THE FUTURE OF THE TRANSPORTATION IS ELECTRIC AND SOLAR!

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Abstract

Decision makers are highly dependent on the information they get before they decide. It is not only the independency but also the completeness and the global view that is crucial but hard to attain. To put objective information on electric and hybrid vehicles and their effects on energy efficiency and the environment at disposal of Governments, local and city authorities, fleet users and industries is one goal of our work. Participation in the Implementing Agreement provides an unique access to insider information and task forces. This saves time, money and accelerates the process of technical transition towards sustainable mobility. The call for co-ordinated action is one thing. This makes information for decision makers and politicians a necessity. But there is a need of closer investigation of a lot of questions concerning the technologies, applications, markets and environmental issues that are also covered by this "Implementing Agreement" and are summarized in this paper.

Keywords: *Public Policy, Sustainable Mobility, Energy Efficiency, Environmental Impacts*

1 Introduction

Since 1993, the Implementing Agreement "Hybrid& Electric Vehicles" (IEA HEV) of the International Energy Agency (IEA) provides a platform to exchange knowledge, experience and strategies among the governments of the member states. In addition, closer investigations of a lot of questions concerning the technologies, applications, markets and environ-mental issues are made in special working groups, so called "Annexes". The variety of topics of these Annexes mirror the worldwide development of vehicles with electric and hybrid propulsion systems: At the beginning the technology has been in the focus, whereas at the end of the 90ies market issues gained importance.
At the end of 2009 the Implementing Agreement "Hybrid&Electric Vehicles" will start its 4th phase. The new programme strategy of the IEA HEV is based on the fact that vehicles with electric drives are 3-4 times more efficient as ICE vehicles. This will lead to a growth of solutions with electric drives like hybrids (including fuel cell vehicles), plug-in-hybrids and electric vehicles.

2 The technical solution is known: it is electric and renewable!

In the IEA - report "Towards a Sustainable Energy Future" in support of the "G8 - Plan of Action" [1] transport is mentioned as "a challenge". Actually the transport sector is consuming 60% of all the oil. The report says:" De-carbonizing transport is more difficult and costly than de-carbonizing power generation. In the medium term, cost-effective efficiency improvements of up to 50% are possible … In the longer term, new technologies will be needed to de-carbonizing transport". In the Energy Technology Perspectives of the IEA [2], "electric and plug-in vehicles" and "hydrogen fuel cells vehicles" are mentioned as the two key technologies for the future.

2.1. 3-4-times more efficient

The best solution and therefore the future will be electric and renewable. Why is this so obvious? Basic physics and nature tell us why:

- The electric drive is 3-4 times more efficient than the combustion processes.
- For the clean and renewable production of the electricity many options already exist ranging from hydro-, wind-power, locally produced biomass power plants to de-centralized solar power stations, photovoltaics etc.

Within the framework of the Large Scale Test with Lightweight Electric Vehicles in Mendrisio (CH), test bench measurements in the automotive department of the University of Applied Sciences Bern compared the energy consumption of the same models "VW Golf" and "Peugeot 106" with

electric-, diesel- and gasoline-drive train [fig. 1]. Measurements in the daily use substantiated this result.

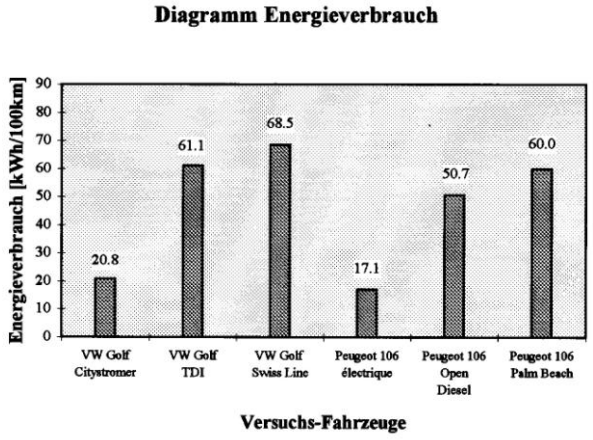

Fig 1 Electric vehicles are 3-4 time more efficient

2.2. What is our sustainable mobility portfolio?

In our Annual report 2008 we compared the ranges of vehicles using all kind of biomass produced on one hectare surface compared to a "Plug-in-Hybrid" with electricity produced by photovoltaics. The picture shows the big advantage of the electric solution over renewable energies. You can repeat this exercise with electricity produced by wind, or by a hydropower plant. The IEA report "Towards a Sustainable Energy Future" mentions that "there is no intrinsic ceiling to variable renewable potential". The integration of renewable electricity into the transport sector can be supported by the use of the "vehicle to grid V2G"-concept which is under investigation by our specialists in the "Plug-In-Hybrid" - Annex 15. Even 100% renewable energies is attainable.

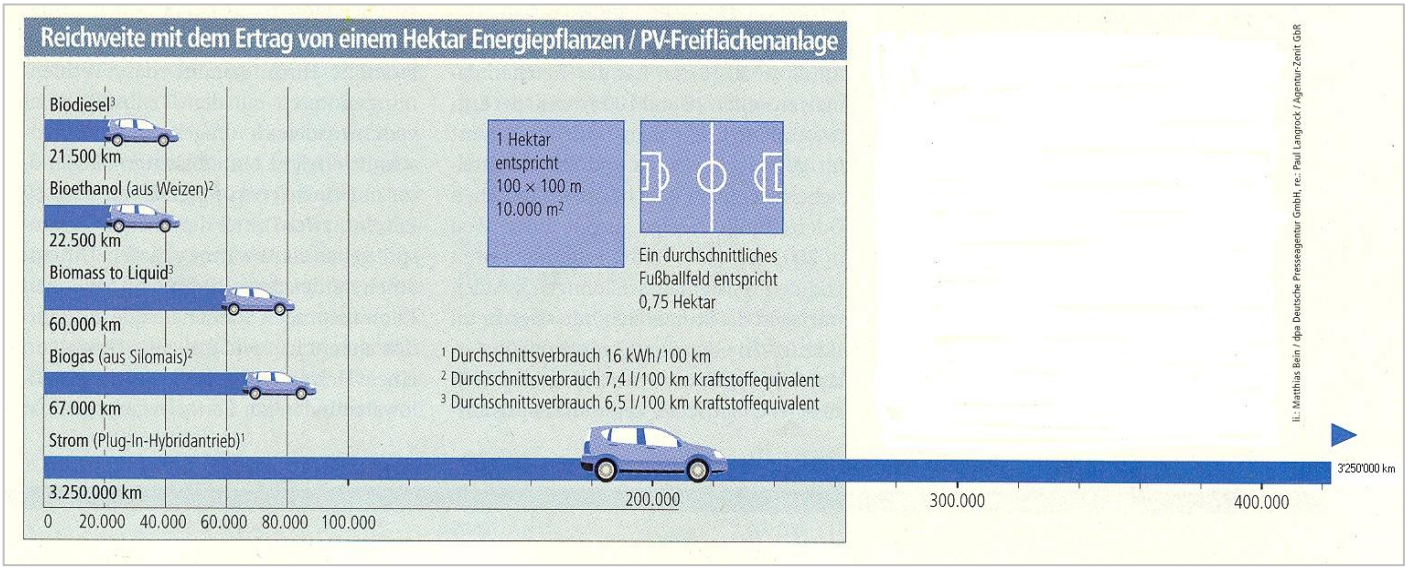

Fig. 2: range achieved by the energy produced on 1 ha land (energy plants vs. photovoltaic installation)

But the conclusion that alternative motor fuels are obsolete is being rash in judgement. For some transportation applications in heavy duty vehicles, large ships and especially commercial airplanes the electric solution is actually not competitive. Alternative motor fuels and later "hydrogen produced by renewable energies" can fill this gap. By using electric drive trains we can limit the use of arable land for the production of alternative motor fuels as a worthy resource for special applications. It lowers the pressure for an excessive use of land in developing and industrialized countries and avoids a destructive competition between food and the use in transportation.

Future transportation may show the following portfolio:

- Use clean electricity for means of mass transportation (railways.,….) as much as possible
- Replace passenger vehicles and buses by trams and electric trolley buses in densely populated areas as much as possible
- Replace diesel buses, diesel trucks etc. by hybrid-vehicles with alternative motor fuels (later perhaps hydrogen) as much as possible
- Replace short distance ICEV-trips by electric vehicles starting with electric 2-wheelers to small lightweight electric vehicles to four-wheeled electric vehicles as much as possible
- Replace mid- and long distance trips by hybrid and "Plug-in-hybrids"-vehicles as much as possible
- Start using alternative motor fuels and perhaps hydrogen in airplanes.

3 International collaboration brings clarity in this change process

The development of such a "sustainable mobility portfolio" is just at a starting point. Many R&D-efforts, demonstration projects and applications are needed to give a detailed picture which could differ from country to country, from region to region and from town to town. But first pieces of the puzzle can already be used today with benefits for the users. As members of the various IEA - Implementing Agreements in the transport sector, countries can share these results and learn from each other. This will speed up the development and saves taxpayers' money.

Among other stakeholders in this field – such as the automotive industry and research institutes – IA-HEV has its own specific position and strength [fig. 3].

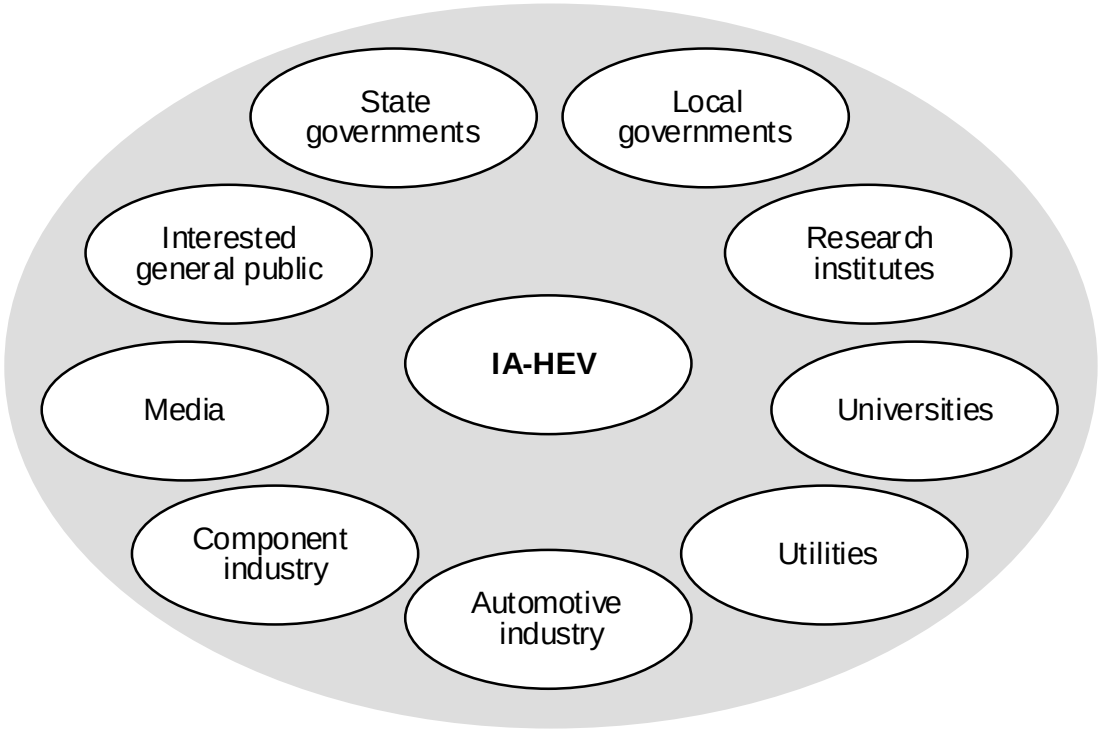

Fig. 3: networking within the IEA IA „Hybrid&Electric Vehicles" provides a huge information platform

3.1. In the transition phase objective information for policy- and decision makers is important

In this transition phase policy/decision makers are relying on objective information on which they can base their decisions and policies. This is the main goal of the IEA HEV in the 4th phase. The delegates in this Implementing Agreement "Hybrid & Electric Vehicles" and the experts working in the "Annexes" form a unique network of experience. These experts have a great knowledge and flexibility to identify the most urgent questions concerning the development of hybrid and electric vehicles and to initiate investigations of common interest for stakeholders and decision makers. The great interest of countries to join this Implementing Agreement during the last months shows that this Implementing Agreement offers a platform of unique possibilities to get objective information.

3.2. Achievements

The active work of an Implementing Agreement happens in working groups - the "Annexes" in the IEA language. To start a working group, at least two or more countries have to find an agreement about a work plan. The work can be shared by cost (cost shared) or tasks (task shared). In this Agreement, the latter is more common. The work is co-ordinated by the Operating Agent (OA) who reports to the Executive Committee (EXCO) of the Implementing Agreement.
The more working groups a country is participating in the higher is its benefit from the co-operation in the Implementing Agreement. By 2008 five working groups have been completed. Actually seven working groups are active and three new ones are in preparation.

The reports on Annexes already concluded mirror the information needs of the first "market intro-

duction phase" in the 1990ies: environmental impacts of electric vehicles, infrastructure, batteries, hybrid vehicles, governmental market deployment strategies. This enabled government administra-tions of the participating countries to shape their policies and to profit from the experiences of other countries. In the second and third phase this Implementing Agreement has been one of the first ex-perts groups informing about the potential of plug-in hybrid technologies (presentation at EVS20 in Long Beach; public workshop at the EVS21 in Monaco 2005), evaluating governmental support to identify successful market deployment strategies (2002) or investigating how learning processes in the automotive industry help to improve the second generation electric and plug-in hybrid vehicles.

In detail, the following achievements have been elaborated by the running Annexes in the 3rd phase:

- **I "Information Exchange":** This working group plays a key role in the programme. It establishes a regular information exchange on hybrid, electric and fuel cell vehicle developments and promotion measures in the member countries as well as the most interesting non-member countries. The working group also works as a "turntable" by publishing the figures and basic information on the Agreement's website. The informal information that is the specific benefit of the participation is only available for the member countries. The Operating Agent of this Annex is the Argonne National Laboratory on behalf of the US Department of Energy.
- **VII "Hybrid Vehicles":** This group of specialists from the USA and Europe worked on new trends concerning components and vehicles. Members of this group have been the first pro-motors of the current trend to "plug-in hybrid vehicles", discussed already in 2001, on the occasion of the EVS20 in Long Beach. The knowledge of this group enabled the governments to influence the model policy of automakers of their country. The Operating Agent of this group has been TNO, The Netherlands. The final report has been published in 2007.
- **X "Electrochemical Systems":** This working group is a continuation of the working group "Batteries" of the first Phase of this Agreement 1993-1999. The new working group focuses on technical special details that are not discussed within the battery community or special battery conferences, like experience with specific test protocols or abuse testing. In 2008 a workshop topic was the availability of Lithium for batteries. The operating agent is the department Energy Storage for Vehicles of the US Department of Energy.
- **XI "Electric Cycles":** In several countries the electric two-wheeled vehicles became a huge market segment in the transport field, especially in China. In several European countries electric bicycles are used for commuter trips and became a small special market niche. Because of different quality standards vehicle do not necessarily match for both market fields, and there are still a lot of open questions concerning standards, licensing or market deploy-ment. This group under the leading of AVERE will conclude its work by the end of the 3th phase
- **XII "Hybrid Heavy Duty Vehicles":** This working group, started in 2007, aims at structuring the information about heavy-duty hybrid vehicle components and configurations. An important aspect of this task is to gain insight in existing and possible applications of hybrid vehicle technologies. Besides the obvious vehicle types like buses and trucks, other applications of conventional heavy-duty vehicle technology like off-road vehicles may be candidates for hybridization. In addition to identify the application area of hybrid technologies, the Annex will also study the current situation of existing hybrid prototypes and standard vehicles. The information gathering will focus on the applied technology, the costs and the merits. This will broaden the insight in these applications and provide essential information for future hybrid vehicle deployment projects. The 'lessons learned' will not only focus on the technical barriers to overcome but also on the required framework (training, support, …) for successful implement-tation projects. Next to these specific subtasks a more general task of information gathering and dissemination will be co-ordinated by the Operating Agent VITO, a dedicated research institute in Belgium.
- **III "Fuel Cell Vehicle Technologies":** Fuel cells as electrochemical systems are not limited by thermodynamic restrictions of combustion processes. Therefore they offer unique advantages concerning energy efficiency and the reduction of noise and exhaust emissions. Considered by many scientists as optimal long-term solution for clean and efficient energy conversion for mobile and stationary applications the transport industry, energy uti-lities and producers of portable consumer pro-ducts invest strongly in the development of this technology. Nevertheless limited lifetime as well as high production costs due to noble metal catalysts have impeded until now the broad

market introduction of fuel cells beyond specialized niches like space applications. But in the last years cheaper and more stable materials for separators and electrodes have achieved major improvements for fuel cell technologies. Rising costs for after-treatment of internal combustion engine emissions due to tightening emissions standards will bring fuel cell vehicles nearer to competitiveness. The HEV-IA will concentrate its activities in its new annex (also started in 2007) not on the development of fuel cells but on tuning their properties as well as using their high potential for their successful application in vehicles. The main focus will be on road vehicles but other means of transport will be considered as well if their specific needs could play an interesting intermediate step for the market introduction of fuel cell vehicles. In this respect boats, aeroplanes and mining vehicles could play an interesting niche preparing the market introduction of fuel cell vehicles**.** Operating Agent is the Austrian Agency for Alternative Propulsion Systems.

- **XIV "Market Deployment / Lessons learned":** The Annex VIII „Deployment Strategies for Hybrid, Electric and Alternative Fuel Vehicles" investigated 95 promotion measures run by governments or other public and private organizations to enable the market deployment of clean vehicle technologies. In a second phase of this Annex the reasons for success and failure in introducing electric and hybrid vehicles into the market shall be analyzed. This is even more important as car manufacturers (and users) have several options in the choice of a clean propulsion technology (alternative fuels like NG, ethanol; fuel cell vehicles). The preliminary results show that car manufacturers underestimated the difficulties in the development of electric propulsion systems and the time frame a market deployment needs. Additionally the interface between vehicle and grid has never been defined between utilities and car manufacturers, and the lack of standards aggravated the problem. The importance to establish a network of sales points with trained staff that also showed competence in maintenance and service has been underestimated as well. More details are discussed in workshops in which representatives of EV and component manufacturers, utilities and project leaders of demonstration programmes share their experiences. This group is leaded by Tom Turrentine of the Institute of Transportation Studies at the UC Davis.
- **XV "Plug-In Hybrid Vehicles"**: This Annex followed the Annex VII "Hybrid Vehicles" (concluded 2007) that already had started to evaluate the options of plug-in hybrid vehicles (PHEVs). PHEVs have the potential of further reduction in oil use and CO_2 over HEV at increased fueling flexibility (grid or liquid). They also offer the exciting option of distributed generation & power storage ("Vehicle to Grid" V2G). This new Annex therefore has the objectives to provide essential information for member countries to better understand the current situation of PHEVs and their related prospects. It will concentrate on advanced battery technologies, other PHEV-specific components, policy issues and marketability, and especially on utilities and the grid. The results of this Annex will be published in 2010. Operating Agent is the Canadian Department of Natural Resources.

3.3. The 4th Phase runs from 2009 - 2014

The next phase that will start in November 2009 will cover the important questions for the development and market deployment of the future clean car.

The main topics will mirror the most stringent issues in today's discussion on sustainable transportation:

- energy consumption
- efficient technologies with focus on battery electric and plug-in hybrid vehicles
- energy storage
- market deployment
- outlook on future sustainable transportation (individual- and mass-transport)

The following important factors to influence the future share of electric, hybrid and plug-in hybrid vehicles are identified by this IA:

- regulatory and other governmental measures to overcome the barriers for large deployment of EVs/HEVs/PHEVs
- advances in battery technology
- application of HEV technology in high-volume vehicle models
- the difference in purchase price between EVs/HEVs/PHEVs and standard vehicles
- the availability of components for EV/HEV/PHEV drive trains
- the quantity of EVs/HEVs/PHEVs that manufacturers will be able to supply.

The first point will still remain a main target of the Annex I "Information Exchange", while the second point is covered by the Annex X "Electrochemical Systems". The steering committee of this Implementing Agreement also agrees that at least one Annex has to deal with market issues. The applica-

tion of EV/HEV/PHEV technology in high-volume vehicle models must be focused by a technically oriented Annex. A continuation of Annex "Deployment Strategies" may focus on various problems that occur as a result of the discrepancy between producers' intentions and consumers' actual use patterns.

Additional Annexes are suggested that will investigate electronics and system integration, materials, questions of the interface between vehicle and grid. This includes answering the question: Where will the electricity come from?, for this does not only affect the sustainability of future transportation but also the efficiency and stability of the grid.

4 The Solar Option

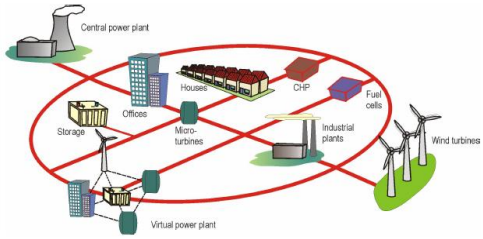

Fig. 4: smart grid (source: R. Horbaty)

An additional aspect is the well established market niche of small EVs used for commuting in city agglomerations, especially electric two- and three-wheelers. The small amount of energy needed for operation can be easily produced by small solar arrays [fig. 5].

Fig 5: 2 x 10 km/day by E-Bike instead of a conventional car saves 2'000 l gasoline in 8 years. This amount of energy can be easily provided by a 60 Wp PV panel

The possibility to store renewable energy – such as wind and solar power - in vehicle batteries adds to the increasing interest in battery electric vehicles. For example, the European Union member states started realizing in mid 2008 that electricity or hydrogen from renewable sources could contribute to the European Commission's plans that 10% of transport needs must come from renewable energy by 2020.

The "Vehicle-to-Grid"-option [fig. 4] requires, in addition to a close co-operation between car manufacturers, battery producers and grid operators which never happened in the necessary consequence before, the consequent implementation of worldwide standards. An international network like the IA HEV can make valuable contributions to such an effort.

5 Results

Besides showing that there is an obvious need for transparency and completeness of information, the current discussions on clean vehicle technologies – the changed judgement of bio fuels is a good example [see fig.2 above] - also show the importance of an international and multi-disciplinary approach. IEA Implementing Agreements by nature have such an approach.

Actually the twelve member countries (Austria/ Belgium/ Canada/ Denmark/ Finland/ France/ Italy/ The Netherlands/ Sweden/ Switzerland/ The United States of America/ Turkey) gain profit of the coordination approach. The IA HEV tries to expand these benefits to new member countries. We are in close contact with interested countries and expect up to 15 member countries at the start of the 4th phase on December 1st, 2009.

References

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Author

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