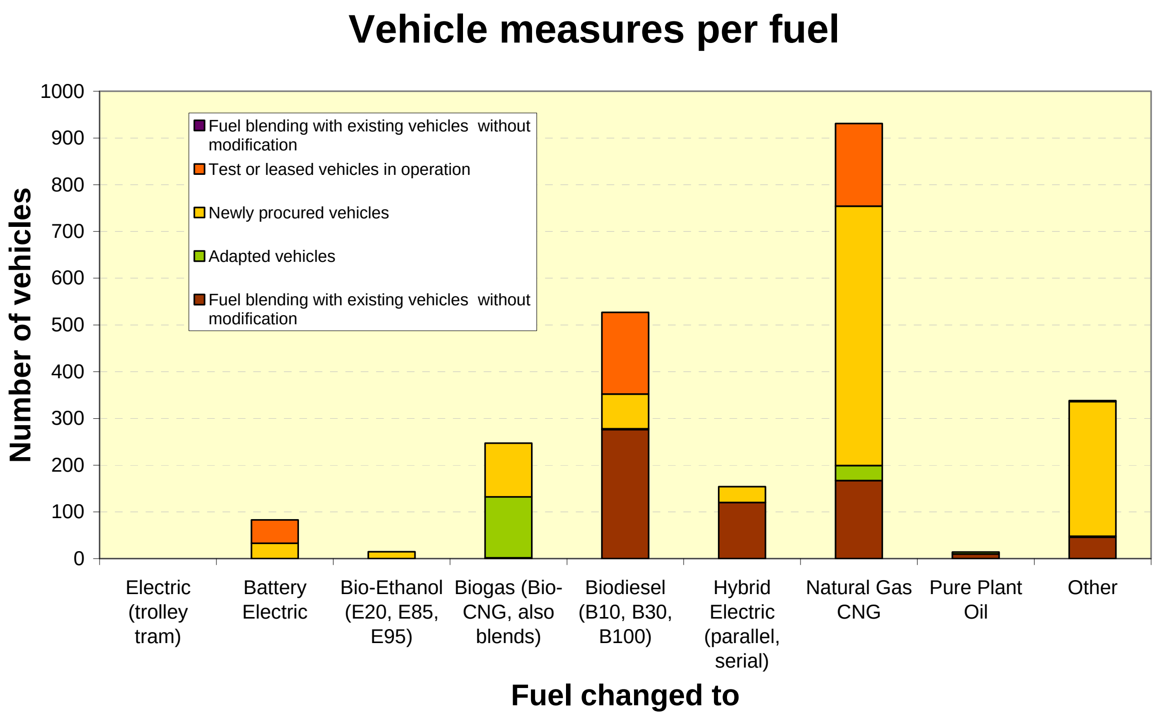

Figure 8 Measures vehicles depending on the fuel type

Especially with CNG, the newly procured vehicles were dominating, whilst for biodiesel the blending was most important. With biogas, vehicles had to be adapted too, may be to be able to use low methane biogas, but this is speculative.

With regards to the characteristics of alternative fuels, we asked for adaptations of the **logistics coping with the reduced autonomy of the vehicles**. After "no changes", "dual fuel capability" was mentioned second often, followed by "restriction to regional transport".

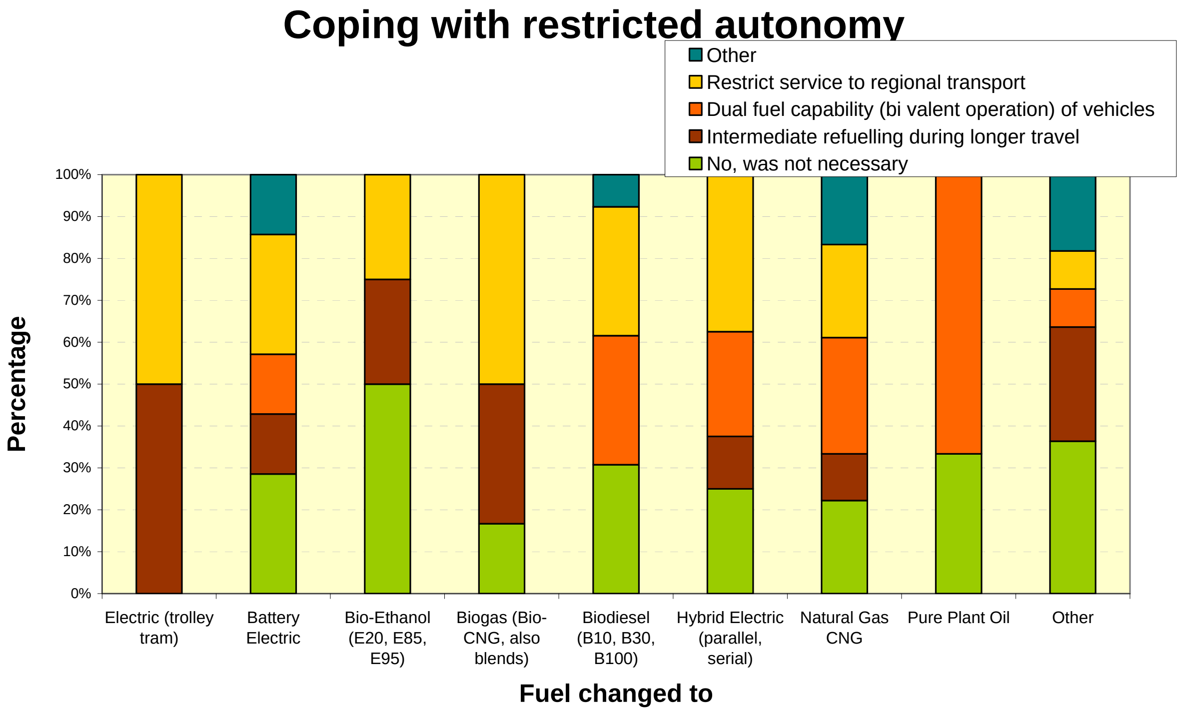

Figure 9 Autonomy related measures depending on the fuel type

Whilst with Bio-Ethanol “no changes” were most frequent as autonomy related measures, with catenary and battery electric and also Bio-gas service was also restricted to regional transport often. Whilst with electric propulsion this is logical for biogas this might not be explained via the vehicle range but the selective availability – especially in regions without natural gas grid connection. Pure plant oil is frequently used in a dual fuel configuration (for technical reasons).

All this underlines assumptions for feasible alternative fuel transport services which may be deducted from the energy density of the storage and the technical limitations as they were started to document in the SUGRE project.

During the Alter-Motive project, new public **facilities** could be noticed in all cases. The figure is not very significant due to a very small number of cases per fuel mentioning changes.

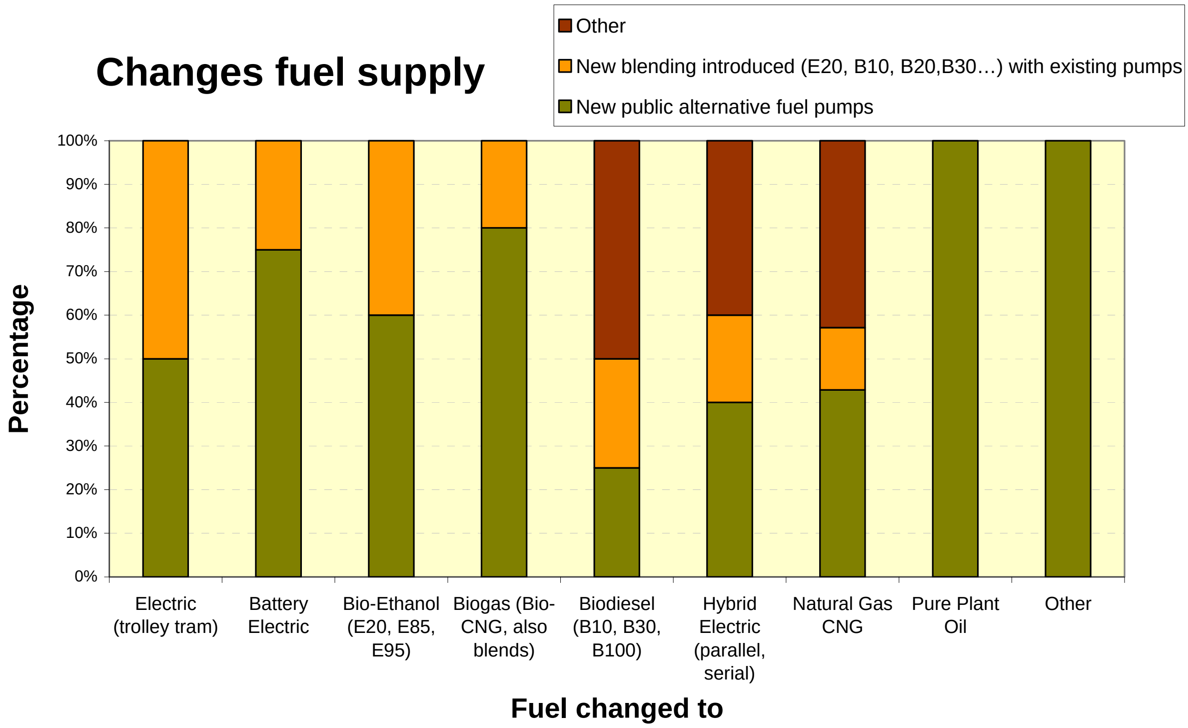

Figure 10: Changes in fuel supply depending on the fuel type

New public pumps were not too frequent with biodiesel, also not with CNG. Blending is valid for ethanol- for catenary electric this answer if correct shall refer to catenary extension.

3.1.3 Results from fleet cases

In general **the total cost of ownership** after the transition was higher with the measures in place (47% of the initiatives said so) or much higher (26%). Some projects (using multiple technologies) have experienced both, higher and lower cost. The following figure differentiates the changes stated per target fuel (fuel switched to).

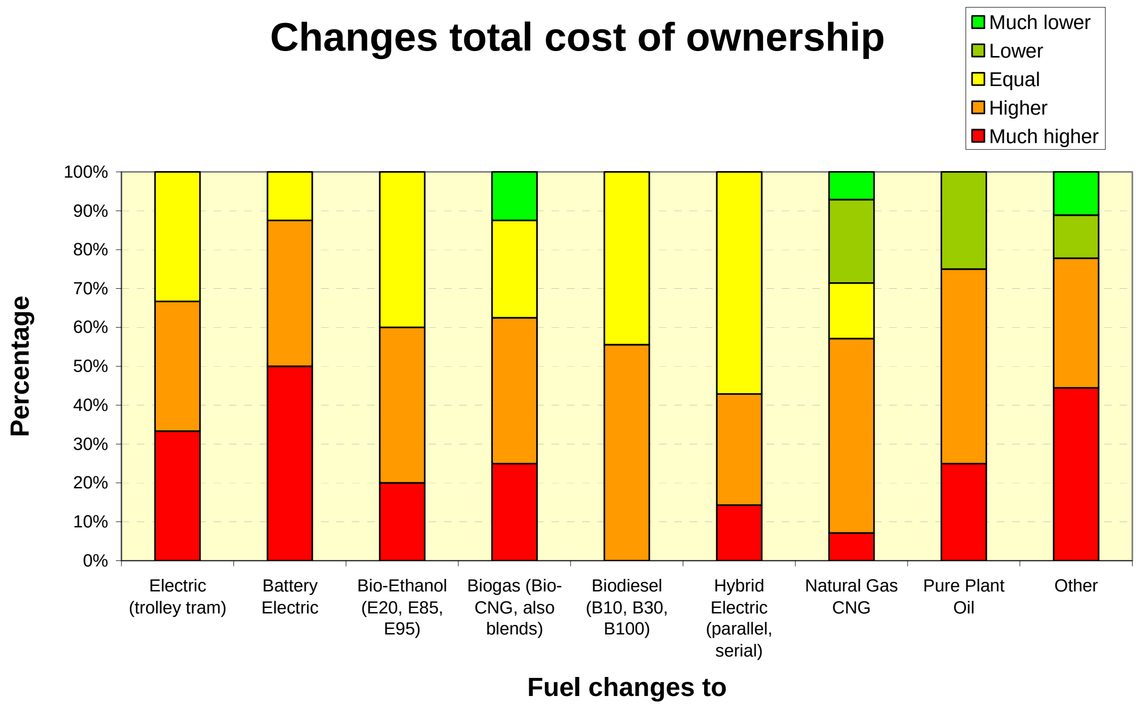

Figure 11 Cost changes depending on the fuel type

Fleets transiting to Compressed Natural Gas (CNG) and biogas managed to reduce the costs at a large scale, whilst the use of pure plant oil could lower the costs, but not that significantly. A tremendous cost increase could be noticed with the use of battery electric vehicles. The use of biodiesel caused only sometimes higher costs, but never significantly higher.

In 75% of the cases **no fuel price fluctuations** were encountered during the course of the project.

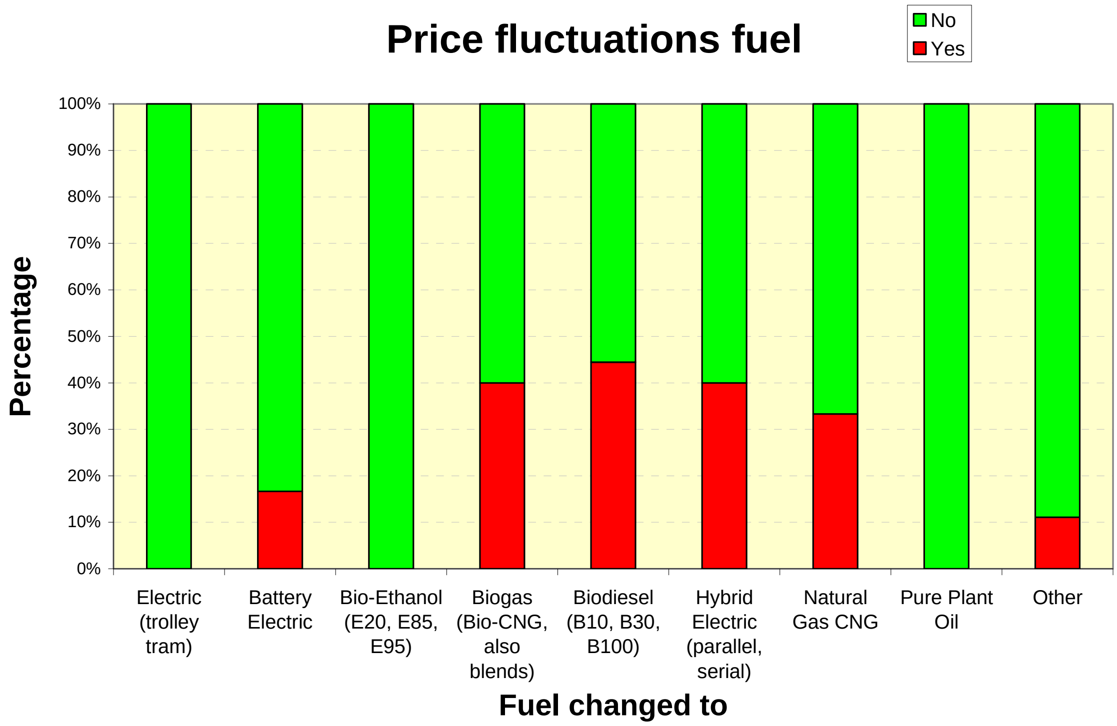

Figure 12 Price fluctuation seen for the fuel type

Cases targeting biogas, biodiesel, hybrid electric and natural gas have seen fluctuations in price more often compared to cases targeting other fuels.

17 times changes of boundary conditions on the national level were reported by the interviewees (some regulations and taxation changed as well as public image of biofuels), 10 reported changes on the local level.

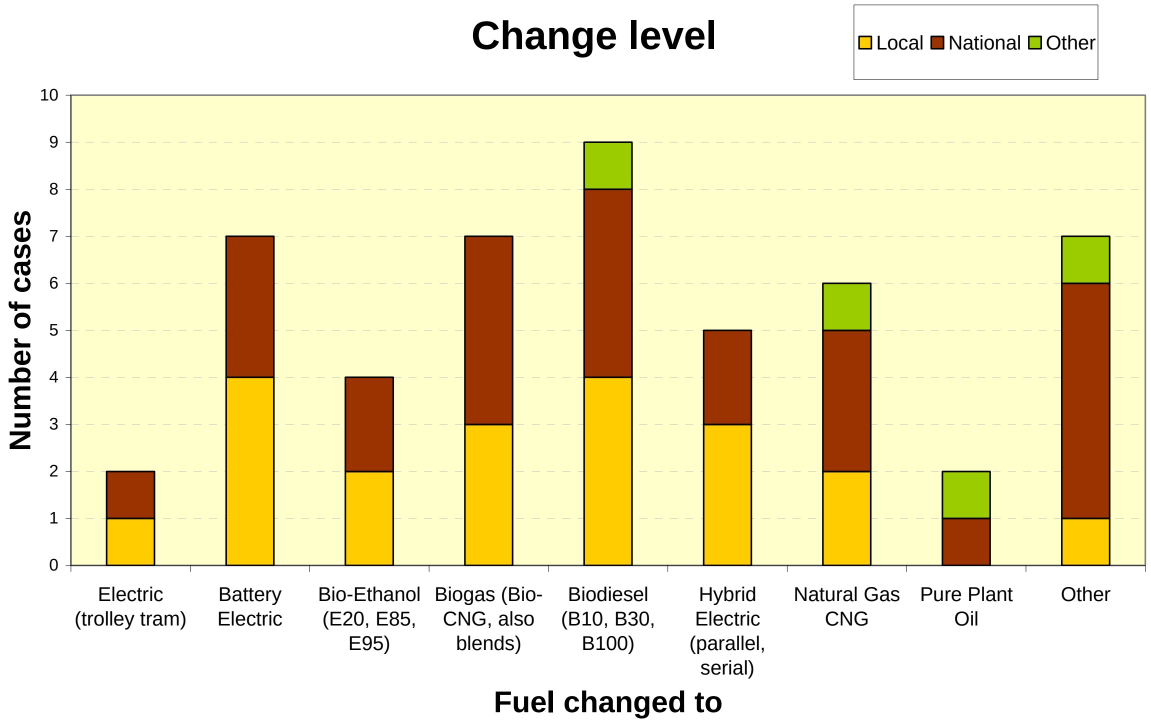

Figure 13 Origin of changes of boundary conditions depending on the fuel type

External boundary conditions were changing most often with biodiesel, but were also mentioned with battery electric and biogas.

The following figures shows the **success factors** in absolute figures; **funding opportunities** were dominating (2.84 points on a scale of 0-4 points) as most relevant success factor, external consulting and staff training were regarded as being less important (1 point) on average:

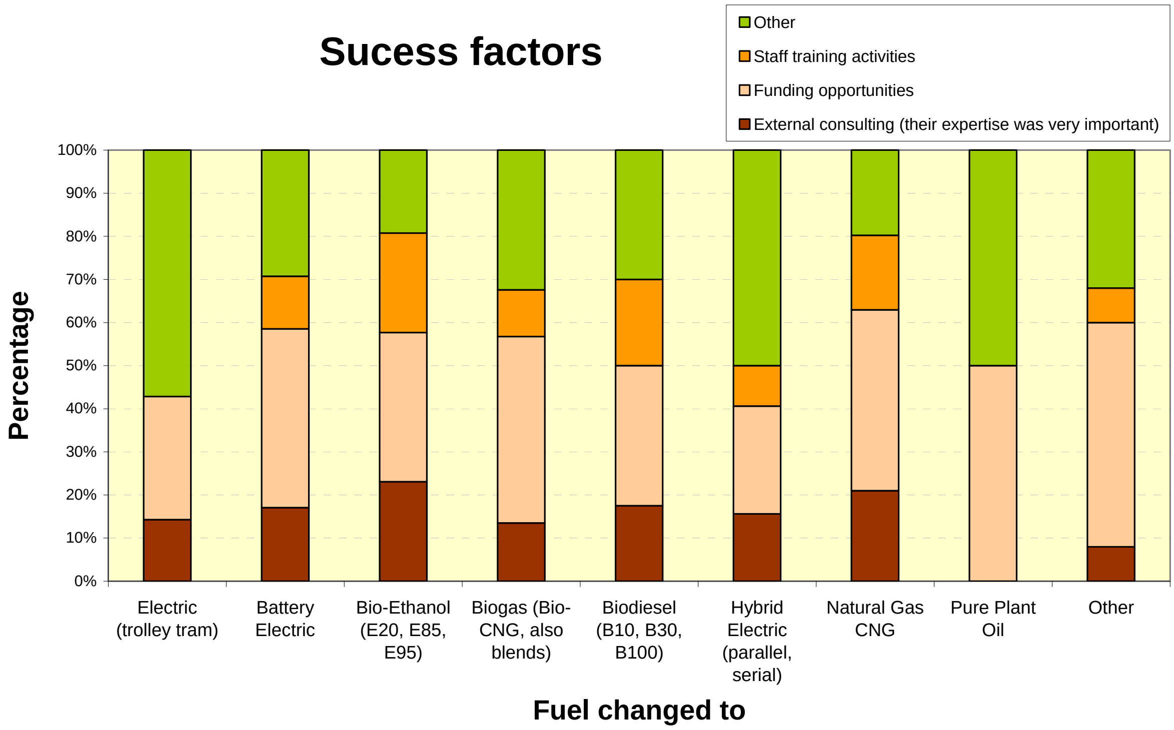

Figure 14 Success factors depending on the fuel type

Staff training was seen as success factor with bio-ethanol, biodiesel and natural gas. Funding was most important on overall – but of lesser importance for HEVs and catenary electric. In return one may say that those technologies are near to “diesel” parity or even better if the catenaries are erected by the city and not the transport provider. Unfortunately it remains unanswered whether such a shared system will work in a liberalised public transport business, with rail it works.

Looking at the successful implementations we can see a larger amount of **extension plans**. In general 44% of the cases plan to **increase the number of vehicles**, 28% include other type of vehicles but only 6% plan a transfer to other fleets.

Normalizing the data (dividing through the number of answers) we get the following figure:

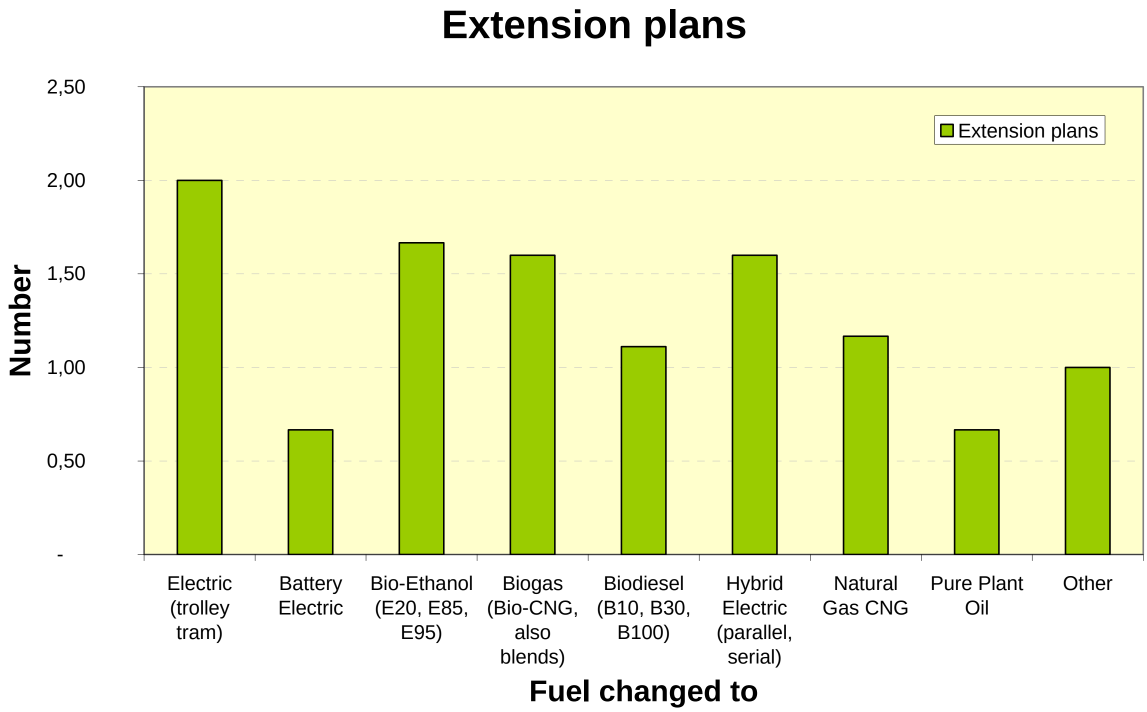

Figure 15 Number of extension plans depending on the fuel type

Catenary electric was most successful, followed by bio-ethanol, biogas and hybrid electric. Battery electric and pure plant oil turned out to be the least successful propulsion solutions. This might give a hint for an effective transition into electric mobility for public transport, namely concentrating more on catenary electric. Looking at the data in detail, the extension plans comprise an increase in the number of vehicles in 16 cases, but also a significant number of initiatives mentioned an extension to other types of vehicles (10).

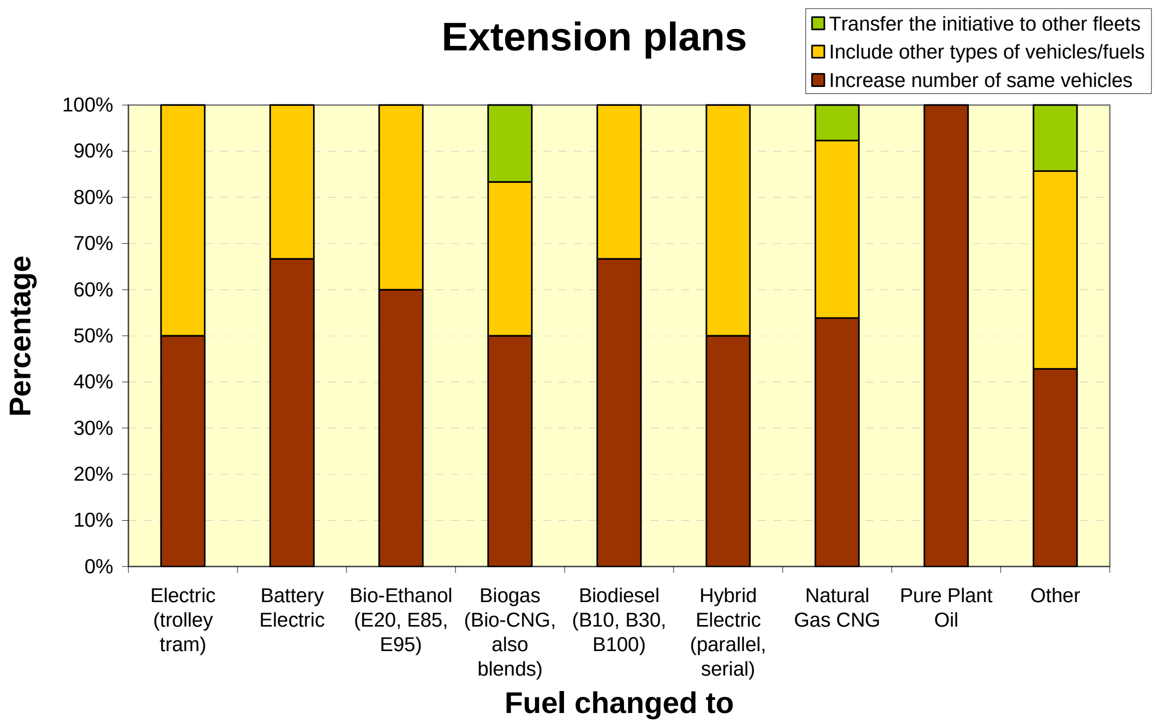

Figure 16 Extension types depending on the fuel type

With biogas, natural gas and other fuel types, a few attempts to transfer to other fleets were reported. If you look at the fleet types, public transport fleets are most capable to succeed (1.14 extension plans per case), but small private fleets and other fleets have also achieved good results (1 extension plan per case). Only logistics companies turned out to face a higher rate of failure having only 0.5 extension plans per case, but the basis for that figure is not big enough for logistics to call that a reliable figure.

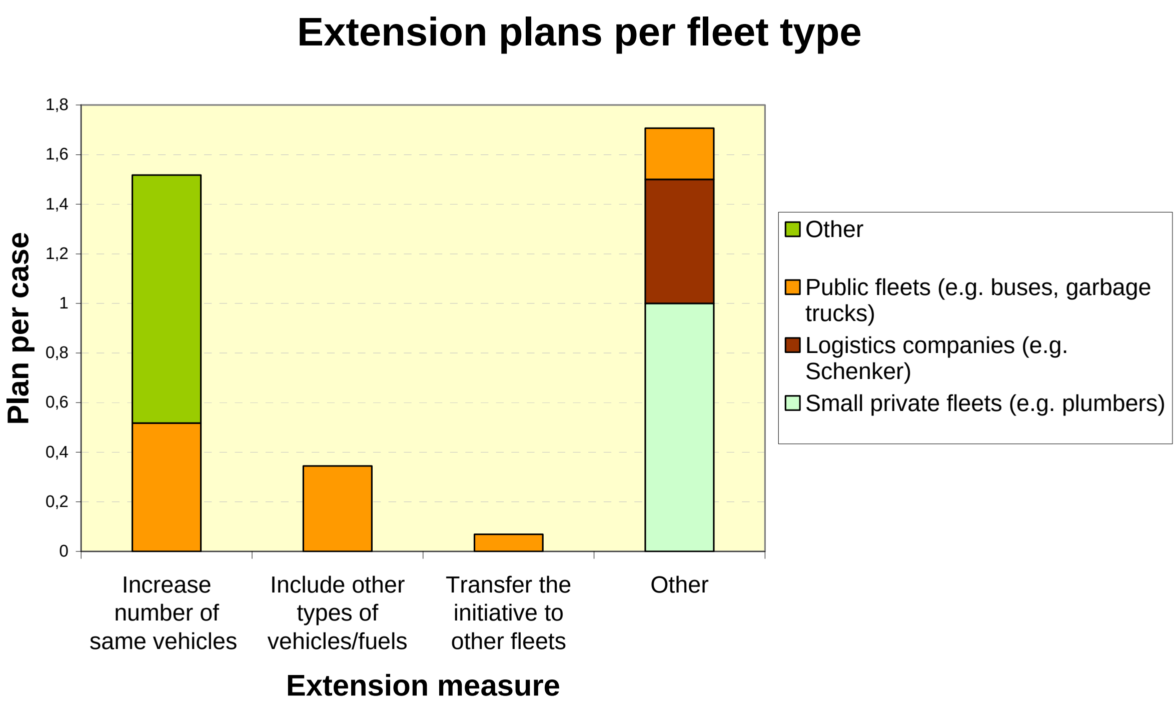

Figure 17 Extension measures depending on the fleet type

Apart from a mixture of other plans mentioned, most of the cases will increase the number of vehicles running on alternative fuels or having alternative propulsion. Second often they intend to include other types of vehicles/fuels and third often they plan the transfer to other fleets. Logistics companies deliver no success here.

There were too few results for some fleet types to differentiate the number of extension plans in a significant way, but it is possible to do that for internal and external **acceptance** ratios shown in the next figure.

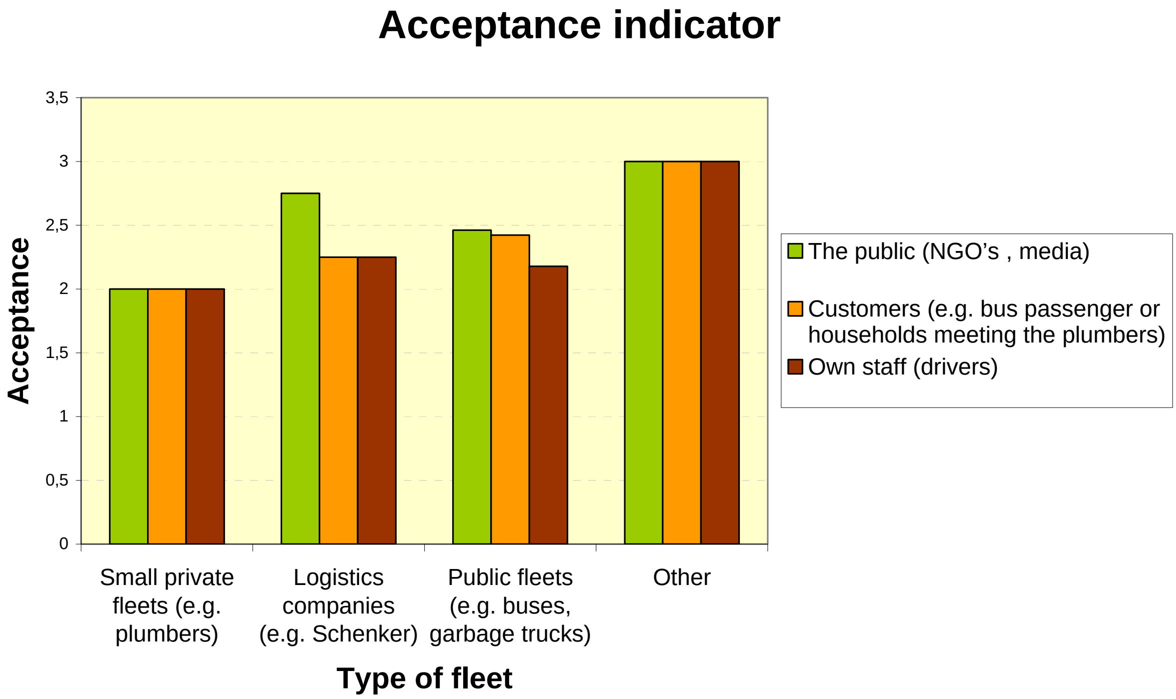

Figure 18 Acceptance depending on the fleet type

Acceptance of the measure was lowest with smaller fleets (but small sample). Logistics and public fleets experienced **lower acceptance** with their **own staff** compared to the public's acceptance which was higher. The following figure provides details concerning the different fleet types:

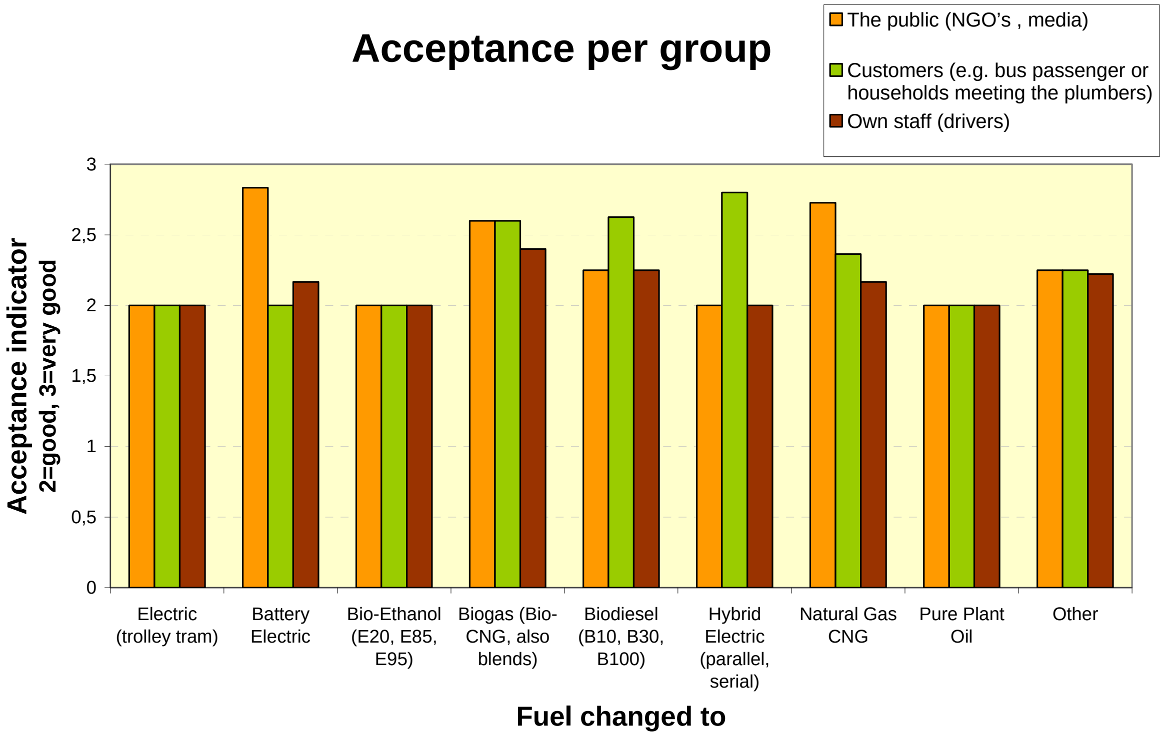

Figure 19 Acceptance depending on the fuel type

If you distinguish fuel types, there are two fuel types with an excellent **customer acceptance** - namely biodiesel and hybrid electric. The **public's acceptance** is especially high with battery electric and natural gas. It has to be said that those are the assumptions of the project teams themselves. The acceptance ranking was quantified (in case of a very good acceptance multiplied by 2, and a total calculated) and divided through the number of cases per fuel to weight it.

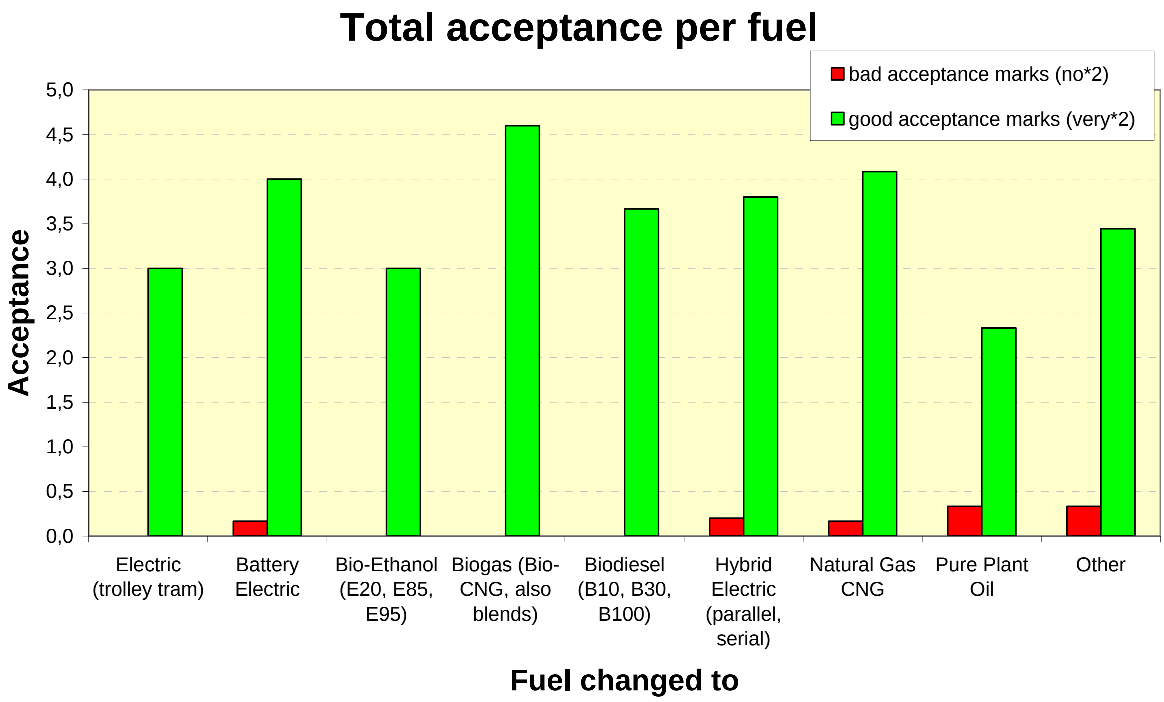

Figure 20 Total acceptance indicator depending on the fuel type

It may be seen that good **acceptance** dominates, especially with biogas, followed by battery electric and natural gas. Very little negative acceptance was experienced with battery electric, hybrid electric, natural gas, but mostly with pure plant oil (and other fuels).

Looking at **the short term challenges** seen by the project team, there is a mixed picture having 41 positive but 27 negative answers in total.

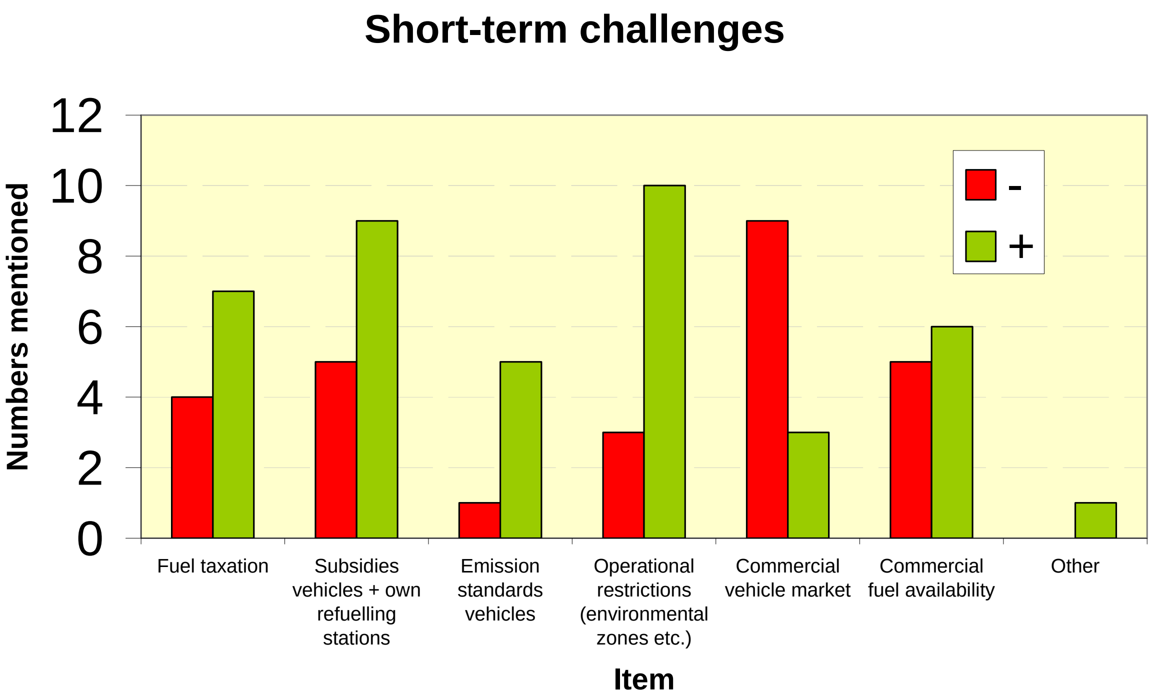

Figure 21 Distribution of short term challenges seen by the interviewees

Fuel taxation, subsidies and commercial availability of fuels have ambiguous outcomes, emission standards and **operational restrictions** are clear on the positive side as challenge and the commercial vehicle market is hindering the implementations. But one can say that al lot of factors has to be considerer when setting up a successful policy in order to avoid obstacles.

Asking for the **long term challenges**, the answers turned out to be more optimistic: For all the answering categories in total, we received more positive expectations (81) and much fewer negative expectations (18).

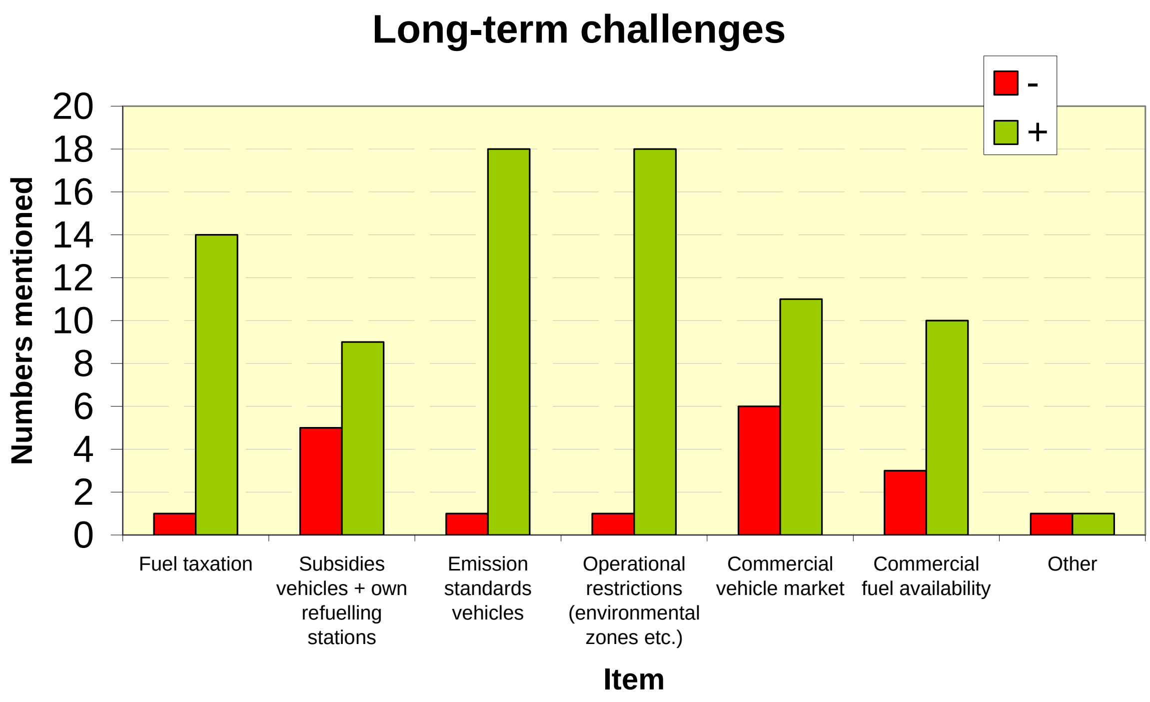

Figure 22 Long term challenges seen

Most **positive expectations** were seen with **emission standards** and operational restrictions, followed by fuel taxation. Those developments are benefiting the implementation of alternative fuels and alternative propulsion. The obstacles mentioned were subsidies and the commercial vehicle market, but also the commercial fuel availability.

3.1.4 Summary of the questionnaire analysis

Most of the cases were starting with a diesel fuelled fleet and the relative majority was heading into CNG, half of them city-based and half co-operating with other cities. Next to CNG were biodiesel (including blends) and battery electric and other (hydrogen). In total 54% of the cases was restraint to one city. Mostly the sample is consisting of public fleets (83%). The low share of logistics companies creates some validity problems. The projects targets were widely distributed, comprising improvement of local air quality, preventing climate change and other issues.

The projects behind the cases were benefiting from existing incentives, subsidies both for vehicles (43% of the cases) and refuelling facilities (13%) were exploited. The primary motivation for fleets is the possibility to improve their image, but there are other arguments too taken serious. Risk reduction and the demand for a secured fuel supply only apply to BEV users.

By choosing an alternative propulsion technology the type of propulsion defines the actions for the project. New battery electric vehicles were developed in cooperation with the producers. For pure plant oil users, own refuelling facilities were built. Alternative fuel supply had to be secured with biogas. In most cases own vehicle maintenance/workshop facilities were upgraded. In the field of CNG new vehicles have to be procured, whilst the use of biodiesel allows blending with the use of existing fuels and thus use of existing vehicles (if qualified). There was hardly any installation of public biodiesel pumps (no sign of rolling out the most feasible solution B30). The dependency on the fuel supply or charging is evident, but captive fleets may help themselves with their own charging or refuelling facilities.

Unfortunately the early adopters of alternative fuels have encountered a significant increase in total cost of ownership. This may be caused by the significant amount of BEV and hydrogen cases in the sample. Price fluctuations were not mentioned with pure plant oil, bio-ethanol and catenary electric, with battery electricity they play a minor role. The financial incentives were seen as most important for the success, external consulting and staff training as less important. The implementation is also affected by other external changes, most of them on national level.

With fleets the transfer issue is not very important finding followers, but in their own domain the projects may seen as successful as 44% of the cases will add same vehicle and 28% widen the scope to other vehicle types.

Generally speaking, the acceptance of alternative fuels is still good; however the acceptance of the staff is lower due to their duty dealing with the adaptation to the alternative propulsion system/fuel.

There were rather logical findings, which may be underlined when advising policy makers:

- It makes no sense to reward purchase of alternative fuel technologies where no vehicles are offered due to industrial problems.
- There should be more focus on incentives targeting automotive industry for developing and offering alternative fuel vehicles on the market
- Most cost effective for a city administration would be clear access regulations, benefiting ultra-low or zero emission vehicles, because general nation wide vehicle emission standards may not be differentiated between long distance and regional transport.
- On a European level, emission standards are seen as way to foster alternative propulsion- however this creates a strong focus on electric vehicles, pushing back most biofuels.
- Recent swift changes in fuel taxation reducing financial support create risks. There is a need for a constant policy keeping exemptions from tax and excise duties predictable

3.3 Results policies

3.1.5 Introduction

Policy cases are projects where administrative bodies are targeting groups of vehicle operators. There were eight cases where we got back questionnaires filled in. The gathering period in 2009 was just the beginning of a couple of projects - unfortunately nearly all on battery electric vehicles- and from those projects no results may be deducted till now since they are in their infancies.

3.1.6 Setting

The introduction of new **incentives** was not frequent, only one parking fee reduction and one subsidy measure were reported from the 8 cases. Most supportive national incentives were fuel tax reductions (2).

As dissemination measure, innovative fleets were presented in mass media. **Labelling** was used in two of five mentioned disseminating cases. **Co-operation** was set-up with the automotive industry in four cases.

The policies were set-up in **cities** in most cases - targeting an improvement of the local air quality.

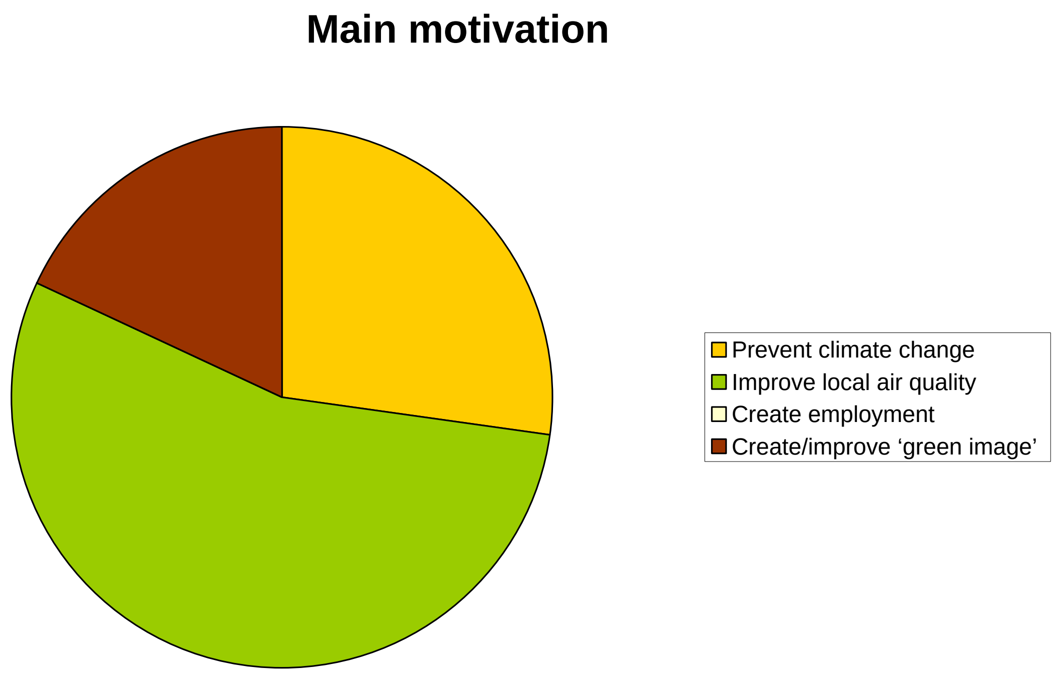

Figure 23 Share of main motivation for policy cases

In five cases public fleets were targeted by the cases. The development of the vehicle market was addressed in two cases. In five cases CNG was the fuel the policy cases were promoting most often, in two cases more fuels were included as catenary electric, Bio-Ethanol and Bio-Gas.

3.1.7 Findings policy case questionnaires

The stakeholder consultation was the longest process, but compared with fleet initiatives time needed for the implementation was shorter.

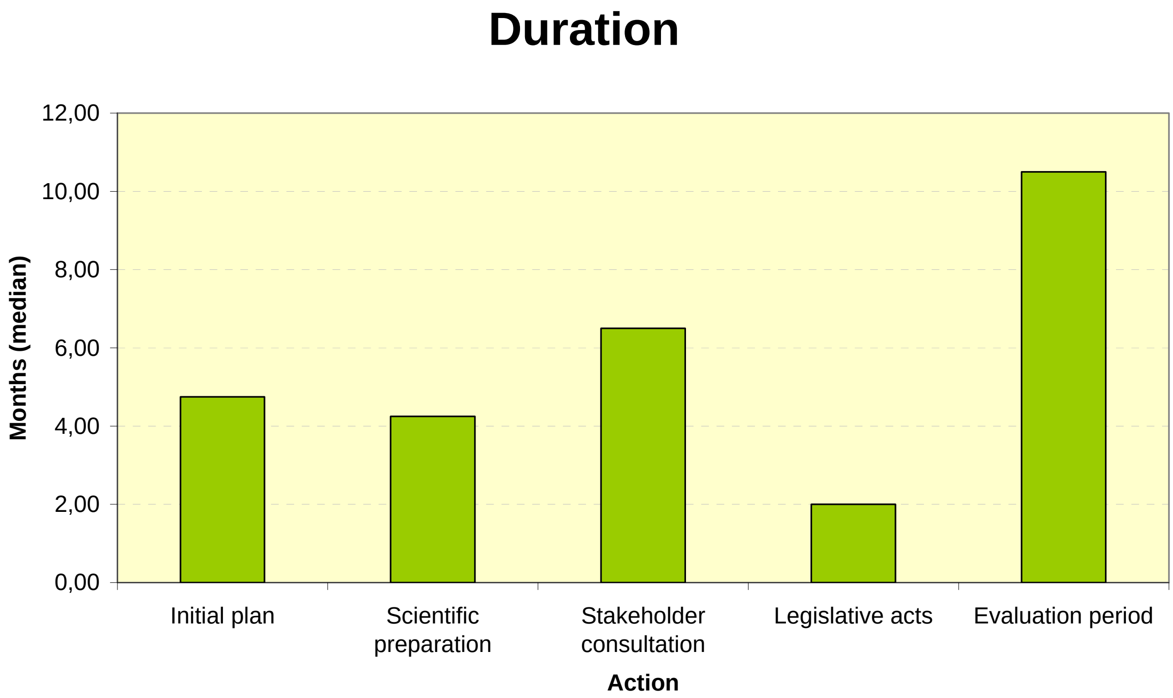

Figure 24 Average duration of project parts

Policy processes do also need a longer evaluation period because **behavioural change** is involved. The time mentioned for the legislative acts was considerably short.

Acceptance with external and internal persons was good for the majority of cases, in two of the eight cases a weak acceptance was reported, one from the public and one from staff.

In five cases an enlargement of the policy initiative is planned. The development of stricter **emission zones**, the commercial **availability** of alternative fuels and **access restrictions** are seen as most positive for developing policies in future.

4 Energetic, economic and ecological analysis

In this chapter an economic, energetic and ecological assessment is provided for the analysed case studies in the scope of the ALTER-MOTIVE project. At first in chapter 4.1 our method of approach is documented. In chapter 4.2 the success criteria are defined.

In chapter 4.3 the major groups of case studies by fuel, such as CNG-, electric vehicles (electricity)-, biofuels-, PPO- and hydrogen-projects, are documented and analysed from an economic, energetic and ecological point of view.

4.1 Method of approach

4.1.1 Energy conservation analysis

We analyse the savings in fossil energy consumption. This investigation is either based on a direct comparison of energy consumption before and after introduction of the case if reported so or based on estimations using typical or average figures e.g. for vehicle kilometres driven and for fuel intensity. The estimation uses the following equation:

$$\Delta E_{FOSS} = (FI_0 vkm_0 - FI_t vkm_t) \cdot V_{subst}$$

With:

FI……………fuel intensity

vkm…………kilometres driven per car and year

V_{subst}………...number of vehicles substituted

Moreover, for biofuels also the gross savings are calculated by taking into account the fossil energy for production:

$$E_{BF} = E_{\mathrm{Re}n} + E_{FOSS_{\mathrm{Re}n}}$$

So total energy balances are:

$$E_{FOSS_{\mathrm{Re}n}} = (f_{e_{FOSS}} FI \ vkm) \cdot V_{subst}$$

With:

f_{eFOSS}………factor of fossil share in biofuels

4.1.2 Economic analysis

The economic analysis is based on identifying the additional costs of alternative cars, costs for new infrastructure and administrative costs.[1]

In estimating the additional costs we used the principle of "additional marginal costs". E.g. for cars or buses we considered only the difference in investment costs of the new alternative vehicles in comparison to a new version of the conventional (e.g. diesel) vehicles. Or otherwise, if no new vehicles are purchased the cost difference is due to adaptation costs.

The costs per year are:

[1] Note, that not for every case study data were available for all of these cost categories.

$$C_y = C_{IS} + C_{CV} + C_{Ad\min} = IC_{IS} \cdot CRF_{IS}(r, t_{IS}) + IC_V \cdot CRF(r, t_V) + C_{Ad\min} \quad [€/yr]$$

Where:

IC_{IS}…………investment costs in infrastructure

t_{IS}……………depreciation time for infrastructure (about 20 years)

C_{Admin}………..yearly administrative costs

IC_V………… investment costs in vehicles

CRF…………capital recovery factor

t_V……………depreciation time for vehicles (about 12 years).

4.1.3 Ecological assessment

This considers mainly the reduction in CO_2-emissions equivalents (comprising methane and other gases with global warming potential):

$$\Delta CO_{2_{equ}} = E_{FOSS_{0j}} f_{CO2_j} - E_{FOSS_{tj}} f_{CO2_j} - E_{\mathrm{Re}n_{tj}} f_{CO2_j} \quad [\text{ton } CO_{2equ}]$$

j…………….. fossil fuel type

f_{CO2j}…………specific CO_2 emission factor (e.g. 2.36 kg CO_2/l biodiesel)

Finally, costs of CO_2 (C_{CO2}) are calculated as:

$$C_{CO_2} = \frac{C_y}{\Delta CO_{2equ}} \quad [€/\text{ton } CO_{2equ}]$$

4.2 Definition of success criteria

4.2.1 Low costs

The target of 100% low costs is reached, when CO_2 reduction costs are lower than 1 EUR/ton CO_2.

Correspondingly, costs of about 30 EUR/ton CO_2 are related to 50% of the “low cost” goal and 0% target is reached when costs are higher than 1,000 EUR/ton CO_2.

4.2.2 CO_2-reduction

With respect to the CO_2 reduction, the target of 100% CO_2 reduction is reached, when the reduction of CO_2 emission due to the analysed case study are higher than 10,000 tons CO_2.

CO_2 reduction of 50% correspond to the CO_2 saving of about 3,000 tons per CO_2. 0% means there was no emission reduction.

4.2.3 Multiplicity

With respect to “Multiplicity” a figure 100% means that this case study is possible in every location in every (EU) country and the fuel is available everywhere. 80% applies if is possible in every corresponding area, e.g. in every city without fuel limitation.

If the measure is possible in most areas, but there are restrictions of fuel availability, then multiplicity is defined as 50%. If the case described is virtually unique, and cannot be duplicated anywhere the target reached is 1%.

4.3 Economic, energetic and ecological assessment of analysed case studies

4.3.1 CNG case studies

The share of CNG projects represent about one quarter of the show cases collected and analysed in the scope of the ALTER-MOTIVE project. The main reasons for the investments in CNG-fleets are:

- Responsibility for the environment and improving company's green image
- The price comparison of CNG and diesel, possibility to save money
- The necessity to avoid driving bans in cities because of increased limits in relation to particulate matter
- Noise reduction

Most of the analysed CNG-case studies have been successful. The technology used is already mature and works without any major problems. Beside dedicated CNG vehicles in use are also bi-fuel (CNG/diesel) vehicles. By CNG vehicles more time for refuelling (approx. 8 minutes) is necessary. This usually causes no extra costs, but the changes in driver's work time management die to longer refuelling time is possible. Some of the disadvantages of CNG vehicles in comparison to conventional diesel engine are:

- Lower engine durability (about 140,000 km)
- Lower weight capacity (due to gas cylinders)
- Lower performance of engine (but for running in city centres the performance is usually not important).

The biggest problem so far of the CNG pilot projects was the low developed network of service stations. Since the CNG-infrastructure is limited, CNG vehicles are usually used in urban areas in public fleets e.g. buses with determined operating ranges. Trips into the outskirts require the ability to switch to a conventional fuel. Dual fuel capability is mostly used in CNG passenger cars or vans. On one hand advantage is that duel-fuelled CNG vehicles could be used across the country or region in spite of limited infrastructure. On the other hand in this case most of the time diesel is used as a main fuel, so that all economic and ecological advantages of CNG vehicles are significantly reduced.

Due to relatively good experience with CNG and good acceptance by all involved groups most of the CNG projects are extended. In some cases CNG is already a part of regular fleets.

However, the missing or low density of CNG refuelling stations is the major obstacle in extending the fleets operations. Some specific CNG features from the analysed projects are depicted in Figure 25.

As shown the impact of municipal policies as well as financial support from public institutions are mostly very relevant. Although the CNG vehicles have lower operating costs, due to the lower fuel costs, in most of cases due to the low operational performance (from 10,000 to 45,000 km per year) and the small number of vehicles, only relatively low part of the extra costs for CNG vehicles can be compensated by fuel costs savings and user benefits. In these cases financial support is very important.

Most of cases (about 95%) were public buses initiated by municipalities.

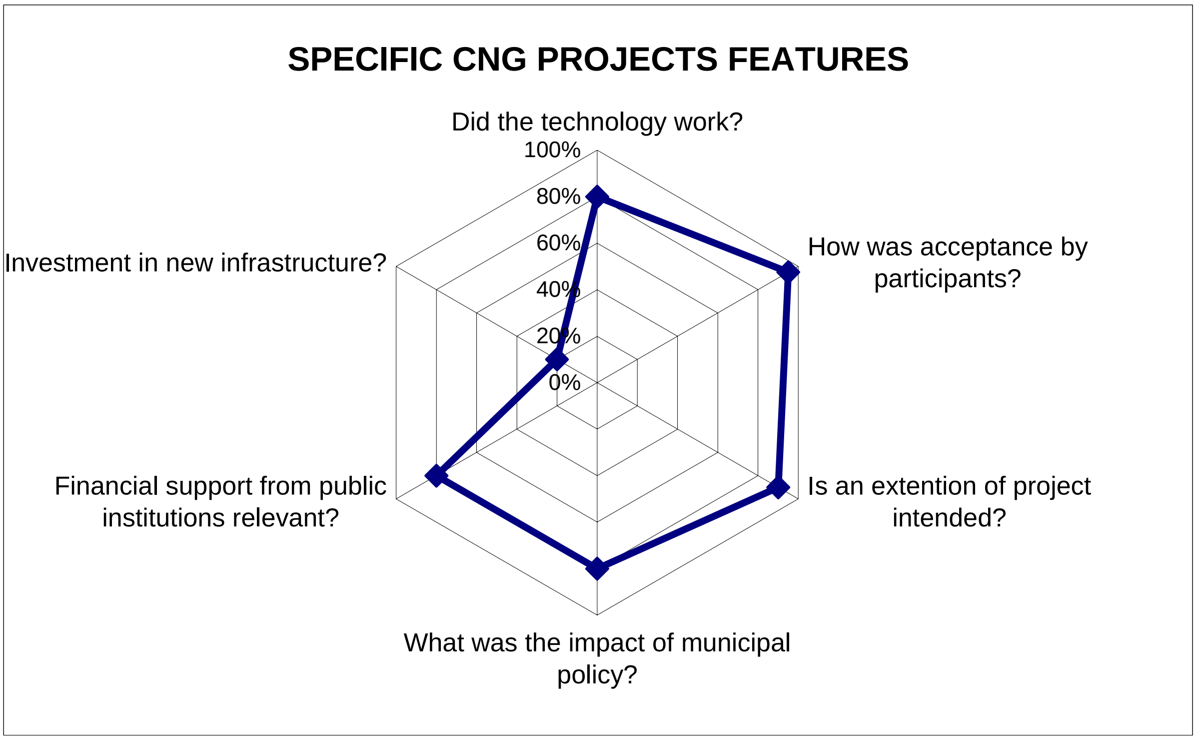

Figure 25 Specific features of CNG projects

As a matter of fact CNG is not a renewable energy carrier, but it ensures great environmental virtues: lower level of noise[2] and lower air polluting emissions. The CNG vehicles have proven to be low-emission alternative to diesel vehicles. The emissions usually go below the requirements of the EEV standard. However, the results regarding the reduction of greenhouse gas emissions are different from case to case (dependent from mileage, vehicle type – dedicated or articulated bus etc.). Thanks to the catalytic converter CNG vehicles emit about 90% less PM_{10} and about 70% less NO_x in comparison to conventional diesel vehicles[3].

Additionally, by using CNG vehicles the level of noise could be reduced for about 4 dB in comparison to diesel vehicles, which is big advantage for vehicle use in cities.

As an example we have shown energy- and GHG–balances of a fleet with 100 CNG buses, see Figure 27 and Figure 27. It is assumed that conventional diesel buses are replaced with dedicated CNG buses with an operating range of 40,000 km per year.

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[2] Annotation by the editor: Noise reduction is lower if you consider the higher RPM in order to achieve the same torque

[3] Annotation by the editor: Emission do increase operating outside the stoichiometric area and with ageing catalysts.

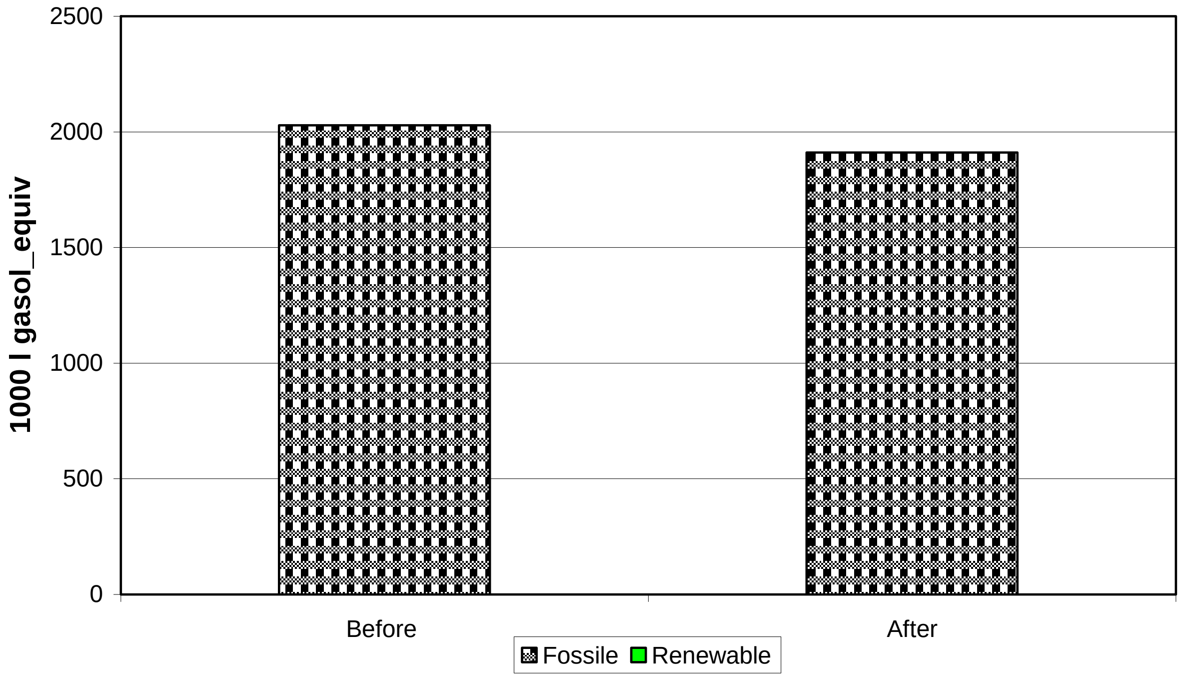

Figure 26 Average energy balances of CNG projects[4]

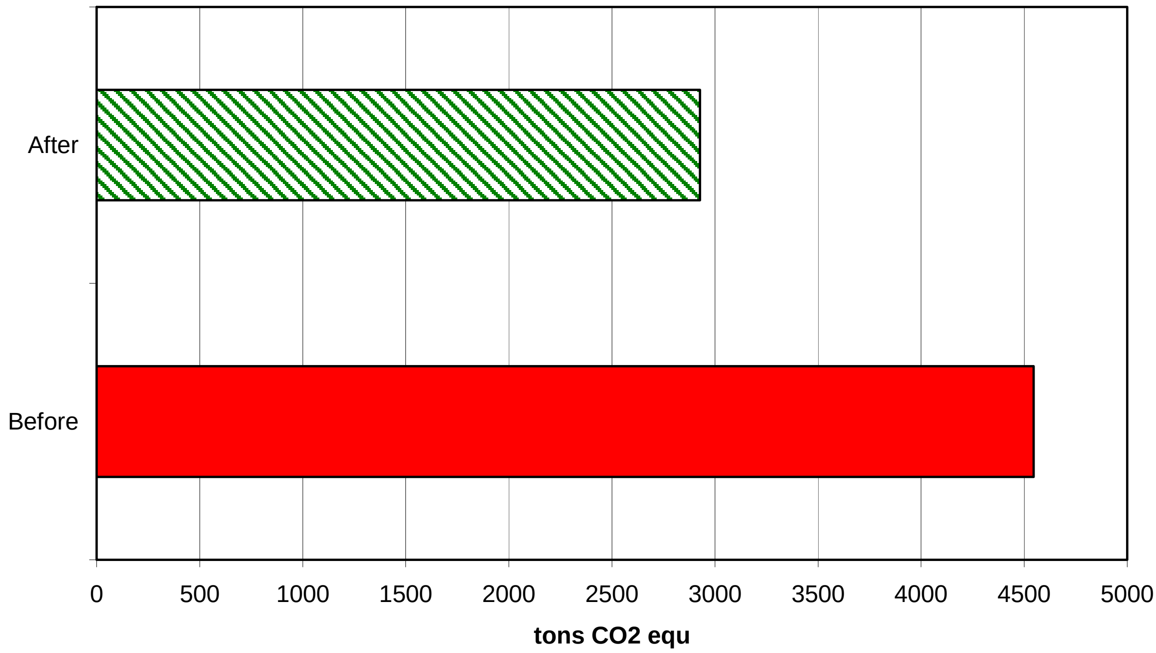

Figure 27: Estimated average of GHG emissions of CNG projects[5]

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[4] Annotation by the editor: A lot of urban transport fleets argue that due to the vehicles higher weight and the spark ignition combustion cycle the efficiency decreases, but in cases where old worn out diesel buses were replaced an efficiency increase is feasible.

[5] Annotation by the editor: Same as with energy efficiency due to the vehicles higher weight and the spark ignition combustion cycle the CO_2 emissions may not decrease as the low carbon content of methane promises, but in cases where old worn out diesel buses were replaced larger CO_2-reductions are possible.

Along the environmental benefits, the CNG vehicles have lower operating costs, due to the lower fuel costs. In some cases the fuel costs could be reduced by 25% - 50%. Maintenance costs are more or less steady, but repair costs could be partly higher.

Using CNG vehicles operating costs are lower, but it will take time to recapture the initial investment costs. In some of the projects beside acquisition or adaptations of vehicles it was necessary to build CNG refuelling station, which, of course, increased costs of the project. The investment in fuel station were up to 800,000 EUR. Yet filling stations only (no building included) are about 190,000-350,000 EUR.

In some projects CNG cars or vans are leased. The costs of leasing are not exceptionally different compared to those of conventional fossil fuels vehicles. The project costs are different from project to project and from country to country. In some cases project costs are not available for public. However, the CNG vehicles have proven to be economic, especially dedicated CNG vehicles.

The fuel consumption of CNG vehicles is significantly lower than that of old diesel engine, but the initial investment costs are higher. By bi-fuel vehicles the conversion costs are approximately 10,000 EUR per bus. But in this case operation costs are higher. The costs of dedicated CNG buses are about 315,000 -385,000 EUR.

The major costs indicators in the example described above are shown in Figure 28.

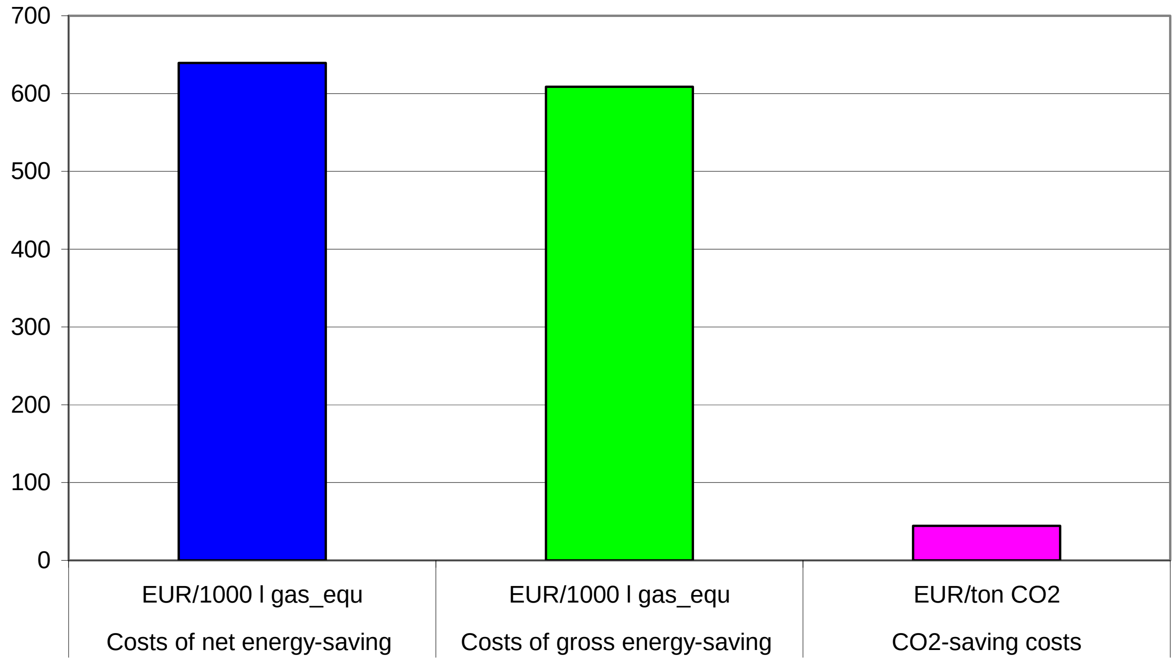

Figure 28 Major cost indicators CNG

However, the most of the CNG case studies could be classified as successful (see Figure 30) Using CNG operating costs could be reduced as well as noise and greenhouse gas emissions. A big advantage is also relatively easy transferability of knowledge and technology.

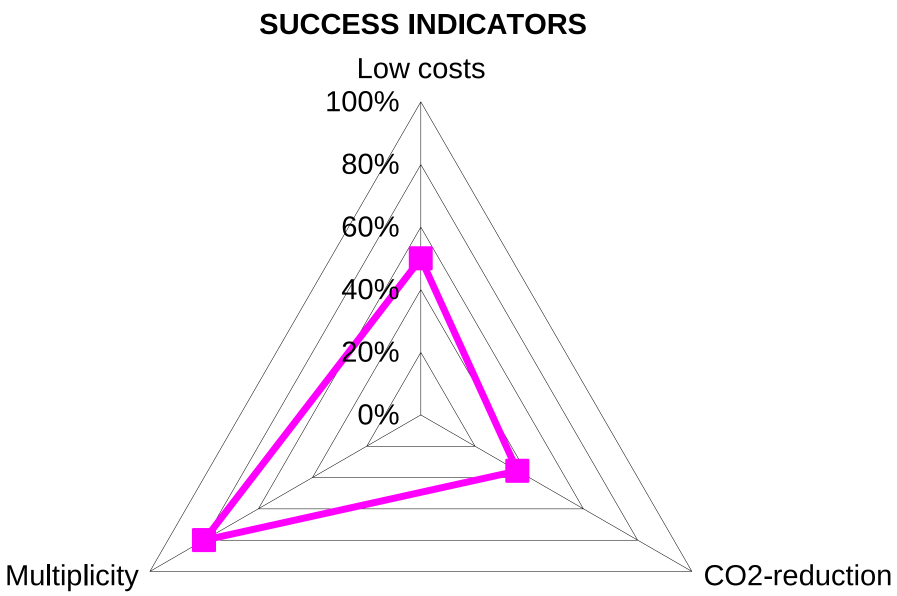

Figure 29 Success indicators of CNG projects

4.3.2 Battery electric vehicle (BEV) case studies

In the last few years interest in battery electric vehicles is rapidly increasing, so that about one quarter of analysed case studies in ALTER-MOTIVE project is related to electro mobility.

The motivation for most of electro mobility case studies is to:

- Learn about economic, technical and social viability of electro mobility as well as about requirements, charging technology and practical aspects of operating charging infrastructure
- Test consumer behaviours and demonstrate acceptance
- Reduce noise, air pollutions and greenhouse gas emission in urban areas.

Most of analysed case studies have been successful. Big public interest in electro mobility can be also noticed.

The electric vehicles used in the case studies are still not fully technically mature and not completely comparable with conventional gasoline or diesel vehicles. Some of the disadvantages of electric vehicles in comparison to conventional ICE engines are:

- Very long charging time (8-10 hours to fully charge)[6]
- Lower operating range (about 50-100 km) in real life
- Lower maximal speed (40-70 km/h) especially for retrofitted electric power trains
- Restricted servicing possibilities due to limited infrastructure.

[6] Annotation by the editor: Recent fast charging facilities do promise a replenishing to 80% in half an hour or even less.

Since the number of charging points is limited, electric vehicles are usually used in urban areas in public fleets e.g. garbage trucks or tourist vehicles with determined operating ranges.

In some cases this problem is solved by using bi-fuel vehicles. Dual fuel capability allows the vehicles to run on two different types of fuels – one alternative and one conventional. Of course, by using bi-fuel vehicles ecological advantage of electric vehicles is reduced.

Due to relatively good experience and acceptance by all involved groups most of the case studies related to BEV will be extended.

However, the number of charging points have to be increased and the operating range of electric vehicles have to be improved.

From the analysed project some specific electric vehicles features are shown in Figure 30.

As shown in Figure 30, the impact of municipal policies as well as financial support from public institutions is mostly very relevant. Since the prices of the electric vehicles are higher than those of combustion engine vehicles, different kinds of measures are necessary to make this vehicles more attractive. E.g. in some cases charging of electric vehicles is free as well as parking space, or the electric vehicles are allowed to enter restricted traffic zones.

However, to provide these benefits to users of electric vehicles in the most of the cases financial support is very important.

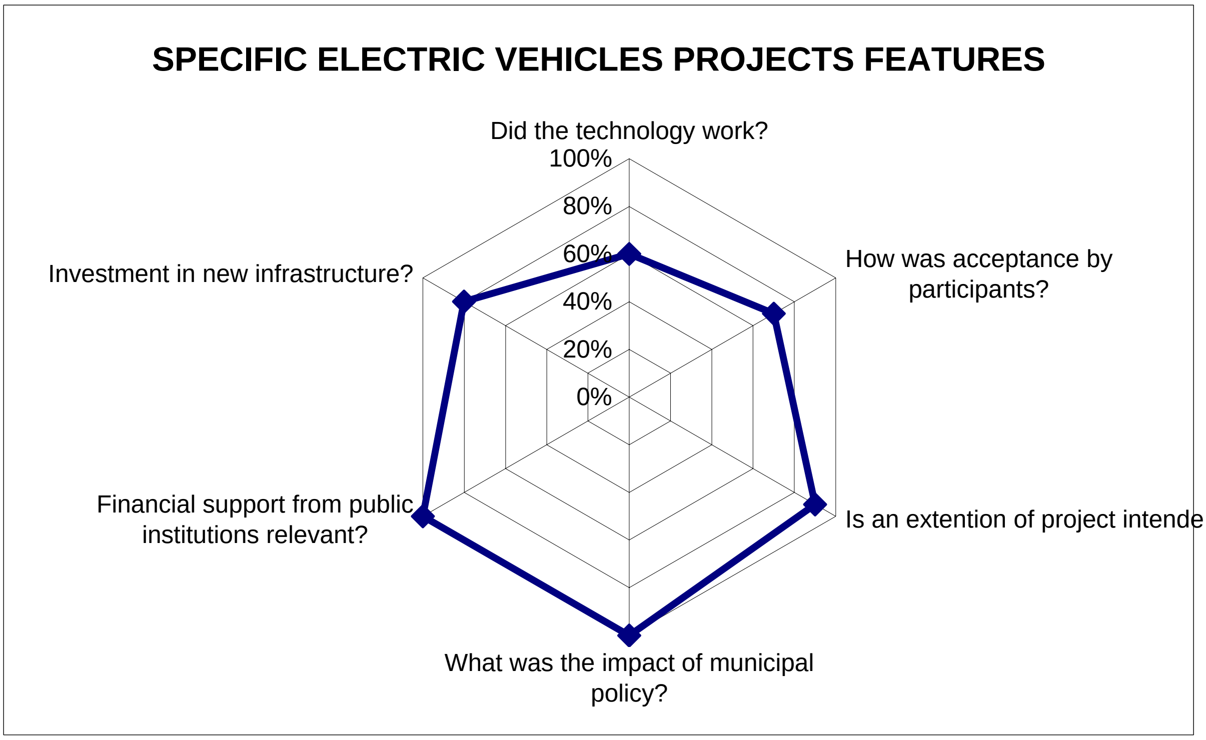

Figure 30 Specific features of battery electric vehicle projects

Electric vehicles are zero-emission at their point of use. However, emissions are being produced during the generation of electricity, the amount depending on the method of generation and art of primary energy which is used for electricity generation. Therefore, the emissions need to be considered on a lifecycle basis. Best option is to use 100% renewable energy for electro mobility. In any case, electro mobility can significantly reduce noise, air pollution and CO_2 emissions in the city.

As an example we have shown energy- and GHG–balances of a fleet with 100 electric vehicles, see Figure 31 and Figure 32. It is assumed that conventional ICE vehicles are replaced with electric vehicles with an operating range of 14000 km per year. In case studies mostly used electric vehicles are Th!ink, Renault Twingo, Fiat Panda, Fiat 500 and Mazda 2. In some cases the larger electric vehicles provided by Mercedes did give some technical problems (not properly working battery). Due to this problem some of the cars have been out of service for longer period. This had a negative impact on the reputation of electric vehicles.

Actually, the best experience is with the small electric vehicles which use is limited to the certain urban areas, e.g. narrow streets in the city centres.

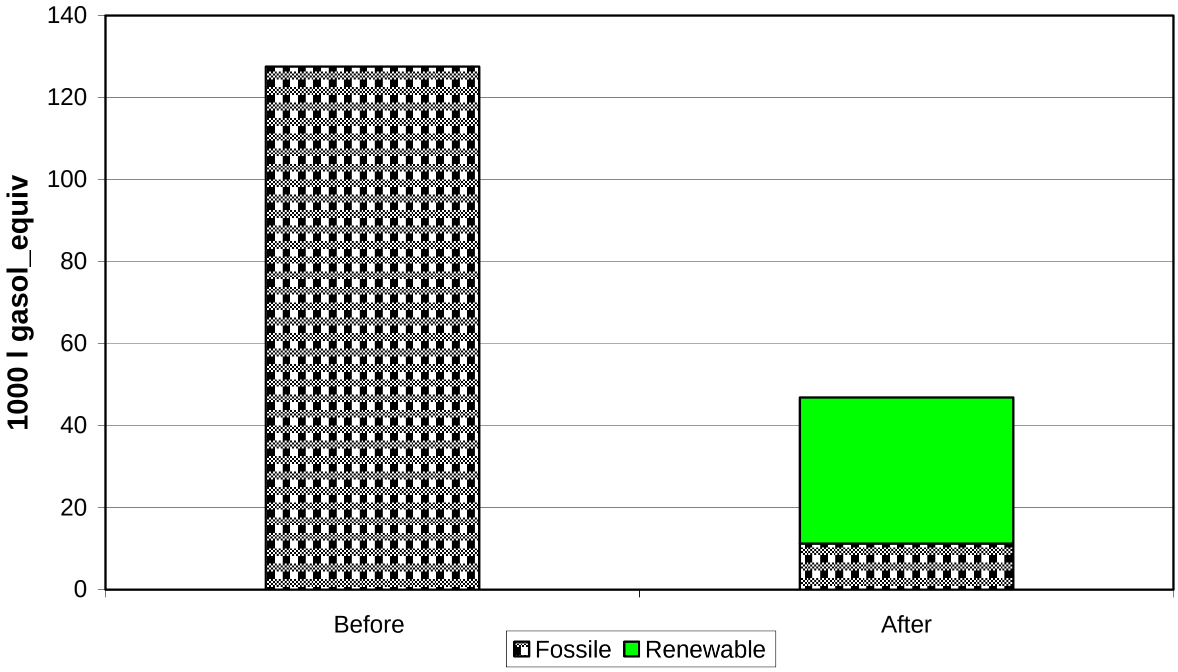

Figure 31 Energy balances of BEV projects

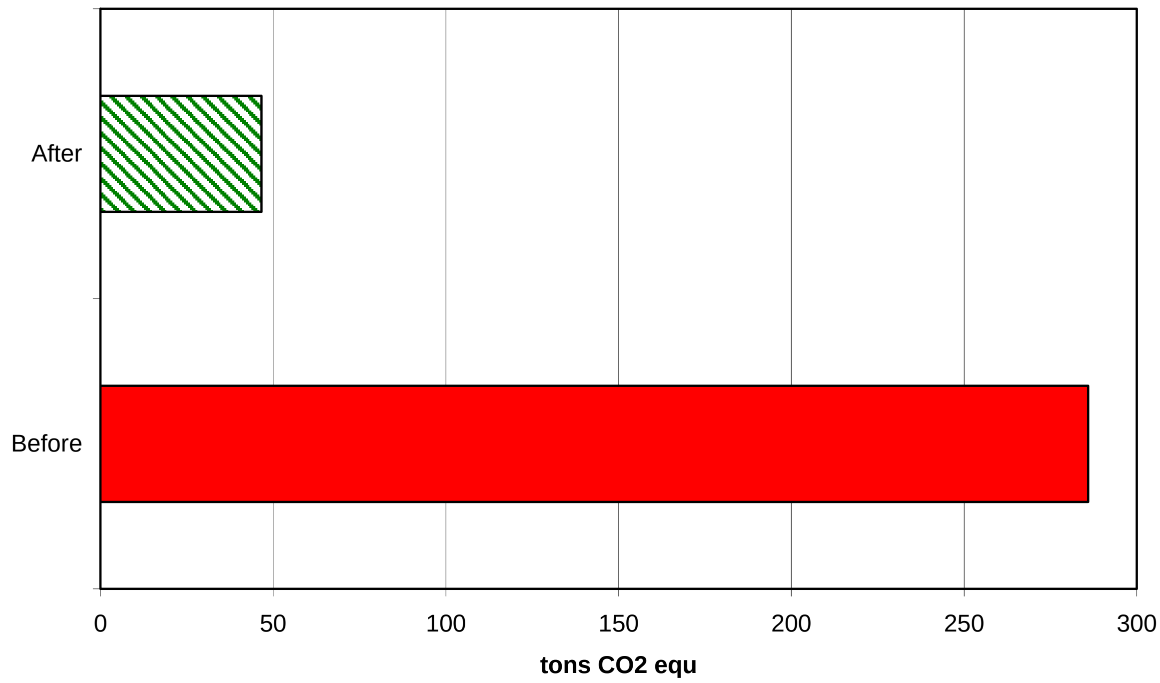

Figure 32 Estimated average of GHG emissions EV projects[7]

Electric vehicles are significantly more expensive to buy than conventional ICE vehicles. Typically for new electric car the price is about 30,000 EUR higher. The batteries are very expensive and have to be exchanged every 2 to 5 years. However, the acquisition costs of small electric vehicles are in the range 14,000 (2-seat model) and 16.000 (4-seat model).

In spite of high investments costs, in some countries with low electricity prices e.g. Norway, electric cars are largely an economic success (cost saving per electric vehicles is about 1 EURO per 10 km travelled). For example, in Denmark the governmental taxes on cars are the highest in the world, but there is no tax on electric vehicles until the end of 2011. This tax exception makes electric vehicles much more competitive with the conventional vehicles.

In some of the projects beside acquisition of electric vehicles it was necessary to build new charging infrastructure, which, of course, increased costs of the project.

In some pilot projects electric vehicles could be used free of charge.

The project costs are different from project to project and from country to country. They are highly dependent of the type of vehicle used e.g. small or large electric cars, motorbikes, bicycles etc. In some cases project costs are not available for public.

The major costs indicators in the example described above are shown in Figure 33.

[7] Annotation by the editor: The CO_2-intensity depends largely on the power mix- especially the share of coal- which may vary from region to region

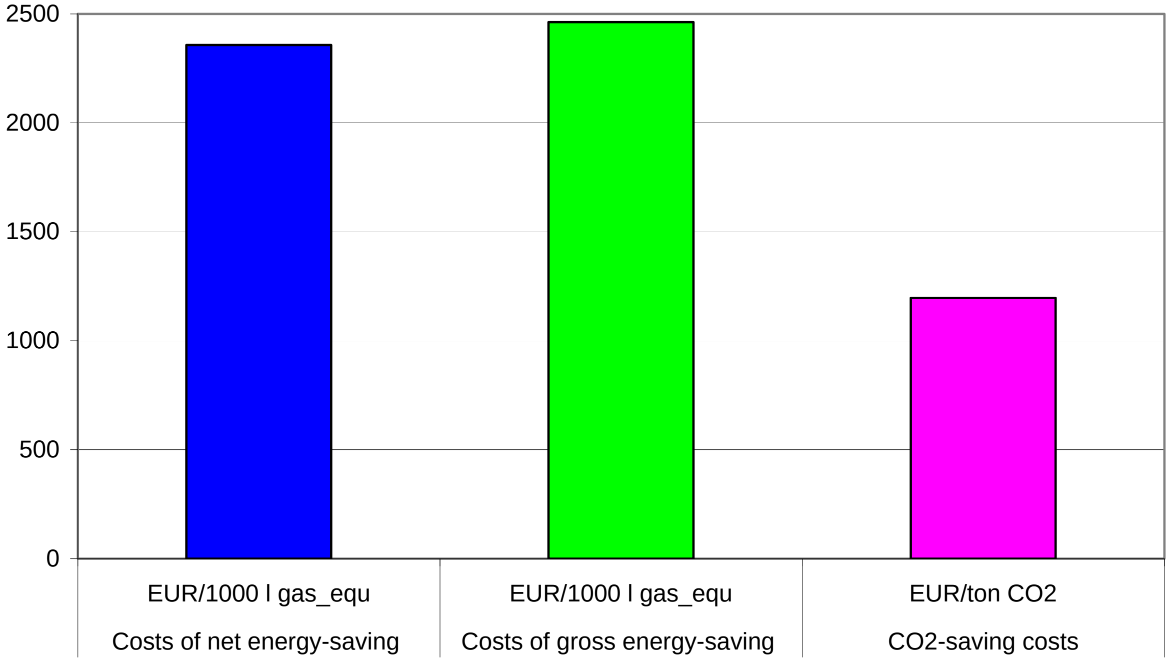

Figure 33 Major cost indicators of BEV projects

However, the most of the case studies related to the electro mobility are successful, see Figure 34. Note that the large CO_2-reduction figure is only reached assuming electricity generation from renewable energy sources. Using electric vehicles local air pollution and greenhouse gas emissions could be significantly reduced as well as noise. A big advantage is also relatively easy transferability of knowledge and technology. Important task for the future is international standardisation of the interface between the vehicles and the charging point.

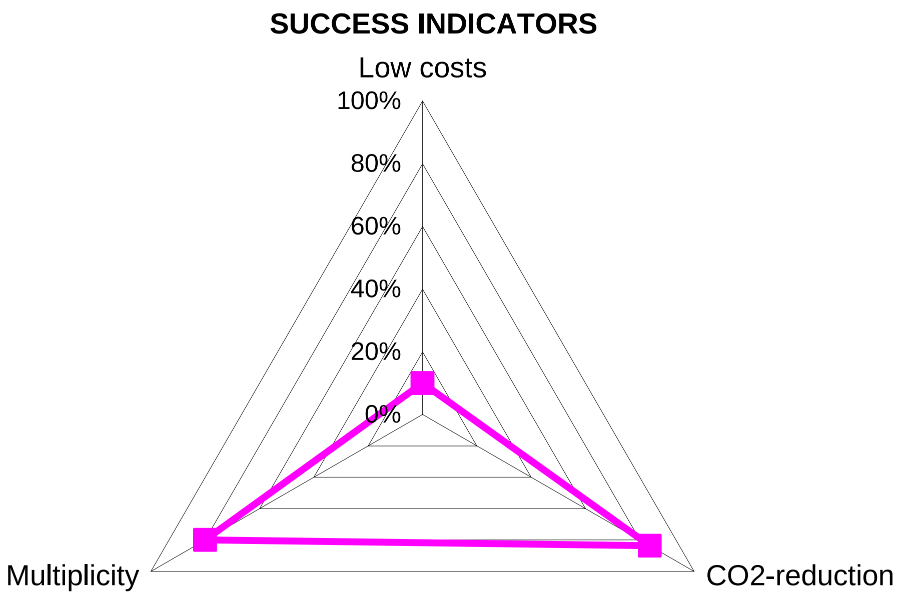

Figure 34 Success indicators of BEV projects

4.3.3 Biofuels case studies

In the last decade interest in biofuels, especially bioethanol and biodiesel was continuously increasing in all European countries. Many countries have set the goal to replace a significant part of fossil fuels by biofuels. In the European Union by the end of this year (2010) 5.75 percent of the energy used for transportation should be biofuels. Biofuels are considered to have the potential to reduce at least to some extent problems in the transport sector, such as growing consumption of fossil fuels, growing import dependency from political instable countries and increasing greenhouse gas emissions.

In most cases biofuels in transport sector are fully implemented, after successful pilot projects. The biofuel projects are usually driven by:

- ecological aspects
- interest in technological progress (to test the use of biofuels in practice)
- image improvement
- the wish to support local biofuel production

Most of analysed case studies have been successful. They have made it possible to gather information about repair, maintenance and service needs when using biofuels.

Usually, a diesel/biodiesel mixture with a percentage between 5% (B5) and 30% (B30) biodiesel was mainly used. Small percentage of biodiesel does not require technical adaptation of the vehicles. In some analysed case studies also pure biodiesel (B100) has been used. The goal was to test pure biodiesel use in conventional ICE vehicles (e.g. Volkswagen LT) without modification. The first experience was positive, without any extra maintenance or other problems.

Bioethanol is usually used as E5 to E10 in conventional vehicles without any additional modification of engine. Higher percentage of bioethanol (E85) is used in flex-fuel vehicles (FFV). The experience with FFV has been good so far, without problems reported.

Some of the disadvantages and problems related to biofuels use in some cases were:

- the number of refuelling stations is limited
- flex-fuels vehicles require about 25% more fuel per kilometre to run on bioethanol
- lack of general regulations and safety rules, no classification and excise duty rates for bioethanol fuel.

Some specific features of analysed biofuels projects are shown in Figure 35.

As shown in Figure 35, the impact of municipal policies as well as financial support from public institutions is very relevant. Most of the tests with biofuels use in vehicles were successful, so that public acceptance is relatively high.

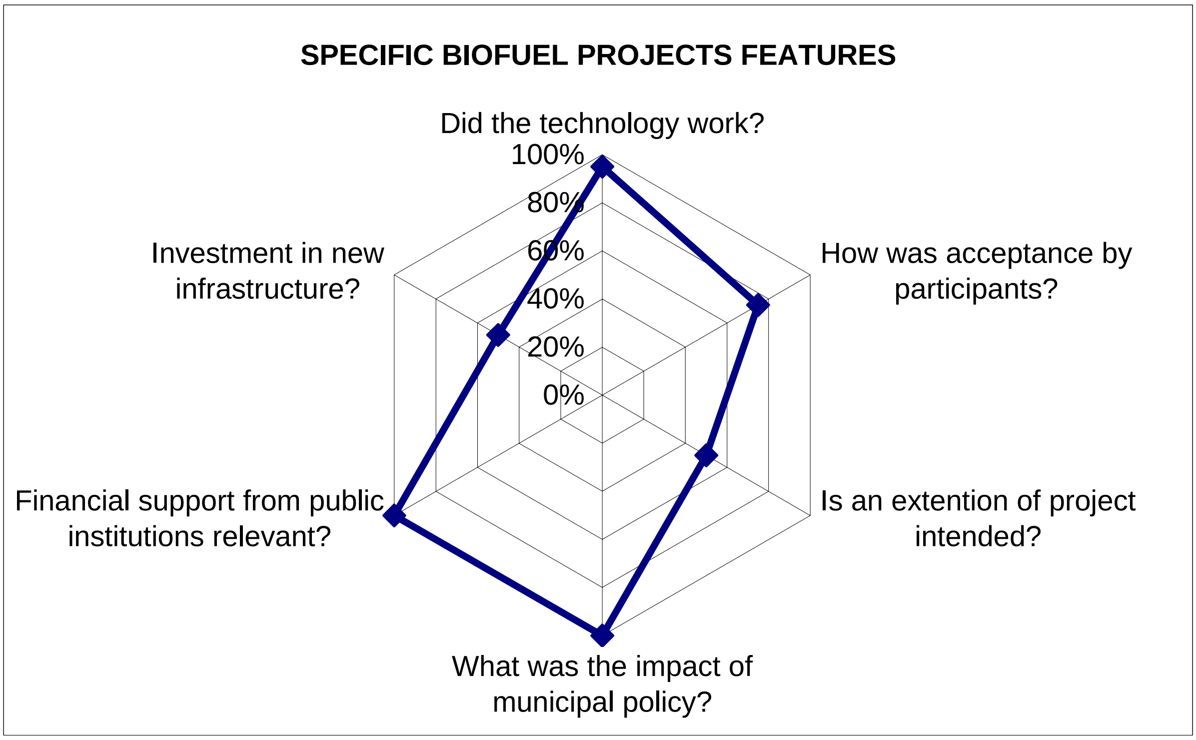

Figure 35 Specific biofuels projects features

One of the main reasons for the use of biofuels in transport is to reduce greenhouse gas emissions. Some case studies have shown that the effect of a particulate catalyst in connection with the use of biodiesel is even better compared to the use of fossil diesel.

The emission tests have shown that today's standard ethanol engine together with standard emission cleaning equipment can achieve emissions significantly lower than Euro 5. Particle emissions could be 10 times lower than Euro 5.

However, it is important that biofuels are produced in sustainable way. Therefore, total emissions need to be considered on a lifecycle basis.

Tested flex-fuel vehicles have also shown good CO_2 emissions performance. Flex-fuels car's emissions are under 100 g/km.

In some cases reduction of CO_2 emissions was lower than expected, which was the reason to switch to natural gas.

As an example we have shown energy and CO_2 balances of a fleet of 100 biofuels vehicles (50 E20 capable vehicles and 50 B20 capable vehicles), see Figure 36 and Figure 37. It is assumed that biofuels are used in conventional ICE vehicles with an operating range of 15,000 km per year.

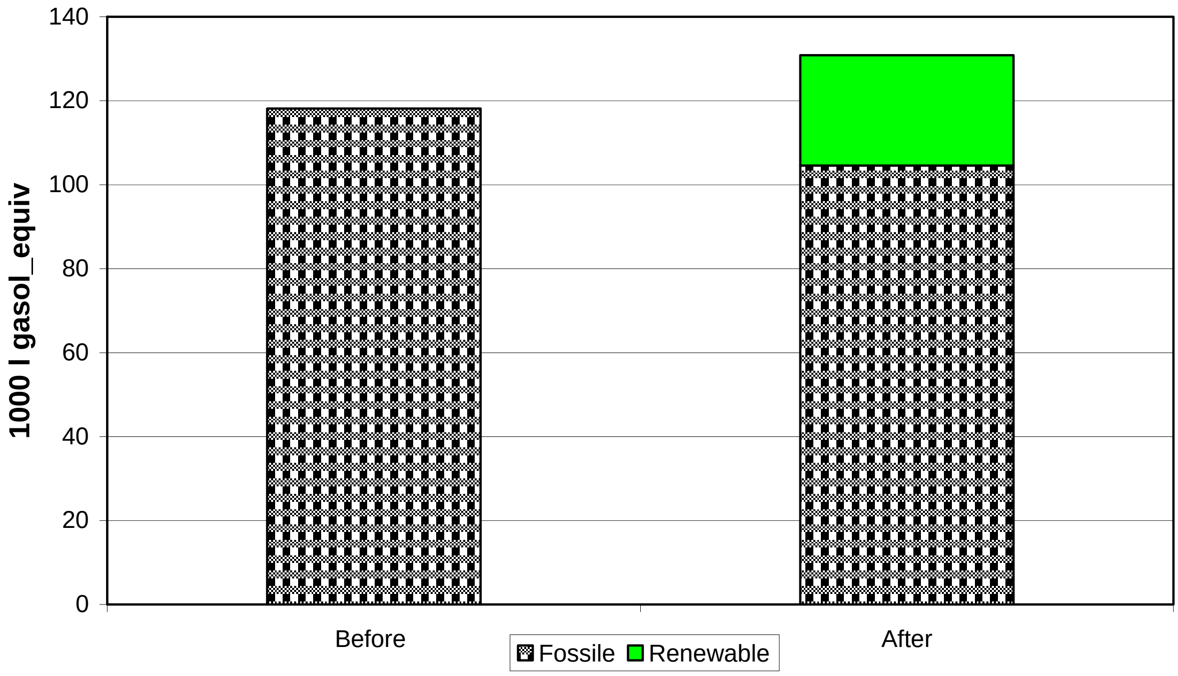

Figure 36 Energy balances of the biofuel project

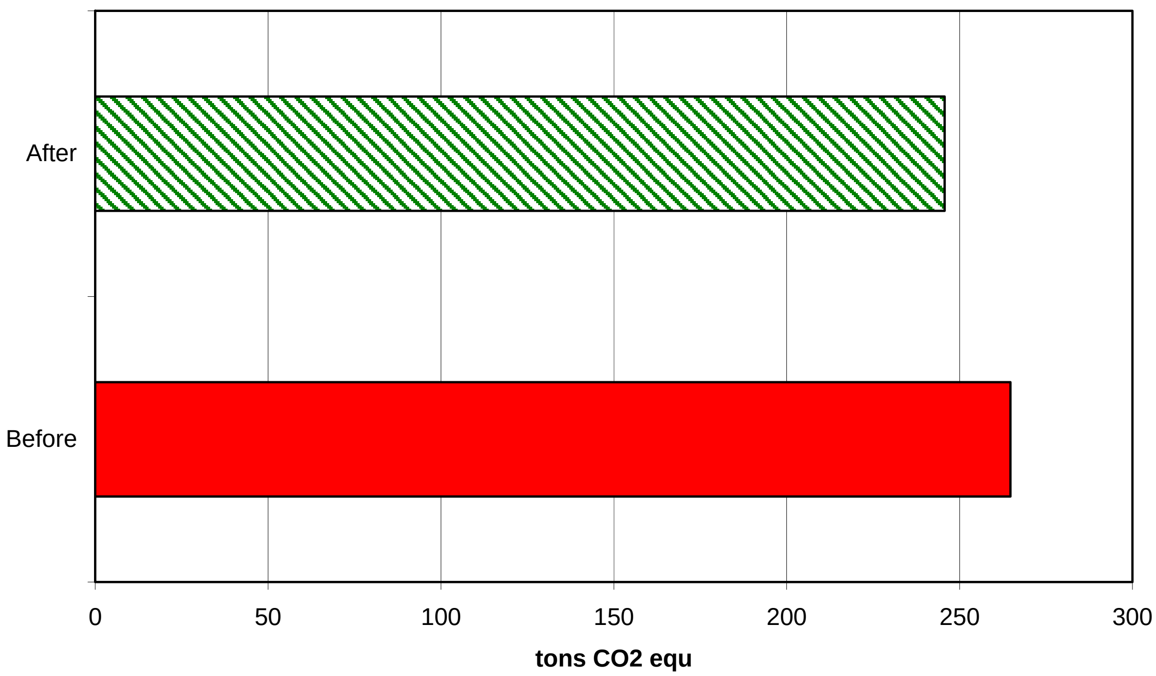

Figure 37 Estimated average of GHG emissions of the biofuel project

Since the prices of the biofuels are higher than those of conventional fuels, fuel duty rebates on biofuels, as well as reduction in vehicle excise duty for environmentally friendly cars (such as E85 vehicles, FFV) are needed.

Basically, there is no financial benefit of using biofuels. In most of case studies total costs of operation were slightly higher than planned.

In some of the projects beside acquisition of vehicles (e.g. FFV) it was necessary to invest in infrastructure – in biofuel refuelling stations. This, of course, increases costs of the project.

However, the additional project costs are very low. So it makes no sense to show the corresponding cost figure.

However, most of the biofuel case studies were successful, see Figure 38. Using biofuels local air pollution and greenhouse gas emissions could be significantly reduced. In some countries biofuel use in transport sector has already long tradition, so that transferability of knowledge and technology is relatively easy. In the future it will be important to improve WTW energy- and CO_2 balances and to make biofuels more competitive on the market.

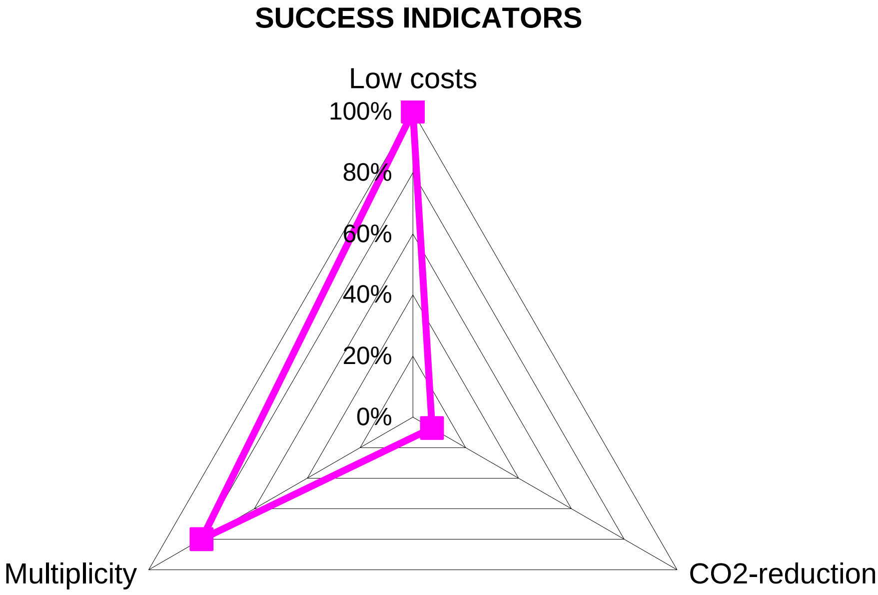

Figure 38 Success indicators of biofuel projects

4.3.4 PPO (Pure plant oil) case studies

In the show cases collected and analysed in the scope of the ALTER-MOTIVE project, about four case studies are related to PPO use in transport sector.

The main reasons for PPO use in transport sector are:

- Responsibility for the environment and wish to improve company's green image
- To test the maintenance and operational characteristics
- To test the effects on the life span of the engine and the feasibility to use PPO in public transport buses
- Conversion of conventional diesel buses to PPO buses could be carried out with low budget
- Tax exemption on PPO, e.g. in the Netherlands there was a tax exemption on PPO for a limited number of projects.

The conventional diesel buses could be converted to drive on PPO. In this case no changes on the engine are needed, only on the fuel circuit. The bus needs two tanks: the large tank is filled with PPO and smaller one with conventional diesel. Since the viscosity of PPO is lower then diesel, PPO has to be preheated. This could be done using cooling water from the internal combustion engine. However, to warm up the cooling water the first 5 to 10 minutes the bus drives on conventional diesel. When the engine is warm enough the fuel has to be switched to PPO. At the end of the operational period (last 10 kilometres) the fuel has to be switched back to conventional diesel.

Operational characteristics like acceleration, top speed and time to repair didn’t change significantly by PPO buses.

Most of analysed case studies have been successful. No negative impact on the lifespan of the engine is detected in case that PPO buses are used for long journeys. In some cases problems are noticed by local buses, which have to make a lot of stops.

However, the experience with PPO use in transport is relatively limited, so that through every pilot project can be learned a lot. Some of disadvantages of PPO vehicles in comparison to conventional diesel engine are:

- Driver has to switch from diesel to PPO after 5-10 minutes of drive
- 10 kilometres before the end of the drive, driver has to switch from PPO to diesel
- Dual fuel delivery system – in some cases maintenance problems are noticed
- Oil and filter change intervals. These intervals are about three times shorter then by conventional diesel.
- Inability to reach EURO5 and EEV emission levels

Some specific features from analysed PPO projects are shown in Figure 40.

Financial support from public institutions is not very relevant, since the projects costs are mostly low. Although, the acceptance by public and customers was good in most of the case studies, the majority of the projects will be not enlarged. In some pilot projects a decrease of CO_2 emissions was lower then expected and fuel cost higher, which was the reason to stop use of PPO and to switch to other alternative fuels.

Due to many technical breakdowns and many oil filter changes, the acceptances of PPO buses by project own staffs was weak.

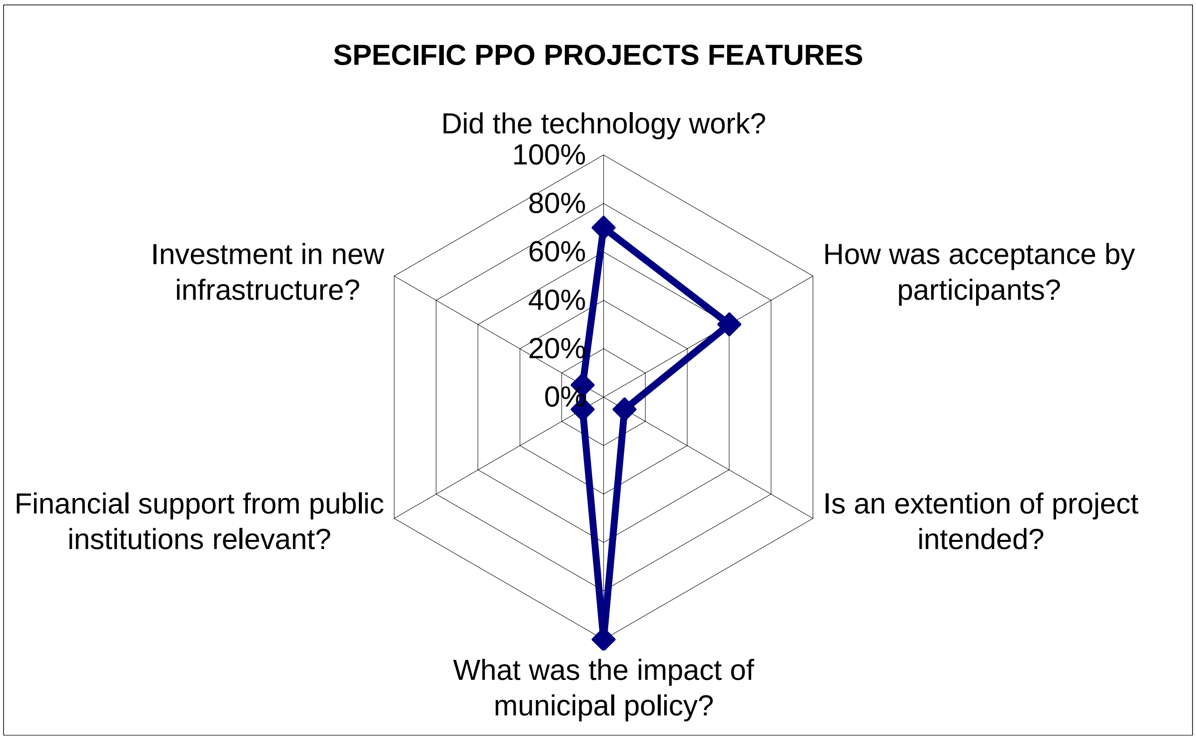

Figure 39 Specific features of PPO projects

As an example we have shown energy- and GHG–balances of a fleet with 50 PPO buses, see Figure 41 and 42. It is assumed that conventional diesel buses are replaced by PPO buses with an operating range of 35,000 km per year.

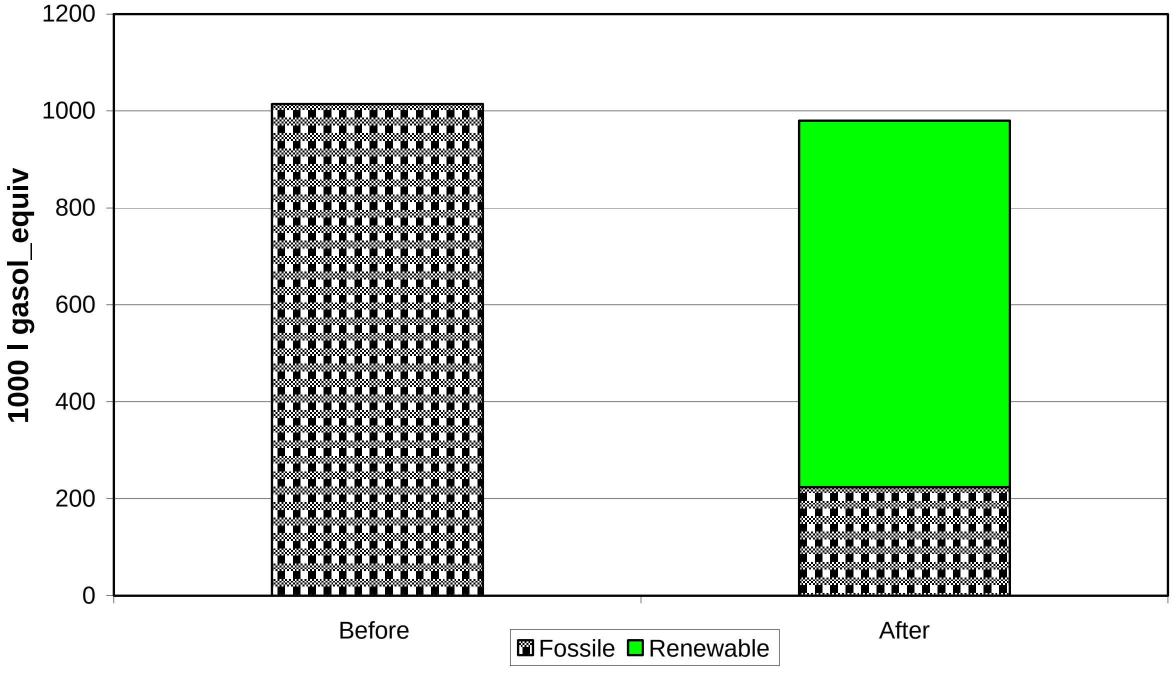

Figure 40 Energy balances of PPO projects

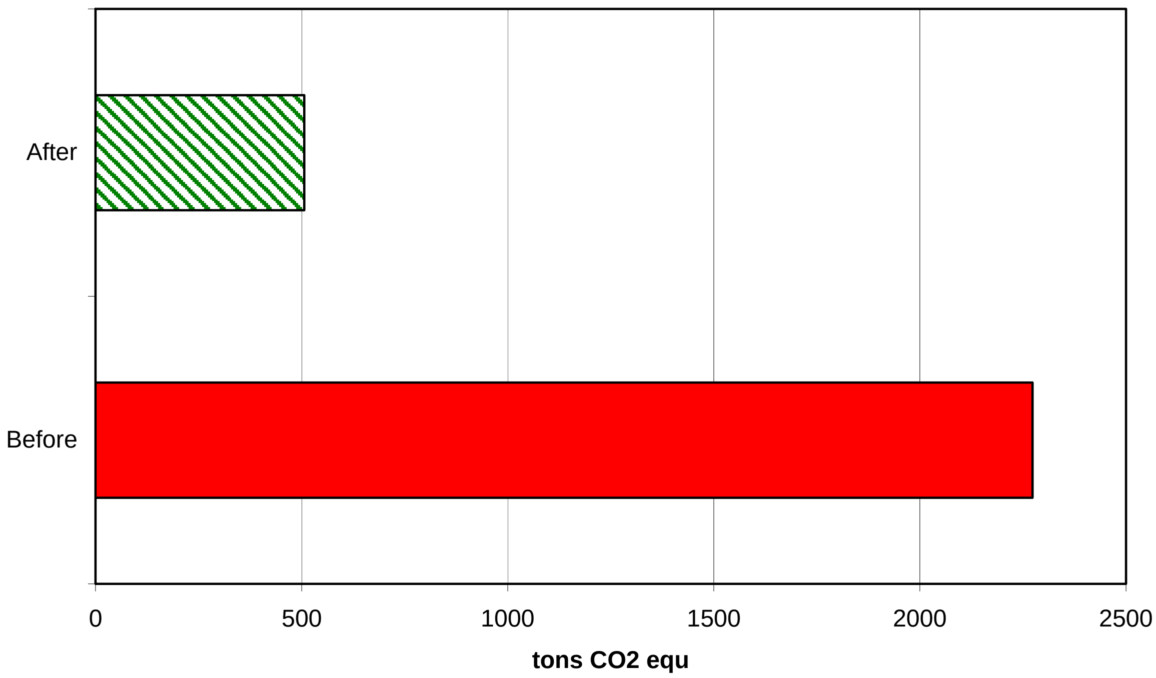

Figure 41 Estimated average of GHG emissions of PPO projects

Beside the environmental benefits, the PPO vehicles could have lower operating costs, only in case of the tax exemptions. In some cases the fuel costs could be even higher. Investments costs in PPO vehicles are slightly higher. The costs for converting the conventional diesel buses to PPO are between 2.500 and 6.000 Euro per bus. Maintenance costs are also significantly higher.

The major costs indicators in the example described above are shown in Figure 42.

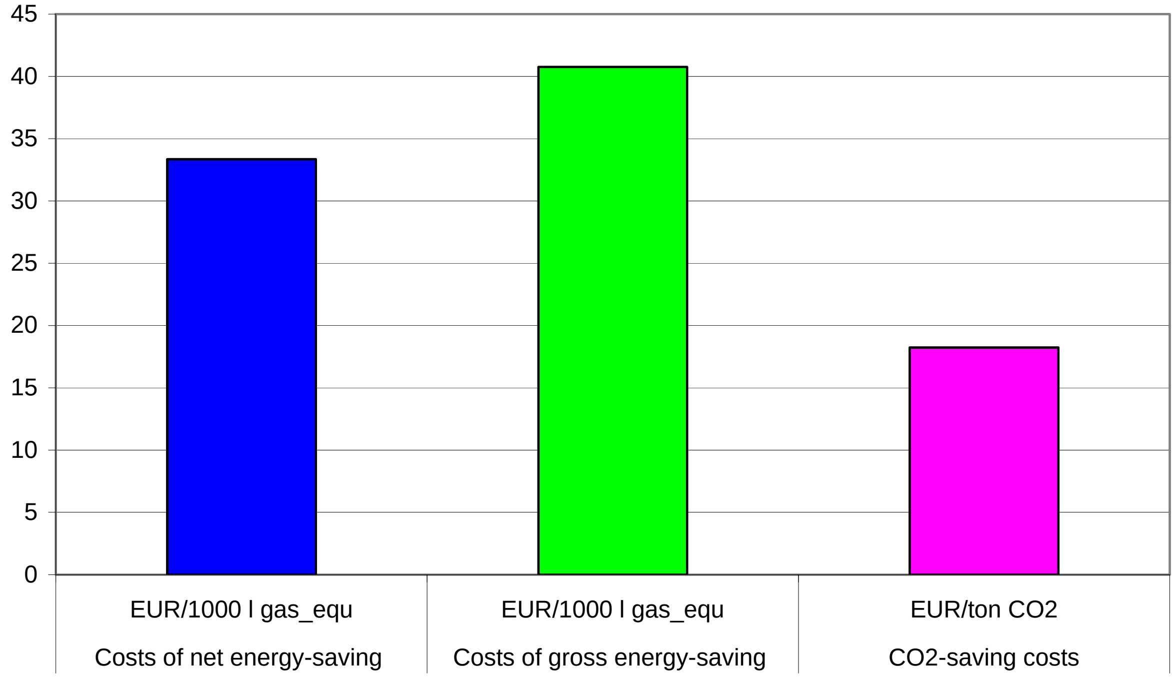

Figure 42 Major cost indicators of PPO projects

However, most of the PPO case studies could be classified as successful, because they provide useful information regarding maintenance and operating characteristics of PPO vehicles, see Figure 43. Using PPO greenhouse gas emissions could be reduced, but PPO is due to high maintenance costs and many technical breakdowns currently not a very attractive alternative to conventional diesel vehicles.

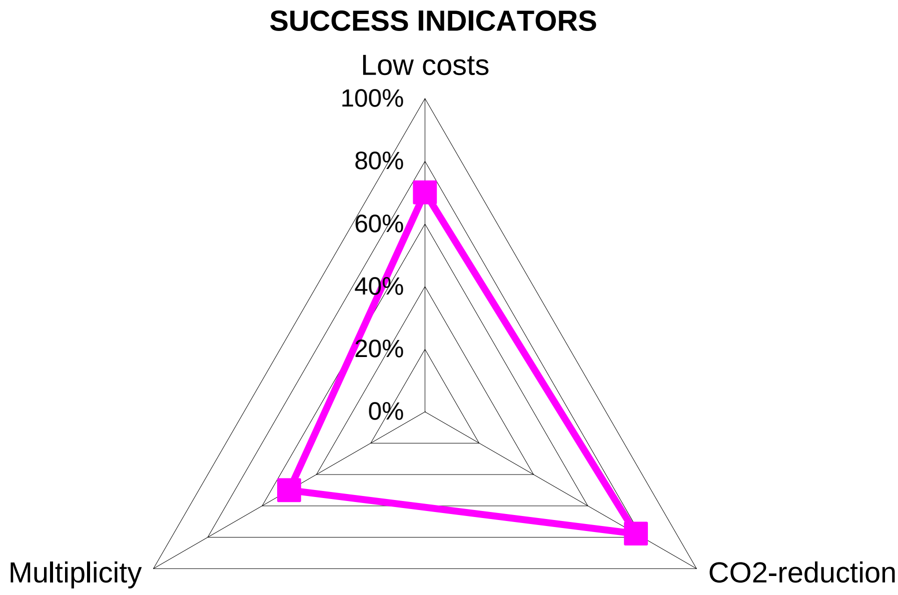

Figure 43: Success indicators of PPO projects

4.3.5 Hydrogen case studies

Since fuel cell technology is still very expensive, number of hydrogen pilot projects is significantly lower comparing to case studies related to CNG vehicles or electro mobility.

The main motivation for most of hydrogen case studies is to:

- Demonstrate advantages of hydrogen vehicles
- Develop methods for the hydrogen production and fuelling
- Improve local air quality by reducing HC-, CO_2-, PM10- and NO_x-emissions
- Test a blend of natural gas and hydrogen

The experience from case studies in general has been very positive. Of course, some projects went through technical difficulties especially with some components of the filling stations, but the lessons of the projects were extremely valuable. However, vehicle technology still requires consequent technological breakthroughs while infrastructure has to be demonstrated and deployed, with the adequate regulatory framework and agreement from society. Acceptance is still limited due to safety issues and high price.

The currently used hydrogen vehicles are still not mature and not economically comparable with conventional gasoline or diesel vehicles. Some of the disadvantages of hydrogen vehicles in comparison to conventional ICE engines are:

- To high costs of the hydrogen technology (technology is still going through development)
- High investment costs in infrastructure
- Missing legislation and safety framework
- Longer refuelling time (8-10 minutes)
- Lower operating range (about 200-250 km, half the range of a diesel bus)- have to be taken into account by scheduling the busses
- Restricted service due to limited infrastructure.

Since the hydrogen infrastructure is very limited, hydrogen is usually produced on site on the fuelling station and used in urban areas.

Using mixture of hydrogen and CNG (hythane) the problem with high costs, low operating range and missing infrastructure could be solved, of course, with much lower environmental benefits. However, in some case studies the blending of hydrogen and CNG has been tested. Blending of 8% hydrogen implies that the conventional buses can be operated without any changes. Blending of 25% hydrogen can be done easily, but some optimization of the fuel system is necessary. Hythane can be distributed in the existing CNG grid. Hythane gives lower fuel consumption and significantly reduce GHG emissions comparing to conventional buses.

Due to relatively high costs and limited acceptance most of the analysed case studies related to hydrogen will not be extended.

However, the hydrogen technology has to be improved and costs have to be significantly reduced.

From analysed project some specific electric vehicles features are shown in Figure 44.

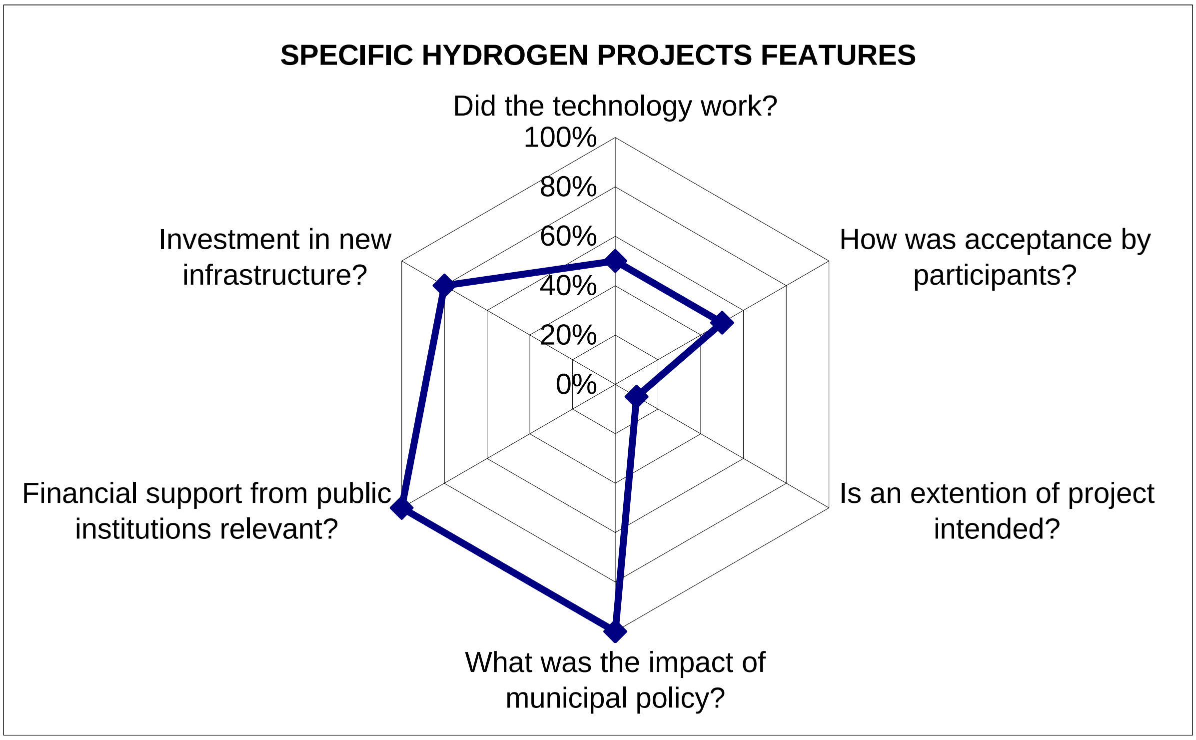

Figure 44 Specific hydrogen projects features

As shown the impact of municipal policies as well as financial support from public institutions is very relevant. Since the prices of the hydrogen vehicles are much higher than of conventional vehicles, further technology improvements and cost reductions are necessary to make these vehicles more attractive.

However, to provide great environmental benefits of hydrogen use in all cases the financial support is very important.

Hydrogen vehicles are zero-emission at point of use. Hydrogen vehicles do not emit PM10, CO and HC. Referring to the NO_x-emissions, the hydrogen vehicles already meet the EURO 6 standards, which will come into effect in 2014. NO_x emissions are below 80 mg per kilometre. However, emissions are produced during the generation of electricity, the amount depend on the method of generation and art of primary energy which is used for electricity generation. Therefore, the emissions need to be considered on a lifecycle basis. Best option is to use 100% renewable energy for hydrogen production. In any case, hydrogen use in transport sector can significantly reduce noise, air pollution and GHG emissions in the city.

As an example we have showed energy- and GHG–balances of hydrogen buses, see Figure 45 and Figure 46. It is assumed that three conventional diesel buses are replaced with hydrogen buses with an operating range of 35,000 km per year.

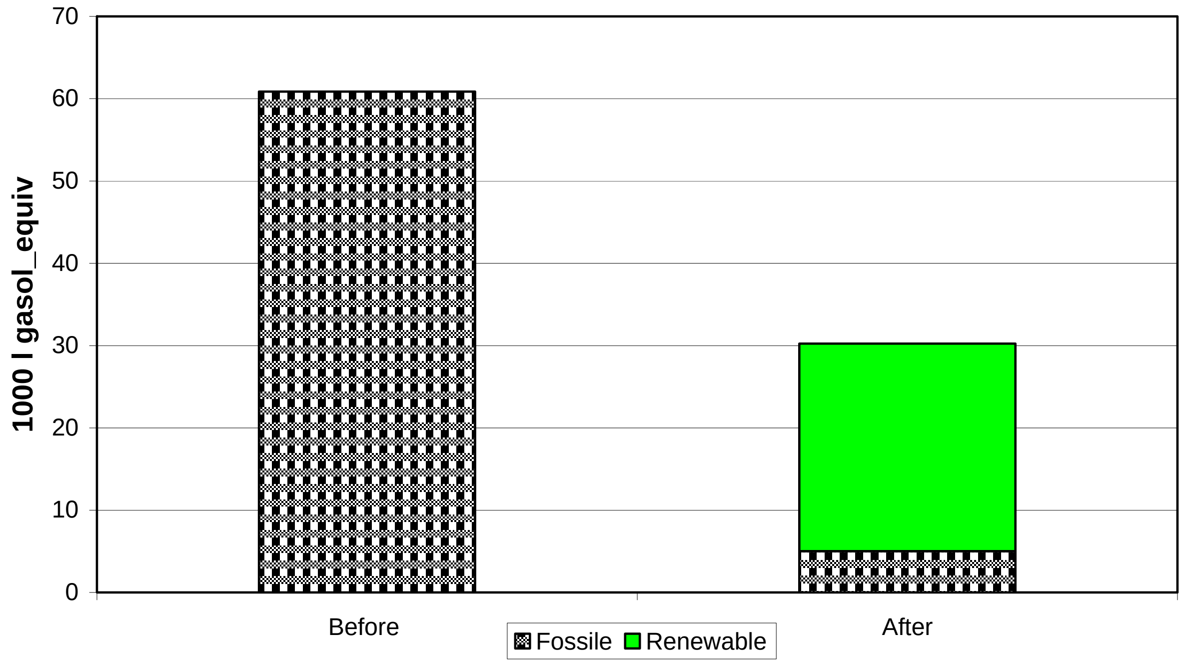

Figure 45 Energy balances hydrogen projects

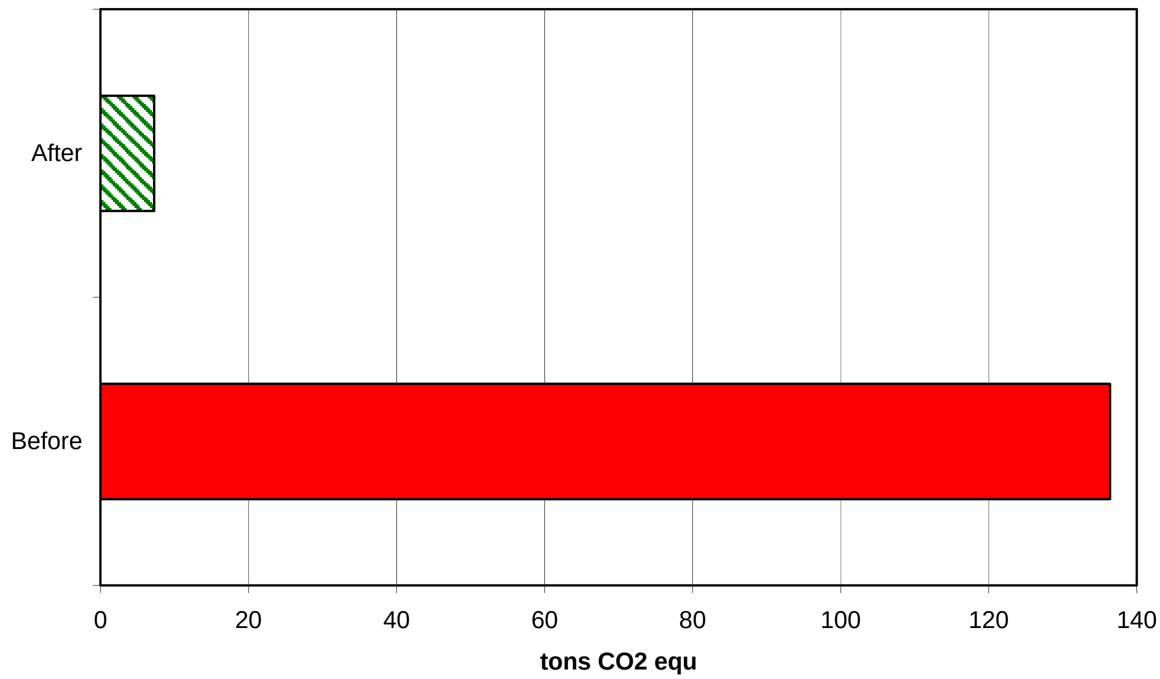

Figure 46 Estimated average of GHG emissions hydrogen projects

Hydrogen vehicles are much more expensive comparing to the conventional ICE vehicles.

A hydrogen bus is for about 80,000 Euro more expensive than conventional bus. Also, fuel costs of hydrogen buses are more than three time higher than fuel costs of diesel buses. This is, of course, very depended on the hydrogen production way.

In some of the projects beside the acquisition of hydrogen vehicles it was necessary to build hydrogen refuelling station. This, of course, increased costs of the project for about 2 million Euros.

The project costs are different from project to project. They are very dependent of the kind of electricity used for hydrogen production. In some cases project costs are not available for public.

The major costs indicators in the example described above are shown in Figure 47.

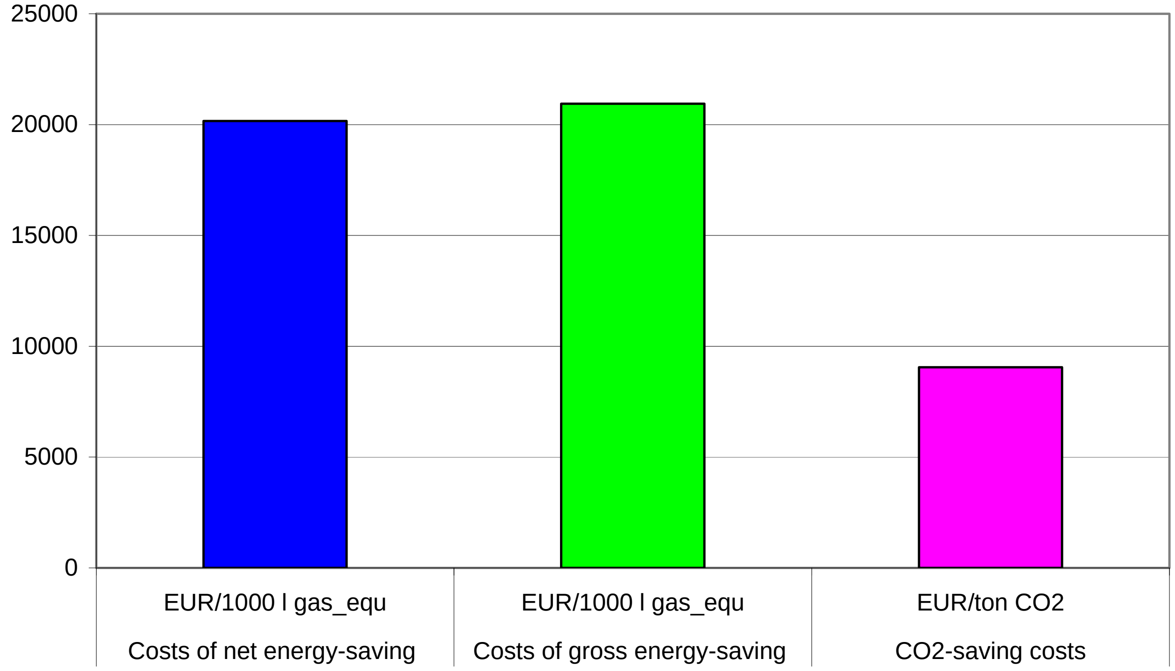

Figure 47 Major cost indicators hydrogen projects

However, the most of the case studies related to the hydrogen mobility are good experience. Using hydrogen vehicles local air pollution and greenhouse gas emissions could be eliminated as well as the noise, see Figure 48. Due to the missing infrastructure, as well as regulatory framework transferability of knowledge and technology is limited.

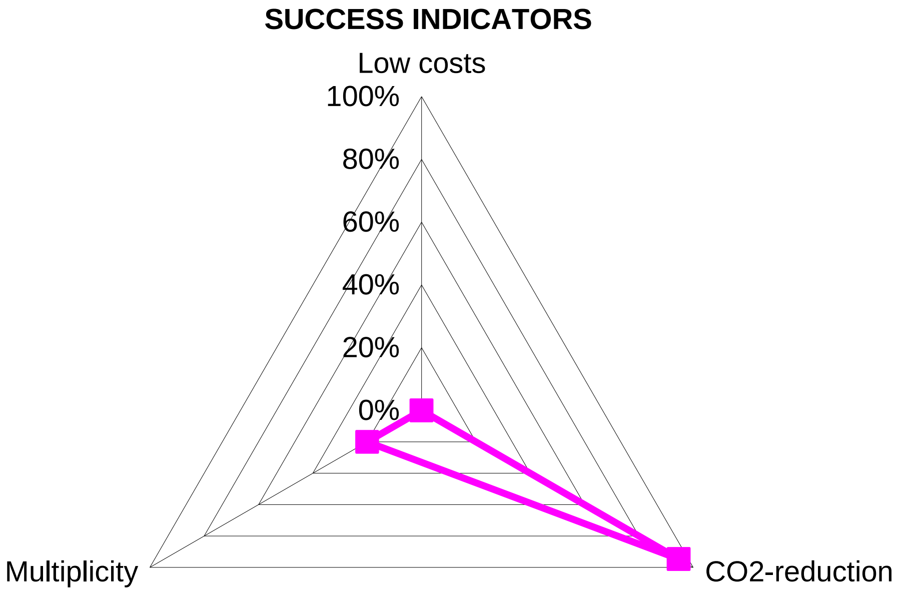

Figure 48 Success indicators hydrogen[8]

[8] Annotation by the editor: CO_2 reduction is only possible with some renewable energy sources

5 Synthesising conclusions

5.1 Introduction

In this report we document the major lessons learned from case studies applying alternative fuels AF and alternative automotive technologies AAMT.

Taking together the results of two surveys one face to face covering the cases amended by an Internet survey and the knowledge gain from the cases, it is possible to conclude targeting the implementation of least-cost policies introducing alternative fuels/propulsion.

5.2 General statements

The major conclusion of the analyses are that there is a **wide range of possible actions, most of these where successful from the technological and ecological point-of-view and virtually all were well accepted by the final users to a large extent**.

For the stakeholders there might be different motivations to join into alternative fuel projects. Table 2 summarizes opportunities and also threats for introducing AF and AAMT from which new arguments may be deducted when setting up new projects. Please note that also threats might be helpful as creative input to discover new opportunities.

Table 2 Opportunities and threats for different stakeholders

Stakeholder/Drivers	Business model/Opportunities	Threats
OEM (e.g. car assemblers, big brands)	Sell added value of AF/AAMT cars, differentiation in the market	Collapse of business model, lack of venture capital
OEM niche players	Cover niches with special requirements by offering AF/AAMT cars.	Vehicle demand crisis
Second tier producers	Show excellence in a supply chain/bailout	OEMs struggling and affecting tier 1+
Vertically integrated fuel companies	Exploit value of existing integrated supply chain	Will act only under pressure of regulations, if not cost effective
Fuel retailers	Widen niches in the fuel market	Acceptance of the public
Agriculture industry	Use market knowledge/act as mediator	Competing food market
Resource owners (producing farmers)	Create strong market demand for biomass	Environmental awareness
Politicians on a federal level	Introduction as mediator of interests, increase media coverage	Aversive media campaigns, stronger topic of public interest
Politicians local level	Focus on local interests and strengthen connection to citizens	Stronger topics of public interest
Vehicle owners + fleet operators	Provide clean mobility fulfilling daily needs	Reluctance to risk money investing in new cars with new technology or new fuels with existing cars
Consulting firms	Sell know-how, research capability and proficiency with tools	Change of priorities
Media	Sell ads of AF/AAMT brands, meet visions of audience by showing clean renewable mobility solutions	Change of strategy
Basic research	Apply inventive force and existing basic knowledge	Lack of results in time
Engineering companies	Sell innovative engineering competence in the field of alternative propulsion	Lack of (application) competence
Journalists/authors	Communicate general messages of the publication via featuring alternative solutions	Saturation with published visions

By no means a project setting should introduce more complexity than needed. However good project management practice recommends to investigate problems at a wider level in the beginning of projects. A **holistic project approach** exploits all supportive effects:

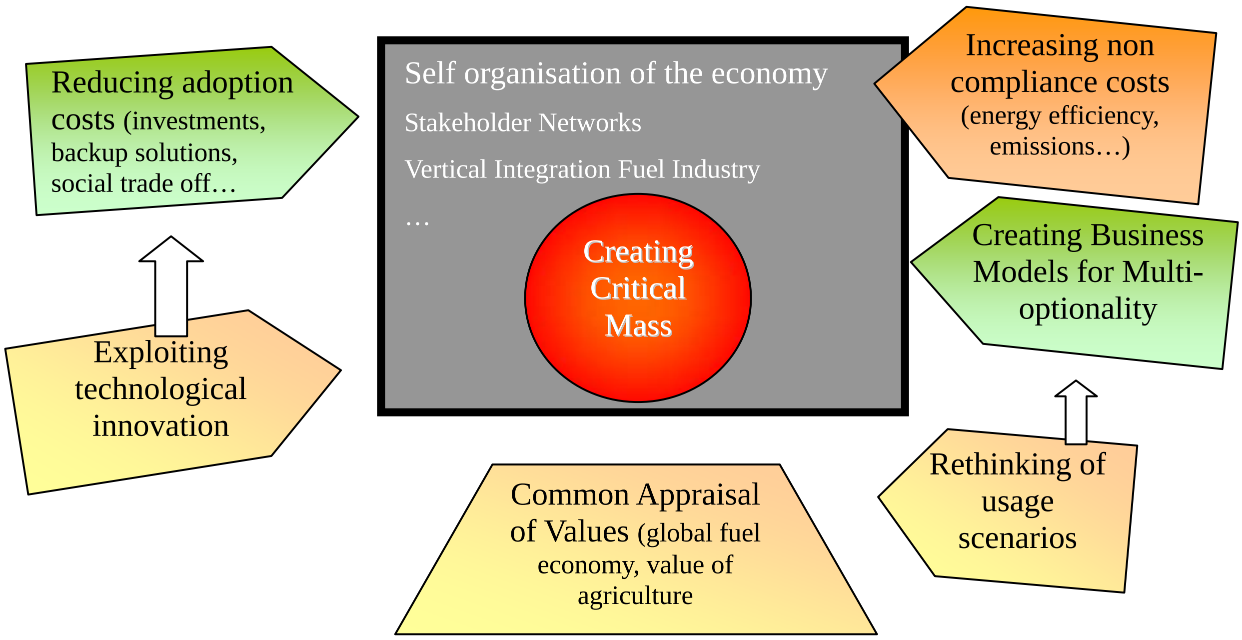

Figure 49: Potential approach introducing alternative fuels/alternative propulsion

5.3 Recommendations for setting up and assessing detailed policies

5.3.1 Observe the fuel characteristics in terms of hurdles to be avoided

Apart from the analysis of future paths some facts might be deducted from the case analysis:

- **Battery electric vehicles** are used in a local (urban) context with fixed range operation; battery exchange is in its infancies but might extend the autonomy of the vehicles as well as the use of range extenders will.
- **Pure plant oil** is more acceptable in rural areas, because it is near to production and criticism with regards to emission and sustainability are lower there.
- Together, **PPO and biodiesel** technology may not be capable to deliver low emission standards now, but are a convenient solutions also for long distance transport whith lower blending
- **Ethanol** may be challenged by sustainability issues like biodiesel from palm oil was, but there were no big hurdles detected for the implementation for E85/E95 other than the absence of market offer of power trains fulfilling European emissions standards, especially with the more efficient E95, which is also deployed only locally because it also lacks E95 suppliers.
- **CNG** technology is mature and the market offer of light vehicles is sufficient, but the filling infrastructure costs as well as the limited CO_2 reduction potential make it an intermediate solutions utilised by cities with severe air quality problems.

- **Biogas** has the same characteristics as CNG when being applied but it needs longer preparation to erect bio gas digesters, search for biomass and solving the not in my backyard problem with regards of the location of the plant.
- **Hydrogen** might be a very clean solution and some steps solved towards the implementation but the economic feasibility is bad, worse than for battery electric vehicles. For both technologies it is very important to secure clean energy sources to have a realistic change to have a lower well to wheel global warming potential GWP.
- **Lower Blends** face less technological problems but only resource and image problems. It might be easier to use biofuels for commercial and public transport which are considered as inevitable transport.
- **Higher Blends** experience similar problems like pure biofuels and have the additional complexity that the time/location of the blending decides on the tax reduction – depending on taxation rules.

5.3.2 Investigate proven policies for your case

Tax deductions with fuels and vehicles are considered as being most effective, followed by access restrictions for other vehicles. Fuel price is seen as most influencing factor although they play a minor role accounting for 11%-15% in the total cost of ownership for a lot of private users[9]. Mandatory corporate average fleet emission schemes were regarded as not as effective (55% answer with “rather no”); awareness raising and build-up of trust had more (may be not significantly) absolute negative rankings.

[9] http://www.news.at/articles/1016/36/267169/sparkasse-auto-500-euro-monat-gesamtkosten-durchschnitt

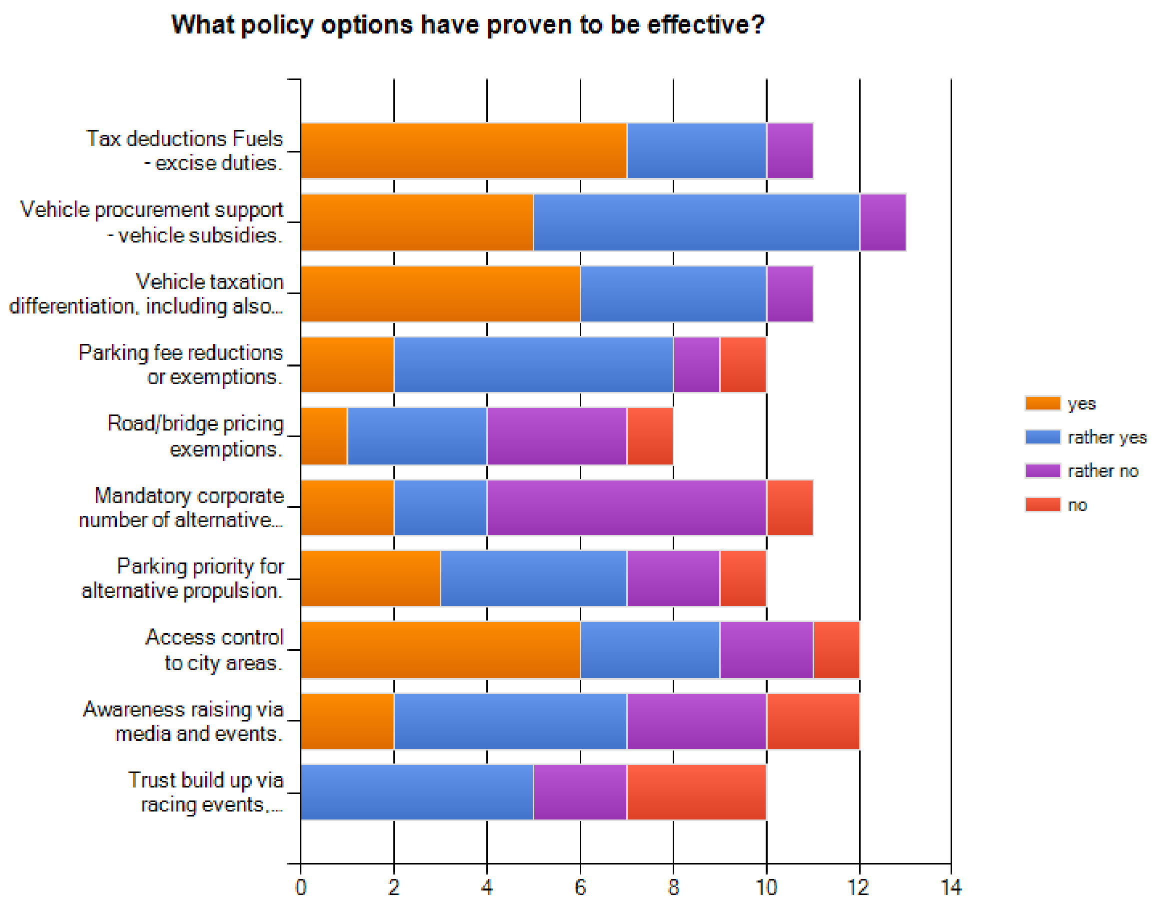

Figure 50 Effective policies

5.3.3 Create long lasting clear and measurable boundary conditions depending on the status of the technology and its uptake

As aforementioned frequent abrupt changes in policy may have a negative impact on the demand for alternative fuels even if some changes are positive in nature. Production and distribution infrastructure may become obsolete after the next negative change. Also the investment in biofuel capable vehicles is lost in case the fuel supply is cancelled due to disincentives. Sometimes measures are targeting wrong fuels not taking into consideration the state of the art. Examples were incentives for B100 use whilst no B100 capable vehicles were available on the market and at the same time a lack of B30 incentives - even if most of the vehicles of the PSA group are B30 capable.

Also for RTD, the targets have to be communicated years ahead since the development of engines and cars needs time. On the other hand the targets should be quantified allowing to assess the progress and to tune the measures.

One positive example is the one million BEV target in Germany coupled to the introduction of environmental zones and clear CO_2 taxation.

However the measures should be applied in the right sequence **in order to be successful**.

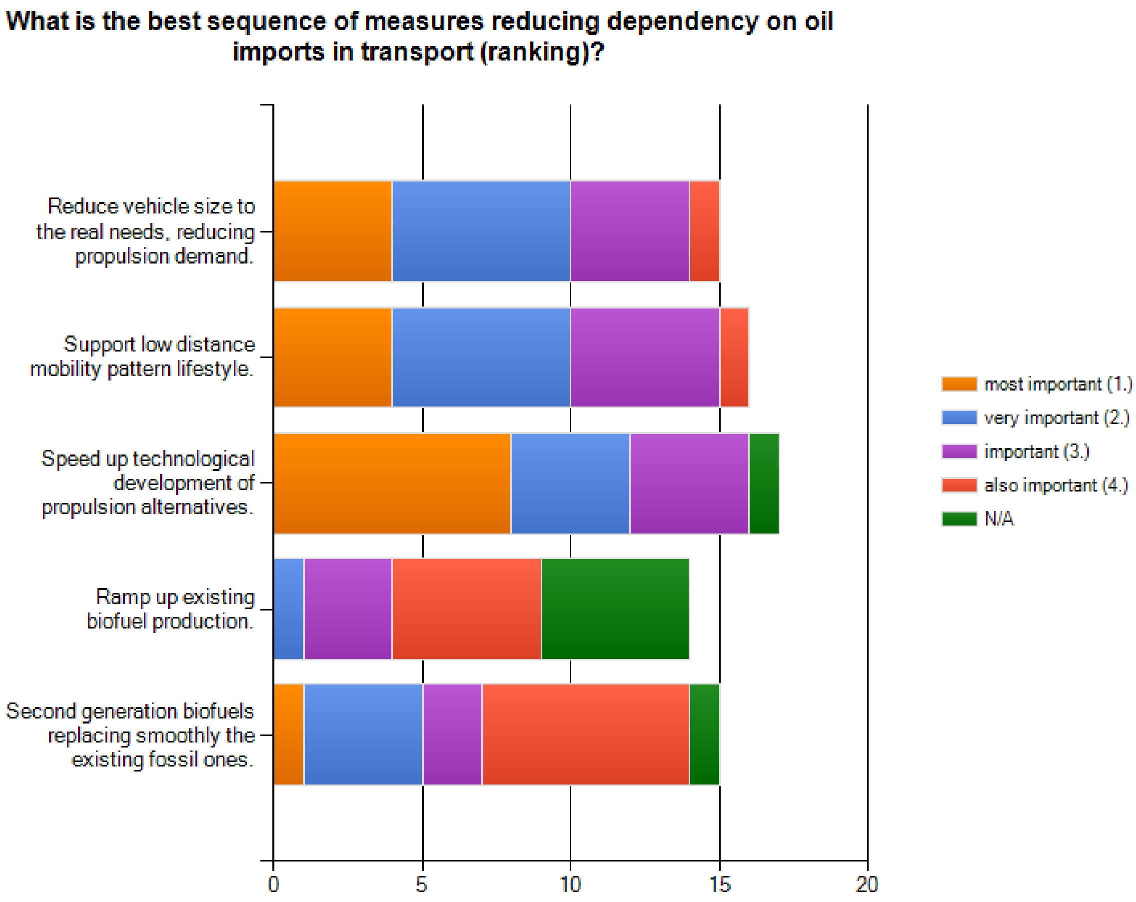

Figure 51 Best sequence of measures

According to the responses, the first step in sequence of measures should be **a technological development** of propulsion alternatives at a fast pace, followed by the **reduction of the vehicle size and support for low-distance mobility pattern lifestyle**. This might be explained that by reducing the fuel demand it will be easier to step in with alternative fuels having short ranges and with efficient city cars the competition with demand for food would be smaller with regards to natural resources.

With 2nd generation biofuels there is a certain ambiguity in the answers, but the Fischer-Tropsch fuels were seen as least important step on average, outstripped by first generation biofuels. This might give evidence for the fact that utilization possibilities for the first generation biofuels are not exploited fully. Using first generation biofuels either as heater fuel for battery electric vehicles or for power generation in range-extended vehicles (in case they use the fuel within weeks, not months) might be investigated.

5.3.4 Introduce dynamics – communicate progressive conditions

In order to boost development in the desired direction the policy should follow the **evolving state of the art**. A good example is the series of ECE standards for the emission of vehicles which reach out far into the future so OEMs may pre plan from the beginning of the development process of a new engine. We also may learn from this example that the start was rather hard making catalysts compulsory by setting up demanding thresholds. Over the years the acceptance of this technology with OEMs has increased. However those legislatory schemes might involve traps if target ranking has different effects for different fuels. Efficiency was ranked higher than urban air quality creating the particulate problem (followed by NO_x) with diesel engines in cities.

The definition of targets is a constant negotiation process which should involve experts in technology and production of power trains but also persons responsible for air quality.

5.3.5 Behavioural changes help to overcome the hen and egg problem

In a typical hen and egg problem two facts influence and block each other. A solution might be to change the requirements so the propulsion technology gets a market and may become more mature. Small uncooled power trains of 200W to 2kW were ideal to introduce battery electric propulsion for ultralight vehicles. It is more difficult to achieve the same time to market figure with power trains of 20kW to 200kW. Policy might use the Pedelecs' success and scaled it up to other/larger/faster vehicles. Switching from cars to two or three wheelers forms a behavioural change and may help to deploy electric vehicles (less complicated low range variants) quicker.

5.3.6 Stricter regulations need communication of a severe problem and good visualisation

It is quite common to challenge environmental zones. This may be countered by showing the difference in air quality between a diesel fleet with and without SCR or change from EURO3 to EURO5/6. The figures need to be visualised showing exposed areas in cities and the long-term effects like decrease in life expectation which is nowadays calculated for each region separately. Penalties for high emitters may be accepted by the public following this awareness campaign.

5.3.7 Discuss side effects and introduce mitigation

Access restrictions as well as use of bus lanes for clean vehicles will work if vehicle are affordable but are typical measures which need mitigation. Access control introduces severe problems for people being not able to afford buying new environmentally friendly cars. It should be investigated if amending measures could help like offering Pedelecs or e-scooters to reach the final destination from the park and ride area outside the city. Public cars are not helpful outside the city, but purchase incentives for BEVs might help.

With Pedelecs we have seen an unwanted side effect which was resolved (in Styria Austria fore example). There were high fixed subsidies per Pedelec and at the same time the possibility to retail cheap imports. To prevent the spread of scrap the subsidy was ceiled to 15% of the end user price. Further issues are whether the right target group is reached or whether there is free riding not contributing to the CO_2 or emission targets[10].

5.3.8 Increase robustness of policy

Implementation of incentives should survive hypes. The rule has two faces. Targeted policy should allow for a concentration of industrial resources to shorten time to market. But there should be enough flexibility in order to allow for corrections. For example a dedicated policy for monovalent BEVs will not be able to reach the masses in the next years whilst incentives for plug-in hybrids PHEV or extended range electric vehicles EREVs may. Until know there still lacks a clear regulative concept for bivalent vehicles. Range extenders are a good means to allow for a smooth transition.

Other possibilities increasing robustness are to have exchangeable fuels. With monovalent biogas the lack of resources is hindering, but taking natural gas as intermediate solution may help to overcome temporary shortages. However strong commitment is needed not to come to an halt after the first step.

5.3.9 Policies should not transport interest of single segments, but might create new mobility industry affecting all segments

There were certainly some lobbies active in the alternative fuel policy. Agrarians profit from the ability to earn money for growing rape instead of fighting with saturated food markets. The situation changes however since demand for food is growing world wide. Some niches may remain attractive using sugar beets in years with high yield and residues from ethanol production for feeding animals. Also with CNG and BEV it is obvious that there are expectations to increase the sale figures with electric utilities. On the other hand some non existing businesses might profit from policies. If you think about new services offering BEVs as rental cars or vice verse ICE-powered cars as vehicles for going on holidays there is room for creativity. In the best case new green jobs are created in industries having higher employment figures per turnover compared to the traditional fossil fuels busines.

5.3.10 Seed financing is more effective than direct object funding

Creating new business needs seed financing. The effect is much bigger when money is spent on the creation of a perfect environment instead of funding buyers of single hand-made BEVs. This translates into the recommendation to focus on generic policies. The lacking industrialisation of those vehicles should be tackled as well as general measure. Generic policy measures do help to come up with least cost implementation.

Table 5 lists some **generic policy measures** which may brake the Gordian knot and reduce implementation risks.

[10] http://graz.radln.net/cms/beitrag/11249546/25359410

Table 3 Some examples for generic policy measures

Measure	Example
Exploiting technological innovation to make propulsion systems smaller and more affordable	New LiFePO4 technology reduces cost per kWh for BEVs allowing more cycles
Reducing adoption cost for new propulsion technologies	Joint procuring reduces investment costs; cost are also reduced by innovation and different usage models. Social acceptance of clean but slow and small vehicles greatly reduces adoption costs for BEVs
Rethinking of usage Scenarios for vehicles	Specifying BEVs for every day use increases investment demand greatly- combining city grade vehicles with car sharing reduces those costs.
Creating Business Models for Multi Optionality in mobility	Rail operators offer cheap rental cars for frequent users. Public cars may be offered too.
Increasing non compliance cost for users of other vehicles	Driving non efficient and polluting (gaseous emissions and noise) vehicles with non-sustainable energy as well as the absolute yearly consumption figures (ecological footprint) shall create additional costs with those users by means of corresponding higher fuel and ownership taxes.

5.3.11 Support alliances working in the same directions

Support policies for Pedelecs have been co-operating with bicycle initiatives. Whilst some of those NGOs are against Pedelec funding co-operation may help to find the right target groups where funding is helpful to reduce car usage. For cars it is similar; electric utilities might be very helpful to take over some risks for example financing batteries – and they should since they will profit from increased electricity sales. This co-operation is already visible with new leasing companies; for example the **Austrian Mobility House** has a close co-operation with utilities. Utilities also give away Pedelecs and scooters at reduced prices (e.g. Energie Steiermark) or offer rental vehicles.

Vertical or horizontal alliances might be suited best depending on the geographical level of the approach. Figure 68 shows the preferences:

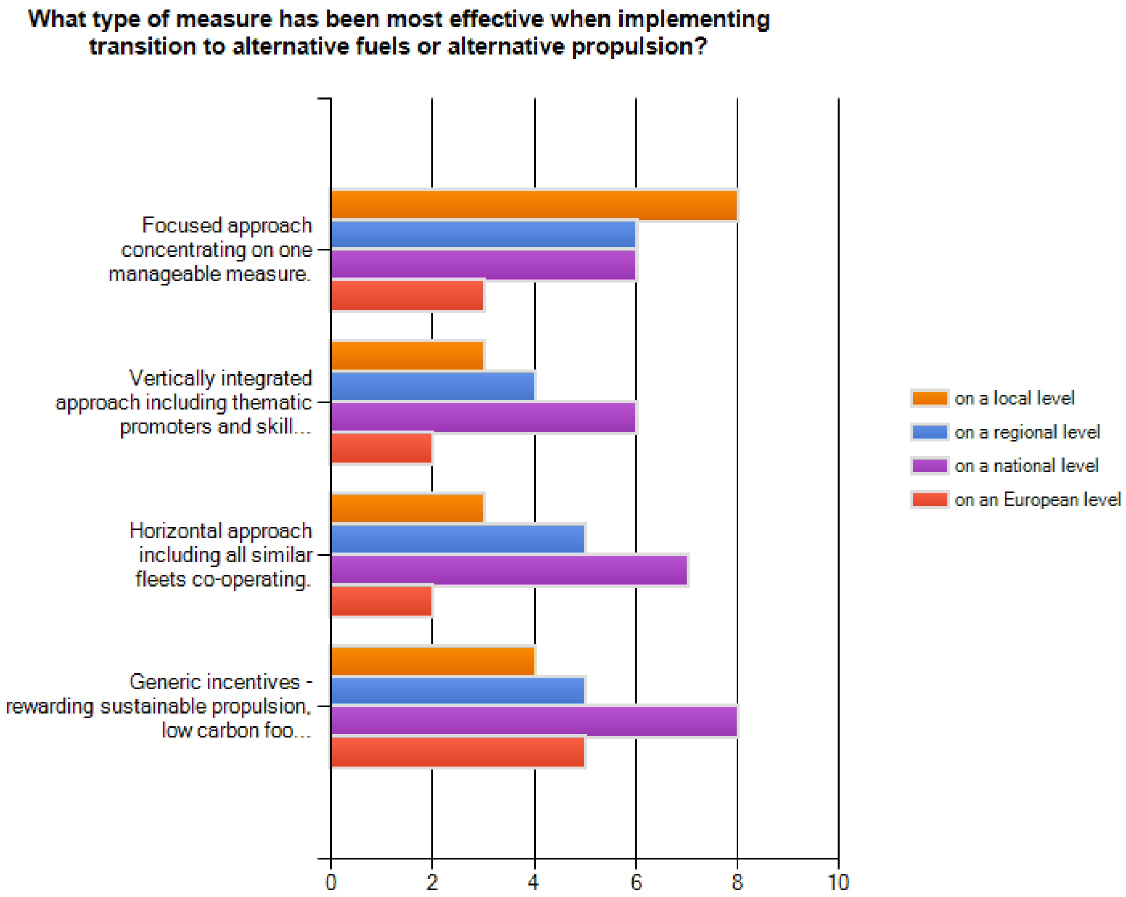

Figure 52 Optimum level of cooperation

Most Alter-Motive fleet cases were practical and focused approaches, the respondents of the additional survey underline that the **focused approach is the best approach on a local level**. All other approaches were attributed to the national level. The highest ranked European level measures were generic incentives. This emphasizes the need for sorting out competition issues amongst national fiscal administrations. Avoiding cross border refuelling traffic will help, so national financial disincentives may be more acceptable reducing federal income to a lesser extent.

There is a link between general traffic policy (speed limits), the market offer and the cost efficiency of alternative propulsion solutions – especially for battery electric vehicles - which should be investigated further in terms of creating alliances. Driving down the vehicle requirements makes electric mobility more feasible. In 2007 one member of the European parliament already was active levelling the maximum velocity to 162 km/h in order to allow concentration on fuel efficient engines but he was not successful[11].

5.3.12 Do not try to implement policies based on your preferences- allow for fair competition of technologies contributing to the targets as well

A fair distribution of financial incentives is needed for technologies distant to the market. Sometimes an explicit RTD focus causes money to be poured into areas where no results may

[11] http://www.focus.de/auto/ratgeber/unterwegs/tempolimit-162-km-h_aid_64113.html

be expected even mid term. This happened with fuel cells which do have their field of application far away from the grid in climates with higher temperatures. In order to raise the independence on oil and the reduction of CO_2, RTD should be focusing on a foresight analysis. In this preparatory work enabling technologies are identified which might lead to a viable mid-term solution. Unfortunately only now the research concerning FCs begins to challenge the problems of catalyst usage. With batteries the basic work with regard to cathodes and anodes has been done to allow for an implementation for local transport. Further progress is to be expected introducing lithium air rechargeable batteries. Before focusing on those technologies or even the power train parts which have to be improved, insight has to be created. For example the integration of parallel hybrid power trains is certainly the nearest to the market promising the highest fuel savings. In this nearness to the market it is important to focus more on fewer technologies and to define measurement conditions for fuel efficiency and equitable emissions. One example is now the debate what MPG figure is to be awarded to serial hybrid vehicles like the Chevrolet Volt (equivalent Opel Ampera). With regard to research, range extender developments should not only include internal combustion engines independent of the combustion principle and FC - because they might be exchangeable in the packaging. For ultralight vehicles (see also A-M cases 34,43,89,94 and 108) also pedal electric power trains not only for two wheelers but full grade highway vehicles like seen in the TWIKE shall be developed further[12].

Independence on technology in the foresight shall guarantee that the first steps in research show the most appropriate technology. Later there might be favourite candidates and the need to fund industrial research and experimental development in areas where no big private money is involved.

5.3.13 Identify also industrial weaknesses and create incentives

One positive example of coping with technological deficits was found in Korea where LPG usage lacked fuel efficiency (A-M case 123). Introduction of direct liquid injection was able to decrease fuel demand and catch up in efficiency when using gasoline. It is obvious that until recently industry in Europe had missed the development of full hybrid power trains in the last 10 years. At present hybrid upper class vehicles with Mercedes and BMW are brought to the market. More helpful might be the attempt of PSA focusing on smaller cars like the 3008, since smaller cars are used in cities more often having the possibility to regenerate braking energy. But also Mercedes and BMW are following with diesel hybrids in 2011 (http://www.dieselhybrid.de/). This gap is now closing. A gap which was never closed is the ability to run pure biodiesel with engines equipped with particle traps. In case policy decides to focus on public transport for running on biofuels, the incentives for engine producers have to be adapted accordingly so usage of B100 is possible achieving EEV emission standards. If policy makers decide that there should be markets like public transport which should be put in a position to run on biofuels, then the incentives should definitely be stronger, motivating engine producers to cover to not so attractive bus engine markets with biofuel enabled engines. This way if totally cut off from fossil fuel, Europe could run part of the transport also including rail and waterway transport independently of imports. To achieve this aim several policies should be joined.

Another very big industrial weakness was the absence of production capacity for secondary batteries. It seems not logical why highly automated industries may not be located in Europe.

[12] http://green.autoblog.com/2010/07/24/automotive-x-prize-tw4xp-evolves-human-hybrid-twike-three-wheel/

But recently a joint venture of GS Yuasa and Mitsubishi is considering production of lithium-ion cells in Europe[13], others like SB LiMotive may folllow.

Last but not least there is a strong bonding of the customers to European brands, some of them are not offering small city cars till now in practice. Corporate average fleet regulations taking into consideration the market figures - and not the number of models - will help to solve this problem motivating the manufacturers to extend their portfolio taking up exsiting design concepts like BMW's Megacity[14] into production. After a longer period of lacking fuel efficient cars with high utility possibly we will see the Audis A2 again and the VW Up replacing the Lupo. Interestingly some brands had designed vehicles for easy packaging (higher floor), but had to leave the room unused because of the lacking maturity of alternative power trains at that time. One example is the Mercedes A class. So to speed up the transition to alternative fuels the sandwich concept should be supported for all vehicle sizes. For example the CNG option was available for a long time in roomy vans like Opels Zafira having enough space under the floor, but not with the more efficient Meriva. Mercedes has a good start here with three battery electric vehicle sizes (Smart fourtwo, Mercedes A, B[15]). It took a long time till offering larger serial hybrid utility vehicles - which would be very useful for the increasing last mile distribution business when produced at a reasonable price.

Regarding innovative ultra light vehicles, not a lot has been visible in Europe since the Piaggo APE was introduced. The development of affordable battery electric power trains for the so-called L6e cars limited by 4kW is very urgent to clean up the microcar segment running partly two strike engines. Further upscaling of the electric motors with water cooling to 15kW may help to push existing vehicle concepts like the SAM (http://www.friends-of-sam.com/). With roof covered (weather protected) scooters - either with three or two wheel design - the pressure from cheap import is higher since they may be transported easier in containers by the masses. Thus European producer might focus on multi-track vehicles either with three or four wheels.

5.3.14 Identify open issues/ demand for research

Policy set-up needs in-depth foresight analysis. Within the ALTERMOTIVE project and especially in WP4 it was not planned to define the demand for research. But a good policy should allow for creating insight beforehand or incorporate foreign studies. Beyond our surveys and analysis' **introducing innovation** to allow for a cost efficient implementation of biofuels is recommended. Some examples:

- Bio-fuel heaters for being able to run battery electric vehicles in colder climates at a higher efficiency[16]
- Range-extended battery electric solutions or plug-in-hybrids may be a good compromise cost-wise having small internal combustion engines. [17]
- Flexible engine cycle machines coping with different type of biofuels.
- Materials for the elevated combustion temperature of methane burning engines

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[13] http://www.automotiveworld.com/news//81731-japan-mmc-s-battery-jv-considers-production-in-europe

[14] http://www.automobilesreview.com/auto-news/bmw-future-electric-vehicle/16834/

[15] http://www.daimler.com/dccom/0-5-633234-49-1264595-1-0-0-0-0-0-12080-0-0-0-0-0-0-0-0.html

[16] http://green.autoblog.com/2010/10/04/volvos-electrification-chief-c30-electric-leases-start-in-2011/

[17] However this is not possible in mountainous regions or for high design velocities.

- In-wheel-motors need the researcher's attention as well as the reduction of the need for precious earth metals with electric motors[18].
- Additional to gas to liquid paths the bio-LPG path should be investigated.

There is certainly more to be discovered in a well focused foresight analysis detailing alterative fuel scenarios.

Even if the 14 recommendations go more into detail leaving safe ground, we hope they may serve as initial ignition for a discussion rendering alternative fuel and propulsion policies more efficient and effective in Europe.

[18] http://www.ifm.eng.cam.ac.uk/ctm/trm/documents/foresight_vehicle_v1.pdf

ANNEX A Questionnaire

Questionnaire (variant addressing fleets)

Questionnaire for deepening the knowledge about the show cases (target group: fleet owners or fleet operators)

The questionnaire should be send to the interviewers in advance to the telephone or face to face interview.

You may tick more than one category if they represent no ranking!

1 Set-Up of the measure of the fleet initiative

1.1 Which area do you cover running your fleet (e.g. whole city of Milano in Italy)

1.2 What was the main motivation/target to invest in the fleet (switch to alternative fuels/alternative propulsion)?

Prevent climate change	Improve local air quality	create employment	Create / improve 'green image'	Other, as: ______________

1.3 Were any incentives considered for your initiative?

Reduced parking fees	Subsidies procure-ment vehicles	Subsidies procurement depot/home filling stations	Emission/ CO_2 based road tolls	Access restrictions for other vehicles	ISO/EMAS [19] or CSR[20] schemes	Other as _________

If the initiative is based on an incentive, please detail your answer:

[19] EMAS: Eco-management and audit scheme, it's a voluntary environmental management system within the European Union

[20] CSR: Certified Environmental Management Schemes/ Corporate Social Responsibility

1.4 Which category does the fleet belong to?

Private/ Individual	Small private fleets (e.g. plumbers)	Logistics companies (e.g. Schenker)	Public fleets (e.g. buses, garbage trucks)	Other ______________

1.5 Was any of the following developed?

New vehicles (together with the producer)	Alternative fuel supply (together with fuel retailers)	Refuelling facilities on site/at your depot	Own vehicle Maintenance/workshops	Other ______________

1.6 What fuels were/are you using? Please describe details:

	Electric (trolley tram)	Battery Elec-tric	Bio-Ethanol (E20, E85, E95)	Biogas (Bio-CNG, also blends)	Biodiesel (B10, B30, B100)	LPG	Fossil Diesel	Hybrid Electric (parallel, serial)	Natural Gas CNG	pure plant oil	Other as ____
Before imple-menting the project											
Now						Not considered as alternative fuel					

1.7 Was it necessary to set up logistics measures coping with reduced autonomy of the vehicles (please comment)?

No, was not necessary	Intermediate refuelling during longer travel	Dual fuel capability (bi valent operation) of vehicles	Restrict service to regional transport	Other as ___________
	Intermediate refuelling might use own newly installed refuelling facilities abroad or existing from other	Dual fuel capability allows the vehicle to run on two different type of fuels – one alternative and one	Restricting service to regional transport means to restrict alternative fuel usage to captive services.	

	companies, fuel retailers	conventional		

1.8 What was the time schedule for the measure described in question 1.7? Please give some indication in months:

Set up/preparing the ground of the project	Decision phase & testing	Small scale implementation	Big rollout (procurement of larger amount of vehicles)	Evaluation period

1.9 For you as a fleet owner/operator, what was the motivation for the initiative (investing in the new fleet)?
Please rank the importance starting with 1 for the most important issue:

__ External forces (policy dictacted from owner or other “higher levels”)
__ Risk reduction with regards to fuel price changes (fuels to choose from)
__ Image (marketing measure for the company)
__ Saving money (fuel costs or grants and operational incentives)
__ Other as: ___________________

Please detail the most important issue:

2 Reactions/Results

2.1 For you as fleet owner/operator: How were the results in terms of total cost of operation of the fleet?

Much higher	higher	Equal	lower	Much lower

2.2 Success factors for getting the initiative into function
Please rank the importance starting with 1 for the most important issue:

__ External consulting (their expertise was very important)

__ Funding opportunities

__ Staff training activities

__ Other ________________

2.3 If using non-fossil fuels, have there been significant price fluctuations of alternative fuels?

Yes No

2.4 If yes, what was your reaction coping with it?

____

2.5 Have you experienced any changes with external boundary conditions? like for example

- legal - easing CNG use, requiring biofuel blend/offer…
- fiscal - reducing motor tax for biofuel vehicles or mineral oil taxes on biofuels
- biofuel bashing in the media

Local	National	Other _____________

If yes, what did change during/after the new fleet was implemented?

2.6 How many vehicles were involved in the fleet initiative?
Please give numbers and also describe the type of vehicles involved (e.g. 3.5t light trucks…)

	Fuel blending with existing vehicles without modification	Adapted vehicles	Newly procured vehicles	Test or leased vehicles in operation
Number				
Type				

2.7 What were the costs of the initiative?

Research activities	Administration of the project	Investment in infrastructure	Investment in vehicles	Use and Maintenace costs

2.8 Indicate the reduction of conventional fuels (due to substitution by alternative fuels or due to a reduction in fuel consumption caused by alternative power trains) percentagewise (e.g. 10% reduction in 2007 in comparison to 2005):

Type of fuel	Diesel	Gasoline	Other, please specify
Initial consumption in _____ (tons/litre/normal m³) for the reference year ______			
% Reduction achieved in year _____			

2.9 Have you made any calculations on reduction of green house gas emissions and/or other pollutants, from implementing your fleet initiative?

In Total:

CO_2	CH_4	PM_{10}	NO_X	Other as ____________

2.10 Acceptance of the project by the different groups- please tick:

	very good acceptance	good acceptance	weak acceptance	no acceptance
The public (NGO's , media)				
Customers (e.g. bus passenger or households meeting the plumbers)				
Own staff (drivers)				

Please detail your answer:

2.11 Were there changes in public fuel supply during the initiative? (if needed in your case)

Yes No

If yes, please describe how the public fuel supply you were using changed:

New public alternative fuel pumps	New blending introduced (E20, B10, B20,B30…) with existing pumps	Other as __________

2.12 Are there any plans to enlarge the initiative?

Increase number of same vehicles	Include other types of vehicles/fuels	Transfer the initiative to other fleets	Other as __________

2.13 Are there impeding threats for the economy of the initiative or incentives with regards to a new potential initiative? Please mark with "+" for positive and "-" for negative influence on your current/future initiative.

	Fuel taxation	subsidies vehicles + own refuelling	emission standards vehicles	operational restrictions (environmental zones etc.)	commercial vehicle market	commercial fuel availability	other

		stations					
Now							
Long Term							

Many thanks for your endeavour and time!

If your show case is on eltis.org you are kindly asked to improve if necessary or hand it over to us.

If your show case is NOT on eltis.org yet you are kindly asked to enter the data or hand this over to us.