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IEE/11/935/SI2.615943

REPORT

D4.3: Evaluation Report

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Version: - final (January 2015)

- 2nd version (November 2013)
- 1st version (January 2013)

Advanced Training and Education for Safe Eco-driving of Clean Vehicles

Co-funded by the Intelligent Energy Europe Programme of the European Union

1 Evaluation of safe eco-driving training programmes – Introduction

In order to determine the quality and impact of the safe eco-driving training programmes for clean vehicles of the IEE project ACTUATE, an evaluation plan was developed. The following evaluation report describes the implementation of the planed evaluation activities during the course of the ACTUATE project (see D.4.1).

Evaluation in ACTUATE is manifold. The partnership looked at the specific project objectives (e.g. the development of high-quality training programmes for safe eco-driving of clean vehicles), what was predicted (IEE performance indicators) and actually accomplished (evaluation of outcome) and how something was accomplished (evaluation of development/introduction process of training programmes). Thus, evaluation meant on the one hand something **formative**, something taking place during the development of the training programmes, e.g. through early drivers feedback to training materials or "pilot" trainings to improve the concept, organisation, quality or effectiveness of the safe eco-driving training programmes. On the other hand, evaluation in ACTUATE was mainly **summative**, drawing information of short-term and long-term impact of the trainings and lessons learnt from the completed training programmes or at a later point in time (e.g. impact of motivational in-house campaign).

Furthermore, to be able to compare the outcomes of the training programmes among partners or, respectively, PT companies, it was necessary that evaluation results of each involved PT company implementing the training programmes were of high quality and produced good and clear results. For this to happen, the evaluation processes in ACTUATE was harmonised in several ways:

- The general approach for evaluating the training quality and energy consumption was consistent across the ACTUATE partner sites. The before-and-after comparisons were carried out consistently.
- The indicators used for measuring the training impacts were consistent across the ACTUATE partners (e.g. use of the same scale for questionnaires, same data template for energy consumption measurements, i.e. kWh/km; see example for trolleybus in Annex III). However, this was not supposed to prevent partners from having their own additional local indicators for evaluation and assessment of the training programmes at the local level.
- The methods of measurement were consistent across all ACTUATE partner sites or, at least, produced widely comparable results. This was ensured in all cases, with the

exception of evaluating the impact of the local motivational in-house campaigns. Different concepts were realised here.

Against this background of manifold requirements and key questions for designing an evaluation programme, the ACTUATE partners considered the purpose, target groups, methods and sources that could be used to obtain data, time and financial resources of the evaluation approach. As a result, the ACTUATE project built its training programme evaluation on the model developed by Kirkpatrick (1994). In the late 1950s, Kirkpatrick introduced a framework for evaluating trainings using 4 levels of measurement, which have been added by a 5th level "Return on Investment" (RoI) Phillips (2003) to justify the cost of training based on ROI and organisational impacts:

- ***Reaction*** – a measure of satisfaction (what the learners thought and felt about the training);
- ***Learning*** – a measure of learning (the resulting increase in knowledge or capability as reflected in the end of the course assessment);
- ***Behaviour*** – a measure of behaviour change (extent of behaviour and capability improvement as reflected on the job performance);
- ***Results*** – a measure of results (the effects on the institutional environment resulting from the learners' performance);
- ***Long-term impact*** – a measure of RoI and intangible outcomes (focus on monetary values such as return on investment)

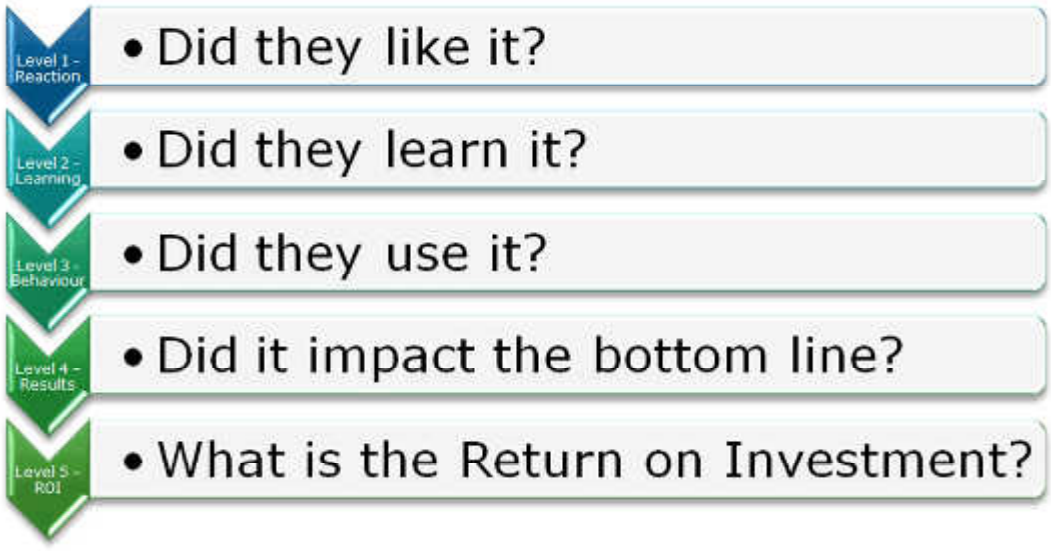


Figure 1: ACTUATE evaluation levels for safe eco-driving training programmes for clean vehicle drivers (according to Kirkpatrick's model 1994)

The ACTUATE evaluation approach followed the amended model of Kirkpatrick considering the five levels not as interdependent hierarchical levels, but as different

levels evaluating the safe eco-driving training programmes for drivers of clean vehicles from different "angles". Combining different quantitative and qualitative data collection methods (e.g. interviews, observations, questionnaires, and energy consumption measurements) and using them for the different levels of Kirkpatrick's model, has ensured a triangulation that increased the validity of our ACTUATE results.

2 Evaluation of safe eco-driving training programmes – Implementation

Formative Evaluation

The objectives or aims of formative evaluation in ACTUATE are the following:

- To improve the quality of the safe eco-driving training programmes for clean vehicle drivers from the beginning
- To determine whether the training programmes meet the defined minimum criteria, training objectives and learning outcomes
- To identify potential strengths and weaknesses of the safe eco-driving training programmes for clean vehicle drivers from the beginning

The formative evaluation in ACTUATE is based on the following principles/activities:

- Early involvement of drivers to receive feedback on training concepts and materials, e.g. to make the training material more understandable (in particular for drivers with foreign mother languages, or to get feedback regarding timetable and size of group (with regard to timing of practical part) for one training session).
- Review of the training concepts/materials by the involved and external PT companies to ensure a continuous improvement process regarding quality of trainings and materials (till the final agreement by ACTUATE partners on "general" training concepts and materials)

Summative Evaluation

Transferred to the ACTUATE context, the essential evaluation questions to be addressed on the five levels of the ACTUATE evaluation framework are illustrated in the table below:

Level	Measurement focus	Questions addressed
Reaction	Driver's perception	What did drivers think of the safe eco-driving training programmes?
Learning	Knowledge/skills gained	Was there an increase in

		knowledge or skill level of the trained drivers?
Behaviour	Worksite (the driver's workplace, line operation) implementation	Is the new knowledge/skill being used on the job/in line operation by the trained drivers?
Results	Business impact on organisation (Public Transport Company)	What effect did the safe eco-driving training have on energy consumption of clean vehicles?
Long-term impact	Return on investment and intangible outcomes	Were the benefits/impacts greater than the cost for the safe eco-driving training programmes? Was there a reduction of greenhouse gas emissions through safe eco-driving of clean vehicles? What effect did the safe eco-driving training have on the drivers' workforce satisfaction? Are there corporate image benefits through improved passenger satisfaction?

The following provides an overview of planned evaluation activities on the five levels of the ACTUATE evaluation framework for safe eco-driving training programmes for clean vehicles:

Level 1 - Reaction

The involved public transport companies measured the drivers' satisfaction through a feedback questionnaire (5 questions to be answered by each driver at the end of the training session, see Annex I) to identify the trained drivers' reaction of what they thought and felt about the safe eco-driving trainings.

However, even though a positive feedback is no indicator that the drivers have learned new skills or gained new knowledge about safe eco-driving principles, it was certainly a valuable filter for bad training as negative reactions can certainly hinder learning.

- **Measurement focus**: Drivers reaction and perception to/of trainings
- **Question(s) addressed**: What did drivers think of the safe eco-driving training programmes?
- **How do we measure that**: Questionnaires after training sessions

Evaluation results:

Questionnaires were distributed among the drivers after trainings were carried out in order to find out about the drivers' perception. As becomes visible in the graphic below, 90% of trained drivers evaluated the quality of the ACTUATE trainings as either excellent or very good. In addition to these highly-positive results, almost 90% of all drivers evaluated the topic safe eco-driving as either "very relevant" or "relevant" for the public transport operator they are working for. About 80% of the drivers found the training to be (very) relevant for their daily work. These are exceptionally good results with respect to the perceived usefulness and quality of the trainings.

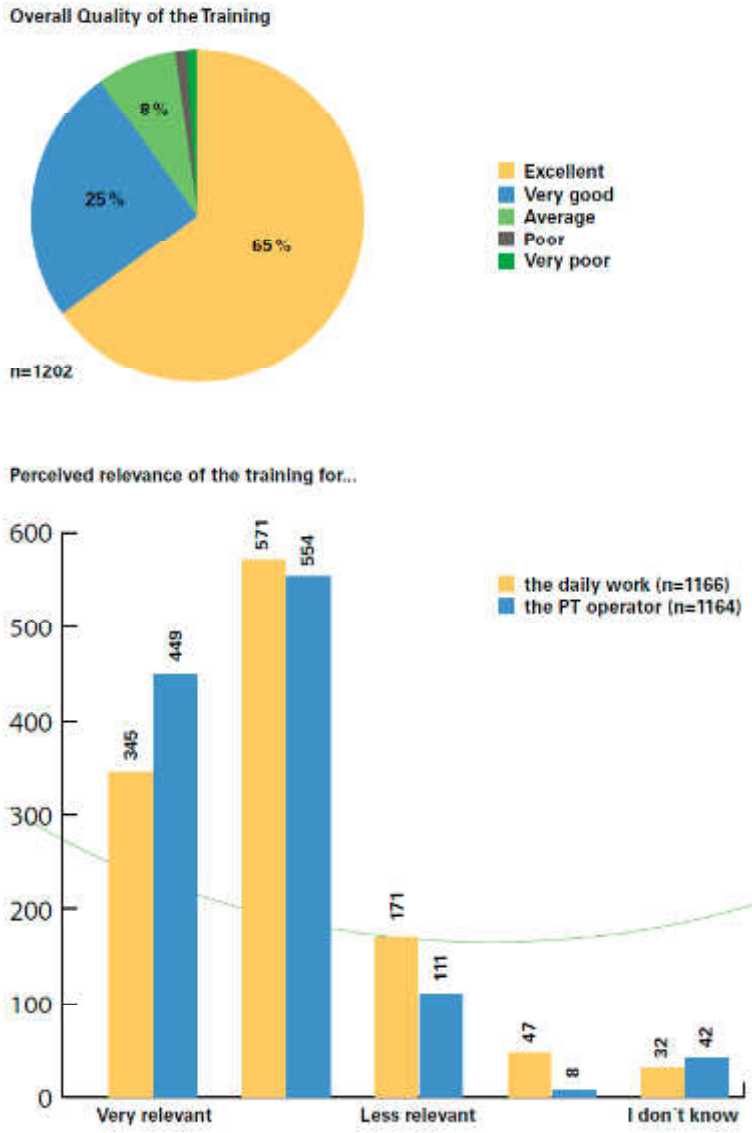
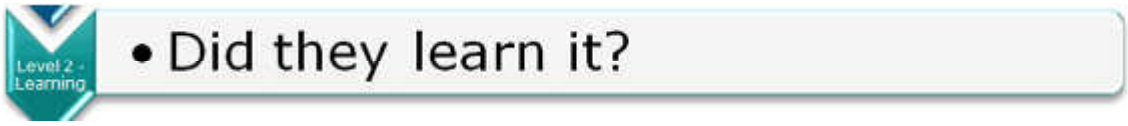


Figure 2: Driver's feedback on the trainings carried out in the ACTUATE project.

Level 2 - Learning



The learning outcomes for the safe eco-driving trainings in the EQF-categories skills and knowledge pre-defined by the ACTUATE partners were basis for the evaluation of how much the drivers have learned. As the safe eco-driving trainings did not foresee any tests, the main method to evaluate whether the driver has learned new skills in terms of safe eco-driving techniques was the measurement of energy consumption during the practical part of the trainings, where the energy consumption of the clean vehicle was measured and recorded by customised software and subsequently displayed on a protocol (see Annex III). Thus, learning success through the application of a new skills and knowledge with regard to eco-driving could be measured during two practical driving sessions related to the comparison of driving behaviour and its impact on energy-efficiency/consumption before and after theoretical input of safe eco-driving principles (see also Training Concepts of involved PT companies, D3.2).

Again, although it is useful to know that the drivers have gained new skills and knowledge through the safe eco-driving trainings, a positive outcome does not mean that the drivers will use the newly learned skills when they are back on the job, i.e. in line operation. However, the energy consumption measurements and the before and after comparison give a clear indicator, if a driver has gained new skills and knowledge and demonstrates the (theoretic) potential of safe eco-driving principles for energy savings.

- **Measurement focus**: Knowledge and skills gained by drivers
- **Question(s) addressed**: Was there an increase in knowledge and/or skill level of the trained drivers?
- **How do we measure that**: Energy consumption measurements during trainings (before and after comparison)

Evaluation results:

All ACTUATE partners carried out energy consumption measurements during the trainings. In order to be able to compare the energy consumption of drivers, the measurements were carried out twice, one time before and one time after the training took place. During the first training session, all energy consumption measurements were still made without the drivers having been educated in the principles of eco-driving.

Only in the second "hands-on" session, the drivers started to apply in practice what they had learnt in theory before. This way, the comparability of the data measured was ensured. Our results show that energy savings during the training varied according to mode of transport and city. In Parma, the trolleybuses showed energy saving potentials that ranged between 4-18%. In Leipzig the energy savings varied according to vehicle type from 13-44% for trams. For hybrid buses the average savings were 10,34%. In Salzburg the average energy savings for trolley buses was 20%. For Eberswalde, the average trolley bus savings were 6,4%. Our partner DPMB estimated average energy savings of 7,6% for trolley buses and 3,4% for trams in Brno. Here, the measurements were carried out differently since the time differential was longer between the two measuring points (about two months). Thus, the numbers from Brno refer more to the next section in which the question is asked whether the drivers made use of an eco-driving style in the long-term.

Protokoll der Testfahrten bei der **ACTUATE** *- Weiterbildung*

Trainer: Pilz

Datum: Samstag, 17. Januar 2015 **O-Bus:** 056

Strecke:		nur 1. Fahrt km-Stand	km	1. Fahrt Uhrzeit	Zeit	2. Fahrt Uhrzeit	Zeit	Durchschnitts-Verbrauch / KWh/km vorher	nachher	Ergebnis
		Abfahrt		Abfahrt		Abfahrt				KWh
1. BH Nordend - HS Boldtstraße, *FR Finow*		208.00	5	9:25	0:14	12:50	0:15	1.72	1.64	-0.08
		Ankunft		Ankunft		Ankunft		Einsparung/ Mehrverbrauch in %		%
Fahrer	Bugdahn, Peter	213.00		9:39		13:05		4.7		95.3
		Abfahrt		Abfahrt		Abfahrt				KWh
2. HS Boldtstr., *FR Finow* - HS Brandenb. Allee		213.00	5	9:40	0:10	13:05	0:12	1.51	1.48	-0.03
		Ankunft		Ankunft		Ankunft		Einsparung/ Mehrverbrauch in %		%
Fahrer	Kriegel, Gerd	218.00		9:50		13:17		2.0		98.0
		Abfahrt		Abfahrt		Abfahrt				KWh
3. HS Brandenb. All. - HS Schöpf. Str., *FR Markt*		218.00	4	9:50	0:10	13:17	0:10	1.48	1.41	-0.07
				Ankunft		Ankunft		Einsparung/ Mehrverbrauch in %		%
Fahrer	Lüdtke, Mario	222.00		10:00		13:27		4.7		95.3
		Abfahrt		Abfahrt		Abfahrt				KWh
4. HS Schöpfurter Str.., *FR Markt* - HS Ostend		222.00	4	10:00	0:15	13:27	0:14	1.72	1.53	-0.19
		Ankunft				Ankunft		Einsparung/ Mehrverbrauch in %		%
Fahrer	Zenker, Hartmut	226.00		10:15		13:41		11.0		89.0
		Abfahrt		Abfahrt		Abfahrt				KWh
5. HS Ostend - HS Boldtstr., *FR Finow*		226.00	5	10:20	0:18	13:44	0:13	1.68	1.46	-0.22
		Ankunft		Ankunft		Ankunft		Einsparung/ Mehrverbrauch in %		%
Fahrer	Lawerenz, Ronny	231.00		10:38		13:57		13.1		86.9
		Abfahrt		Abfahrt		Abfahrt				KWh
6. HS Boldstr., *FR Markt* - BH Nordend		231.00	5	10:43	0:15	14:00	0:13	1.68	1.56	-0.12
		Ankunft		Ankunft		Ankunft		Einsparung/ Mehrverbrauch in %		%
Fahrer	Vegelahn, Maximilian	236.00		10:58		14:13		7.1		92.9
						Durchschnittliche Gesamteinsparung:		7.1		

Figure 3: Protocol from our partner BBG from Eberswalde and measuring device of driver's test rides during the ACTUATE trainings.

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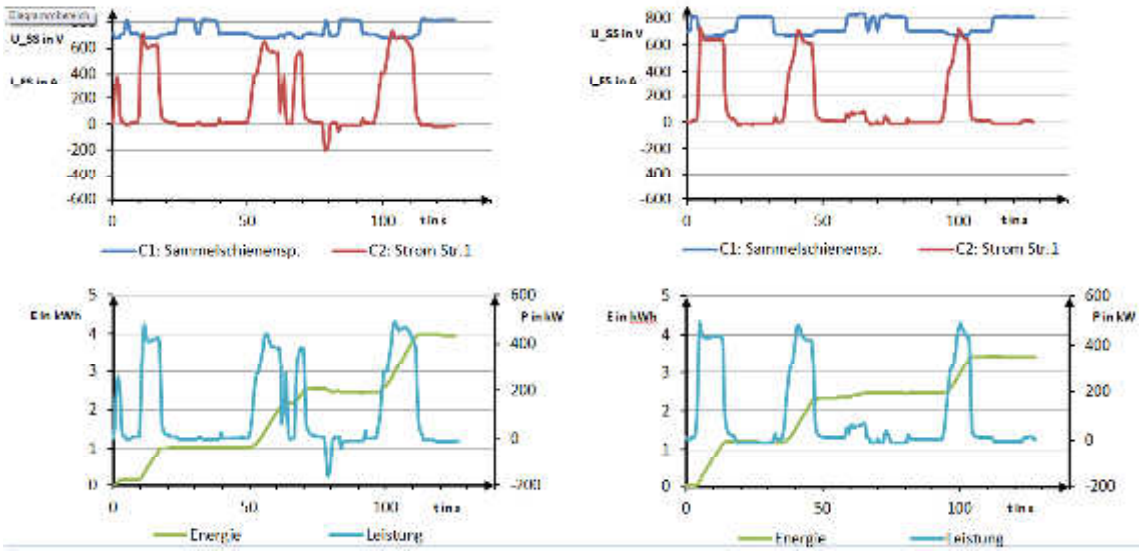

Figure 4: Example tram evaluation before and after the trainings from Leipzig (left: bad driving behaviour, right: good driving behaviour)

Level 3 – Behaviour

This level measured the extent to which the drivers applied the new knowledge and skills on the job. The evaluation at this level was difficult as it was often impossible to predict when a change in behaviour would occur and thus required a well-thought-through evaluation approach, e.g. when, how often or how to evaluate.

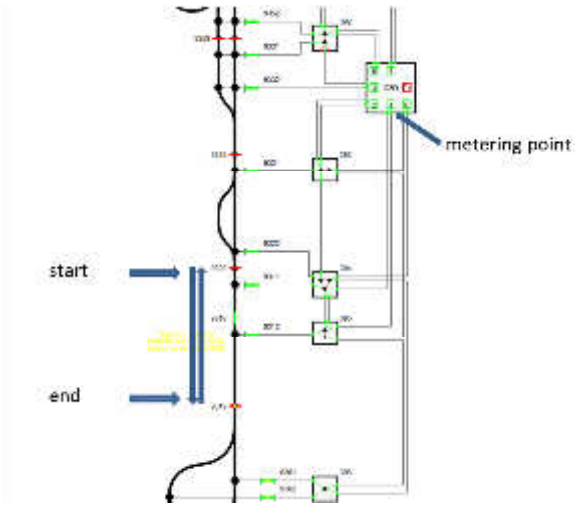

Figure 5: Example of a measurement section used by our partner LVB in Leipzig. The length of the section was around 850 metres long and included 2 tram stops in each direction.

Furthermore, the ACTUATE partners discussed problems that could occur and hinder reaching a clear picture of the effect of trainings on the energy consumption (as the main evaluation indicator). It was necessary to think this well-through as the chosen measuring method, measuring energy consumption at certain rectifier substations (on a chosen line section), is not only influenced by the driving behaviour, but several other framework conditions, which cannot be influenced by the trainings or the drivers respectively (see figure below).

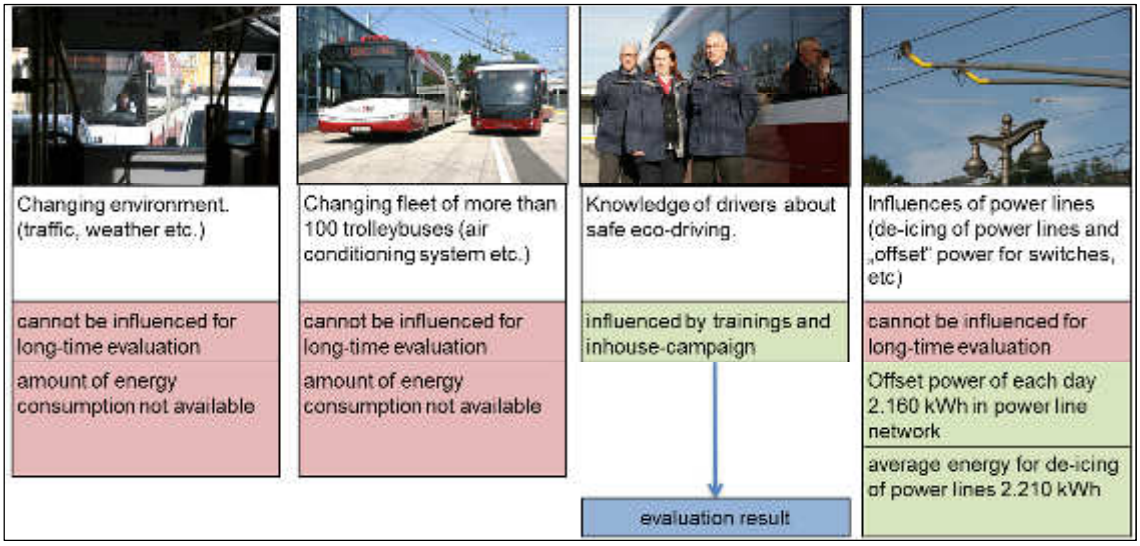

Figure 6: Overview of external influences having an impact on long-term energy consumption measurements in ACTUATE (example from Salzburg)

Even though it was difficult to separate external influences (e.g. traffic or weather conditions) from the impact of the driving style of drivers, all public transport companies involved in the ACTUATE project have measured the energy consumption of their clean vehicle fleets over a period of several weeks to months, either on a single vehicle or on line basis (measuring the energy consumption between two selected network/rectifier sub-stations), before the implementation of the safe eco-driving training programmes. By this, the energy consumption (where possible shown separately for the energy use of the drive train, e.g. exclude side auxiliaries) of the clean vehicle fleets was measured before the training programmes for safe eco-driving started and could be used as a baseline for comparison to after –training effects. For this, the public transport companies measured energy consumption of trained drivers on chosen vehicles/lines in operation again after the training programmes. Even though these long-term before and after comparisons of energy consumption are influenced by several dependencies at this evaluation level, the results were a sound indicator for the usage of safe eco-driving by the trained drivers on the job.

The consideration of external influences affecting the transfer of or application of trained/learned safe eco-driving principles at the drivers workplace was very important to determine from case to case whether there was a case for non-transfer of learning or level 2 respectively. Therefore, the ACTUATE partner SAG added to the quantitative data basis of energy consumption (the measurement of energy consumption of trams is most difficult) qualitative observation data to focus on the driver's performance. SAG integrated "good" safe eco-driving criteria into their quality assessment of drivers. This was carried out by quality "inspectors" travelling with the drivers "en route" and observing the driver's performance. These quality "inspectors" looked for certain criteria such as implementation of high rolling times, use of the electric brake or purposeful use of auxiliary units.

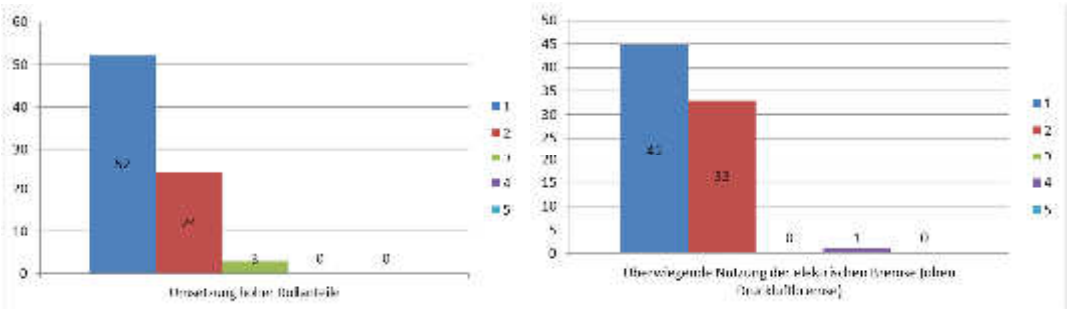

Figure 7: Qualitative driver's evaluation by SAG – Idling times and use of the electric brake in Salzburg.

In addition, there is a certain risk that the transfer of new skills and knowledge is only effective on the driver's short-term memory. To limit this "risk", the ACTUATE partners developed in-house motivation campaigns in order to motivate drivers to apply and retain their newly acquired eco-driving skills. All ACTUATE partners designed motivational in-house campaigns, which ranged from bonus programmes to internal team competitions, e.g. "driver of the month", and incentives related to short knowledge tests (partly based on e-learning modules).

The impact of each single in-house campaign element on level 1 "reaction" and level 2 "learning" was evaluated by the involved PT companies (see described concepts for in-house campaigns in D5.1 Dissemination Plan). The impact on level 3 "behaviour" was cross-checked with results of energy consumption measurements for the period after the campaign activity.

- **Measurement focus**: Driving behaviour, application of skills and learning, implementation at worksite (the driver's workplace, line operation)
- **Question(s) addressed**: Is the new knowledge/skill being used on the job/in line operation by the trained drivers?

- **How do we measure that**: Pre- and post-training energy consumption measurements, driving behaviour observation

Evaluation results:

As can be seen in the energy savings overview below, the ACTUATE partners achieved an average of 4,5% reduction in energy consumption. This result varied across all cities and partners, ranging from 2,5-3% for trams in Brno and Leipzig to 6,4% or 6,5% respectively for trolleybuses in Eberswalde and Brno.

	Approximate annual costs for energy to operate clean vehicle fleets (in EURO)	Average energy savings – based on long-term evaluation	Money savings (in EURO)
Eberswalde (Trolleybus)	353.303	6.4%	ca. 22.500
Salzburg (Trolleybus)	540.000	6%	ca. 32.000
Leipzig (Trams)	7.000.000	3%	ca. 210.000
Leipzig (Bus)	5.625.000	4%	ca. 225.000
Brno (Tram)	3.043.370	2.5%	ca. 76.000
Brno (Trolleybus)	1.126.950	6.5%	ca. 73.250
Parma	300.000	4%	ca. 12.000
Total money savings for ACTUATE partners			ca. 650.750
Average energy savings		4.6%	

Figure 8: ACTUATE average energy savings based on long-term evaluation

Level 4 – Results

At this level, the ACTUATE partners evaluated the success of the safe eco-driving programmes for clean vehicles in terms of reduced energy consumption and consequently cost savings for the operation of the clean vehicles. Besides the cost savings for the public transport companies, the indicator of reduced accidents through an anticipatory and forward-looking driving style, which is an elementary factor of safe eco-driving, was supposed to be measured as a "result" of safe eco-driving training programmes for clean vehicles. However, it was very difficult to evaluate this dimension of safe eco-driving in the very short project period. For a sounds analysis of the consequences of eco-driving on the number of accidents a longer period of time

would be needed with a substantial dedication of time and resources to this topic only. For now, we can only say that the concept of eco-driving involves a very defensive driving style. Thus, it is to be assumed that this could also have positive effects on the numbers of accidents.

- **Measurement focus**: Business impact on organisation (Public Transport Company)
- **Question(s) addressed**: What effect did the safe eco-driving training have on energy consumption of clean vehicles?
- **How do we measure that**: Calculations of cost savings based on identified (if possible) energy savings through energy consumption measurements

Evaluation results:

In total, the money savings projected for all ACTUATE partners will be 650.750€ per year. This has been calculated on the basis of current annual costs for energy to operate the existing fleet and the average energy savings. Again, the money savings per city vary according to mode of transport, operational costs for energy and vehicle fleet. As only one example, Leipzig will have the biggest savings potential due to their quite big current operational costs.

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Parma	300.000	4%	ca. 12.000
Total money savings for ACTUATE partners			ca. 650.750
Average energy savings		4.6%	

Figure 9: ACTUATE partner money savings calculated for one year

Level 5 - Long-term impact

For the long-term impact, the ACTUATE partners assessed the monetary benefits of the training programmes for safe eco-driving of clean vehicles (see level 4 "results" above), including further tangible benefits like reduction of abrasion effects on clean vehicles, which are of importance due to high cost per unit for clean vehicles, and on the needed infrastructure in case of trolleybus or tram systems. These monetary benefits were compared to the cost for the development and implementation of the safe eco-driving trainings (based on experiences made by the ACTUATE partners).

Besides the suggested ROI view, the ACTUATE partners also included intangible outcomes of the safe eco-driving training programmes like corporate image benefits through improved passenger satisfaction (there were 2 questions dedicated to the passengers perception of safe eco-driving to be integrated into regular annual/bi-annual marketing/passenger surveys of the involved PT companies, see Annex II). The ACTUATE partners did a questionnaire survey hereby getting the opinions of more than 4000 people. As can be seen in the figure below, passengers really appreciate the eco-driving intentions of our project partners and would even, at least the majority of people, accept slightly longer travel times for that.

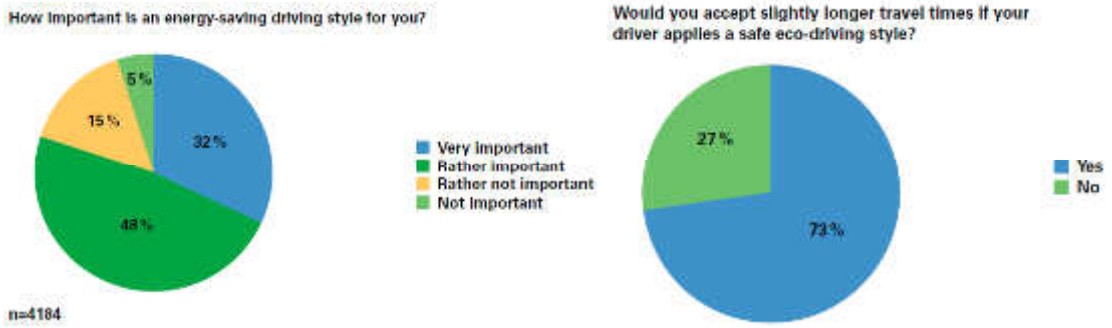

Figure 10: Passenger survey on the perceived importance of eco-driving

Another presumed and intangible outcome was the reduction of the employee's illness status, as for example in Germany the tram driver job has the highest status of employer's illness at present. During the project lifetime we received from several drivers the feedback that eco-driving and the emphasis on "looking ahead" has a very positive impact on their well-being and stress-level. Ultimately, this might result in

health benefits that could result in monetary benefits due to the current high sick leave rates. It was impossible for us, though, to further research this. Just as much as with the effects on numbers of accidents, the effects of eco-driving on stress-levels would need to be analysed more substantially in a long-term study.

A further evaluation indicator, of utmost importance for IEE projects is the environmental impact of ACTUATE's trainings through reduced GHG emissions. Therefore, ACTUATE had clear targets on reduction of greenhouse gas emissions defined in the common performance indicators of the Intelligent Energy Europe programme.

The long-term impact evaluation on reduced greenhouse gas emission was also based on the energy consumption measurements before the implementation of the training programmes in the course of the ACTUATE project. As a baseline, 2020 scenarios have been developed for each involved transport company: an "optimistic" (6% reduction of energy consumption) and a "realistic" (3% reduction of energy consumption) scenario (see D6.1 Set of IEE Common Performance Indicators).

- **Measurement focus**: Return on investment and intangible outcomes
- **Question(s) addressed**: Were the benefits/impacts greater than the cost for the safe eco-driving training programmes?; Was there a reduction of greenhouse gas emissions through safe eco-driving of clean vehicles?; What effect did the safe eco-driving training have on the drivers' workforce satisfaction?; Are there corporate image benefits through improved passenger satisfaction?
- **How do we measure that**: survey on passenger perception of safe eco-driving, calculations of GHG emission reductions based on energy savings through energy consumption measurements (in case of adequate results on level 3), workshop based on a use-oriented cost-effectiveness evaluation approach enabling a monetary assessment of investment measures and intangible impacts (NOWS approach)

Evaluation results:

The ACTUATE consortium members from Salzburg, Leipzig, Parma, Brno and Eberswalde as well as the industry partner van Hool made a cumulative investment of about 682.000 EURO into the development of the safe eco-driving programmes for clean vehicles. This includes all costs, also spent on measurement equipment, printing of training materials and the accompanying implementation of in house motivation campaigns (but without project management cost and overhead rates).

This one-time investment pays off already almost one year after the implementation of the safe eco-driving trainings, as the companies can save about 650.000 EURO per year in total (see table above). The following example shows the cost-benefit ratio for the LVB in Leipzig, which trained 1.350 drivers (750 tram and 600 bus drivers) in safe eco-driving (supported by a driving school partner from Leipzig). As can be seen, Leipzig saves 435.000€ per year but only had to invest one time only 130.000€.

	Costs in EURO: (mainly personnel cost)
Training development and introduction	40.000
Training implementation	50.000
Training monitoring and evaluation	20.000
In house motivation campaign	20.000
Drivers personnel cost[4]	-
Total cost:	130.000

	Benefits:
Energy saved (tons of oil equivalent / year)	299
CO_2 emissions avoided (tons / year)	1.597
Money saved (EURO / year)	435.000

Figure 11: Cost-benefit ratio for ACTUATE project partner Leipzig

	Tram	Trolleybus	Hybrid Bus	Total
Number of vehicles in ACTUATE's partner fleets	635	261	19	915
Total annual energy consumption of vehicles before the action (kWh)	105.113.225	30.846.829	5.987.800	141.947.854
Annual energy consumption after trainings with 4,5% savings (kWh)	100.383.130	29.458.722	5.718.349	135.560.201
Energy saved during the ACTUATE project (kWh)	4.730.095	1.388.107	269.451	6.387.653

Figure 12: Energy savings per year by ACTUATE partners based on a 4,5% scenario

Based on the overall reduction of energy consumption by 4,5% as a result of the eco-driving trainings applied in ACTUATE's public transport partner companies, this leads to primary energy savings of 549 tons of oil equivalent per year and a reduction of 2.938 tons of greenhouse gas emissions per year. Projected by 2020 (starting from 2015) the ACTUATE partners would save primary energy savings of 3.294 tons of oil

equivalent by 2020 and a reduction of 17.628 tons of greenhouse gas emissions by 2020. Thus, ACTUATE partners will save nearly 18.000 tons of greenhouse gas emissions by 2020 through the application of safe eco-driving of their clean vehicle fleets. With about 190 tram, 150 trolleybus and approximately 50 cities operating hybrid, battery-powered or hydrogen-fuelled buses in Europe, there is vast potential to upscale the effects of the ACTUATE project.

3 Formative Evaluation

The objectives or aims of formative evaluation in ACTUATE were the following:

- **To improve the quality of the safe eco-driving training programmes for clean vehicle drivers from the beginning on**

In order to assess the overall quality of the safe eco-driving training programmes, the ACTUATE partners distributed questionnaires among the drivers after trainings were carried out. 90% of trained drivers evaluated the quality of the ACTUATE trainings as either excellent or very good. Almost 90% of all drivers evaluated the topic safe eco-driving as either “very relevant” or “relevant” for the public transport operator they are working for. About 80% of the drivers found the training to be (very) relevant for their daily work. These are exceptionally good results with respect to the perceived usefulness and quality of the trainings.

- **To determine whether the training programmes met the defined minimum criteria, training objectives and learning outcomes**

Generally speaking, the **overall aim of the trainings**, to impart knowledge, enhance skills and provide expertise in energy-efficient, eco-friendly and safe driving of clean vehicles was achieved. This can be seen when a) comparing the post-training with the pre-training results showing that drivers applied the new skillsets and knowledge acquired through our trainings. However, not only were these new skills made use of in the short-run but also in the long-term. This can be seen by looking at the impacts our trainings had. ACTUATE project partners are estimating an average total energy reduction of 4,5% on average per year.

The **requirements of the trainings** were to some large extent fulfilled. The *trainings on eco-driving maximised the energy savings* for our PT partners by optimizing fuel consumption and energy recuperation. The average reduction of 4,5% per year was a quite good success in this regard.

The *training material for safety aspects of clean vehicles* was produced for each vehicle type and received with great interest.

Likewise, *training material for specific bus types and tram control technology* was produced taking into account such hybrid bus differences as serial and parallel drive systems or the energy efficient supercaps technology for trolley buses. The latter received substantial recognition in our trolley bus brochures. In our tram brochures we also elaborated on chopper control and foot pedals (in contrast to set-point devices) that enable trams to perform an even, energy efficient acceleration and braking.

The *pre-instruction and briefing of trainers and technical experts by bus and tram manufacturers about specifica of vehicle types* was only partially fulfilled. There was generally an introduction and exchange when the vehicles were handed over from manufacturers to PT operators. However, an in-depth introduction including lessons about how to eco-drive were only carried out by our ACTUATE partners VAN Hool and TEP.

As a last requirement, it was specified that *trainings were only carried out for drivers that are on duty of clean vehicles.* This was only relevant since Parma and BBG only have a small percentage of clean vehicles in their vehicle fleet. In Salzburg, Leipzig and Brno this is entirely different since all drivers are, at least to some degree, operating clean vehicles.

Regarding **the content of the training**, the ACTUATE consortium agreed to provide information on various very specific topics related to the eco-driving of clean vehicles.

(A*) Information about dangerous high voltage parts in the vehicles*:

For trams this topic is being dealt with in the chapter "Vehicle control and energy supply" in the brochure (p. 15-22) and the "Driving practice" chapter in the presentation (p. 17-29). For trolleybuses you can find information in the brochure in the chapter "The trolleybus system" (p. 14-22) and in the presentation in the chapter "Working principle of the trolley bus system" (p. 20-28). For hybrid buses you can information in the "Safety" section in the brochure (p. 6 and 7) and in the presentation in the chapter "Safety aspects on hybrid buses" (p. 38-44).

(B) *Information about energy flow in vehicles and characteristics of electrical parts and losses (incl. energy consumption of different aggregates, e.g. heating and air-conditioning technology)*

For trams the topic energy flow is being covered in the presentation in the section "Basic knowledge" (p. 4-15) and in the brochure in section 3 "Vehicle control and energy supply" (p. 15-23). For trolleybuses there is information in the brochure in the

section “Economic driving with trolleybuses” (p.22-27), especially including a section on “Conscious use of the heating, air-conditioning and ventilation system”. In the presentation there is a special page on “Conscious use of heating and air-conditioning” (p.46). For hybrid buses there is useful information in the brochure in the chapters 3 and 4 (p.8-11) and in the presentation in the “Basic knowledge” section (p. 14-27).

(C) *Information about the ideal drive-cycle between stops:*

The ACTUATE consortium provided good information about the ideal drive-cycle or driving curve for trams in the brochure in the chapter “Factors influencing energy consumption” (p. 8-14) and in the “Basic knowledge” section in the presentation (p. 5-16). For trolleybuses there is information in the brochure in the chapter “Driving conditions” (p. 12 and 13) and in the presentation in the chapter Eco-driving a trolley bus” (p. 31-46).

(D) Information about interrelation of economics and safety and driving style:

For trams there is information in the presentation in the section “Who benefits from eco-driving?” (p. 3). For hybrid buses information is provided on page 7 “3 rules of eco-driving” and on pages 11 and 12 “Who benefits from eco-driving?” For trolleybuses information was compiled in the presentation on page 54 “3 rules of eco-driving”.

(E) *Information about behaviour in the event of malfunctioning or accidents:*

For trams the topics malfunctioning/ accidents are covered in the brochure on page 24 “Malfunctions” and in the presentation in the chapter “Safety aspects for trams” (p. 30-33). For trolleybuses there is information in the “Safety” chapter in the brochure (p. 28-32) and in the presentation on the pages 50-52. For hybrid buses there is information in the brochure on page 12 in the “Training” section and in the “Safety” section in the presentation (p. 38-44).

(F) *Information about environmental impact*:

For trolleybuses there is information about the environmental impact in the “Economic driving with trolleybuses” section in the brochure (p. 22-27) and on page 10 in the “Energy source – e-mobility” section. For trams there is useful information in the “Basic knowledge” section in the presentation (p. 5-16). For hybrid buses there is useful information in the presentation in the “Basic knowledge” section (p. 14-27).

(G) *Information about efficient braking and accelerating:*

For trolleybuses there is information in the brochure in the chapter “Energy-efficient braking with the electric brake” (p. 25) and in the presentation in the chapter “eco-driving a trolleybus” (p. 32-46). For trams information was gathered in chapter 2

"Factors influencing energy consumption" (p.8-14) and in the "Basic knowledge" section in the presentation (p. 5-16). Relevant information for hybrid buses is provided in the brochure in the chapter "Relevant factors" (p. 6-7) and in the presentation in the chapter "Basic knowledge" (p. 14-27).

Regarding the **learning outcomes of the trainings**, it can be said that mostly all drivers achieved an energy reduction during the measurements through a better understanding of the eco-driving style and a consequent energy efficient braking and accelerating. For example, the trolleybus operator TEP from Parma achieved ca. 18% energy reduction in their test rides realising an energy reduction of 0.26kWh/km. This was reached in particular by using the retarder more often which was one of the very crucial observations made by our ACTUATE project partner Van Hool during the trainings.

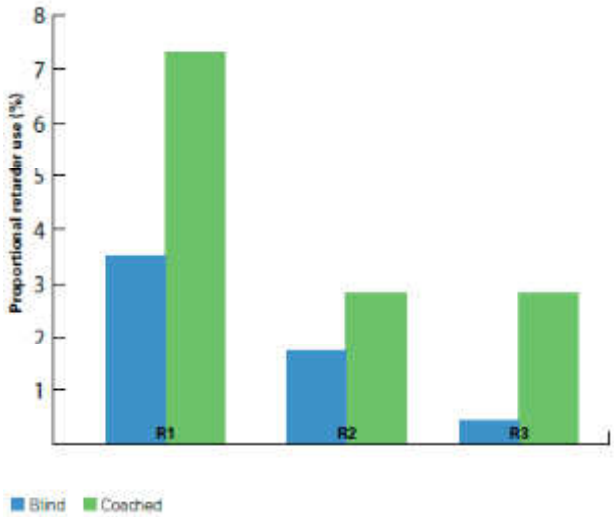

Figure 13: Increase of retarder use during coached eco-driving training rides with trolleybus drivers in Parma.

Generally speaking, a savings potential of around 20% on average was achieved by the trained drivers. Thus, the increase in skills and competence was evidenced here. Drivers clearly showed the ability to apply their newly acquired knowledge about ideal drive-cycles between stops including topographic conditions. However, this was the only knowledge-dimension that could be proved through our measurements. For all other knowledge-dimensions (e.g. about kinematic chain, about behaviour in the event of malfunctioning or accidents, etc.) we cannot provide a direct proof since we did not test these learning objectives with clear controlling measurements. Only our partner SAG from Salzburg did actual knowledge-tests with the drivers after the trainings, as part of their in-house campaigns. As can be seen in the graphic below, most drivers were able to retain the knowledge gained during the trainings (e.g. on using the electric brake or the optimal energy-efficient driving cycle).

Figure 14: Example questions asked by our partner SAG in Salzburg after the trainings had been carried out. The answers marked in red are the right ones.

Below is an example provided for the learning outcome description on "Efficient braking and accelerating to optimise energy-efficiency of clean vehicle types".

Example for learning outcomes description

Learning Topic	Safe eco-driving
Learning Objective	Efficient braking and accelerating to optimise energy-efficiency of clean vehicle types
Directive 2003/ 59/EC objectives (according to Annex I)	1.3: ability to optimise fuel consumption (by applying know-how with regard to points 1.1 and 1.2) 1.1: to know the characteristics of the transmission system in order to make the best possible use of it (curves relating to torque, power, and specific consumption of an engine etc.) 1.2: to know the technical characteristics [...] in order to control the vehicle, minimise wear and tear and prevent malfunctioning (limits to the use of brakes and retarder, combined use of brakes and retarder, making better use of speed and gear ratio, efficient ways of slowing down and braking on downhill stretches)

Learning Topic	DE	AT	IT	CZ
Reference to National Qualification Frameworks	Level 1 German Qualification Framework (Berufskraftfahrer) = level 4 in EQF;	N/A	N/A	N/A
National specifics	In-house training organised by the employer is allowed; training programme and details of module must be in compliance with BKrFQG; practical driving is not compulsory and simulators may also be used.	In-house training organised by the employer is allowed; use of simulators is not allowed; practical driving is not compulsory.	In-house training organised by the employer is allowed (but only for companies with at least 80 employees); practical driving is not compulsory.	In-house training organised by the employer is allowed; practical driving is not compulsory

Learning Outcomes		
Skills	**Knowledge**	**Competences**
• To be able to drive electric powered clean vehicles in an energy efficient and safe way; • To be able to brake and accelerate in the most energy efficient way	• Knowledge about kinematic chain/energy flow electric power train; • Knowledge about the ideal drive-cycle between stops incl. topographic conditions; • Knowledge about characteristics of electrical parts and losses	• Ability to apply knowledge about ideal drive-cycle between stops and recuperate highest possible amount of energy based on knowledge about topographic conditions

Figure 15: Learning outcome example.

With respect to the **educational principles of the trainings**, the ACTUATE consortium made use of the "Experiential Learning Model" developed by Kolb. This "experiential" approach means that learning is relating to or resulting from experience. The ACTUATE pilot trainings for trolleybuses, hybrid buses and trams showed that the biggest "aha-experiences" for learners (drivers) were achieved during the practical sessions of the first ACTUATE trainings for safe eco-driving. The drivers learning effect was mainly based on concrete driving experiences regarding the comparison of the old driving behavior and testing the new eco-friendly driving style (incl. the debriefing with actual energy consumption data).

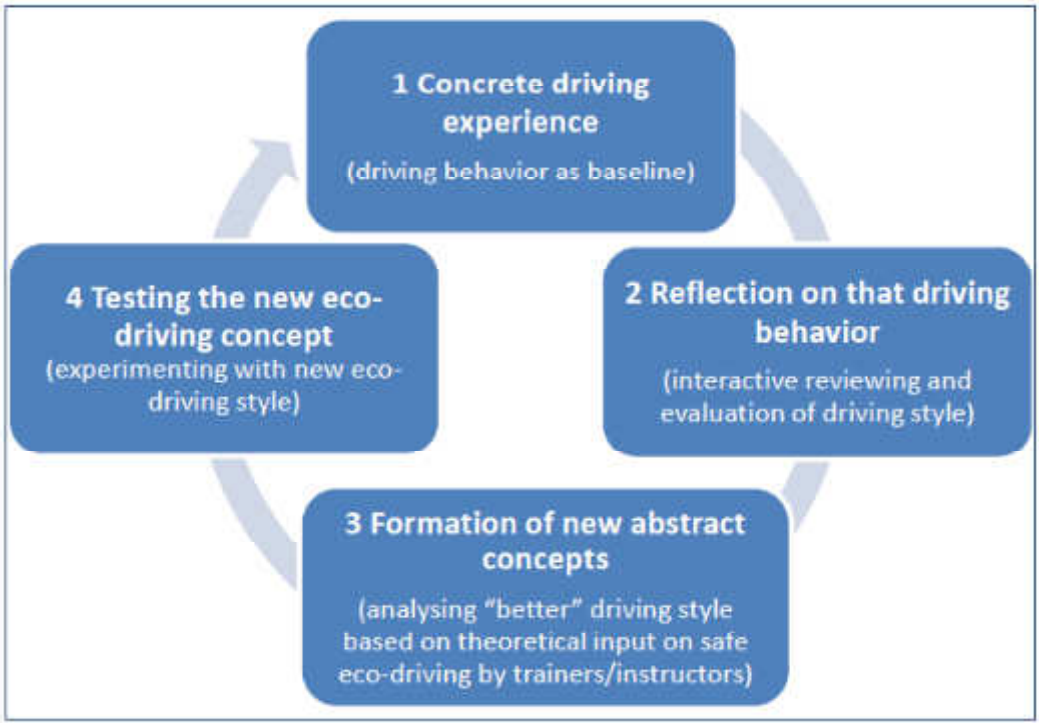

Figure 16: ACTUATE's experiential four stages learning cycle (adapted after Kolb's learning cycle)

Based on this approach, the ACTUATE consortium came to the conclusion that in order to experience the difference and the impact of the new safe and eco-friendly driving behavior, each driver should have two short practical driving sessions to enable a comparison between the "old" driving style and the "new" eco-friendly driving style. Therefore, the practical part of the trainings should take approximately half of the time of the total training session (depending on the size of learner groups). To support the learning effect and to have evidence for the impact of the "new" driving style on energy-efficiency optimisation of the clean vehicle, the practical sessions should be evaluated together with the drivers by measuring the energy consumption and discussing the results during the training courses.

- **To identify potential strengths and weaknesses of the safe eco-driving training programmes for clean vehicle drivers from the beginning**

Strengths - What went well?

One of the things that went really well in the project was the development of the trainings and trainings material. This implied not only to produce the material for the different clean-vehicles but also to operating the trainings and evaluating them thereafter. Furthermore, the project consortium was very successful in defining minimum criteria.

Also, the ACTUATE consortium put a heavy emphasis on the involvement of the senior management. Thus, the support for our eco-driving initiatives was always ensured, e.g. in order to run pre-tests, carry out the trainings or develop in-house campaigns to motivate all drivers. This early-on commitment and involvement by all levels was of very high importance in order to be successful with the trainings.

Another successful element was the in-house campaigns carried out by all project partners in order to raise awareness and motivate the drivers to adapt an eco-friendly driving style. It is particularly noteworthy that our partners came up with very different campaigns that were all successful. As only two extraordinary examples, the driver-personalized image campaign run in Parma and the green driver license carried out in Leipzig were very convincing and successful.

Weaknesses - What went not so well?

It needs to be mentioned that the measurements proved to be more difficult than could be anticipated. First and foremost, the acquisition and calibration of the equipment was very time and resource-consuming. Often, products lacked the expectations and requirements our partners had on them. This was the case, for instance, when data was too diffuse and not specific enough in order to wholesomely measure the different energy consuming units. For the project it was necessary to be able to separate between influencing factors and differentiate the driver's impact from other potential factors.

Related to that is the necessity to think about external influences and factors from early on. The ACTUATE partners tried to "exclude" external factors in their analysis as much as possible. But as the trainings themselves were a pilot project, it was not always easy, for example, to run trainings exactly during the same months during a year. And even if this could be realized, weather conditions could of course not really be influenced. This "exclusion" of external influences and determining factors has been considered from very early on by the ACTUATE partners. They planned their local evaluation activities as best as possible against this background. However, the long-term impact evaluation

of “pure” eco-driving effects would have needed more time and in, particular, a very good measurement equipment, which could not be realised within ACTUATE.

Also, it proved to be very difficult to involve other partners from the industry. Often companies showed a very reserved and cautious attitude towards the ACTUATE project since one industry partner (Van Hool) was directly involved in the project. Their caution can mostly be explained by data protection issues and the reluctance to working with direct competitors. This should have been anticipated from very early on.

A last difficulty was encountered when carrying out the in-house campaigns. It should be known from the onset which incentives can be given to drivers. For example, our partner LVB in Leipzig was not able to actually realize some of the incentives promised to the drivers because of tax reasons and concerns from the workers council. Thus, such important organizations as workers councils should be involved from a very early stage on when introducing eco-driving measures in a given organization.

References

Kirkpatrick, D. (1994): Evaluating Training Programs: the four levels. San Francisco.

Phillips, J.J. (2003): Return on Investment in Training and Performance Improvement Programs. 2nd Edition, Butterworth-Heinemann, Burlington.

Annex I: D4.2: Evaluation questionnaire on quality and relevance of safe eco-driving trainings:

Evaluation form: ACTUATE training (EN)

Dear employee/ colleague,

With your help we would like to check up on the quality of our education and training programme. We would appreciate if you can take some time to go through this questionnaire and answer the following questions:

1. **How do you assess the overall quality of the training**?
   1 excellent/ 2 very good/ 3 average / 4 poor/ 5 very poor

   1 2 3 4 5

   remarks:…….

2. **Were you already aware of the topic of Eco-Driving before the training**?

   Yes, through…….. No

3. **How do you rate the relevance of this topic**?
   very relevant/ relevant/ less relevant/ not relevant/ I don't know

   - for the public transport operator: 1 2 3 4 5

   - for your daily work routine: 1 2 3 4 5

4. **How do you assess the quality of the written training and education material being used**?

   Amount/scope: exactly right/ too little/ too much/ useless/ did not receive any
   Quality: very good/ good/ sufficient/ poor/ very poor

How do you assess the content of the training and the way it was brought across?
1 excellent/ 2 very good/ 3 average / 4 poor/ 5 very poor

1 2 3 4 5

Annex II: D4.2: Evaluation questions on passenger perception of relevance of safe eco-driving trainings:

1. How important is for you the fact that your bus /tram driver is applying an energy-efficient and eco-friendly driving style (eco-driving)?

   Answer options:
   very important, rather important, rather unimportant, absolutely unimportant

2. Would you be willing to accept a slightly longer travel time when a safe eco-driving style is applied by the driver?

Annex III: D4.2: Example for energy measurement data protocol for practical part of safe eco-driving trainings (trolleybus, SAG):

Energieverbrauchsanzeige Protokoll

Cegelec Transport

Fahrername	Osterer
Fahrzeugnummer	308
Datum	01.06.2012
Fahrtstrecke	Kommunalfriedhof - Birkensiedlung - Kommunalfriedhof
Bemerkungen	Reifendruck +10% an jeder Achse vom ideal
	Halt an allen Haltestellen

Summenwerte:

Parameter	Zählerstand	
Messdauert	**0,21**	Std.
Distanz	**5,80**	km
Durchschnittsgeschwindigkeit	**31,53**	km/h
(für den Zeitraum wenn das Fahrzeug eine Geschwindigkeit größer Null hatte)		
Gesamt aufgenommene Energie	**10,73**	kWh
(elektrische Arbeit) aus der Fahrleitung		
Gesamt rückgespeiste Energie	**2,06**	kWh
(elektrische Arbeit) in die Fahrleitung		
Summe aus gesamt aufgenommener Energie	**8,67**	kWh
(elektrische Arbeit) aus der Fahrleitung minus gesamt rückgespeister Energie in die Fahrleitung		
Gesamt verbrauchte Energie für Antrieb	**9,92**	kWh
Gesamt produzierte Energie für Antrieb	**3,65**	kWh
Gesamt verbrauchte Energie für Hilfsbetriebe	**1,22**	kWh
(Lenkung, Kompressor, Batterieladung)		
Gesamt verbrauchte Energie für Heizung	**0,00**	kWh
Gesamt aufgenommene Energie pro gefahrenem Kilometer	**1,85**	kWh/km
Gesamt rückgespeiste Energie pro gefahrenem Kilometer	**0,36**	kWh/km
Summe aus gesamt aufgenommener Energie pro gefahrenem Kilometer	**1,50**	kWh/km
(elektrische Arbeit) aus der Fahrleitung minus gesamt rückgespeister Energie		
Verbrauch Fahrbetrieb pro gefahrenem Kilometer	**1,08**	kWh/km

Co-funced by the Intelligent Energy Europe Programme of the European Union