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***Abstract* — Carbon assessment is beginning to be widely used in research. It is used to quantify the amount of Greenhouse gases (GHG) emissions of an activity and even tend to be part of the indicators that serve to evaluate labs. Databases and tools are available. Methods as well but they have to be adapted to each case, depending on the activities of the organization or company to be studied and the way people in charge want to build their assessment. This article aims at proposing a method for the assessment of GHG emissions of research projects. Being organized around the different activities within a research project, this method takes into account all aspects of the project. It allows a good picture and analysis of GHG emissions linked to a project.**

Keywords — Assessment method, greenhouse gases emissions, research.

I. INTRODUCTION

Greenhouse gases (GHG) due to human activities lead to increase global warming [1]. Reduction of GHG is thus a key challenge of the century. Several research activities are dealing with this by proposing innovative systems, like the mobility sector, strongly involved, that develops electric vehicles [2]. As any other activities, research also leads to GHG emissions. Some "Carbon Care" actions has been developed to reduce the emissions of GHG, including IEEE-VVPC or other conferences [3][4]. A dedicated method has been developed in that aim. But this method is not yet adapted for a complete research project. The PANDA H2020 European project is focused on the development of an innovative method for testing virtual and real prototype of various electrified vehicles [5]. In this project a specific Carbon Care action has been defined in order to extend carbon footprint assessment to the first step of the electrified vehicles' development.

Based on the past experience of L2EP on Carbon Care action [6] and French national Data bases on GHG emissions [7], this paper aims to adapt the Carbon Care action to an entire research project. If the methods are generally described, an accurate definition of the action perimeters and of all steps are required.

II. FRAMEWORK OF THE STUDY

A. The studied PANDA project

The objective of PANDA project is to reduce the development time of electrified vehicles through standardization of the models and simulation. Such a unified approach will enable 1) an easy reuse of models for different development phases and 2) a reduction of the real testing of subsystems by virtual seamless testing. The main goal of this project is to provide unified organization of digital models for seamless integration in virtual and real testing of all types of electrified vehicles and their components [5].

It is based on a strong consortium composed of 11 partners, 4 Universities (Lille, Brussels, Cluj-Napoca Romania and Belfort) and 7 industrial companies (Siemens, Valeo, TÜV SÜD Battery testing, Renault TR, Typhoon HIL, Unireseach and Bluways) from 6 different European countries (France, Romania, Belgium, Germany, The Netherlands and Serbia).

The impact of this project is to develop electrified vehicles to globally reduce the GHG of the transport sector.

But, this project will also lead to emit GHG by its internal activities. Carbon assessment at the very beginning, at the development stage, is not usual but it seems also important to evaluate the carbon cost of a new method of development and to add it to the general assessment of electrified vehicles.

B. Global Carbon Care method

A global method has been proposed in [4]. It is composed on 4 main tasks that are: 1) estimation or assessment of the GHG emitted by the project; 2) reduction of the GHG of the activities; 3) awareness of the participants and other stakeholders; 4) and mitigation of the GHG emitted. Because of its complexity, the most sensitive task is the assessment of the GHG which deserves a strict organization for a successful Carbon Care action.

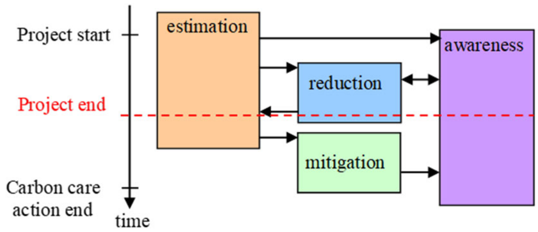

Fig. 1: Global organization of the carbon care action

C. Perimeter of the study

The first step consists in a clear definition of the perimeter. When, where and what for are basically the 3 questions to be addressed when defining the perimeter of the GHG assessment. They allow to cover the three sides, temporal, organizational and operational, of the study's perimeter. The temporal perimeter means the total duration of the project. The location is related to all places where the project takes place. The operational perimeter deals with all the partners' direct and indirect activities.

D. Assessment method

Having decided this, data have to be structured in order to be sure of taking everything into account but only once and avoid duplication. In that aim, 3 main parts have been defined: development, management and dissemination. Each of them is then subdivided into 3 sub-parts: functioning, travel and equipment.

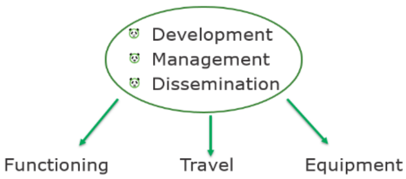

Fig. 2: Organization of a study for GHG emissions' assessment

- Development phase

The GHG emissions in the development phase are those of normal daily work. Its functioning sub-part is then the direct (energy) and indirect (mainly those linked to the building, but also linked to the office's equipment like laptop etc…) In short, all GHG emissions linked to the daily activities of the project. Travel is commuting every day from home to work place. Equipment is what is used and have been bought to run the project.

- Management phase

The GHG emissions in the management phase are emissions for management meetings. Its functioning is mainly the energy of video-conference. There is also travels to meeting places. Equipment are related to small equipment for videoconference but also the sharing platform used by the partners to manage the project.

- Dissemination phase

This last part deals with the activities to promote the project, e.g. conferences, workshops, flyers, energy for the website. Travels are related to presentations of the project to target events. Regarding equipment, multi-media devices are considered.

Meals are not considered in this approach because they are considered as being part of daily life, and not working time. Accommodation in the management and dissemination's travels are also neglected. Indeed, according to our first calculation, their impacts are very low, almost unimportant in comparison with related travels. Therefore, spending time on gathering data on this topic was time-consuming and useless.

For each partner, a Carbon Care correspondent who gathers data (and author this paper) has been identified. This collaborative work is updated for every year of the project.

III. ULILLE EXAMPLE

To illustrate this approach, the example of PANDA's Univ. Lille team during the first year of the project is presented

A. Considered team

This team is composed of 10 persons (2 professors, 5 professor assistants, 1 PhD candidate, 1 post-doctoral fellow and 1 engineer). Their implication in the project depend on the activities they focus on. But as they declare their working hours for the project on an on-line tool, this information is quite easy to find. They are from different labs but all located in the same place, "Cité scientifique" campus of University of Lille.

B. Assessment for Univ. Lille

- Development phase

After investigating several possibilities, the GHG emissions linked to functioning in this phase are estimated by using factors for direct and indirect emissions for $1m^2$ of office. The working space of each participant and time they spend on the project are then enough to get an estimation.

At the time, according to data bases, average factors of $1m^2$ of office are considered for France: 22 and 20 CO_2-eq.m^2/day for respectively direct and indirect GHG emissions.

The estimation for travels is much easier as factors of vehicles' emissions are more common in data bases. Moreover, factors include both direct and indirect GHG emissions [4]. The commuting mean and trip of all the team members are reported in Table 1. The total commuting distance is computed for the working days per year for this project in particular. Using the emission factor, the yearly GHG is thus obtained.

Table 1: travel GHG per year

Member ID	Vehicle	km/day	PANDA km	kg CO2-eq
M1	electric vehicle	10,4	520	49
M2	subway	10,8	1339,2	8
M3	subway	14,4	144	1
M4	car	40	440	114
M5	car	13	104	27
M6	subway	6,8	57,8	0
M7	train	51	3978	45
M8	car	7,5	75	19
M9	subway	7,2	144	1
M10	car	20	160	41
TOTAL				**305**

During the first year of the project, no equipment was used. This part of the study cannot be addressed at this stage but the 2 next years of research will imply equipment (batteries, ECU-HIL and cloud) and we will take into account their GHG emissions, direct and indirect. For sure, this part will not be the easier one and will take time. Our idea is thus to fully estimate the emissions of equipment bought for the project and to focus on direct GHG emissions only for the equipment already at the lab that we use for the project. According to the temporary figures we have for some of the other partners of the project (VUB and Renault TR), equipment could considerably modify the share of each part of the general carbon assessment.

- Management phase

Table 2: functioning

Videoconf/meetings on site	number of connexions	kg CO2-eq (/h/connection)	time of connection (h)	kg CO2-eq
event 1	2	0,157	1	0,31
event 2	3	0,157	4,5	2,12
TOTAL				**2,43**

We consider that taking part in a management meeting does not request more energy than working during a normal day at the office. The room is bigger when we are all together, but there is just one room and we do not use more screen or lamp than when we are in our individual offices. The only complementary tool and use of energy during this kind of management meetings (in normal time, before the pandemic) is videoconferencing. That is why we focus here on it.

Videoconferencing was organized for 2 meetings at Univ. Lille during the first year of the project (table 2). For the sack of clarity, both are listed here but of course, as they are not attributed to one partner in particular but for the general management of the project, these costs will be gathered with those of the other meetings.

Thanks to recent publication, it is now possible to estimate the emissions of a videoconference [8]. With a few general information about meetings (number of connected persons and length of the connection), GHG emissions generated by videoconference can be measured.

Table 3: travel

Member ID	Plane (km)	kg CO2-eq	Train (km)	kg CO2-eq	kg CO2-eq
M1	5120	1156	1902	16	1172
M2	5120	1156	1902	16	1172
M3	-	0	1252	5	5
M4	-	0	210	10	10
M5	-	0	440	2	2
M6	-	0	1252	5	5
M7	5120	1156	440	2	1158
M8	-	0	210	10	10
TOTAL					**3534**

Just like for the development phase, it is quite easy to evaluate travel GHG emissions. Once factors of emissions are found in data base, the only information we need are the list of travels for management purpose and how many persons take part in them (table 3).

Last point for this management phase is equipment which is basically the sharing platform or in other words, a cloud. The approach is actually the same as the one we have for the cloud we use in the development phase: based on the following drawing (fig.1), the idea is to evaluate the energy cost of data storage and its increase at the time of use. By getting information from our provider such as how big are our data in Gb and kWh per day for the storage, how many processors are used for our data, the energy cost when using them, how much the energy cost increases at the time of use and the location of our datacenter, it would be possible to assess the energy consumption of our activity.

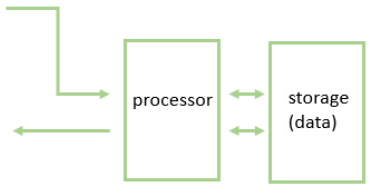

Figure 1: cloud energy

- Dissemination phase

As previously, the functioning sub-part for dissemination phase is not big. As we consider that taking part in a conference does not request more energy than working during a normal day, travel bulks large in this dissemination phase.

Table 4: travel

Events	Participants	Means of transportation	kms (location)	kg CO2-eq
RERI	2	local express train	110 (Arras)	2
MRSEI	2	high speed train	440 (Paris)	3
VPPC	2	high speed train + plane	18380 + 440 (Hanoi)	8212
TOTAL				**8217**

Like for development and management parts, GHG emissions for travels are quite simple to evaluate: once lists of conferences or events' places, of means of transportation and of participants for the length of time that is under consideration are available, all we need is the factor of emissions for each means of transportation (table 4).

The project website in our main communication tool and stands for PANDA dissemination equipment. Each page having its own amount of emissions, a good average could be home and news pages. A useful tool for carbon assessment of internet pages [9] gave us the two numbers that allow us to calculate an average of 2,65g CO_2-e/visit/page. During the first year of PANDA, we know that 3 578 pages were viewed which gives 9,5kg CO_2-eq for this first year.

C. Global GHG emissions and discussion

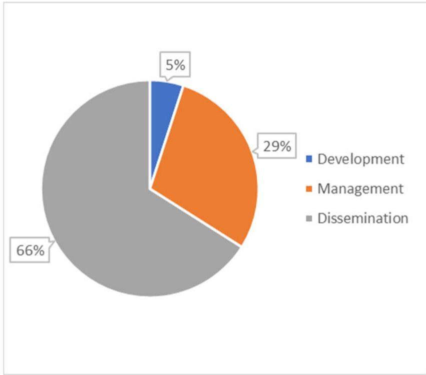

Fig. 2: GHG emissions of Univ.Lille team during the first year of PANDA project

It has to be noted that at this stage of the project (by the end of the first year), equipment is missing. That being said, we notice that the dissemination part of the project is the biggest in terms of GHG emissions for the first year of the project on the Univ. Lille side (fig.2).

Of course, travels are responsible for this as air and road transports are respectively the first and third sectors that contribute the most to GHG emissions [7]. It is worth noting that in between them is ICT (Information and Communication Technologies) [8] and that digging deeper about cloud we use in the framework of this project, both for the project management and simulation phase in the project itself, and going on with listing our remote meetings, especially since lockdown, that generate GHG emissions.

IV. Conclusion

In the framework of this project, we try to adapt what we had learnt so far from previous experiences on Carbon Care. Based on existing tools, we are setting an approach of carbon assessment that fit a research project's organization and could be as reliable and efficient as possible. Not too surprisingly, because of travels, dissemination is the part of the project that contribute the most the GHG emissions by the end of the first year.

Even if we still have to dig deeper and wait the end of the project to get results, what can be said right now about Carbon Care is that it is important to start this kind of action from the beginning of the project. It allows to imply all the partners, as it could not be other than a team work, and gather data little by little to manage information. It is also important to define from the beginning a unified approach and to centralize partners 'data through someone dedicated to this task.

We presume that the equipment part will be bigger than we though. Travels cannot obviously be left aside. They are the biggest costs for the 3 phases. And finally, digital aspects have to be strengthen: there are many studies with various results on this topic and as some other works are still being published [10], it will be important to take them into account.

_ACKNOWLEDGMENT

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