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Energy Efficiency Engagement Training in SMEs: A Case Study in the Automotive Sector

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Abstract: Energy efficiency requirements in Europe are set by the Energy Efficiency Directive, considering energy audits as a systematic procedure to determine the savings in energy costs. These kinds of tools provide useful information for companies to identify opportunities for the improvement of their energy performance. However, the regulation is only applied for non-SMEs in Europe, which make up only 0.2% of the total number of European companies. Compared in terms of the value added or the number of employees, these companies are still at a lower percentage than small and medium enterprises. The wide versatility of small companies, however, makes it difficult to determine a regulation that promotes the objective of the Directive in a uniform way. For this reason, one aspect that is being worked on with small companies is raising awareness and training in energy aspects, encouraging them to carry out activities to improve their energy performance based on their own initiative. In this regard, within the framework of an H2020 research project based on the automotive sector, the E2DRIVER project, a collaborative–cooperative training methodology has been designed to motivate and empower the key actors within a company. This paper describes the methodology and its implementation in different companies in European countries, providing some representative results.

Keywords: energy efficiency; energy audits; automotive sector; energy efficiency awareness; SMEs; industrial sector

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1. Introduction

The E2DRIVER, "Training on energy audits as an Energy Efficiency DRIVER for the automotive sector", project is an H2020 research project within the topic LC-SC3-EE-8-2018–2019—Capacity building programs to support implementation of energy audits in SMEs. The E2DRIVER project is an improvement of the INDUCE program [1], which in its conclusions determined that the methodology can be a very useful tool to promote energy efficiency in a company of any industrial or service activity in Europe, due to its flexibility and adaptation to any environment. In addition, it improves the results of the actions carried out [2]. In this case, the methodology developed is implemented in SMEs in the automotive sector.

The European Energy Efficiency Directive (EED) 2012/27/EU required member states to use energy more efficiently at all stages of the energy chain and, in particular, at the industrial and services level [3,4]. The 2012 Directive, as amended in 2018, sets rules and obligations for the EU's energy efficiency targets. In December 2018, the amended Energy Efficiency Directive (EU) 2018/2002 entered into force, updating some specific provisions from the previous Directive and introducing several new elements. An energy efficiency target of 32.5% was set, compared to projections of the expected energy use in 2030. In absolute values, these targets translate into a final energy consumption of

956 Mtoe and/or a primary energy consumption of 1273 Mtoe in the EU-28 in 2030 [5]. The industrial sector currently accounts for 26.1% of the total final energy consumption. The automotive value chain represents a direct consumption of 3.6 Mtoe [6,7]. Automotive suppliers represent an interesting area within automotive production chains, since they produce 75% of the vehicle value, with an annual turnover of EUR 600 billion [8]. Providing 13.8 million jobs (direct and indirect), the automotive industry is a key EU employer. Due to its strong economic links to many other industrial sectors, it has an important multiplier effect in the economy. On the other hand, energy audits are currently only obligatory in non-SMEs, making it difficult to achieve the objectives set by the European Directives. In addition, the automotive sector is historically characterized by a hierarchical structure, with a small number of major manufacturers or companies at the top of the pyramid and a deep ramification of smaller partners. For this reason, the project proposes the implementation of the E2DRIVER methodology in SMEs considered as tier 1 and tier 2 suppliers in the automotive sector, as well as extrapolating it to other sectors later.

The main objective of this paper is to present the results of the application of the training methodology based on the concept of "Ontological Flip Teaching" in a real industrial environment [9], specifically applied to energy efficiency training for students linked to productive companies in the value supply chain of the automotive sector. The E2DRIVER methodology is designed to flexibly introduce an applied energy culture to workers at all levels of an organization. The result is the training of a certain number of employees so that they are able to autonomously implement a continuous energy culture with routine follow-up and obtain energy efficiency results applied to their real process needs.

The E2DRIVER methodology was tested and validated in thirty-five companies from the automotive supply industry in four countries that represent over 50% of the EU employees in this sector: Spain, France, Italy, and Germany. Moreover, a total of 54 trainers, 45 external and 9 internal, were certified in the E2DRIVER training methodology, which will ease the replication of the project results and the business consolidation of the E2DRIVER platform.

Section 2 of this document presents the implementation phases of E2DRIVER training and the underlying methodology. The virtual reality used in the face-to-face sessions is also shown. Section 3 describes the main qualitative and quantitative results achieved during the project, after the completion of the training in the E2DRIVER companies. Section 4 discusses the obtained findings and finally provides a set of conclusions. Finally, Section 5 shows the overall conclusions of the project and the implementation phase.

2. Literature Review

2.1. SMEs in Automotive Supply Chain

Small and medium-sized enterprises (SMEs) represent more than 99% of all businesses in the EU and a similar trend can be observed in the automotive sector [10]. As a result, SMEs account for a large part of the industrial activities involved in vehicle manufacturing, with a 26% share of the sector [11].

The hierarchical structure of the automotive sector is represented by a pyramid with a few companies at the top and a deep ramification of supplier companies supplying them [12]. In the following, the main players in the automotive sector are described in hierarchical order [13]:

- Original equipment manufacturers (OEMs): companies involved in the design, marketing and assembly of the final product;
- Tier 1 suppliers: companies working close to the OEMs, producing mainly automotive-grade hardware, doors, bumpers, brakes, wheels, gearboxes, powertrain, transmission and steering systems, etc.
- Tier 2 suppliers: companies supplying electrical and/or electronic machinery and equipment, metal products, communication machinery and equipment, bearing assemblies and pumping units not directly to OEMs;
- Tier 3 suppliers: supply raw materials (metals, plastics and glass).

Tier 1 suppliers have increased their specific weight over the years, including in the design process at the global level, by increasing connections with car assemblers [14].

However, it should be noted that automotive suppliers, which consume around 88-92% of the total energy needed in the manufacturing process, dominate the energy consumption of the entire sector, while assemblers are less energy-intensive [15].

Companies are often involved in different supply chains at the same time, so that a company category changes with the market, and it could be a Tier 1 in the automotive chain and a lower tier supplier in another sector [16]. Automotive suppliers represent an interesting area within the automotive production chain, as they produce 75% of the value of vehicles, with an annual turnover of 600 billion euros. Despite this production share, it should be noted that in the past, Research and Innovation (R&I) expenses were only 1/3 covered by suppliers in 2007, while the remaining part was supported by the OEMs. The situation has reversed over the years and the suppliers' effort is expected to reach 2/3 of the total amount, as reported by the European Association of Automotive Suppliers [17]. CLEPA, which represents more than 3000 SMEs, also estimates that the European supply industry annually invests more than EUR 20 billion in research and innovation through the registration of several patents and the introduction of a wide range of products and solutions on the market.

In terms of the composition of the final product, the production of a car consists mainly of the body shop, paint shop and final assembly, where the vehicle is built with its body, chassis and transmission system [18] using electricity and fuel as energy carriers. Fuel is used for direct heating or to produce the steam used in painting, space heating and car washing. Electricity is used during assembly phases in painting, heating, ventilation and air conditioning, lighting, compressed air systems, welding and generic material handling [19].

2.2. Importance of Energy Efficiency for SMEs in Automotive Sector

Section 1 described the need to introduce regulations and incentives to improve the energy efficiency of non-SMEs. Currently, regulations only affect non-SMEs by obliging them to carry out regular energy audits, which represent less than 1% of the total number of companies in the EU [20]. However, in the sectoral study on energy efficiency improvement, a significant reduction in the specific consumption of both SMEs and non-SMEs has been observed. No separate data are available.

As the complexity of vehicle production has increased with the growing demand for safer, cleaner and smarter cars, this also affects energy demand during production. However, energy consumption per car produced has been reduced by 16.9% since 2005 (Figure 1), demonstrating that the automotive industry is continuously working to improve the energy efficiency of production [20]. The reported value of 2.3 MWh of energy consumed per car produced in 2018 is in line with values published by Oh et al., in 2014 [18]. However, if a complex supply chain is included in the contribution, the total energy consumption related to the car manufacturing industry will be considerably higher: Energy-intensive supply chain processes include, for example, the production of raw materials, such as steel, aluminium, plastics and glass; the forming and manufacturing of parts, components and subsystems; the assembly of hundreds of these elements to make the vehicles; and the distribution and sale of the vehicles [18].

Figure 1. Energy consumption during car production in automotive industry (source: ACEA, 2019 [20]).

2.3. VR in Training

VR is currently used in different areas of research, industry and academia. VR platforms offer the possibility for people to interact with simulated environments and achieve pre-implementation learning in real cases. The main advantage of VR is its ability to present complex information in a way that is accessible to diverse audiences in an engaging and easy-to-understand format [21]. VR can deliver individualized content and experiences, facilitating and enhancing the delivery of effective outcomes such as knowledge transfer [22]. VR is more than a form of entertainment and is currently used for areas such as education [23], medical training [24], tourism [25], and sports coaching [26].

3. Materials and Methods

3.1. E2DRIVER Methodology and Training Phases

As mentioned above, the aim of the E2DRIVER project was to make SMEs in the automotive sector more aware of the benefits of implementing energy audits, as well as consider their recommendations. The reason why an action towards this objective is necessary is due to different factors, among which we can highlight the fact that European SMEs are not legally obliged to carry out audits; the inability of some companies to see that they have a range of actions in energy management, and that this management can have important impacts on their profit and loss accounts; a considerable lack of time; lack of staff; prioritization of other business aspects; high investment costs, etc. [27].

Considering all of these factors, and especially the lack of a legal obligation [28], it was concluded that the way to encourage the use of energy audits was through training and awareness-raising actions. Hence, the E2DRIVER project was born. This project emerged as an awareness-raising tool that proposed different pedagogical, methodological, and focus innovations, and was refined during the project to become a tool fully focused on the purpose explained above.

As defined in Deliverable 4.4 of the E2DRIVER project, the methodology is "a way of generating and executing Capacity building programs about energy audits and energy efficiency adapted to the needs and interests of the Automotive sector's companies". Therefore, it can be seen as the process of generating customized training schemes for companies.

However, it must be acknowledged that, although initially only this pedagogical approach was considered as part of the E2DRIVER methodology, in the fine-tuning process that took place after the pilot phase of the project, it was decided to include a consultancy

phase where an exercise of suggesting energy efficiency measures was performed. This was done for two main reasons: firstly, because it allowed the teachers to focus the training phase on the specific case of the company for the identification of specific energy efficiency measures, and secondly because this specific focus had a clear impact on the company to see first-hand that energy audits and thinking about energy efficiency can have an important impact on the company as a business in the short, medium, and long term.

All of these considerations have been further developed in the project and compiled in a guide for trainers, which will soon be made public in its final version. The purpose of presenting the E2DRIVER methodology in the form of a trainer's guide is primarily to disseminate as much as possible the way of working developed in the project, such that energy experts and training institutions can replicate the solution beyond the end of the project.

Having taken all this into account, the different phases of the E2DRIVER methodology are explained below [29].

Firstly, Phase I, Characterization, takes place, which consists of carrying out a study on a company where the solution is to be implemented to identify technical and nontechnical aspects that have an impact on the company's energy performance and from which measures can be taken. In this way, the entity is required to provide consumption data and identify key people in the process as well as the characteristics of its industrial process. It is also recommended that a preliminary list is made of the people that those conducting this study think should be trained.

In this Characterization phase, the company should be classified according to the level of energy efficiency existing before the training in order to adapt the interaction with the companies to the current level of the energy efficiency culture. In this way, companies can be classified into three groups: companies that have never carried out any type of efficiency-based action; companies with intermediate knowledge and implementation of measures; and companies with a long history and knowledge of efficiency projects.

Having studied the characteristics of the company and its workers in depth, we would move on to Phase II, Customization, where, starting from the resources developed in the project, a match is made between the needs/interests of the company and the training materials to create a definitive version of the training for this company. This customization process is conducted through two basic mechanisms: Firstly, so-called "Adjustment sessions" are carried out, which are direct meetings with the companies and are used to adjust the practical exercises and face-to-face sessions to the company's requirements. As for the online part, it is personalized through another mechanism that has been developed within the E2DRIVER e-learning platform (E2DRIVER.uv.es) and that allows for an automatic customization of the contents. This is an integrated algorithm that is displayed as a classifier test the very first time the trainees enter in the platform and suggests a specific training itinerary to trainees and, subsequently, makes specific materials appear and disappear according to the user's academic and professional background.

Once the training experience has been fully adapted to the company and each of its employees, Phase III, Implementation, can begin. Implementation will follow the Ontological Flip Teaching approach [9], which is a powerful pedagogical innovation that has underpinned the project since its inception. It consists of semi-face-to-face training, with 4 weeks of online training through the E2DRIVER platform in which the trainee has to consult the customized contents; 1 week of autonomous work in which the trainee has to generate an academic work, which in this project is focused on the identification of concrete efficiency measures for the company; and, finally, a series of face-to-face sessions in which the results of the autonomous work are shared and in which the trainer tries to guide the trainees to achieve a clear identification of potential energy improvements in the company. Additionally, in this face-to-face part, generic awareness-raising actions are carried out for plant operators.

After Implementation, Phase IV, Evaluation, begins, in which the trainees' performance is evaluated; immediately after, Phase V, Consultancy, is developed. In this consultancy

phase, the energy efficiency measures identified and the result of the sharing in the face-to-face sessions are taken into account in order to suggest and, eventually, implement specific energy efficiency measures. In this phase the company has a follow-up and support from the trainer (who is also an expert in energy efficiency), as well as specific recommendations that allow the company to verify the benefits of the measures.

3.2. Virtual Reality Training System

In the context of the project, the learning of content-related audit procedures was also supported by new technologies, such as virtual reality (VR). A so-called VR training system (VRTS) was developed, supporting self-training and the assessment of measuring procedures performed on an electrical switchboard that are typically part of an energy audit or power management inspection.

The inspiration for this activity came from considering that, besides requiring theoretical knowledge, audit procedures involve operations similar to those mentioned above, which are very practical. In order to acquire the necessary skills, traditional training materials may not be fully effective, and it has been demonstrated that VR can help [30,31]. In fact, with VRTSs it is rather easy to organize hands-on exercises that simulate scenarios that could expose the trainees to potential risks, or could require expensive, rare, or fragile instrumentation, which is actually the case of the considered domain; VRTSs also allow for the adapting of the training to the trainees' actual needs, delivering continuous advice and feedback in addition to monitoring his or her progress and outcomes in an objective and repeatable way [32–35].

The VRTS developed in the project focuses on the use of a measuring and data-logging tool to record the current, voltage, and power values of a virtual switchboard over a period of time by making all of the necessary connections and using the appropriate personal protective equipment (PPE) to avoid the possible risks associated with electric shocks and arcs.

After wearing a VR headset, the trainee is immersed in a virtual environment that reproduces (both visually and spatially) a generic electric room that can be found in a factory. The trainee faces the switchboard, and a voice-over starts, instructing him or her, step-by-step, on the operations to be performed, also highlighting with visual and aural cues relevant objects in the environment. The trainee can move (also physically) in the environment and interact with it by using the hand controllers of the VR kit. He or she should open the switchboard to assess its configuration; then, wearing insulating gloves and/or a protective helmet, use a tester to test the power line to be measured. Depending on the configuration, he or she may have to use insulating sheets on it. After this, the voice-over begins to instruct the trainee on how to connect the measuring tool to the switchboard using both voltage and current probes; the trainee needs to choose the proper probes based on the actual current values and cable sizes. He or she then has to configure the measuring tool, setting the chosen probes for voltage and current measurements, the monitoring period, and the sample interval; afterwards, he or she can also use the tool to ensure that all of the connections were made correctly, checking the phasors. He or she could then start the recording. In this way, the assessment of the energy consumption of the loads supplied by the switchboard is performed in the defined period of time. Before leaving the room, he or she must place a warning sign to inform about the presence of exposed active conductors. A screenshot of the VR environment is shown in Figure 2. Screenshot of the VR training environment: some of the connections between the measuring tool and the switchboard have been completed by the trainee, who is operating the hand controller to move in the virtual space and interact with its objects [32–35].

The functioning of the VRTS described above has been named the guided mode (GM), as it is meant for self-training; the devised VRTS supports also a second mode, named the evaluated mode (EM), in which the voice-over and cues are disabled, and the trainee is requested to perform the whole procedure autonomously. His or her actions are monitored, and, at the end, a report is generated that lists the possible errors made.

Within the project, the VRTS has been used with trainees from selected companies by asking them to first go through the GM and then the EM in order to assess the acquired knowledge and skills. Nevertheless, the VRTS could also be exploited in other ways: for instance, it is being used outside industrial settings with the students of engineering courses at the Politecnico di Torino university in Italy as a complement or an alternative to laboratory experiences in real electric rooms, or as a medium to support novel didactic modalities, such as, e.g., immersive learning-by-teaching experiences.

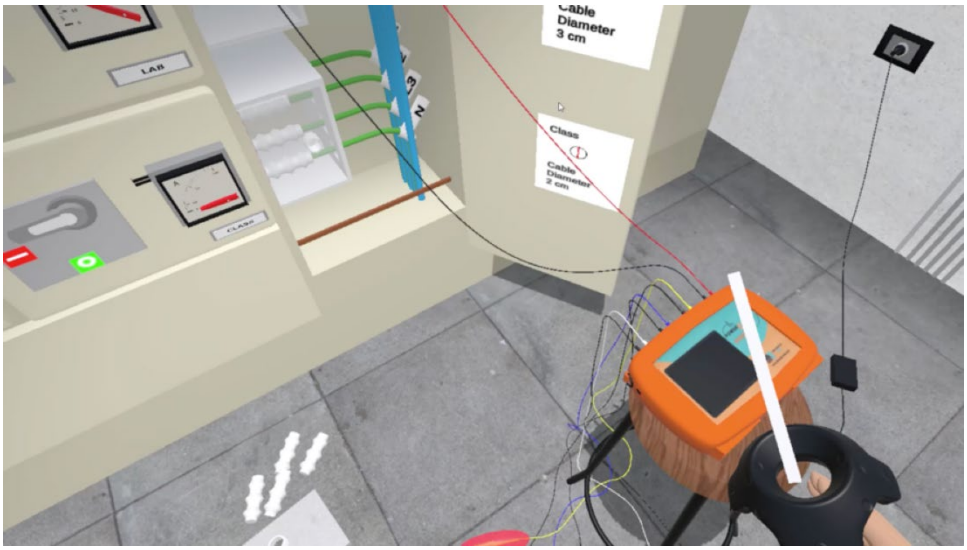

Figure 2. Screenshot of the VR training environment: some of the connections between the measuring tool and the switchboard have been completed by the trainee, who is operating the hand controller to move in the virtual space and interact with its objects.

4. Results

For the current situation at the European level, the results show there is not a deep characterization of the automotive supply chain regarding the structure and the specific energy consumption of each involved activity. However, as mentioned above, the automotive industry is one of the sectors with the greatest potential for improving its energy efficiency in the European Union [36]. According to the ACEA, continuous work on improving energy efficiency in the automotive sector has led to a reduction in energy consumption during vehicle production of 28.1% between 2005 and 2020 [6].

Currently there are no training courses that take into account the needs of the learner and the characteristics of the workplace. This paper introduces an innovative training methodology (Flip Teaching) in an industrial training environment. Trainees acquire knowledge directly related to the production processes of their industrial environment and energy efficiency. This customized and interactive training allows trainees to transfer their acquired training to their job responsibilities in order to optimize consumption.

This paper includes some of the monitoring results achieved in the E2DRIVER project regarding the energy, economic, and environmental indicators, as well as some organizational, behavioral, and sociocultural aspects.

The monitoring is part of Phase V (Consultancy). It is likely to be ignored once the training program has been carried out, but it is of great importance in the process, not only because it provides closure, but also because it provides very useful information for both the company and the trainer. If the company intends to implement certain measures, including training and raising awareness among its employees to achieve greater efficiency and to improve the energy performance, it needs to know if the actions taken were useful and how they can be improved. Alongside the continuous improvement process (plan–do–check–act or adjust) applied, for example, to energy management (ISO 50001:2018) [37,38],

the E2DRIVER methodology can be carried out once, but periodically addressed again, only in those aspects that are more relevant to the company's needs or that need to be improved. Furthermore, the monitoring does not only support the individual E2DRIVER companies, but also assures the continuous improvement and fine-tuning of the E2DRIVER methodology during the development phase of the project.

As already mentioned, an in-depth study of the automotive industry was carried out at the beginning of the project to establish a baseline [39]. This study showed a great heterogeneity of the sector, mainly due to the complex structure of the automotive supply chain with a wide range of products and the interaction of many stakeholders. This sector heterogeneity was also observed for the 35 pilot and replication companies participating in the E2DRIVER project, which cover different areas of production activities, such as electrical equipment, spare parts, design, etc. For instance, the annual energy consumption of the E2DRIVER companies ranged from less than 0.6 GWh up to more than 63 GWh (The average company consumes 7.7 GWh/year. Six of the thirty-five participating companies were officially non-SMEs, of which four with comparatively high energy consumption (more than 20 GWh/year) dominate the statistics. One of the non-SMEs participated only with a single site. If the five non-SMEs are excluded, the average energy consumption is about 2.6 GWh/year. Two of those companies belong to the German category "Mittelstand". These kinds of "Mittelstand" companies have between 250 and 499 employees, and they usually have similar challenges to SMEs. Therefore, the training concerning energy efficiency and energy audits needs to be similar.). Furthermore, the estimated energy savings ranged from less than 1% to nearly 50% for a quite ambitious company [40].

Yet, during the in-depth study at the beginning of the project, it could be observed that, unfortunately for the automotive sector and in particular the automotive supply industry, only scarce data were available, which made the definition of an initial benchmarking baseline difficult. This particularly makes sense when taking into account the fact that the automotive suppliers are often SMEs, where, as pointed out in the previous sections, energy audits are not mandatory. Moreover, due to the high competition in the supply chain, energy consumption data are often treated confidentially by the companies.

This paper tries to draw on the companies that participated in the project to close this data gap. In this sense, in addition to the nine pilot companies, the E2DRIVER project established a replication phase during the last period of the project, in which 26 companies from the automotive supply industry in Germany, Italy, Spain, and France were involved.

4.1. Energy, Economic and Environmental Impact

In terms of energy, economic, and environmental indicators, the resulting impact on the 35 companies involved was evaluated by the means of a "before-after-comparison". A first energy assessment was carried out before the start of the training during Phase I, followed by a subsequent second energy assessment after the end of the training to be able to know and compare the impact that Phase III could have on the different companies. While the latter took place about three months after the completion of the training for the pilot companies, such a time span was not feasible for the replication companies due to the end of the overall project. Hence, it should be taken into account that the estimated savings potential from the replication companies is based on planned and partially implemented energy efficiency measures rather than already implemented measures due to the short time span.

Thus, finally, the impact of the E2DRIVER project was evaluated considering a sample of valid data from 34 companies (Only one company, which participated in the training, did not share their data in the project due to internal data protection restrictions. The company was a non-SME that had already conducted two energy audits and whose motivation to participate in E2DRIVER was more about using the platform and training materials.). From this sample, the average values were determined, as shown in Table 1. Considering the great variations detected between countries in the previous in-depth study [39] and the general

lack of data for the automotive supply sector, the monitoring results of the E2DRIVER companies represent added value for future benchmarking approaches. Nevertheless, certain limitations have to be mentioned.

Table 1. Average impacts per year and per company of the E2DRIVER project (source: [40]).

Impact	Value/Enterprise	Unit
Investment	129,108	EUR
Energy savings (final energy)	697,540	kWh
Electricity	376,987	kWh
Natural gas	320,552	kWh
Energy savings (primary energy)	1123,147	kWh
Energy costs avoided	59,324	EUR
Electricity costs avoided	49,125	EUR
Natural gas costs avoided	10,199	EUR
Greenhouse gas (GHG) avoided (EU electricity mix)	127,310	$kgCO_2$
GHG avoided due to electricity	95,378	$kgCO_2$
GHG avoided due to natural gas	76,933	$kgCO_2$

Some of these limitations might be that companies are not static: the amount of production and the products are changing over time, and these facts impact the energy consumption. New machineries or production facilities might be installed, which are not triggered by the trainings. In addition, events might occur (e.g., layoffs) that might affect the social climate in the organization and the sociocultural dimensions addressed by the training. Indeed, the negative impact of the economic crisis following the COVID-19 pandemic and the energy prices' increase in the commitments of many companies, which were faced with rising costs and a lack of employees, must be taken into account. Additionally, due to the pandemic, 2020 and 2021 might not be representative years in terms of the companies' energy consumption, as there were, e.g., unplanned production shutdowns. This is why the companies were asked to estimate their energy savings on the basis of normal operation for the reference year of 2019. Moreover, due to the fact that the replication companies in particular only had a very limited time until the end of the project to make concrete decisions, planned and implemented measures had to be taken into account and their expected impacts had to be evaluated. Although the determination of energy savings is quite connected to the aforementioned uncertainties, it is assumed that via the close supervision through the project consortium and by addressing the person in the company who should know best (e.g., energy manager), a fairly robust dataset was obtained. However, due to the fact that the automotive supply industry is inherently very diverse in terms of products and processes, a definition of a representative sample might not entirely be feasible in general. Furthermore, the energy consumption of the companies is above the automotive industry average (2.2 GWh/enterprise in 2017 according to [41]), which has a direct influence on the savings. A direct transfer of the evaluation results to other companies is therefore only appropriate if they possess similar energy consumptions.

4.2. Organizational, Behavioral and Sociocultural Impact

Finally, as detailed from the beginning, the E2DRIVER project addresses not only energy but also cultural, behavioral, and organizational aspects.

In terms of organizational aspects, the companies were asked to assess 23 organizational aspects of two subject areas (Figure 2): (1) the general evaluation of energy management and KPIs as well as (2) the basic check of energy control, including aspects in the areas of policy, procedures in place, training, and actions. For each aspect, the status of implementation at the time before the training has been assessed as follows (fully implemented: 3 = green, partially implemented: 2 = yellow, and not implemented: 1 = red). During the training, some or all of these aspects identified as relevant for the training were addressed. After the training, the same aspects were questioned again. The changes

in scores work as indicators for the success of the training regarding the organizational aspects. Thereby, each change in the scores of the aspect is monitored, which means that it is considered if an aspect was not or partially implemented before and how its status was changed by the training. A look at the aspects that have improved after the training in the 34 companies with valid datasets (Figure 2) shows a total number of improved scores of 345, i.e., a total score of 10.1 per company, providing a clear indication on the effectiveness of the E2DRIVER training. Having a closer look at the areas in which aspects improved (Figure 2) reveals that the training addressed all of the possible areas and also led to an improved score of the different organizational aspects in the different areas. Furthermore, there is no aspect which was not addressed and improved by at least one company. The aspects most frequently improved were No. 8 and 18, relating to increased knowledge of energy efficiency regulations in the respective country and a positive impact on employees' knowledge of energy use, followed by many other aspects which were improved.

In terms of behavioral and sociocultural aspects, results from a performed questionnaire designed to measure the perceived impact and improvements of energy culture, as well as the feedback from the trainees after finishing the training, give an overall very positive picture (Figure 3). The sociocultural aspects that were evaluated in that questionnaire can be grouped into four sections: (1) rise in awareness and "quick wins" in behavior regarding energy efficiency in the companies' working contexts; (2) knowledge, skills, and responsibility gained; and (3) general feedback on the training in order to further improve the program in the future as well as to evaluate the (4) virtual reality sessions. Exemplarily, in Figure 3 one can see that the trainees indicated additional impacts of the training: 87% answered that the training showed them practical ways to perform work tasks more energy efficiently (i.e., rather agreed with the statement or even higher), 91% answered that awareness of energy efficiency in general increased, and 88% answered that they intended to perform even better in regard to energy efficiency in the future. The dotted line indicates the average positive answer rate of 89%. Individual testimonies from the companies confirm that they felt that the training they received was effective and, furthermore, they expressed gratitude for the tools that they were provided with; in several cases they even developed an action plan to ensure the continuity of the methodology.

		Total number of improved scores influenced by trainings
	Energy management & KPIs	
1	Do you manage energy consumption in your company?	12
2	Does your location use key performance indicators (KPIs) for energy management?	15
3	Are there specific targets for reducing energy consumption or for improving energy efficiency (e.g. % / per unit produced)?	15
	General assessment energy management	
4	Has there been any interest in conducting energy audits in your company?	17
5	Is your company interested in implementing a management system if it doesn't already have one (e.g. ISO 9001/ISO 14001/ISO 50001)?	9
6	If energy management is not integrated in certified management system, please specify which departments are related to energy efficiency initiatives and control in the organization	11
	A. Energy. B. Environment. C. Quality. D. Production. E. Maintenance. D. Other, please specify.	
	Basic check energy control	
	Internal policy	
7	Do you know the regulation that apply in your country and region about energy efficiency?	33
8	Is energy efficiency a decision criterion for purchasing new machines or systems (e.g. in the specification sheet)?	11
9	Are investment criteria based on risk (e.g. payback time < 3 years) and / or internal rate of return?	12
	Procedures in place	
10	Is the energy use known and available (e.g. in an Energy Savings Plan, Energy efficiency plan, or from your monitoring information)?	13
11	Has the organization determined the main energy aspects based on energy use? Is this information up to date?	17
12	Is there a measuring, evaluation and monitoring concept on energy consumption?	13
13	On which level(s) is data on energy consumption collected? On the level of…	3
	…the entire production site …a single building …individual production areas or production lines …individual machines or systems …no data collection on energy consumption	
14	If energy consumption indicators are used; on which levels are they used? On the level…	10
	…the entire production site …a single building …individual production areas or production lines …individual machines or systems …no data collection on energy consumption	
15	Do you benchmark your energy consumption?	12
16	According to the requirements of the energy management policy obligations of energy efficiency, is there a 'plan of execution', to improve energy performance?	17
	Training	
17	Is the necessary knowledge and information in the field of efficient energy use known? Have the employees who are able to influence energy use been instructed or educated?	32
18	Have you identified concrete needs in the energy training of employees? Please specify (for example: specific processes or utilities, energy audit procedures, measurement equipment, etc.)	13
	Actions	
19	Are there regular internal information exchanges about the energy performance and energy management obligations at executive and board level? And is there agreement on in what way and to whom the energy performance is communicated?	20
20	Are sufficient financial means made available for managing and improving the energy performance (use and efficiency)?	6
21	Do you monitor areas of Significant Energy Use (SEUs)?	16
22	In case of deviating energy use, is the cause investigated and are measures taken to prevent repetition?	19
23	Do you perform an annual (or more frequent) internal evaluation of energy performance? Do you report on the functioning to the board?	19
	Total	345
	Total per company	10.1

Figure 3. Total number of improved scores of organizational aspects influenced by the trainings (sum of all companies, without necessarily being fully implemented, i.e., score changed from red to yellow, red to green, or yellow to green).

5. Discussion

In the literature review, Section 2, a reduction in the specific energy consumption to produce the vehicles has been detected [20]. However, this reduction is not due to an action triggered by regulations but by the technological improvement and replacement of the equipment itself [19]. In other words, a greater potential for improvement is expected in

case of training initiatives or changes in regulations that promote the knowledge of the main processes and consumptions [3–5]. The number of companies working to improve energy efficiency based on training programmes for their own employees is practically non-existent at present.

Taking into account the energy results obtained, potential energy savings and improvements in energy performance were achieved in 100% of the participating companies. There was a great heterogeneity in the sample; therefore, it is observed that the savings were not linked to the intensity of energy consumption or the turnover of the company.

The obligation to carry out energy audits is currently only applicable to large companies, which represent only 0.2% of all companies at the European level [42]. In the participating companies, it has been detected that energy consumption is not always linked to the size of the company but is associated with the energy intensity of their production processes. Therefore, there is a need for energy efficiency regulation related to consumption and not to turnover.

The energy savings detected are as significant in electricity as in thermal energy sources such as natural gas. Therefore, the automotive sector has different energy sources, and in all of them it is possible to optimize consumption due to the complex structure of the automotive supply chain with a wide range of products and the interaction of many stakeholders.

Regarding the organizational aspects, all of the points assessed were improved after the training, especially the topics related to regulations and general knowledge of energy uses in the companies themselves. Therefore, it is clear that there is a great lack of knowledge of the specific regulations on energy efficiency in SMEs, due to the fact that energy audits are not compulsory.

Regarding the behavioral and sociocultural aspects, the customized training of the E2DRIVER project in terms of effectiveness was very positive. The percentage of trainees indicating that the training was effective was 89%; therefore, it can be determined that the customization and selection of only necessary content to be applied in their facilities is the best way to deliver practical training.

6. Conclusions

Companies in the automotive sector are complex and heterogenous, and there is no straight relationship between energy consumption and turnover. Accordingly, a regulation that obliges energy audits only for non-SMEs does not imply control of the majority of the energy in the automotive sector since this indicator is not always representative of their energy intensity. In addition, non-SMEs represent only 0.2% of all companies at the European level. This heterogeneity is also observed in the 35 companies participating in the project, with energy consumption ranging from 0.6 to 63 GWh in terms of annual energy consumption. In other words, the current regulatory framework for energy efficiency based on turnover does not take into account the large number of existing companies, the SMEs, regardless of whether they consume more or less energy. This fact makes it difficult to carry out an energy diagnosis that can show them the level of efficiency and the possibilities for improvement.

Taking into account the difficulty of establishing a theoretical baseline, the results of the project have shown energy saving possibilities within the companies of between 1% and 50% of the total consumption. The average energy savings based on the sample of the 35 companies was 697,540 kWh/year. Using the average energy consumption values of 2.2 GWh/year for companies in the automotive sector, the average energy savings obtained are very high, indicating a large savings potential for companies in this sector.

In organizational and behavioral terms, the companies have shown positive results with regard to the training received, with a direct impact on each of the institutions. In particular, the improvement in terms of knowledge of the regulations concerning energy efficiency issues and the improvement in energy efficiency knowledge shown by the employees after the end of the training are emphasized.

Regarding individual behavior and awareness actions, post-training surveys were carried out to assess the predisposition to modify daily energy habits and the usefulness of the training content for the energy culture of the company. The results show a very positive score, specifically over 80% in all cases, which translates into a very large impact between the situations before and after the training. In the individual analyses carried out by the trainees, the customization of the training was highlighted as a relevant point for the success achieved. This is mainly due to the limited time available for training, and the more the training content is adapted to the needs of the company the easier it is for the trainee to apply this knowledge on a practical level in his or her organization.

Future research lines could expand and make the necessary adaptations to use the methodology in other energy-intensive industrial areas such as the paper industry, steel, chemicals or non-metallic minerals. It would also be advisable to introduce this training model to the transport, household and service sectors.

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