Institute for Internal Combustion Engines and Thermodynamics
Inffeldgasse 21A
A-8010 Graz
http://fvkma.tu-graz.ac.at

Institute for Powertrains and Automotive Technology
Getreidemarkt 9
A-1060 Wien
http://www.ifa.tuwien.ac.at

Ao.Univ.-Prof. Dipl.-Ing. Dr. Stefan HAUSBERGER

Graz University of Technology

TECHNISCHE UNIVERSITÄT WIEN
Vienna University of Technology

Univ.-Prof. Dipl.-Ing. Dr. Bernhard GERINGER
Director
tel.: +43-1/ 58801-31500
fax: +43-1/ 58801-31599
bernhard.geringer@tuwien.ac.at

Date: 04th March 2011

International Organization of Motor Vehicle Manufacturers
attn: H. Jürgen Stein
4, rue de Berri
F 75008 Paris

Quote to the Informal Group on Heavy Duty Hybrids

Title

Development of an exhaust emissions and CO_2 measurement test procedure for heavy duty hybrids (HDH)

Content

1 Experience and expertise of the consortium

The work is offered by a consortium consisting of University of Technology Vienna and University of Technology Graz. Main partners are:

- Vienna University of Technology, Institute for Powertrains & Automotive Technology (IFA): Prof. Dr. Bernhard Geringer, Prof. Peter Hofmann, D.I. Bernhard Schneeweiss, D.I. Robert Rosenitsch
- University of Technology Graz, Institute for Internal Combustion Engines and Thermodynamics (TUG): Prof. Dr. Stefan Hausberger, Dr. Martin Rexeis, Dr. Jürgen Blassnegger, D.I. Antonius Kies, D.I. Raphael Luz

Institutes from the faculties for Electrical Engineering from both Universities will be involved for consultancy where relevant.

The consortium shall cover all relevant fields of expertise necessary to fulfill the tasks and shall provide sufficient manpower to handle the work in the short period outlined in the request for quote and in the informal document No. GRPE-61-16.

1.1 Institute for Powertrains & Automotive Technology (IFA) of the Vienna, University of Technology

Director: Prof. Dr. Bernhard Geringer

Apart from **scientific education** for students at the Vienna University of Technology, further main tasks of the institute for Powertrains & Automotive Technology (IFA) include **research** and consultant activity. For this purpose are approximate 60 employees available, of which one half represents scientists and the second half specialised staff.

The research pays attention to all aspects of engineering and improvement of vehicles with special **emphasis to „power train“**. Beside in-house basic research, applied research occupies an eminent part within the work of the institute, by order of important enterprise, like vehicle manufacturers.

The expansive field of work within the scope of **conventional vehicle improvement** contains components development for mixture preparation, ignition, exhaust gas after treatment, caloric management etc.. Therefore **newest developing tools** are used, which include particularly one- and three-dimensional (3D-CFD), except for special measuring devices (fast exhaust emission measuring devices and optical equipments). A further focus is set on **alternative Developments** and their future applications. Alternative drive train concepts of different **hybrid concepts** including **fuel cells** are investigated and optimized concerning performance and emission characteristics. New operating and combustion processes for alternative **bio fuels of 1st and 2nd generation including hydrogen** are developed. This work is completed by evaluating the state of technology concerning future environmental impacts.

At last with the test equipment, **chassis dynamometer for PC inclusive climatic chambers until -35°C**, owned by the institute the requirements are fulfilled to generate **expertises to quantify the engine performance, the efficiency and exhaust emission** of vehicles of different kinds, as well as to verify fuel characteristics. By means of forecast instrument created at the institute the influence of future technologies can be predicted concerning emission development.

At the Institute for Powertrains & Automotive Technology (IFA) of the Vienna University of Technology intelligent control strategies were developed enabling the reduction of NOx emissions and consumption by means of a parallel diesel-hybrid powertrain. Furthermore, different hybrid powertrain concepts were analyzed with the aim of demonstrating their advantages and disadvantages concerning the achievement of these goals. In this context a simulation model was **developed similar to HILS called EIL (Engine-in-the-Loop)**. It used to obtain a high accuracy of results

Special references according to “HILS”:

[1] T. Prachar, A. Caldevilla, G. Lux, A. Pöltenstein, S. Winter, L. Magerl, P. Hofmann: "Consideration of different hybrid powertrains with the help of a model in longitudinal dynamic using DymolaTM"; Vortrag: 2006 SAE World Congress, Cobo Center, Detroit, USA (eingeladen); 03.04.2006 - 06.04.2006 Doc. No. 2006-01-1126, SP-2008.

[2] Magerl, L.; Winter, S.; Hofmann, P.; Geringer, B.: „Using a simulation tool for concerted choice and adaptation of components for hybrid vehicles” EAEC 2007, 11th European Automotive Congress, 30 May – 1 June 2007, Budapest, Hungary.

[3] Winter, S.; Magerl, L.; Hofmann, P.; Geringer, B.; Kapus, P.:Effizienz- und Dynamiksteigerung eines Hybridantriebsstranges durch gezielte Synergiemaßnahmen in Kombination mit einem direkt einspritzenden aufgeladenen Ottomotor. Tagung Direkteinspritzung im Ottomotor VI, HdT Essen, 12. & 13.6.2007.

[4] Lux, G.; Winter, S.; Hofmann, P.; Geringer, B.: Application of Thermal Management to Reduce Fuel Consumption in Hybrid Power Trains. 5th Symposium Hybrid Vehicles and Energy Management. 20th and 21st Feb. 2008 Braunschweig.

[5] Lux, G.; Winter, S.; Hofmann, P.; Geringer, B.: Thermomanagement zur Verbrauchsabsenkung in Hybridantriebssträngen. 6. Tagung Wärmemanagement des Kraftfahrzeugs (incl. Energiemanagement) 16. bis 17. Juni 2008 in Berlin.

[6] Lux, G.; Winter, S.; Hofmann, P.; Geringer, B.: Thermal Management of Hybrid Electric Vehicles. A3PS Konferenz: Hybrid and electric vehicles, energy storage technologies and control systems, Vienna, October 21st 2008.

[7] Schneeweiss, B.: Simulationsgestützte Entwicklung von Betriebsstrategien für ein Dieselhybridfahrzeug. IAV-Tagung “Simulation und Test in der Automobilelektronik”, 31.5-1.6.2010, Berlin.

[8] Schneeweiss, B.; Teiner, P.: „Hardware-in-the-loop-Simulation am Motorenprüfstand für realitätsnahe Emissions- und Verbrauchsanalysen“, ATZ extra „Automotive engineering partners“, Springer Automotive Media, Mai 2010

[9] Geringer, B.; Fischer, S.; Hofmann, P.; Lauer, T.; Möltner, L.; Schneeweiß, B.; Teiner, P.: „Neue Ansätze und Entwicklungsmethoden zur Minimierung der NOx-Emissionen von Dieselmotoren“, 31. Internationales Wiener Motorensymposium, 29.-30. 04. 2010, Wien. VDI Reihe 12 Nr. 716.

[10] Teiner, P.; Schneeweiß, B.: „Evaluation of NOx and Fuel Consumption Reduction Potential of Parallel Diesel-Hybrid Powertrains using Engine-In-the-Loop Simulation”, Small Engine Technology Conference, 28.-30. 09. 2010, Linz. SAE-Paper Nr. 2010-32-0128

The Institute for Powertrains & Automotive Technology (IFA) of the Vienna University of Technology has therefore expertise with task 1 and 2

1.2 University of Technology Graz, Institute for Internal Combustion Engines and Thermodynamics (TUG)

The Institute for Internal Combustion Engines and Thermodynamics at TUG was and is co-ordinator of different work packages of successful long term international projects related to development tasks of conventional and alternative propulsion systems and of simulation and measurement of light and heavy duty vehicles (e.g. ERMES, EU 5th to 7th framework projects, COST,..). Stefan Hausberger is member of expert panels such as the European Strategic Transport Technology Plan (STTP) and the Transport Advisory Group (TAG) and of the ERMES steering committee.

Special references according to “HILS”

A work relevant for the HILS project performed at the Institute is the LOT 2 in the development of a CO_2 certification procedure for HDV, funded by DG Clima. TUG is leading the consortium of LOT 2 and thus involved in all steps of the process. Similarly to the HILS method the CO_2 certification procedure most likely will be based to a large extent on a simulation tool with standardized test data as input (engine, transmission, auxiliaries, driving resistances etc.). Synergies between these approaches will support the development of the test procedures but especially can simplify the later application for the certification of engines and vehicles if the procedures are harmonized in data demand and methods.

The Institute for Internal Combustion Engines and Thermodynamics at TUG also develops a vehicle longitudinal dynamics and emission model (PHEM, Passenger cars and Heavy duty Emission Model) which simulates vehicles with conventional and with hybrid propulsion systems and is applied in several national and international projects since the year 2000 (recently the project HERO with BMW Steyr and the project EHEV with Magna E-Cars are dealing with HEV development for passenger cars and for a city bus respectively).

Some relevant publications

[1] Luz R., Hausberger S.: User Guide for the Model PHEM, Version 10; Institute for Internal Combustion Engines and Thermodynamics TU Graz, Graz, 2009

[2] Renhart W., Magele C., Hausberger S., Zallinger M:, Luz R.; Recent NiMH-battery Modeling Supported by Finite Element Thermal Analysis, 20. Symposium on Power Electronics, Electrical Drivers, Automation and Motion (SPEEDAM), Pisa, 14.-16.06.2010

[3] S. Hausberger, W. Stadlhofer , J. Blassnegger, A. Flanschger: Performance of Clean City Bus Technologies in Real World Traffic; 18th International Symposium Transport and Air Pollution, 18.-19.05.2010, Zürich

[4] Zallinger M., Luz R., Hausberger S., Hirschmann K., Fellendorf M., Coupling of microscale traffic and amission models ro minimize emissions by traffic control system, 18th International Symposium Transport and Air Pollution, 18.-19.05.2010, Zürich

[5] Hausberger S., Stadlhofer W., Blassnegger J., Rexeis M., et.al: Saubere Stadtbustechnologien Nachrüstlösungen und Neufahrzeuge; Broschüre aus dem Projekt ICUT, Institut für Verbrennungskraftmaschinen und Thermodynamik, Jänner 2010

[6] Rexeis M.: Ascertainment of Real World Emissions of Heavy Duty Vehicles. Dissertation, Institute for Internal Combustion Engines and Thermodynamics, Graz University of Technology. October 2009

[7] Zallinger M., Tate J., Hausberger S., Goodman P., Evaluation of a Coupled Micro-Scopic Traffic Simulator and Instantaneous Emission Model, 7th International Conference on Air Quality - Science and Application 2009, Istanbul, 24.-.27.03.2009

[8] Hausberger S.: Simulation of Real World Vehicle Exhaust Emissions; VKM-THD Mitteilungen; Heft/Volume 82; Verlag der Technischen Universität Graz; ISBN 3-901351-74-4; Graz 2003

[9] Schmitzberger M: Emissionsverhalten von SUV's und Potenzial einer Hybridisierung; Diplomarbeit am Institut für Verbrennungskraftmaschinen und Thermodynamik der TU-Graz; Oktober 2007

[10] Zallinger M., Le Anh T., Hausberger S.: Improving an instantaneous emission model for passenger cars; Transport&Airpollution Conference; ISBN: 3-902465-16-6, Graz 2005

2 Quote on the tasks (cost, timing)

Based on Kokujikan No. 281 of March 16, 2007[1] the informal group would like to conduct a research program, which covers the five tasks listed below. Four of the five tasks are offered here.

The costs listed for each task are valid only if all four tasks are ordered. Costs for performing only individual tasks have to be negotiated on demand.

2.1 Overview on offered work

Here the main packages for each offered task are summarized.

Task 1: "Investigation and modification, if applicable, of the HILS model and interface (chapter 1); this should include a proposal for a verification method (chapter 5) w/o vehicle testing."

Until November 2011 following work can be performed:

- A detailed review of the Japanese HILS system and the open software
- An analysis of possible improvements and relevant gaps for a global regulation (e.g. inclusion of cold start tests in the simulation tool to cover the EURO VI test

[1] TEST PROCEDURE FOR FUEL CONSUMPTION RATE AND EXHAUST EMISSIONS OF HEAVY-DUTY HYBRID ELECTRIC VEHICLES USING HARDWARE-IN-THE-LOOP SIMULATOR SYSTEM

procedure and eventual needs of adaptation for regional differences in vehicle designs)

- Work shops and/or smaller meetings with OEM's and stakeholders to identify if all relevant input and output parameters from HDH-ECU's are considered and if all hybrid architectures can be simulated. Elaboration of options to fill gaps if relevant.
- Analysis of the necessary preparation work and efforts to run a HILS system at IFA and/or TUG in a potential next phase of the project in the year 2012 to validate the approach suggested in the actual project with a HDH vehicle and its ECU.

Task 2: "Investigation and modification, if applicable, of the HILS component testing (chapter 2)"

Until November 2011 following work can be performed:

- A detailed review of the Japanese test procedure for obtaining parameters of the engine, electric motor and electric storage device of Heavy-Duty Hybrid Electric Vehicles, which are to be inputted in the HILS system.
- An analysis of possible improvements and relevant gaps of the component testing. An analysis if the measurement methods, the device calibration and the test room conditions are appropriate and in accordance with international standards, especially for batteries.
- It is to verify how complex the setup has to be chosen to achieve future technological development.

Task 3: *"Extension of HILS to non-electrical hybrids": <u>not considered</u> in this phase of the project due to limited capacities.*

Task 4: "Inclusion of PTO operation, which normally takes place outside the test cycle"

Until January 2012 following work can be performed:

- Elaboration of options to simulate PTO power demand in conventional HDV and in HDH according to different vehicle categories and mission profiles
- Elaborate options to transfer the PTO related differences in engine work between conventional HDV and HDH into a benefit system within a HDH test procedure.

Task 5: "Development of WHVC weighting/scaling factors to represent real world vehicle operation"

Until January 2012 following work can be performed:

- Analysis of typical profiles for vehicle speed and propulsion power demand as well as of the corresponding engine load courses for representative driving cycles for conventional HDV according to different vehicle categories and mission profiles (data will be gained from the work performed together with

ACEA on this topic in the actual process of developing a HDV CO_2 certification procedure for DG Clima)

- Elaborate weighting factors for the different parts of the WHVC (urban, road, motorway, if necessary further splitting in sub-cycles) which result in similar profiles for vehicle speed and propulsion power as the representative driving cycles for each vehicle category and mission profile. Vehicle categorisation will follow the approach in the HDV CO_2 certification procedure (actual DG Clima project lead by TUG, see chapter 1.2) to establish compatible systems to enable efficient certification procedures
- Elaborate option(s) to use the HILS method also in the HDV CO_2 certification procedure for a possible future CO_2 certification of hybrid HDVs. A possible option shall result in CO_2 values comparable to the results gained with the HDV CO_2 certification procedure designed for conventional HDV. *Explanation: both, HILS and HDV CO_2 certification, are based on similar simulation methods. In the HDV CO_2 certification procedure however, the data of the actual vehicle model to be certified shall be considered while HILS uses rather generic data for vehicle categories. Since both procedures will result in specific CO_2 values the overall effort for the certification of HDH (engine and possibly in future also the CO_2 emissions for the entire vehicle) can be minimised if both approaches are harmonised already during the development phase*.

2.2 Preamble to the work

The main goal of the project is to develop an emissions and CO_2 test procedure for Heavy Duty Hybrids (HDH), which should be worldwide established. The test procedure should be based on the HILS (Hardware-in-the-Loop Simulation) method. As starting point the WHVC (World Harmonized Vehicle Cycle), the test cell environment, data evaluation procedures and emissions calculations specified in gtr (Global Technical Regulation) n°4 under the 1998 Global Agreement will be used. According to the informal document No. GRPE-60-11 the final procedure shall result in outputs that are quantifiable, verifiable, and reproducible and that provide a method for assessing real world compliance broadly and on a case by case basis, shall be capable of incorporating updated information and new data to produce the most accurate outputs, and shall be appropriately transparent as to allow governmental entities the latitude to easily assess its performance and ensure accuracy and a level playing field.

In a first step in this project, the potential of HILS is to be investigated and described comprehensively to achieve a formalistic, cheap and simple method, which prevents manipulation and guarantees comparable result all over the world.

2.3 Description of the Tasks and related costs

The single tasks are separated into work packages, which are described in the following. Travel Costs are estimated at € 25.000.-. Additional travel cost will be charged separately.

2.3.1 Task 1

Task 1 covers: "Investigation and modification, if applicable, of the HILS model and interface (chapter 1); this should include a proposal for a verification method (chapter 5) w/o vehicle testing".

WP 1-1: Review of interface and software setup

Initially it is to check the plausibility in form and content of the Japanese test procedure for exhaust emissions and consumption concerning different architectures of heavy duty electric hybrids, as given in "Kokujikan No. 281 of March 16, 2007".

Verifying the compatibility of the ECU with the input/output data structure in the Japanese HILS routine.

Assessment of the open source-code depending on documentation and regarding accessibility and demand of extensibility.

WP 1-2: Review of vehicle related data and methods

TUG will cover the vehicle related part of task 1. This includes the review of the simulation methods and the generic data used to simulate driving resistances in the Japanese HILS approach and the comparison of relevant data and methods with the development in the HDV CO2 certification procedure. Where relevant, suggestions for harmonization will be made.

WP 1-3: Analysis of improvements and relevant gaps for a global regulation

Analysis of the hybrid architectures necessary to cover the engine packages worldwide and especially in Europe. Improving necessary HILS criteria to determine input data, like driving resistance, component temperature, including of cold start tests in the simulation tool to cover the EURO VI test procedure, and others. Appoint needs of adaptation for regional differences in vehicle designs.

Analysis for a standard interface connecting the hardware (HDH ECU) with the HILS software. Identifying the working parameters of the ECU, to cover all necessary requirements of the different manufacturers now and in future.

WP 1-4: Meetings with OEM's and stakeholders

Visiting Japan for a practical demonstration of the HILS measurement methode.

Investigation if all relevant input and output parameters of the hybrid architectures are considered, which are necessary to cover all engine packages worldwide and especially in Europe. This will be done in international Workshops and smaller informal meetings with the government authorities and heavy duty manufacturers.

WP 1-5: Analysis of the necessary preparation work run a HILS system

Analysis of the necessary preparation work and efforts to run a HILS system at IFA and/or TUG in a potential next phase of the project in the year 2012 to validate the approach suggested in the actual project with a HDH vehicle and its ECU.

Tab. 1: Work packages task 1

WP No.	WP Title	Cost of WP in €	Partner	Start – MM/JJ	End - MM/JJ
1	Review of interface and software setup	15.000	IFA	04/2011	09/2011
2	**Review of vehicle related data and methods**	12.000	TUG	04/2011	11/2011
3	Analysis of improvements and relevant gaps for a global regulation	12.000	IFA	06/2011	11/2011
4	Meetings with OEM's and stakeholders	6.000	IFA/TUG	04/2011	11/2011
5	Analysis of the necessary preparation work run a HILS system	10.000	IFA	08/2011	11/2011
Total		55.000			

2.3.2 Task 2

Task 2 covers: "Investigation and modification, if applicable, of the HILS component testing (chapter 2)"

WP 2-1: Detailed review of the test procedure for obtaining HIL input parameter

A detailed review of the test procedure for obtaining parameters of the engine, electric motor and electric storage device of Heavy-Duty Hybrid Electric Vehicles, which are to be inputted in the HILS system. Check of the plausibility of the Japanese method of obtaining input parameters concerning engine, electric motor and electric storage device, and the definition of their specific characteristic.

WP 2-2: Analysis of improvements and relevant gaps concerning component testing

It is to verify if the Japanese component testing could be adopted for worldwide and European requirements. It is to determine, if all for worldwide regulations necessary parameters will be obtained within the Japanese component testing procedure.

WP 2-3: Improvements for future technological development

An analysis of necessary supplements for future hybrid-related components. Investigation, if the list of tested components could cover the future technological developments.

Tab. 2: Work packages task 2

WP No.	WP Title	Cost of WP in €	Partner	Start – MM/JJ	End - MM/JJ
1	Detailed review of the test procedure for obtaining HIL input parameter	15.000	IFA	04/2011	09/2011
2	**Analysis of improvements and relevant gaps concerning component testing**	15.000	IFA	06/2011	10/2011
3	Improvements for future technological development	15.000	IFA	08/2011	11/2011
Total		45.000			

2.3.3 Task 3

Not offered

2.3.4 Task 4

Task 1 covers: Inclusion of PTO operation, which normally takes place outside the test cycle.

In the time frame until January 2012 the development of a fully applicable methodology for PTOs can not be offered due to restrictions in the manpower available in 2011 at the Institute. However, options will be elaborated and the data demand for these options will be described. For one vehicle mission profile data will be provided as example. To obtain usage data for the various PTO applications needs a close cooperation with the OEMs and a coordinated data collection process. It is suggested to start this work after a proper option is selected to guarantee an efficient data collection and analysis work.

The method for a PTO benefit system has to be based on the HILS methodology which will be reviewed and, if applicable, modifies in Task 1. Assuming that the basic methodology of the Japanese HILS system will be followed, in task 4 following work will be performed.

WP 4-1: Options to simulate PTO power demand

Possible approaches to simulate PTO power demand in conventional HDV and in HDH according to different vehicle categories and mission profiles will be described.

One option will follow a bottom up approach (useful work of the equipment driven by the PTO as input), the second option will be based simply on an average power demand at the PTO.

WP 4-2: Options to transfer different engine work into a benefit system

A HDH allows the generation of the energy demanded at the PTO during phases of high engine efficiency or even from brake energy recuperation. Thus an advantage in fuel efficiency and also in pollutant emissions against conventional HDV can be achieved due to less demand of work from the combustion engine and operation at engine loads with higher fuel efficiency and/or lower specific pollutant emissions.

In WP 4-2 also a consultation of experts from the OEMs will be made to collect ideas for an efficient benefit system. The most promising approach will be elaborated in more detail to show the feasibility and the possible barriers which have to be overcome before such a procedure can come into force.

From today's point of view, options to be elaborated will be a simple "correction factor", based on the ratio of engine work from the HDH compared to the conventional HDV up to options to include PTO power demand into the HILS simulation to obtain a "PTO corrected" profile for the engine torque and engine speed. Since PTO power demand is not included in the standard WHTC test procedure explicitly, a detailed simulation of PTO corrected engine load profiles however seem to

WP 4-3: Collection of data for one vehicle mission profile

The data necessary to operate the option elaborated in WP 4-2 will be collected from existing measurements at TUG and at the OEM's. With this data the resulting "correction factors" will be assessed for the vehicles mission profile

Tab. 3: Work packages task 4

WP No.	WP Title	Cost of WP in €	Partner	Start – MM/JJ	End - MM/JJ
1	Options to simulate PTO power demand	10.000.-	TUG	04/2011	10/2011
2	Options to transfer different engine work into a benefit system	10.000.-	TUG	08/2011	11/2011
3	Collection of data for one vehicle mission profile	8.000.-	TUG	11/2011	01/2012
Total		28.000.-			

2.3.5 Task 5

Task 5 covers: "Development of WHVC weighting/scaling factors to represent real world vehicle operation".

The approach suggested is, to define weighting factors for the single WHVC parts, which result in similar distributions of vehicle speed and propulsion power as well as of their derivatives for the weighted WHVC as can be observed in typical driving situations for each vehicle category under consideration. This should also lead to representative engine load cycles for the HDH (alternative parameters to be considered can be discussed). This leads to the following WPs.

WP 5-1: Analysis of typical profiles for vehicle speed and propulsion power

Representative driving cycles can be gained from the work performed together with ACEA on the HDV CO2 certification procedure (chapter 1.2) for defined vehicle categories and mission profiles. Figure 1 shows the actual status of the foreseen classification scheme. Since in the HDV CO2 test procedure a representative engine load course for the vehicle which is certified seems to be crucial to get meaningful CO2 values for different vehicle categories, rather high effort is put into the classification and the corresponding driving cycles there.

These “representative cycles” will be used to calculate with the model PHEM the power demand to run the corresponding vehicles in these cycles in e.g. 1 Hz resolution. Then the frequency distributions for the power demand, the vehicle speed and their derivatives over time will be analysed together with the engine power and engine speed which is calculated for the conventional vehicles.

ACEA CO2 workgroup HD - TF2 - Mission

Cycle/Mission Classification Trucks– *Summary Table ≥ 7,49 t*

Vehicle cycle/mission	Description	Payload factor*	Average yearly run distance (km)
Long Haul	Delivery to international sites more than one day trip	75%	135.000
One daytrip	Delivery to national/international sites on a 1 day trip.	75%	115.000 (1 shift) 160.000 (2 shifts)
Regional delivery/collection	Regional delivery of consumer goods from a central warehouse to local stores (innercity or suburban, also mountain road goods collection, ...)	50%	60.000
Urban delivery/collection	Distribution in cities or suburban sites of consumer goods from a central store to selling points.	50%	40.000
Municipal utility	e.g. garbage trucks, road sweepers, ...	50%	25.000
Light off road-construction zone	Construction site vehicles on light mission (e.g concrete mixers) 10% off-road	50%	60.000
Off-road use -heavy off road	Construction site vehicles on heavy missions. 60% off-raod	50%	40.000

*) weight for CO2/FE-simulation = individual overall curbweight** + (payloadfactor x maximal individual payload***)

**) depending on the vehicle class 3 different vehicle configurations are possible : tractor+semitrailer or rigid+body+trailer or rigid+body OEM's provide only the tractor or rigid curbweight

) maximal individual payload = vehicle class specific reference weight* – individual overall curbweight

****) reference weight = vehicle individual GVW or GCW released by OEM but maximal up to legal limit

Figure 1: draft vehicle classification scheme from the HDV CO_2 procedure (source ACEA)

WP 5-2: Elaboration of weighting factors for the different parts of the WHVC

The WHVC will be split into different parts (urban, road, motorway, if necessary further splitting in sub-cycles) and for each of the sub-cycles similarly to the method in WP 5-1 a simulation with PHEM and the analysis of the frequency distributions of the resulting courses of propulsion power demand, the vehicle speed and their derivatives over time together with the engine power and engine speed will be performed.

Then for each vehicle category defined in Figure 1 (or if necessary a modified classification scheme) weighting factors for the WHVC sub-cycles will be calculated, which result in the same frequency distribution for the weighted WHVC as the original “representative driving cycles”.

For the validation a model of a Hybrid city bus will be run in PHEM or in a similar simulation tool in the WHVC and in the representative original cycles and the resulting engine load patterns as well as the simulated fuel consumption and raw exhaust gas NOx emissions will be compared.

WP 5-3: Elaborate option(s) to use the HILS method also in the HDV CO_2 certification procedure

It seems to be crucial to harmonise the HILS method and the HDV CO_2 certification method already in an early stage of the work. The actual project seems to be the best (because actually the only) carrier for such a harmonisation.

Since both methods are similar to a large extent, harmonised data sets for generic values and for default values could allow a simple application of the HILS tool also for the calculation of the CO_2 emissions from HDH.

Two options will be analysed:

a) Applying the original driving cycle and the driving resistance data of the actual vehicle instead of the WHVC and the generic vehicle data as input into the HILS tool to simulate fuel consumption and thus CO_2 emissions per vehicle kilometre.

b) Applying the specific fuel efficiency value gained from the HILS tool with the weighted WHVC and with the generic vehicle data as input into the HDV CO_2 tool. Most likely the fuel efficiency has to be normalised to the useful propulsion work [g/kWh-work at the driven axis] to consistently depicture the advantages of the HDH architecture against the conventional vehicle.

From the results a proposal for harmonisation of the two test procedures will be elaborated where ideally the results from HILS can be used as input into the HDV CO_2 certification procedure.

Tab. 4: Work packages task 5

WP No.	WP Title	Cost of WP in €	Partner	Start – MM/JJ	End - MM/JJ
1	**Analysis of typical profiles for vehicle speed and propulsion power**	14.000.-	TUG	04/2011	12/2011
2	**Elaboration of weighting factors for the different parts of the WHVC**	6.000.-	TUG	10/2011	01/2012
3	**Optional: Elaborate option(s) to use the HILS method also in the HDV CO2 certification procedure**	21.000.-	TUG	04/2011	01/2012
	Total including options	41.000.-			

Best regards,

Prof. Bernhard Geringer