SustainML

Application Aware, Life-Cycle Oriented Model-Hardware Co-Design Framework for Sustainable, Energy Efficient ML Systems

Report on communication, exploitation and dissemination (M18)

Deliverable D7.5

WP7 - Dissemination, Exploitation and Management

This project has received funding from the European Union's Horizon Europe research and innovation programme (HORIZON-CL4-2021-HUMAN-01) under grant agreement No 101070408

eProsima The Middleware Experts

DFKI

Inria

upmem

RPTU Rheinland-Pfälzische Technische Universität Kaiserslautern Landau

IBM

Project

Title:	SustainML: Application Aware, Life-Cycle Oriented Model-Hardware Co-Design Framework for Sustainable, Energy Efficient ML Systems
Acronym:	SustainML
Coordinator:	eProsima
Grant agreement ID:	101070408
Call:	HORIZON-CL4-2021-HUMAN-01
Program:	Horizon Europe
Start:	01 October 2022
Duration:	36 months
Website:	https://sustainml.eu
E-mail:	sustainml@eprosima.com
Consortium:	**eProsima (EPROS)**, Spain **DFKI**, Germany **Rheinland-Pfälzische Technische Universität Kaiserslautern-Landau (RPTU)**, Germany **University of Copenhagen (KU)**, Denmark **National Institute for Research in Digital Science and Technology (INRIA)**, France **IBM Research GmbH**, Switzerland **UPMEM**, France

Deliverable

Number:	**D7.5**
Title:	**Report on communication, exploitation and dissemination (M18)**
Month:	18
Work Package:	WP7 - Dissemination, Exploitation and Management
Work Package leader:	eProsima
Deliverable leader:	eProsima
Deliverable type:	Report (R)
Dissemination level:	Public (PU)
Date of submission:	2024-03-31
Version:	v2.1
Status:	Finished

Version history

Version	Date	Responsible	Author/Reviewer	Comments
v1.0	16-03-2023	eProsima	Raúl Sánchez-Mateos Lizano	First draft
v1.1	18-03-2023	eProsima	Mario Domínguez López	Review
v1.2	27-03-2023	eProsima	Raúl Sánchez-Mateos Lizano	Applied suggested changes and final version
v2.0	18-03/2024	eProsima	Raúl Sánchez-Mateos Lizano	Update communication and dissemination report (M18)
v2.1	27-03/2024	eProsima	Jesús Poderoso Martín	Review

© 2024 SustainML | HORIZON-CL4-2021-HUMAN-01 | 101070408

Executive summary

SustainML project aims to develop a design framework and an associated toolkit, the so-called SustainML, that will foster energy efficiency throughout the whole life-cycle of Machine Learning (ML) applications: from the design and exploration phase including preliminary iterations of training, testing and optimizing different system versions all the way to the final training of the production systems (which often involves huge amount of data, computation and epochs) and (where appropriate) continuous online re-training of the inference process during deployment. The framework will optimize the ML solutions based on the application tasks, covering from hardware to the high-level architecture model. It will also integrate both previously scattered efficiency-oriented research and novel Green-AI methods. Artificial Intelligence (AI) developers from all levels of expertise can make use of the framework leveraging its emphasis on human-centric interactive transparent design and functional knowledge cores, instead of the common blackbox and fully automated optimization approaches.

This report corresponds to *Deliverable D7.5 - Report on communication, exploitation and dissemination (M18)* of the SustainML project. This deliverable addresses all the communication, dissemination and exploitation tasks performed by the SustainML project partners during the first half of the project dedicated to reaching the target audience of each partner, and achieving the project objectives.

This deliverable begins by covering the main fundamentals of the SustainML Dissemination and Communication Plan (DCP), with special attention to those actions that increase the interest and awareness of the SustainML framework and research results. Among these actions are the definition of the strategy, vision and road map of the project, as well as the promotion of the project results to ensure awareness of these by the target audience.

Next, the tools created for the dissemination of SustainML in the different events in which SustainML has participated or is intended to participate, as well as the internal and external tools used for the dissemination of the obtained results, such as templates for reports, emails and contact, are explained.

Moreover, this report describes the communication and dissemination activities conducted during the first eighteen months of the project. During the first half of the project, SustainML partners have attended events and seminars to disseminate SustainML as well as to communicate the existence of the project and its various lines of research. Research articles have also been published to promote interest in the scientific community, paying special attention to AI researchers.

Finally, this deliverable covers the exploitation plan of the SustainML project, describing first the joint exploitation plan, which applies to all members of the SustainML consortium, and concluding with the description of the individual exploitation plan of each partner.

© 2024 SustainML | HORIZON-CL4-2021-HUMAN-01 | 101070408

Contents

Acronyms

AI	Artificial Intelligence.
AML	Algebraic Machine Learning.
AML-IP	Algebraic Machine Learning - Integrating Platform.
DCP	Dissemination and Communication Plan.
DNN	Deep Neural Network.
GA	Grant Agreement.
HCI	Human-Computer Interaction.
HW	Hardware.
HWA	Hardware Acceleration.
KPI	Key Performance Indicator.
ML	Machine Learning.
OEM	Original Equipment Manufacturer.
OMG	Object Management Group.
PESO	Paid, Earned, Shared, Owned.
R&D	Research and Development.
ROS	Robot Operating System.
RTL	Register Transfer Level.
SEO	Search Engine Optimization.
SERP	Search Engine Result Pages.
SME	Small and Medium-sized Enterprises.
SWOT	Strengths, Weaknesses, Opportunities, and Threats.
TSC	Technical Steering Committee.

1 Introduction

1.1 Purpose of the document

This report describes the main activities of communication, exploitation and dissemination of the results of the different research areas and application domains within the SustainML project.

Communication activities encompass all those activities aimed at bringing the research results to the attention of multiple audiences in an understandable manner for all targeted groups. The ultimate goal is to inform stakeholders about the benefits of the novel machine learning techniques being developed under the SustainML project such as the SustainML framework, as well as the tools and research surrounding this novel AI tool. This is done in accordance with the guidelines of the public policy perspective of EU research and innovation funding, considering aspects such as the contribution to competitiveness and the resolution of social and ethical challenges.

Furthermore, dissemination consists of those activities focused on publicly sharing the results of research and innovation with the target audience for each one of the research fields that comprise the SustainML project. The target audience are AI researchers, individuals who want to improve their AI skills, businesses of all sizes that are trying to adopt AI to solve their problems, industry players and policy makers.

It is crucial to generate interest in the target audience by communicating and disseminating solid and robust results that can be contrasted and evaluated by the scientific and industry community. That is why the main purpose of the first version of this document is to establish the dissemination and communication strategy of the SustainML project, while the second version focuses on the main scientific dissemination of research results obtained so far.

1.2 Communication approach

SustainML project aims to develop a design framework and an associated toolkit, the so-called SustainML, that will foster energy efficiency throughout the whole life-cycle of ML applications: from the design and exploration phase including preliminary iterations of training, testing and optimizing different system versions all the way to the final training of the production systems (which often involves huge amount of data, computation and epochs) and (where appropriate) continuous online re-training of the inference process during deployment. Therefore, the aim is to draw the attention of the target audience interested in the efficient application of ML algorithms and to promote and raise the interest of Greener-AI solutions proposed by this framework, incorporating the SustainML framework in the design steps of any ML developer.

The intention is to communicate the core idea that the same or similar results can be achieved for certain ML applications without the need for computationally expensive solutions, using algorithms, technologies and hardware appropriate to each specific problem.

The key message intended to convey is that SustainML framework will be continuously developed and supported in the future. One of the main problems involving potential stakeholders, who are looking for stable, efficient and long term projects, is the belief that the progress and results of the SustainML project will no longer be supported once the project comes to an end. A number of user guides, tutorials and supporting materials to facilitate the use of SustainML framework will be created in order to ensure that this will not happen, thus eliminating the uncertainty of the initial investment in the adoption of SustainML framework in the ML developers design process. It is intended to state that SustainML is only the project that provides the necessary funding to promote SustainML framework research, which will be exploited and supported after the project ends.

Emphasizing the market orientation and global dimensions of SustainML and the tools is of primary

importance for the development and exploitation of this framework and associated toolkit. Thus, a differentiation is made between research activities and results, placing them in the context of market exploitation and research.

Since the research results will be publicly available, and the SustainML components are open source products, third party collaboration in the development and improvement of the products resulting from the project is encouraged. All these aspects and actions considered, together with the publication of reports, articles and conferences, will make the SustainML project more transparent to the stakeholders.

Finally, it is important to mention that the development of open source products makes the number of collaborations to the project increase significantly, making the interaction of third parties with these products more open, agile and flexible. Moreover, this favors the acceptance of SustainML by the AI community.

2 Communication and dissemination strategy

This section describes the communication and dissemination strategy to be adopted by the SustainML project within the framework of the Dissemination and Communication Plan (DCP).

First, the communication and dissemination objectives are introduced, followed by the methodology to be used to achieve these objectives. Next, the brand positioning strategy based on the key points of purpose, perception, personality, positioning and promotion of SustainML is introduced.

Target audiences are analyzed for each of the different lines of research. Due to the heterogeneity of the conducted research within the SustainML project, which ranges from the specific ML application requirements modelling to represent the taxonomy of the vast majority of ML applications; energy optimized HW architectures provided as Register Transfer Level (RTL) libraries; novel Human-Computer Interaction/-Collaboration paradigms; and prototypical SustainML software developments. The key messages and the channels used to deliver these messages to the already-defined target audience are described.

This section ends with the road map of the dissemination and communication plan from the project start to the end dates.

2.1 Communication and dissemination objectives

The main objective of the communication effort hitherto undertaken has been that of maximizing the impact and benefits of the SustainML project by bringing it closer to the target audiences for each of the lines of research. This is accomplished in an orchestrated manner by inquiring about the stage of the project at each moment of its past and future lifetime since the target audience varies depending on the status of the research. That is, the intended audience changes depending on whether the project is in a research phase and supported by scientific publications, or whether it has products such as the SustainML framework accessible to end users that can be corroborated, tested and used in the industry.

Therefore, clear and measurable objectives are set to check the acceptance status of the project among the different target groups to provide adequate information and promotion of the project concept and its direction promptly.

Communication materials are designed to have a clear branding and market positioning. Special attention will be paid to the results obtained in the previous and ongoing years (2022 - 2024) to maximize the exploitation of these results in later 2024. This communication and dissemination plan aims to define the most effective communication channels, tools, and mechanisms for each target audience to maximize the impact in each phase of the project. In addition, the impact of the communication is monitored to take corrective and preventive measurements if necessary to maximize the visibility of the SustainML project.

The following are the main objectives of the communication strategy:

- CO1: to give a clear message of the mission, objectives, and results of the SustainML project by formulating key messages tailored for the different target audiences.
- CO2: to support and promote collaboration with other relevant projects, the industry, communities, and global initiatives that increase awareness of the SustainML project and facilitate outreach to potential customers or end-users.
- CO3: to make the results of the project understandable to the community.
- CO4: to attract new researchers to create a community around the SustainML project and specifically low energy consumption ML methods and tools.

- CO5: to attract early adopters to test the implementations resulting from the project and create a SustainML framework community to introduce our developments to the pre-existing Robot Operating System (ROS) and eProsima community.
- CO6: to support targeted communication of the project results to prepare the basis for future exploitation.

The main objectives of dissemination are aligned with the communication objectives to ensure that the project has a medium and long-term impact through the publication of research results. The dissemination objectives are listed below:

- DO1: dissemination of the project results and the technical, technological, and scientific developments resulting from the SustainML project throughout its execution, as well as the benefits, use cases, and exploitation scenarios derived from the use of such results.
- DO2: to create partnerships with other global projects to publish and make use of our results to promote indirect dissemination of the SustainML project.
- DO3: facilitate the exploitation of the results by the community of developers who assess and provide feedback on the use of the tools created during the project.
- DO4: facilitate access to the research results so that the scientific community can validate, contrast, and corroborate the publications made.
- DO5: publication of the project results in web pages and forums of the different target communities to gain visibility among these communities.
- DO6: perform a market segmentation analysis to focus each of the research areas on their potential users/customers to enhance the exploitation strategy.

2.2 Methodology

The methodology followed in SustainML to meet the communication and dissemination objectives is based on the adoption by the consortium of the use of elements that guarantee the communication of a common message. This is achieved through a combination of traditional marketing elements such as scientific publications and participation in events, as well as online tools that help to easily understand SustainML's vision, mission, and proposal.

Specific actions are taken in the communication strategy to gain early adopters of the developed tools that would help disseminate SustainML and energy-optimized ML methods to the target developer community, by encouraging their peers to use this tool.

2.2.1 Marketing funnel

This section introduces and describes the main stages of the marketing funnel of the SustainML project to reach the target communities.

Awareness The main objective of the awareness activities is to make the target audience aware of the SustainML brand and the SustainML framework and associated toolkit. Through these, SustainML's digital presence is strengthened, promoting familiarity with the project and building a reputation through media adoption. The following are described the aforementioned awareness activities:

- Generate SustainML framework product awareness through social media and digital media activities.
- Management of sponsored events with high digital media presence.

- Presentation of SustainML project, framework, and toolkit in target communities to gain brand awareness and technical benefits.
- Search Engine Optimization (SEO):
  - Keyword research to position SustainML, thus making the content relevant to the searcher's queries.
  - SEO on Page: optimization of web pages to improve SustainML's ranking in search engine results by including keywords in titles and content.
- Use of social media to engage potential customers, improve community relations, and increase awareness. The social media strategy is built with organic content but could include paid ads such as banners or pay-per-click (on Twitter or LinkedIn) to reach the target audience if needed.
- Partners attendance to relevant national and international events to raise awareness of SustainML.

Interest The objective of the interest activities is to increase the number of searches related to the SustainML project, which increases website traffic. This is a good indicator of growing interest in the project among the target audience. These activities are:

- Generation of branded content and banners for specialized communities, focusing on the exploitation of relationships.
- Generation of digital content marketing material, due to the significant reduction of in-person events, such as infographics, videos, interviews, and testimonials.
- Online technical and business events focused on engaging policymakers, researchers and users.

Consideration Consideration activities are aimed at creating a community around the SustainML project through the following media:

- Technical blog posts.
- Workshops and online presentations.
- Educational material to facilitate incorporation of SustainML framework into the ML development process.

Conversion Conversion is ensured by providing the first results of the project to the SustainML community established in the previous phase. This is accomplished by promoting open communication with the community and by encouraging and motivating early adopters and community members to actively participate in events organized by the project partners. This phase is reinforced with:

- Periodic newsletter covering the main achievements in the project.
- Emails summarizing the main events and uses of the SustainML framework by the community.
- Use of success stories to convert and engage those members of the community who are less actively involved.
- Webinars, Q&A sessions, online demo use cases, tutorials, and training.
- Referrals to encourage our advocates to become brand ambassadors. Introduce brand advocates by promoting their participation in sponsored content and webinars to present their implementation and research outcomes so they may as well gain referrals.

The above points are summarized in the SustainML marketing funnel diagram shown in Figure 1.

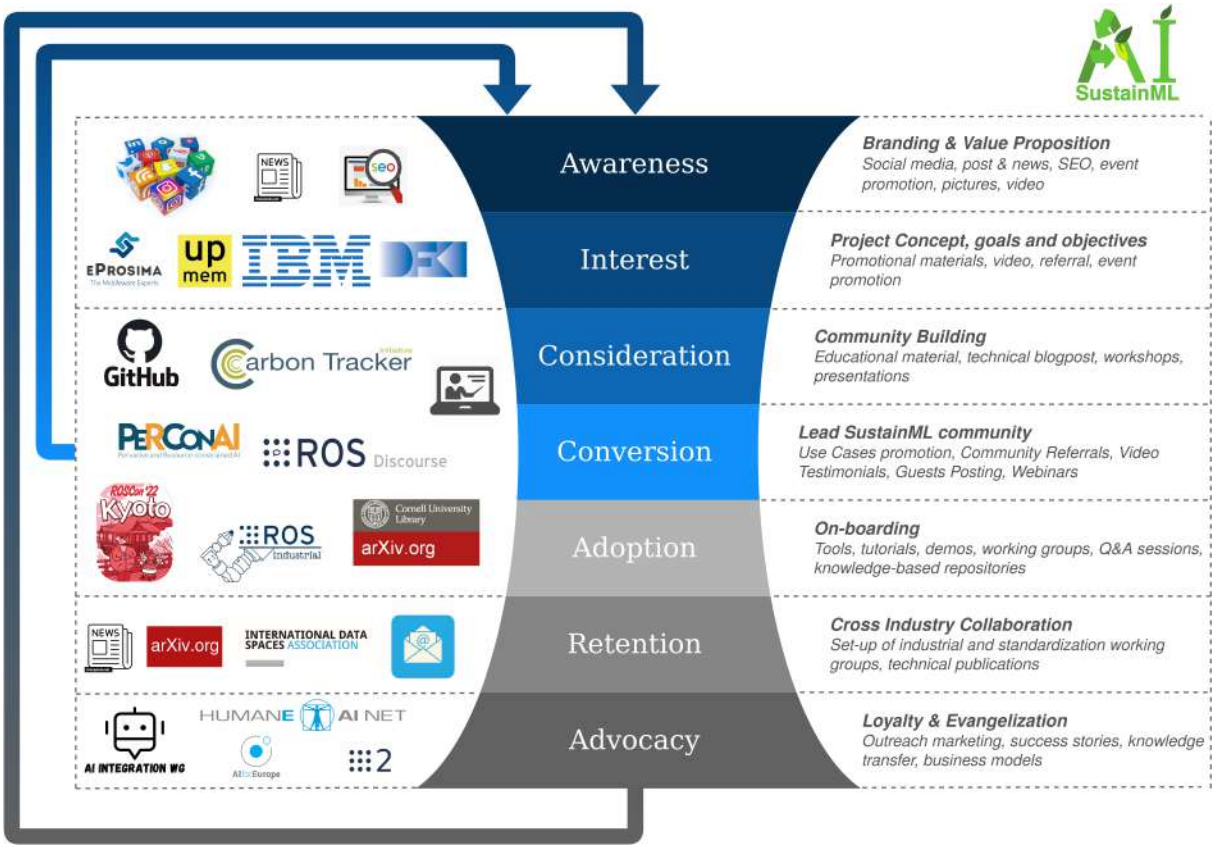


Figure 1: SustainML marketing funnel

2.2.2 PESO Model

The ideas outlined above result in a 360º marketing strategy that can be visualized in the PESO Model of the SustainML project shown in Figure 2.

2.3 Brand positioning

SustainML's brand positioning and identity have evolved during the first half of the project and will continue to expand and improve over the next years of the project's realization. This development is guided by the following aspects:

- Purpose: identifies the rationale for the project and the contribution to the SustainML end users as well as the knowledge contributed to the AI research community.
- Perception: how novel Green AI methods are recognized and adopted by the community.
- Personality: defines the tone of the messages to be disseminated according to the target audience, as well as the nature and content of those.
- Position: determines the position of SustainML framework and Green AI methods in today's collapsed market of available AI technologies and ML development frameworks.
- Promotion: defines the core element of our speech at events and conferences, including those sponsors and ambassadors of the SustainML brand.

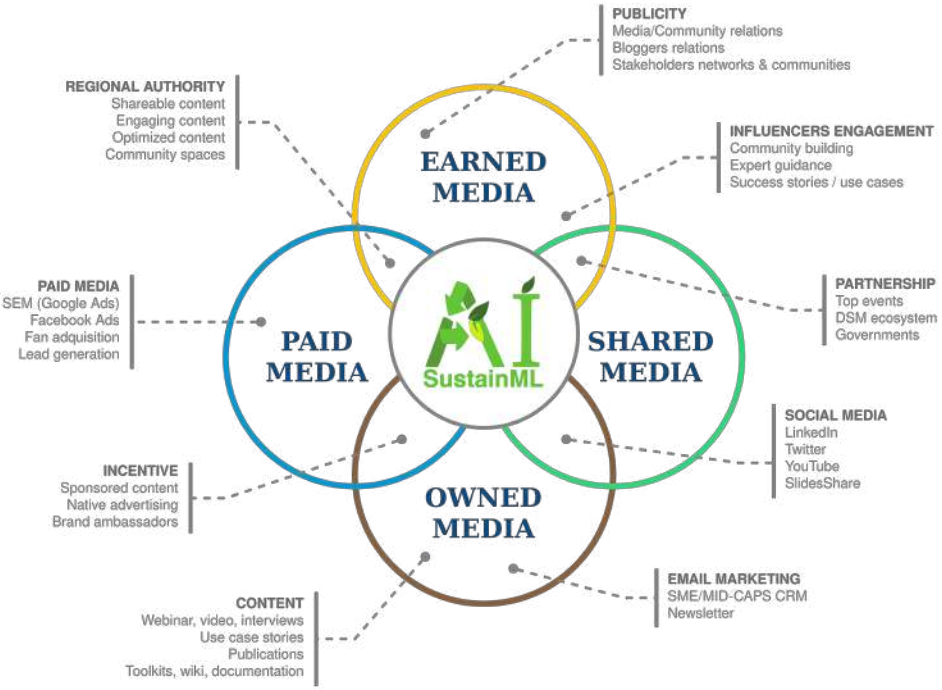


Figure 2: SustainML PESO Model

As explained above, SustainML proposes a new working paradigm in the development of ML applications as it allows developers to consult the SustainML framework on the Green AI techniques that are best suited to the ML problems they intend to solve, which applies to the entire lifecycle of ML applications. This requires developers to integrate the use of the SustainML framework into the design and approach phase of ML solutions for specific problems.

Among SustainML project partners is DFKI, a leading AI research institute that aims to promote collaboration with other EU projects to increase the visibility of SustainML research and results. DFKI together with Inria, RPTU, and KU will undertake research projects on methodologies for efficient use of ML algorithms.

Furthermore, the SustainML project benefits from eProsima's position in the ROS community. eProsima, as a member of the ROS 2 Technical Steering Committee (TSC), aims to bring Algebraic Machine Learning (AML) to the robotics industry by providing mechanisms that ease the integration of SustainML framework in ML applications for the robotics field. Thus, the SustainML framework, an open-source platform developed at eProsima, will be the way to achieve the goal of bringing Green AI methodologies to the ROS community. Furthermore, thanks to SustainML being a European initiative, the foundations for the creation of a European ROS community aiming at the integration of Green AI in the ROS ecosystem are in place.

The SustainML framework and associated toolkit will be released under open-source licenses, thus fostering the community's contribution to the development of these new technologies.

2.3.1 Brand messaging Framework

The SustainML message framework is a structured representation of the unique key of the SustainML framework and associated toolkit features in the ML market. It presents in a clear and easy-to-understand

manner the differentiating elements of the SustainML brand from other existing ML development frameworks. This includes the value proposition, the target audience, and the competitive differentiator.

The SustainML brand message framework will slightly change as the project progresses. Still, it builds the foundation for the creation of a SustainML business model and all its related functions such as marketing, communication, dissemination, business development, public relations, user support, etc.

The SustainML brand message framework is presented in Figure 3.

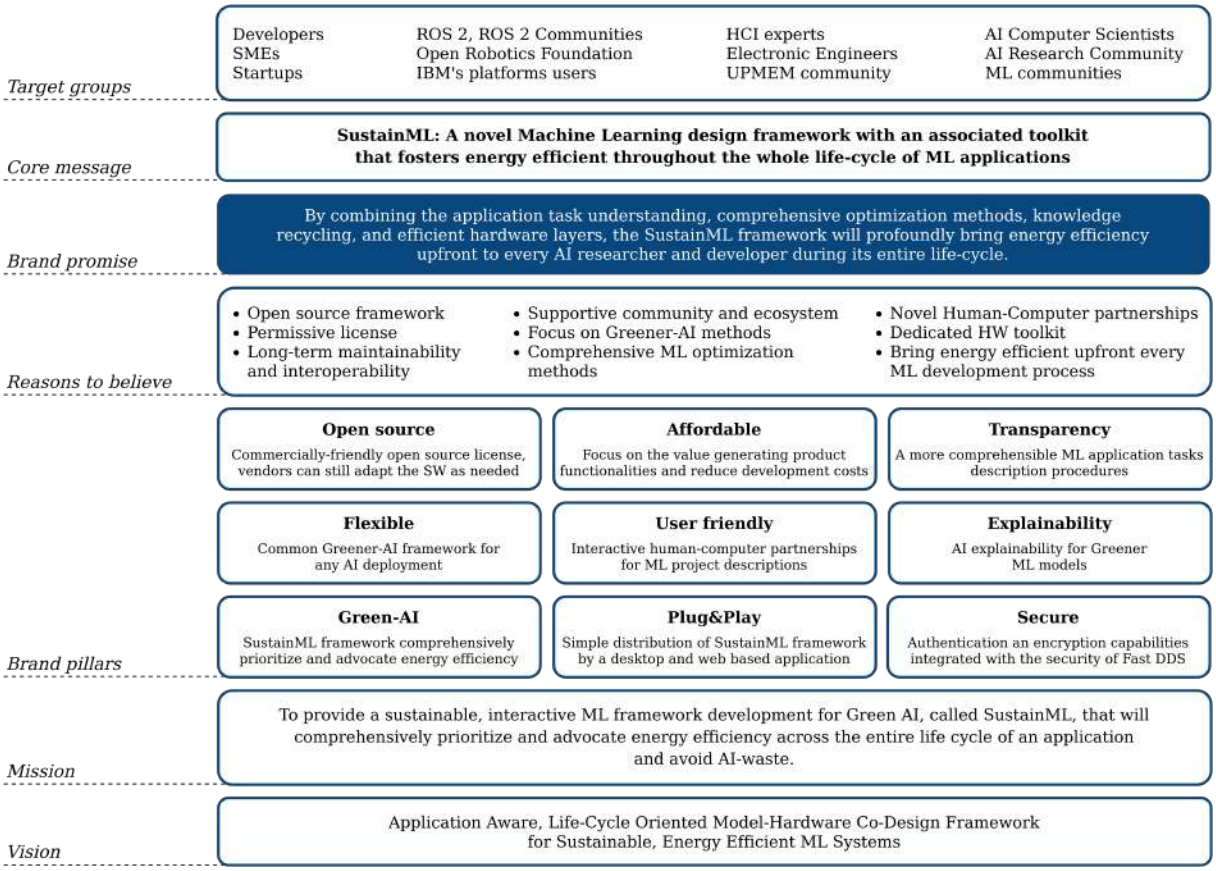


Figure 3: SustainML message framework

Vision

Application Aware, Life-Cycle Oriented Model-Hardware Co-Design Framework for Sustainable, Energy Efficient ML Systems

Mission To provide a sustainable, interactive ML framework development for Green AI, called SustainML, that will comprehensively prioritize and advocate energy efficiency across the entire life cycle of an application and avoid AI waste.

Brand promise By combining the application task understanding, comprehensive optimization methods, knowledge recycling, and efficient hardware layers, the SustainML framework will profoundly bring energy efficiency upfront to every AI researcher and developer during its entire life cycle.

Core message

SustainML: A novel Machine Learning design framework with an associated toolkit that fosters energy efficiency throughout the whole life-cycle of ML applications

Reasons to believe

- Open source framework.
- Permissive license.
- Long-term maintainability and interoperability.
- Supportive community and ecosystem.
- Focus on Green AI methods.
- Comprehensive ML optimization methods.
- Novel Human-Computer partnerships.
- Dedicated Hardware (HW) toolkit.
- Bring energy efficiency upfront every ML development process.

Brand pillars These are summarize in Figure 4

- Open source: commercially-friendly open source license, vendors can still adapt the SW as needed.
- Affordable: focus on the value-generating product functionalities and reducing development costs.
- Transparency: a more comprehensible ML application tasks description procedures.
- Flexible: Common Green AI framework for any AI deployment.
- User friendly: interactive human-computer partnerships for ML project descriptions.
- Explainability: AI explainability for energy efficient ML models.
- Green AI: SustainML framework comprehensively prioritizes and advocate energy efficiency.
- Plug&Play: Simple distribution of SustainML framework by a desktop and web-based application.
- Secure: authentication and encryption capabilities integrated with the security of Fast DDS[1].

2.4 Target audiences

This section presents the target audiences of the SustainML project.

AI researchers The SustainML framework will stimulate novel Green AI methods across the full scope of AI from hardware to model architecture in the AI research community. The framework serves as a central collection of efficient methods from the HW stack to operation and model structures, and higher-level training process optimizations, including the novel interdisciplinary methods developed from this project.

[1] `https://github.com/eProsima/Fast-DDS`

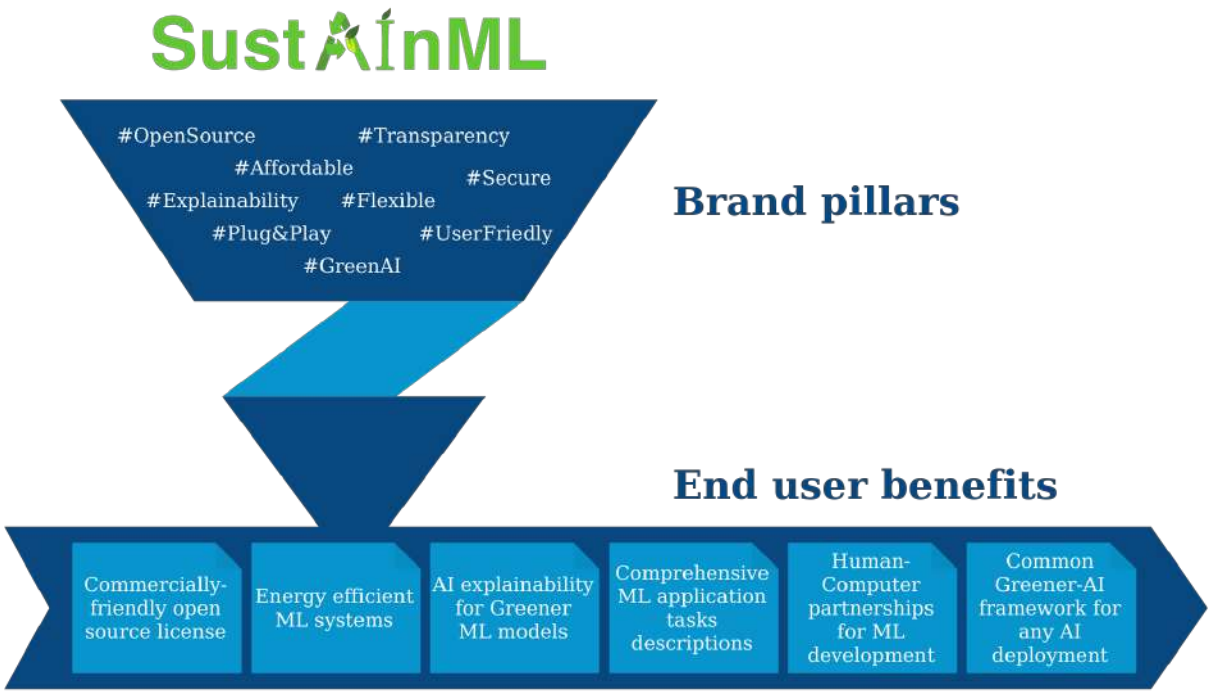


Figure 4: SustainML brand pillars

SustainML partners will also generalize existing niche methods that solve specific problems to adapt to similar tasks, aiming to stimulate and accelerate research on new energy efficiency through this concentrated and multi-stack environment. AI researchers can have a convenient overview of all the originally segmented efficient methods.

From novice to experts AI developers Currently, the AI developer community bases its development of ML applications on prior knowledge and the most widely accepted technologies in the community. This often results in ML applications that are not specifically designed for the problem they are intended to solve, but based on the reusability of existing ML methodologies and technologies.

The SustainML framework aims to provide developers with solutions adapted to the problems they intend to solve, focusing wherever possible on proposing energy-efficient solutions, relying on Green AI methods throughout the entire ML development lifecycle.

AML is a novel technology that allows exploiting the use of ML in distributed systems. That is why Algebraic Machine Learning - Integrating Platform (AML-IP) is presented as a platform that allows the connection of AML nodes which will be seamlessly integrated into ROS 2. Therefore, the developer community is targeted to exploit this platform as a unified AML integration method instead of relying on customized solutions for each application.

Moreover, application software developers will be the main users of the SustainML framework, integrating it into their end-user applications design process. They will also benefit from the open-source integration, benchmarking, monitoring and evaluation packages released under the SustainML project.

Furthermore, the developer's community will help validate the development of the framework and the various open-source tools for Green AI applications, making the development process more efficient and avoiding AI waste.

SMEs, startups and large enterprises We aim to fill the current gap, wherein the tools for broad AI adoption are directly inherited from AI research with little attention paid to efficiency. Instead of bringing design overhead, SustainML will help avoid AI waste seamlessly during the entire design process through our multiple specific objectives. We will overturn the classical 'black box' conception of Deep Neural Network (DNN) since our approach emphasises on transparency and functionalities of internal components of DNN models through the interactive process. We aim to empower the surging AI adoption to these ever-growing target groups while delivering expert experiences in efficiency and explainability.

Other communities and working groups Table 2 shows the list of target communities as well as the partners in charge of raising awareness of the project results among these communities.

Target community	Partner(s) involved
ROS 2 TSC	EPROS
ROS / ROS 2 community	EPROS
Open Robotics Foundation	EPROS
AI Integration Working Group	EPROS
AI/ML accelerators adopters	UPMEM
Deep Learning Competence Center	DFKI
ICT-48 community	DFKI
Humane-AI-Net community	DFKI
AI4EU platform partners	TUK
Human-Computer Interaction researchers	Inria

Table 2: SustainML target communities and partners responsible for raising awareness

2.5 Key messages

The key messages conveyed throughout the project vary depending on the phase of the project, i.e., the information communicated is not the same in the initial phases of the project, focused on research and development, as in the final phases dedicated to the exploitation and contribution of external entities to the project. In this section, we present the initial and results publication phases, which are of interest considering the current state of the SustainML project.

2.5.1 Project launch and first half of the project

At this project phase, the SustainML final product is neither mature enough nor yet sufficiently tested to involve the AI developer community in the use of the SustainML framework. That is why at this stage the main focus is on the dissemination and communication of SustainML research within the AI research community through the publication of papers and research articles.

The starting point of SustainML is the characterization of the ML tasks that the user needs to solve. This characterization should be specific enough to be able to obtain the efficiency-accuracy tradeoff of the different ML approaches suggested, as well as to be the foundation of the user's descriptions and interaction with the SustainML framework. At the same time, the resource optimization methodologies

are investigated from different perspectives. From the hardware point of view, we started the development of an open-source toolchain for hardware exploitation and embedded energy modelling methods, which will be integrated into the final SustainML framework.

2.6 First results obtained and tools releases

The message focuses on highlighting the benefits of the SustainML framework to promote its adoption by the AI research and developer community.

- Developers can describe their tasks for solving an ML problem, while the framework will analyze the need of the task, divide, and encode the problem. Then the framework will suggest several ML models that the developers can reconfigure.
- The SustainML framework is an interactive assistant that guides the developers through the entire development and implementation process, leveraging the above model to help them achieve their design goals while minimizing energy consumption considering the entire expected life cycle.
- SustainML framework is a unique ML framework that prioritizes energy efficiency from hardware to model levels.
- By providing a collective registry of efficient methods, the SustainML framework will accelerate Green AI research.
- SustainML framework enables bidirectional exchanges between humans and algorithm, and hardware and model.
- SustainML safeguards the sustainability of AI by addressing AI waste and optimization.

2.6.1 Elevator pitch

An elevator pitch has been prepared to deliver a unified message in those lightning presentations of the SustainML project at conferences or events where the project is being promoted. It summarizes the goal of the SustainML framework.

> SustainML framework is a sustainable, interactive ML framework development for Green AI that will comprehensively prioritize and advocate energy efficiency across the entire life cycle of an application and avoid AI waste.
>
> Developers can describe their tasks for solving an ML problem, while the framework will analyze the need of the task, divide, and encode the problem. Then the framework will then suggest several ML models and the developers can reconfigure the model during the interactive design process.
>
> The SustainML framework is not yet another AI studio tool. It collects research on the detailed footprint of various computing and data hardware, as well as the development of novel hardware accelerators optimized for different layers and operations. So, the users will see the estimated CO2 footprint, hardware resource and training time during the design process, before these costs occur.
>
> Such a framework can be used by any user who needs to develop ML solutions: a novice user will know why certain model structures are better suited for specific tasks; intermediate users or experts from other fields who want to use AI to solve their problems can leverage our framework to develop efficient models that are optimized to their goals with the knowledge from AI experts; and finally AI researchers can skip the problem describing process and

leverage the efficiency transparency of the framework to benchmark and optimize their ML models' carbon footprint.

This results in a SustainML framework that brings energy efficiency upfront to every AI researcher and developer during its entire life cycle.

2.7 Key channels

The main communication and dissemination channels of the SustainML project are represented in the marketing funnel shown in Figure 1. The use of these channels may be independent or combined depending on the target audience, the key message according to the status of the project, and the research results to be disseminated. These are summarized in the following points:

- Social media: each partner will make use of its social networks as the main channels for awareness and communication of the status and results of the project. All activities are promoted through the partners' media including YouTube, Twitter, LinkedIn, or SlideShare. Given the partners' collaboration with communities in their respective research and development fields, the advantage will be taken from the support of third parties acting as evangelists and advocates.
- Online and offline international events: an effort is made to disseminate the project through dedicated events as well as events where partners are present.
- Online webinars: designed to target developers.
- Working groups and community building: both the project's website and social networks act as main entry points for the project's audience.
- Earned and shared media: all social media content generated and created by project partners or end users will be shared through the partners' and influencers' media. The goal is that the SustainML community strive to create valuable content that can be easily shared with others.
- Offline channels: although this is not the most relevant medium nowadays, the project results should be made available in physical spaces. Brochures, posters/roll-ups, event stands, presentations and other written content are intended to attract the audience and generate interest in physical events. The described offline communication means are intended to visually impact the target audience by increasing their interest in the project, its goals, activities, and results through a clear and concise message.

2.8 Roadmap

This section presents the roadmap of the dissemination (Figure 5) and communication (Figure 6) activities.

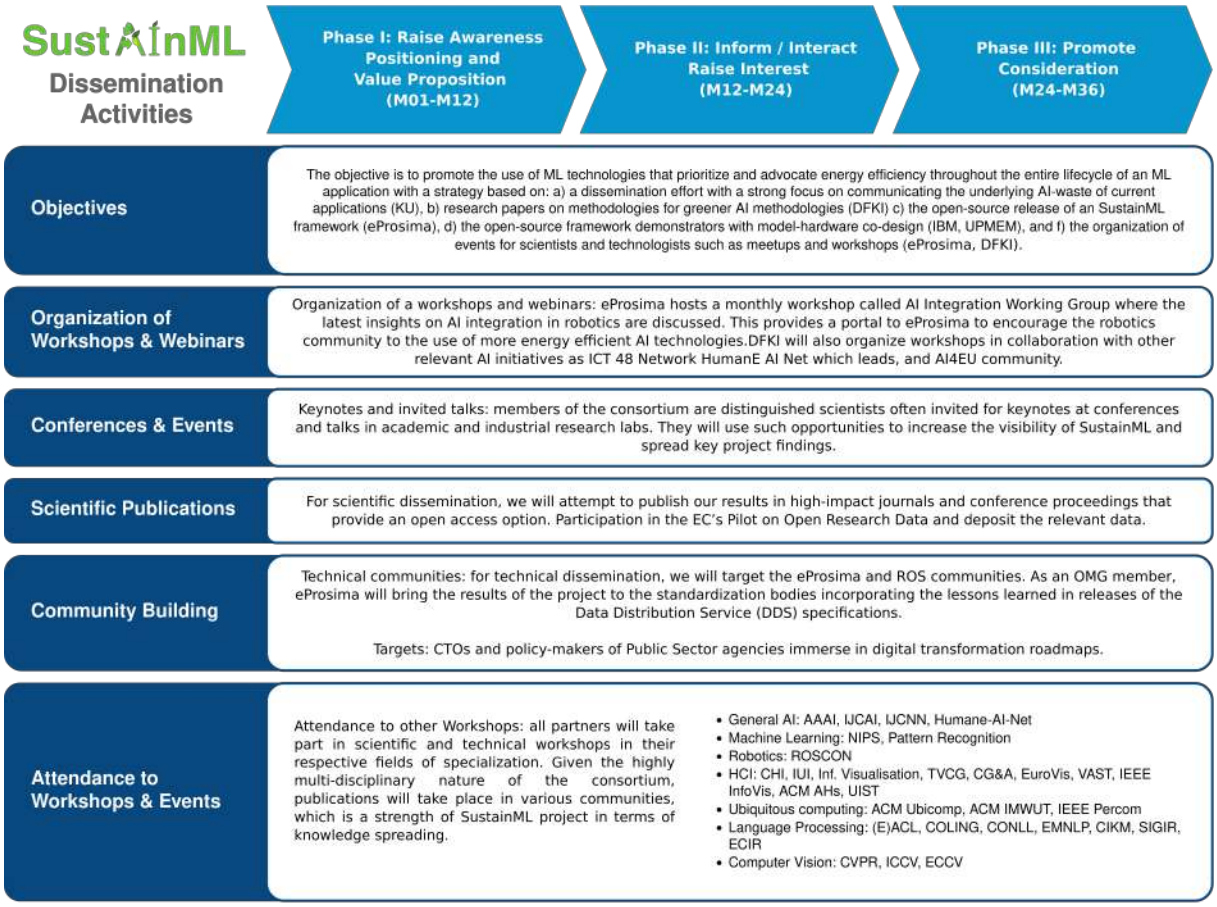


Figure 5: SustainML dissemination activities

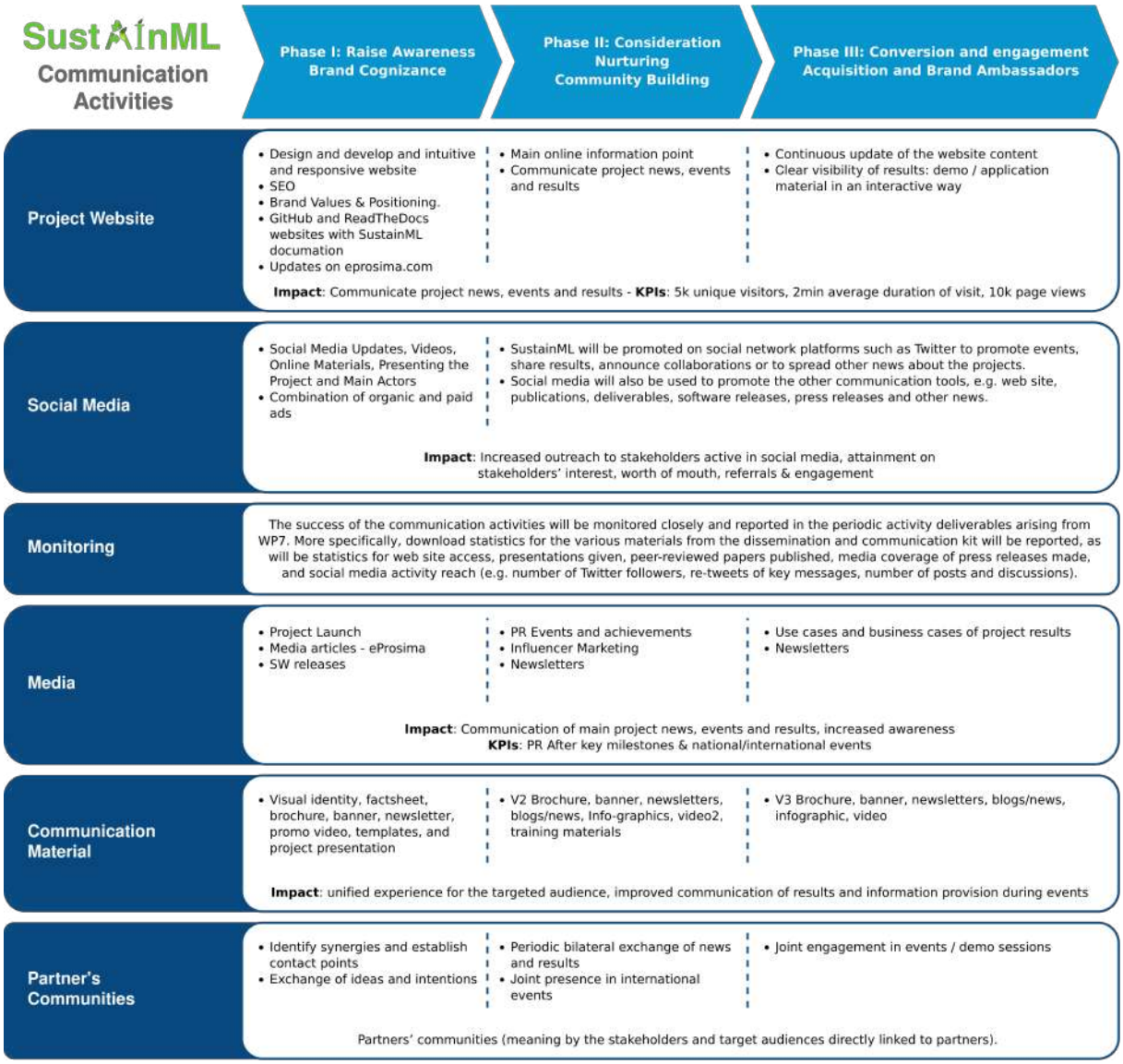


Figure 6: SustainML communication activities

3 Communication and dissemination activities report

The report of all dissemination and communication activities conducted during the first half of the project is described in this section. It is important to mention that during this initial phase of the project, great efforts have been placed in the realization of promotional and marketing materials to raise awareness of the SustainML project and the SustainML framework. Although during this phase of the project, software implementations of the SustainML framework have already been carried out, this phase has been mainly focused on research tasks, leaving the dissemination of innovation and implementation of tools that exploit research results for the following phases of the project. Therefore, dissemination tasks are focused on the publication of scientific papers to reach and engage the community of AI researchers, leaving the adoption of developer communities and end users of the SustainML framework for the next phases of the project in which a tangible, tested and stable product will be available.

3.1 Current Phase

The current Phase of the project is *Phase II: Inform, interact and raise interest.* As the project is in an early development stage and the technology is not mature enough to generate market attraction, the marketing efforts are currently focused on the creation of content around the SustainML framework and energy-efficient ML methods to generate interest and expectation and start building an early community of SustainML framework potential adopters.

3.2 Communication materials

During the first semester of the project, the materials that will be used in the communication and dissemination activities of the SustainML project, such as in-person and online events, workshops, conferences, webinars, etc., have been created. This section starts off by explaining the official SustainML logo and the visual identity of the SustainML brand; continues with the presentation of the promotional tools to be used; and concludes with the support tools for internal communication.

3.2.1 Logo

The central element of the logo is the green leaves in the green AI letters, chosen to associate the brand with the universal element that represents ecological issues. The objective of the brand is represented in the form of green leaves, which is adjusted and refined in order to summarize the project's mission: "Application Aware, Life-Cycle Oriented Model-Hardware Co-Design Framework for Sustainable, Energy Efficient ML Systems".

Figure 7: SustainML Logo

It is worth mentioning that the original project logo presented in SustainML grant agreement has been replaced by a new logo, very similar to the original but containing the name of the project. This is intended to make the association between SustainML's logo and the project more easily recognisable.

(a) Original SustainML logo (b) New version of SustainML logo

Figure 8: Comparison between original and new SustainML logos

3.3 Visual identity

3.3.1 Logo variations

Different versions of SustainML's corporate logo have been designed to be applicable to each type of presentation and background.

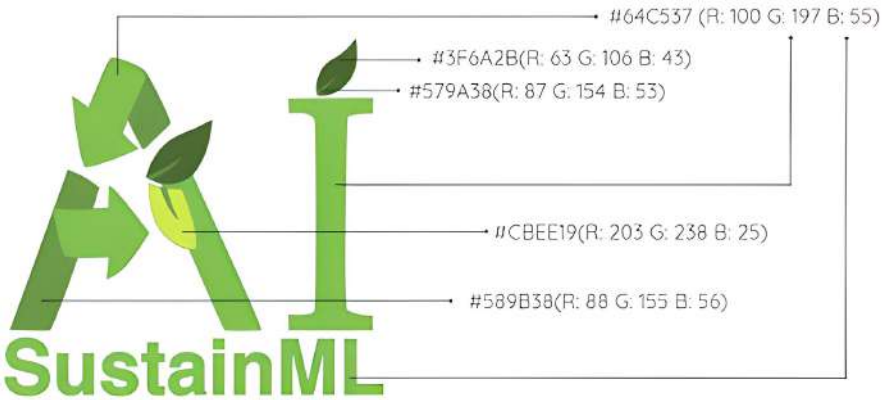


Figure 9: Color positive main version of the SustainML logo

(a) Black main version of SustainML logo

(b) White main version of SustainML logo

(c) Dark blue (#09487E) main version of SustainML logo

(d) Light blue (#0895CD) main version of SustainML logo

Figure 10: One ink main versions of SustainML logo

Figure 11: Color positive secondary version of the SustainML logo

(a) Black secondary version of SustainML logo

(b) White secondary version of SustainML logo

(c) Dark blue (#09487E) secondary version of SustainML logo

(d) Light blue (#0895CD) secondary version of SustainML logo

Figure 12: One ink secondary versions of SustainML logo

3.3.2 Typography

Fonts The fonts used in the various dissemination and communication materials of the SustainML project are listed below.

- Roman Serif: default font for documentation and reporting.
- Lato: font used for titles, headers and texts in presentations.
- Arial: font used as an alternative of Lato for texts in presentations.

Colors Main colors are defined, which are the leading and predominant ones in the graphic materials and visual compositions of SustainML, and secondary colors, which are used as a support to the main colors, to highlight and add contrasts in SustainML's graphic materials. The secondary colors are always accompanied by the main ones, and are never the predominant colors in the visual materials.

Figure 13: Main colors for SustainML marketing materials

Figure 14: Secondary colors for SustainML marketing materials

3.4 Promotional material

Several promotional materials have been created to summarize the mission and vision of the SustainML project and to reach the target audience. These materials are intended to serve as an attraction at conferences and live events in which the SustainML consortium participates in order to disseminate SustainML framework and the results obtained from research and innovation. Although these material are meant for live events, they will also be disseminated via online platforms of the corresponding events and partners websites.

Figure 15 shows an example of a poster produced for the dissemination of SustainML at events and the engagement of our target audience.

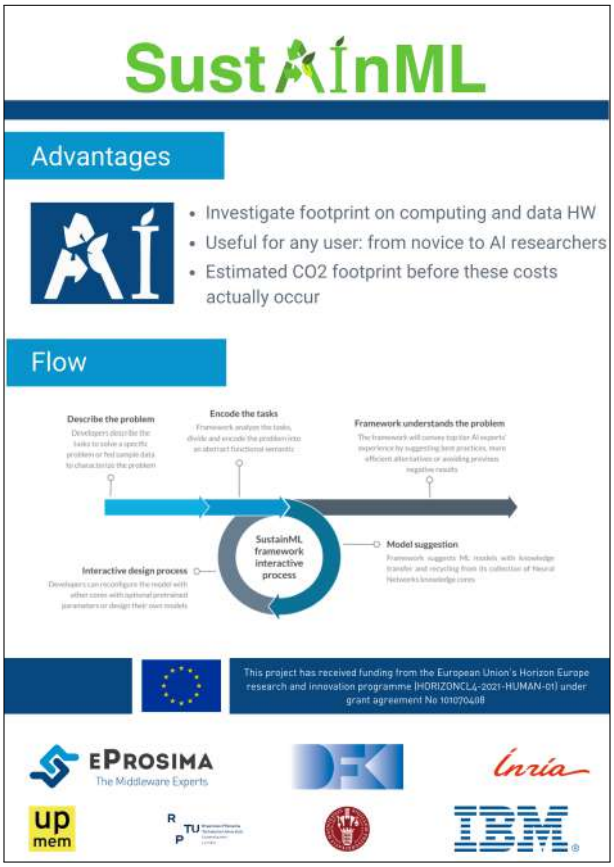


Figure 15: SustainML promotional poster

SustainML participated in Horizon Europe AI & Robotics Launch event, held on 17th October 2022 and organized by ADRA-e[2] and AI4EUROPE[3]. As a result of this participation, a video presentation of the project and the poster shown below were produced.

(a) Page 1 (b) Page 2

Figure 16: SustainML brochure for Horizon Europe AI & Robotics Launch event 2022

Another brochure has also been prepared paying special attention to define a clear and friendly message that best represents the idea of the project and captures the attention of the target audience. This brochure is shown in Figure 17.

[2] https://adra-e.eu

[3] https://ai4europe.eu

(a) SustainML brochure - page 1

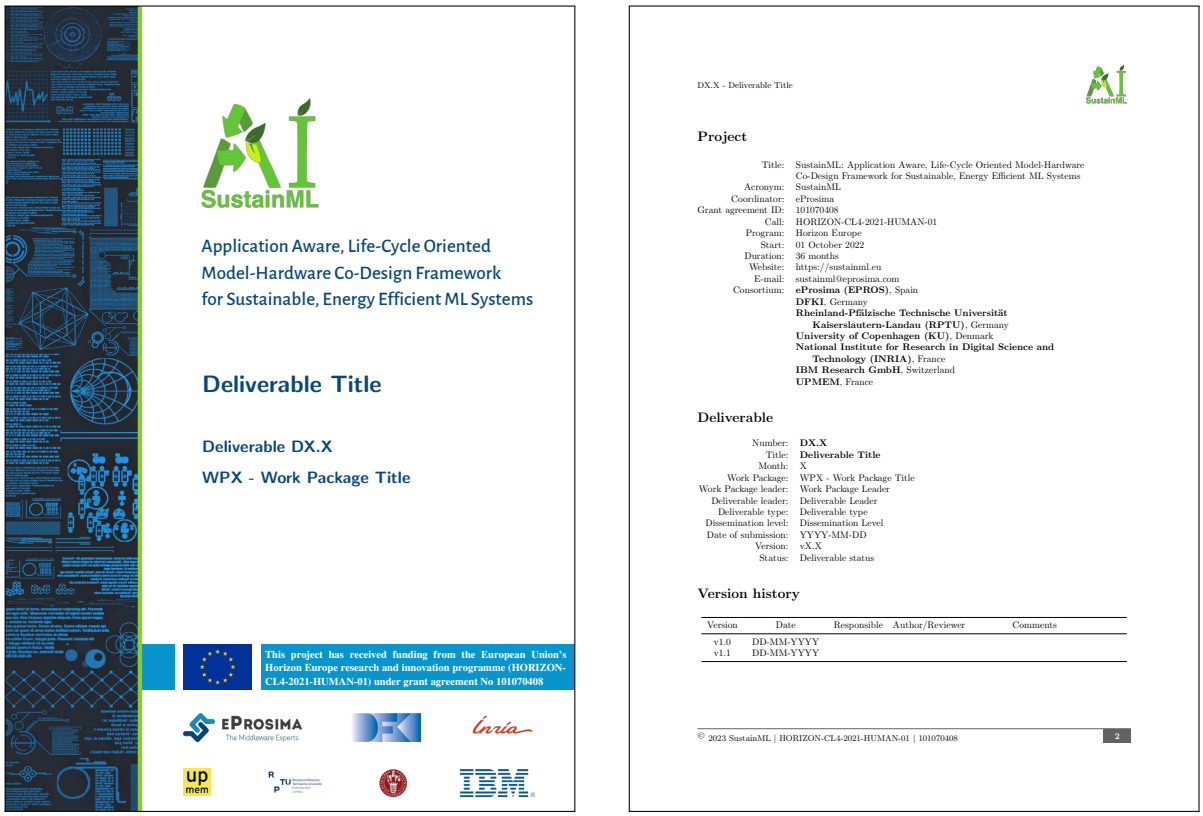
(b) SustainML brochure - page 2

Figure 17: SustainML brochure

3.5 Internal support tools

An important aspect of dissemination and communication is the achievement of homogeneity in the documents presenting research and innovation results of the SustainML project. This format homogeneity applies to project deliverables, presentations or any other material produced.

In order to achieve this format homogeneity, we have created templates for documents and reports (Figure 18), and presentations (Figure 19) available for any member of the consortium.



(a) SustainML report template - page 1

(b) SustainML report template - page 2

Figure 18: SustainML report template

Figure 19: SustainML presentation template

3.6 Meetings and events

This section lists the events in which the SustainML partners have participated in the dissemination of the SustainML project.

3.6.1 Events summary

This section displays a summary table (Table 3) with all the events that consortium members have attended to disseminate the SustainML project and communicate research results. As can be seen, most of these events are aimed at disseminating the SustainML project objectives and impact.

Partner	Event	Participation	Contributors	Place	Date	URL
KU	Talk at SINTEF[4]	Carbon footprint of Deep Learning	Raghavendra Selvan	Oslo, Norway	15/03/2023	Not available
EPROS	Establishing the next level of "intelligence" and autonomy Clustering Workshop Event	SustainML: Application-Aware, Life-Cycle Oriented Model-Hardware Co-Design Framework for Sustainable, Energy Efficient ML Systems	Raúl Sánchez-Mateos, Lara Moreno	Online	03/02/2023	Talon Events[5]
EPROS	Launch Event: Paving the way towards the next generation of R&I excellence in AI, Data and Robotics	SustainML project presentation	Raúl Sánchez-Mateos, Daniel Cabezas	Online	17/10/2022	Adra-e Events[6]
EPROS	ROS 2 AI Integration Working Group	SustainML project introduction	Raúl Sánchez-Mateos	Online	28/06/2022	ROS Discourse post[7]
KU	ROS 2 AI Integration Working Group	Carbon Footprint of Deep Learning	Raghavendra Selvan	Online	28/02/2023	ROS Discourse post[8]
KU	Talk at Chalmers University[9]	Carbon footprint of Deep Learning	Raghavendra Selvan	Gothenburg, Sweden	17/04/2023	Not available
UPMEM	ABUMPIMP 2023	Event organizer	Yann Falevoz, Julien Legriel, Massimiliano Bartoli	Limassol, Cyprus	28/08/2023	ABUMPIMP 2023[10]

[4] https://www.sintef.no/en/

[5] https://talon-project.eu/eventsestablishing-the-next-level-of-intelligence-and-autonomy-clustering-workshopevents/

[6] https://adra-e.eu/events/paving-way-towards-next-generation-ri-excellence-ai-data-and-robotics

[7] https://discourse.ros.org/t/ros-2-ai-integration-working-group/26119/5

[8] https://discourse.ros.org/t/ros-2-ai-integration-working-group/26119/22

[9] https://www.chalmers.se/

[10] https://www.upmem.com/abumpimp-2023/

UPMEM	ROS 2 AI Integration Working Group	Accelerate and improve the energy efficiency of AI applications with UPMEM PIM	Yann Falevoz	Online	October 2023	ROS Discourse post[11]
INRIA	HCI for climate change	Paper presentation	Eya Ben Chaaben, Janin Koch	Hamburg, Germany	28/04/2023	HCI for climate change[12]
DFKI	Pro²Future Scientific Symposium on SUSTAINABLE AND COGNITIVE PRODUCTS AND PRODUCTION SYSTEMS of the Future	Keynote: The Future is Cognitive - Edge Embedded AI for Smart Production	Paul Lukowicz	Linz, Austria	22/06/2023	Pro²Future 1st Scientific Symposium[13]
DFKI	IEEE Percom Workshop PerConAI	Keynote: Resource Optimized Human Activity Recognition	Paul Lukowicz	Biarritz, France	15/03/2024	PerConAI 2024[14]

Table 3: Events summary

3.6.2 Future events

The events already scheduled to promote SustainML research and innovation results are shown in Table 4.

Partner	Event	Participation	Contributors	Place	Date	URL
UPMEM	ABUMPIMP 2024	Event organizer	Yann Falevoz, Julien Legriel, Meven Mognol, Sylvan Brocard	Madrid, Spain	28/08/2023	ABUMPIMP 2024[15]

Table 4: Future events

3.7 Scientific publications

Table 5 shows the scientific papers published so far and those expected to be published in the coming months.

[11] https://discourse.ros.org/t/ros-2-ai-integration-working-group/26119/39

[12] https://sites.google.com/fbk.eu/hci-climate-change/home

[13] https://www.pro2future.at/symposium-1/

[14] https://2023.perconai.iit.cnr.it/

[15] https://www.upmem.com/abumpimp-2024/

Partner	Type	Title	Media	Contributors	Date	URL
DFKI	Publication in Conference Proceedings/Workshop	A Knowledge Distillation Framework for Multi-Organ Segmentation of Medaka Fish in Tomographic Image [1]	International Symposium on Biomedical Imaging (ISBI), IEEE	Jwalin Bhatt, Yaroslav Zharov, Sungho Suh, Tilo Baumbach, Vincent Heuveline, and Paul Lukowicz	April 2023	https://ieeexplore.ieee.org/document/10230689
KU	Publication in Conference Proceedings/Workshop	Efficient Self-Supervision using Patch-based Contrastive Learning for Histopathology Image Segmentation [2]	Northern Lights Deep Learning Conference	Nicklas Boserup, Raghavendra Selvan	23/01/2023	https://doi.org/10.7557/18.6798
INRIA	Publication in Conference Proceedings/Workshop	Addressing Sustainable ML Life-cycles through Human-Centered Design	HCI for climate change	Eya Ben Chaaben, Janin Koch	28/04/2023	https://sites.google.com/fbk.eu/hci-climate-change/home
DFKI	Publication in Conference Proceedings/Workshop	Latent Inspector: An Interactive Tool for Probing Neural Network Behaviors Through Arbitrary Latent Activation [3]	International Joint Conference for Artificial Intelligence (IJCAI 2023)	Daniel Geißler, Bo Zhou, Paul Lukowicz	May 2023	https://www.ijcai.org/proceedings/2023/832
DFKI	Publication in Conference Proceedings/Workshop	FieldHAR: A Fully Integrated End-to-end RTL Framework for Human Activity Recognition with Neural Networks from Heterogeneous Sensors [4]	IEEE International Conference on Application-specific Systems, Architectures and Processors (ASAP23)	Mengxi Liu, Bo Zhou, Zimin Zhao, Hyeonseok Hong, Hyun Kim, Sungho Suh, Vitor Fortes Rey, Paul Lukowicz	July 2023	https://doi.org/10.1109/ASAP57973.2023.00029
UPMEM	Publication in Conference Proceedings/Workshop	Energy Efficiency Impact of Processing in Memory: A Comprehensive Review of Workloads on the UPMEM Architecture	Workshop on Performance and Energy-efficiency in Concurrent and Distributed Systems (PECS 2023, Co-located with Euro-PAR 2023)	Yann Falevoz, Julien Legriel	2024	Accepted, conference presentation done, pending Camera Ready
RPTU	Article in Journal	Novel Adaptive Quantization Methodology for 8-bit Floating-Point DNN Training [5]	Springer Journal of Design Automation for Embedded Systems (2023)	Mohammad Hassani Sadi, Chirag Sudarshan, Norbert Wehn	16/02/2024	https://link.springer.com/article/10.1007/s10617-024-09282-2

INRIA	Publication in Conference Proceedings/Workshop	Framing the Intersection of Sustainability with HCI and Machine Learning	International Conference on ICT for Sustainability (ICT4S). IEEE Computer Society, 2024	Eya Ben Chaaben, Janin Koch	-	Pending
DFKI	Publication in Conference Proceedings/Workshop	User-Rich Representations Adapt Better: Leveraging Large-Scale Unlabeled Data for Contrastive Online Adaptation for Human Activity Recognition	IEEE Percom	Pedro Martelleto Bressane Rezende, Vitor F Rey, Bo Zhou, Sungho Suh, Paul Lukowicz	-	Pending
DFKI	Publication in Conference Proceedings/Workshop	CoSS: Co-optimizing Sensor and Sampling Rate for Data-Efficient AI in Human Activity Recognition [6]	AAAI 2024 Sustainable AI workshop	M. Liu, Zimin Zhao, Daniel Geißler, Bo Zhou, Sungho Suh, Pual Lukowicz	January 2024	https://arxiv.org/pdf/2401.05426.pdf
DFKI	Publication in Conference Proceedings/Workshop	The Power of Training: How Different Neural Network Setups Influence the Energy Demand [7]	AAAI 2024 Sustainable AI workshop	D. Geißler, Bo Zhou, Mengxi Liu, Sungho Suh, Paul Lukowicz	January 2024	https://arxiv.org/pdf/2401.01851.pdf

Table 5: Scientific publications

3.8 Posts analytics

This section shows the dissemination activities carried out to date for the dissemination of the SustainML project. As explained in subsection 2.4, the target audience to be reached with these posts are developers, applied computer science community, SMEs, startups and large enterprises that are going to use the SustainML framework. The problem with these communities is that they require that the developments can be tested and evaluated so it is difficult to reach them at the moment due to the lack of SustainML framework implementation and validation. This is why efforts have been put into creating marketing material for events rather than creating posts on social networks or developer community forums.

3.8.1 Social Media

The SustainML presence on social media has been moderate in the first half of the project given the nature of the target audience we are addressing when publishing on these platforms. The early stage of the project, which is in the research phase, implies that the target audience at this point is scientists, mathematicians and researchers, rather than developers and end-users, who are unable to test a stable and functional product at the moment. This is why, as mentioned in subsection 2.8, the presence in social media is reduced in the launching phase of the project to focus all efforts on scientific publications. Nevertheless, posts have been published on platforms such as Twitter and Linked-In so as to promote SustainML's presence in the events in which it has participated, shown in Table 3.

(a) SustainML presentation tweet

(b) Presentation of SustainML at ROS 2 AI Integration Working Group promotion tweet

(c) SustainML new release

Figure 20: Twitter and LinkedIn post examples

3.8.2 SustainML website

A project website has been created which is still to be improved in terms of accessibility and acceptance by new collaborators and adopters of the SustainML framework, and researchers interested in sustainable and energy-efficient ML methodologies. It is accessible at the following link: `https://sustainml.eu/`.

It is worth mentioning that a complete redesign of the project website will be carried out in the second half of the project.

The website also has a news section where the latest project progress will be added, as well as events in which any of the members of the consortium are participating by promoting SustainML. Below is a summary table with the analytics of the news published so far:

Title	Publication Date	Impressions	URL
SustainML kick-off meeting	9/12/2022	45	https://sustainml.eu/index.php/news/16-sustainml-kick-off-meeting
Carbontracker: Predicting the Deep Learning CO2 footprint	21/04/2023	129	https://sustainml.eu/index.php/news/17-sustainml-carbontracker
Introducing a Simple and Efficient Framework in Green AI	22/06/2023	10	https://sustainml.eu/index.php/news/19-introducing-a-simple-and-efficient-framework-in-green-ai
Challenges in Embedded Devices & Artificial Intelligence	22/06/2023	39	https://sustainml.eu/index.php/news/20-sustainml-embedded-ai
UPMEM's Euro-Par Minisymposium: Unleash the Power of PIM!	02/08/2023	39	https://sustainml.eu/index.php/news/21-sustainml-upmem-s-euro-par
New Project Reading Group: Explore, Learn and Collaborate	07/09/2023	24	https://sustainml.eu/index.php/news/22-sustainml-reading-group
New Carbon Tracker Release	7/12/2023	16	https://sustainml.eu/index.php/news/27-new-carbon-tracker-release

Table 6: Posts on SustainML news website

3.8.3 eProsima News

On the eProsima website, news will be published in order to promote SustainML among the users of eProsima products. Below is a summary table with the analytics of the article published so far:

Title	Publication Date	Impressions	URL
SustainML - New Green AI project coordinated by eProsima	November, 2022	548	https://www.eprosima.com/index.php/company-all/news/291-sustainml-new-green-ai-project

Table 7: Posts on eProsima news website

3.8.4 ROS Discourse

The ROS community is one of the main target audiences of eProsima for the dissemination of SustainML framework. That is why the ROS Discouse channel is used to reach and attract AI applied robotics community by publishing the news resulting from the development of the SustainML framework.

During the first half of the project, eProsima held eight ROS 2 AI Integration Working Group meetings, in which up to seven different speakers participated, three of which are part of the SustainML project. Furthermore, there have been four talks dedicated to the SustainML project.

Following are the analytics of the thread made in ROS Discourse promoting the SustainML project talks in the eProsima's ROS 2 AI Integration Working Group.

Title	Publication Date	Views	Likes	Replies	URL
ROS 2 AI Integration Working Group thread (SustainML talks)	22/09/2022	7k	79	38	`https://discourse.ros.org/t/ros-2-ai-integration-working-group/26119`

Table 8: Posts on ROS Discourse

3.9 Other posts, news and publications

In addition to the above, each partner has its own channels for the communication of project results. These range from the partners' own official websites to contributions to external journals and online media.

Title	Publication Date	Impressions	URL
UPMEM teams up to kick off an ambitious EU initiative for the sustainability of AI workloads	14/12/2023	1138	https://www.upmem.com/upmem-teams-up-to-kick-off-an-ambitious-eu-initiative-for-the-sustainability-of-ai-workloads/
The Necessary Rabbit Hole of Tracking Carbon Emissions in Machine Learning	21/03/2023	-	https://dustinwright.substack.com/p/the-necessary-rabbit-hole-of-tracking
Trends in the Compute Requirements of Deep Learning	04/04/2023	-	https://dustinwright.substack.com/p/trends-in-the-compute-requirements
It's Easy Being Green in Machine Learning	18/04/2023	-	https://dustinwright.substack.com/p/its-easy-being-green-in-machine-learning
Der Energiehunger der KIs (*The energy hunger of AIs*)	03/04/2023	-	https://www.sueddeutsche.de/wissen/chat-gpt-energieverbrauch-ki-1.5780744?reduced=true
Réduire l'empreinte carbone de l'apprentissage automatique (*Reducing the carbon footprint of machine learning*)	03/05/2023	-	https://www.inria.fr/fr/reduire-empreinte-carbone-apprentissage-automatique-ihm?mtm_campaign=Le%20Fil%20scientifique%20%E2%80%93%20mai%202023&mtm_kwd=empreinte%20carbone%20apprentissage%20automatique

Table 9: Other posts, news and publications

4 Assessment of KPIs

The goal, marketing actions and target Key Performance Indicators (KPIs) for the communication activities defined according to the communication and dissemination strategy of section 2 are detailed in Table 10. As explained in Figure 6, the main efforts are focused on the publication of research papers and participation in events to disseminate the SustainML project and research results.

Activity	Target goal	Defined actions	Target KPIs
SustainML website	Provide general information about the project	Frequent updates of SustainML website and SEO	SustainML website within the five first Search Engine Result Pagess (SERPs)
Participation in technical conferences and workshops	Raise awareness on technical and scientific communities	· Presence at ROS World/ROSCon; · Presence at HumanE AI Network; · Presence at relevant Human-Computer Interaction (HCI), ML, ROS and Hardware Acceleration (HWA) conferences and workshops	(end of year 1 / year 2 / year 3) · > 5/15/20 technical presentations (uploaded on SlideShare) · > 125/375/500 attendees in total · > 12/37/50 downloads from SlideShare
On-site demonstrations and presentations to customers/users	· Attract customers; · Raise awareness	Presentations and or demonstrations to target customers/users	35 performed by end of project
Scientific publications	Scientific dissemination	Publication to journals and magazines	> 10 publications by end of project
Presence at major trade fairs	· Market awareness; · Go-To market	Presence with dedicated space within eProsima's or some partner's booth	≥ 2 large trade fairs by end of project
Production of marketing material	Dissemination of SustainML brand and results of Research and Development (R&D)	Flyers, brochures, promotional material	A flyer, a brochure and an infographic

Active presence on social networks	Raise awareness of SustainML framework among developers and end-users	Regular posts through eProsima and other partners channels starting from the second phase of the project	· > 3 posts/month (Twitter, LinkedIn, Facebook) · 1 video/year on YouTube · > 10 average likes/share per post
One-to-one communication	Raise awareness on target audiences through targeted information	Newsletter	Featured articles in SustainML website new section

Table 10: Target KPIs

5 Exploitation plan

This section covers the exploitation plan of the SustainML project, focusing on the exploitation of project results, being the key result the SustainML framework and associated toolkit. First, the joint exploitation plan is discussed, which applies to all members of the SustainML consortium. EPROS, as the project coordinator and WP7 leader, will guarantee that the exploitation plan presented in this document is agreed and conducted by all partners. Then, the section concludes with the description of the individual exploitation plan of the partners, detailing the goal of their individual exploitation plan, their target audience, and the results and impact expected by each one of them.

5.1 General exploitation plan

This sections presents the general exploitation plan to be followed by all partners in SustainML consortium.

5.1.1 Project's mission and vision

The rapid growth of AI research and applications has led to significant energy consumption and carbon emissions, which can have a negative impact on the environment. As the demand for ML applications continues to grow.

SustainML project mission is to provide a comprehensive, sustainable, and energy-efficient ML framework that enables researchers and developers to create applications that are optimized for their goals while minimizing their environmental impact. By prioritizing energy efficiency throughout the entire life-cycle of an application, we can help mitigate the environmental impact of machine learning and contribute to a more sustainable AI development. Our goal is to make sustainable and energy-efficient machine learning accessible and practical for all users, from novice to expert, and to foster a community of responsible and environmentally conscious AI researchers and developers.

Our vision is to establish SustainML framework as an assistant tool for sustainable and energy-efficient machine learning development. SustainML can provide users with the tools and knowledge they need to make informed decisions about the energy and environmental impact of their machine learning applications.

SustainML project aims to create a more sustainable future through responsible and energy-efficient AI development.

5.1.2 Target customers and stakeholders

The main customers of SustainML framework and associated toolkit are presented in the following list:

- AI Researchers
- AI consulting companies
- Companies specializing in ML applications
- HCI companies
- Hardware acceleration Original Equipment Manufacturers (OEMs)
- AI engineers
- Software developers

Note the relevance of this project in the AI research community, so new potential customers are expected to be added in future versions of this document.

Also please refer to subsection 2.4 for more information on the target audience and the activities carried out to engage this groups.

5.1.3 Strategic approach to materialize the vision

To materialize a reality in which SustainML framework is used to efficiently address ML problems, it is necessary to provide a user-friendly framework, as well as an infrastructure that exploits the capabilities and advantages of ML methods provided and HW toolkit. In addition, it is required that the user's interaction with SustainML keeps complexity to the minimum in order to engage the developer community and facilitate its incorporation into target communities.

In addition, an effort is required to build an energy efficient Green AI ecosystem promoted by SustainML consortium through well-defined standards and community building efforts. These efforts in particular will be the basis for the project to achieve the visibility and influence required for it to be adopted by a larger number of AI researchers, users and developers worldwide.

The keys to the success of the project lie in the development of the key results shown in Table 11:

Key result	Type	Contribution
ML models	Open source research results	ML models that allow the energy/performance tradeoffs to be estimated for various applications with various ML methods on different hardware architectures including ways to specify the complexity/requirements of different applications. The models will be systematically evaluated and published in peer-reviewed venues.
ML methods	Open source research results	ML methods for various domains to be optimized (and optimizable through appropriate parameterization) for low energy consumption. This will include methods specifically tailored towards different types of model architectures (in particular variants developed in the project). A set of selected methods will be provided as a "toolbox" that will be usable as building blocks for the framework.
Use cases and demonstrations	Open source demonstrations	These will be developed in WP6, providing the basis for dissemination to customers and industrial partners.
Human Computer Interaction Paradigms	Open source research results	Human Computer Interaction paradigms and user interface concepts implemented in WP4. The aim is to create new interaction and visualization approaches that will allow users to interactively explore the trade-offs of competing ML models together with intelligent agents.
Educational material	Open source documentation	To advance knowledge and train other researchers in Green AI materials that we will use for our workshops and tutorials will be expanded and put together into a kit that will be made available to the community for both student courses and the education of workshops, tutorials, public discussions.

Hardware architecture toolkit	Open source library	Energy optimized hardware architectures (WP2) including a toolkit of most important components for the framework and the exploration kit will be provided as RTL libraries. Design will be evaluated through key novel results published at relevant conferences. Novel Process-in-memory (PIM) methods will be prototypically tested.
SustainML framework	Open source framework	Integration of research results in an unified framework that will allow researchers and developers to design ML applications focused on Green AI technologies.

Table 11: Key result of materializing the vision

The activities corresponding to the realization of the SustainML project vision in order to achieve the key results appearing in Table 11 are based on the following fundamental principles:

- Commercial exploitation, with special focus on the European market.
- Alignment with activities that are being developed in related fields of research in the European Union, whether other projects of the Horizon Europe[16] programme or new EU projects.
- Acceptance of the results by the international community.

SustainML Project website The SustainML project will maintain an owned website in order to have an openly accessible space where partners will showcase every new accomplishment achieved as the project progresses. The URL of this webpage is the following: `https://sustainml.eu/`

One of the main strategies of the SustainML exploitation plan is to maintain up-to-date the SEO of this website. These are the actions that have already taken place to pursue this goal:

- The website is indexed in Google
- URL is SEO optimized
- ALT attribute implemented in all images.
- HTML Headers (H1, H2, H3) are SEO optimized.
- Meta-description implemented.
- Robots.txt file implemented, which prevents Google Crawler from accessing (and exposing) internal URLs of the website.
- The website has Google Analytics implemented as a tool to get feedback from and improve the SEO.

5.2 Competition and SWOT analysis

The SustainML project aims to make AI researchers and developers aware of and adopt ML solutions that prioritize energy efficiency. This implies that the framework to be developed in this project must be

[16] `https://research-and-innovation.ec.europa.eu/funding/funding-opportunities/funding-programmes-and-open-calls/horizon-europe_en`

integrated into the design cycle of current ML applications. For this to be possible, it is necessary that the SustainML framework provides valid solutions and backed by experts in the field. Thus, it will be possible to create a community that encourages the development of Green AI technologies.

Moreover, the SustainML framework is positioned as the only ML framework that prioritizes energy efficiency from the creation of ML models to the hardware used for training, validation and exploitation.

The following preliminary Strengths, Weaknesses, Opportunities, and Threats (SWOT) analysis was presented in *Section 2.2 Measures to maximise impact - Dissemination, exploitation and communication* of the SustainML Grant Agreement (GA).

- Strengths
  - Our framework is uniquely positioned as no other ML frameworks prioritizes energy efficiency from hardware to model levels.
  - The participants cover a wide range of disciplines that are essential to deliver the proposed vision and work plans.
  - Many of the participants have a long history of successfully working together in other projects.
  - The participants are very well connected and embedded in the EU AI community including AI4EU and other initiatives crucial for dissemination and exploitation.
  - Bidirectional exchanges between human and algorithm, hardware and model, architecture and life-cycle.
  - Industrial participants covering different parts of the value chain with direct opportunities of exploitation.
- Weaknesses
  - Our aims are extremely ambitious (aiming to cover any possible AI applications through problem modeling and knowledge binning) given the project volume.
  - Many of the core technologies we want to build on are cutting edge and yet to be proven in broader practical applications.
  - Other emerging machine learning methods beyond DNN, such as algebraic machine learning or liquid neural networks that may prove to be more efficient and replace DNNs in popular application are not covered.
- Opportunities
  - Safeguard the sustainability of AI through addressing AI-waste and optimization.
  - Accelerate Green AI research by creating a collective registry of efficiency methods.
  - Promote transparent and explainable AI through the semantic parameterized space, interactive agents and functional knowledge cores.
  - The proposed efficiency methods registry has the potential to become the central exchange hub for efficient AI research.
- Threats
  - Other ML design frameworks mentioned in 1.1 may incorporate resource optimization methods.

  - Transition in AutoML[17] research towards task description, HCI and more focus on SoC level resource awareness.
  - Unforeseeable risks emerging technology.

As stipulated in the GA, the previous SWOT analysis has been reviewed by the consortium and some significant changes have been applied. The opinions and feedback received by each of the partners in the multiple meetings of the SustainML project have been taken into account, resulting in the following new SWOT analysis (**bold text** indicates additions while ~~crossed out text~~ denote deletions):

- Strengths
  - Our framework is uniquely positioned as no other ML frameworks prioritizes energy efficiency from hardware to model levels.
  - The participants cover a wide range of disciplines that are essential to deliver the proposed vision and work plans.
  - Many of the participants have a long history of successfully working together in other projects.
  - The participants are very well connected and embedded in the EU AI community including AI4EU and other initiatives crucial for dissemination and exploitation.
  - Bidirectional exchanges between human and algorithm, hardware and model, architecture and life-cycle.
  - Industrial participants covering different parts of the value chain with direct opportunities of exploitation.
  - **Novel Human-Machine Computing paradigms applied to the SustainML framework interactive process.**
- Weaknesses
  - Our aims are extremely ambitious (aiming to cover any possible AI applications through problem modeling and knowledge binning) given the project volume.
  - Many of the core technologies we want to build on are cutting edge and yet to be proven in broader practical applications.
  - Other emerging machine learning methods beyond DNN, such as algebraic machine learning or liquid neural networks that may prove to be more efficient and replace DNNs in popular application are not covered.
- Opportunities
  - Safeguard the sustainability of AI through addressing AI-waste and optimization.
  - Accelerate Green AI research by creating a collective registry of efficiency methods.
  - Promote transparent and explainable AI through the semantic parameterized space, interactive agents and functional knowledge cores.
  - The proposed efficiency methods registry has the potential to become the central exchange hub for efficient AI research.

[17] `https://www.automl.org/automl`

  - **More relevant AI applications generalized to any use case with no consideration of energy efficiency in their models.**

- Threats
  - Other ML design frameworks mentioned in 1.1 may incorporate resource optimization methods.
  - Transition in AutoML[18] research towards task description, HCI and more focus on SoC level resource awareness.
  - Unforeseeable risks emerging technology.
  - **Popularity of user-interacting generative neural networks to address ML problems.**

5.2.1 Unique Selling Propositions (USPs)

SustainML project proposes a novel ML framework with an associated hardware toolkit for designing ML applications prioritizing energy efficiency along the whole ML life-cycle. The key unique selling propositions of this project are:

1. Sustainable and energy-efficient AI development. The SustainML framework is being thought to promote energy efficiency in ML applications development process by providing users the mechanisms to understand the the ML models they are designing, and the energy consumption and carbon footprint of their ML applications, i.e. by giving them transparent insights into the energy and environmental impact of their work. SustainML provides a comprehensive approach to sustainability, incorporating the entire life-cycle of an application, from design to deployment.
2. Low entry barriers for users. The framework is intended for any user of ML to be able to work with it, from novices to expert researchers, since the workflow for each of them will be different. Novice users will be able to see the internal behavior of the DNNs proposed by the framework, while researchers will be able to use ML recycling techniques to investigate and add new models and solutions.
3. Interactive and user-friendly. Within the scope of the SustainML project, new paradigms of human-machine interaction/collaboration will be studied and subsequently applied to the SustainML framework in order to improve user interaction with the framework and thus reduce the barrier to entry for new users who want to incorporate SustainML into their AI design processes.
4. Comprehensive optimization methods. SustainML framework will offer comprehensive ML optimization methods, including the development of novel hardware accelerators. The framework collects research on the detailed footprint on various computing and data hardware, enabling users to make informed decisions during the design process about the energy and environmental impact of their applications. By providing users with comprehensive optimization methods, SustainML ensures that users can develop efficient models that are optimized to their goals, reducing the energy consumption and carbon footprint of their ML applications.
5. Knowledge recycling. The framework incorporates the reuse of pre-trained models and transfer learning techniques, which enable users to recycle knowledge and avoid unnecessary training time and energy consumption.
6. CO2 footprint transparency. The SustainML framework provides users with estimated CO2 footprint, hardware resource, and training time during the design process, before these costs actually occur, which enables users to optimize their ML applications to reduce their carbon footprint.

[18] `https://www.automl.org/automl`

5.3 Individual exploitation plan

This section describes the individual exploitation plan of each of the SustainML consortium members, as well as the target audience, expected results and impact of each of them.

5.3.1 eProsima (EPROS)

Exploitation plan eProsima plans to leverage the results of improving current products as eProsima Visual ROS[19], a tool developed as a result of their participation in the DIH^2 H2020 project (Task 5.3), while Task 5.2 will serve as a foundation for future products and tools, together with their current developments for AML in the H2020 ALMA project[20].

Moreover, eProsima has experience when it comes to facing the many challenges that exploiting Open Source (OS) software entails, following a commercially successful strategy based on offering consultancy as well as freemium services. The company is committed to Open Source software and open standards (such as Object Management Group (OMG), to which it contributes) and thereby a similar approach is planned for the exploitation of the SustainML framework.

Target group / audience / stakeholders eProsima's target audience are software developers, the ROS 2 community, and end-users of ML applications who would benefit from exploiting the capabilities of SustainML framework by integrating this new technology into their ML model development process.

Expected results / impact The expected outcome of the exploitation activities carried out by eProsima is that of making the ROS community aware of the SustainML technology, so that they would start to integrate the use of this framework into their projects. Also, aside from the robotics sector, it is intended that those developers applying ML technologies to real problems become aware of the energy efficiency implied by using a model adapted to the specific problems they want to solve.

5.3.2 DFKI

Exploitation plan DFKI will mainly target publication venues in the ubiquitous computing, machine learning and IoT fields, including ACM IMWUT, IEEE IoT, Elsevier Information Fusion, etc. The outcome of the project will be closely connected with other on-going projects including STAR, XAINES, Sustainable Embedded AI. The proposed project will help DFKI consolidate the position in sustainability, transparency and Green AI research. DFKI will integrate the task understanding, transparency and best practice catalog aspects into the lectures of artificial intelligence and embedded intelligence, which are given by the same department in the University of Kaiserslautern. The SustainML framework as a tool will also help accelerate DFKI in developing AI solutions in all application domains including public and industrial projects. DFKI Kaiserslautern operates a Deep Learning Competence Center[21], which is dedicated to helping industrial partners use and learn about state-of-the-art ML methods and will be involved in the project.

[19] https://eprosima.com/index.php/company-all/news/323-visual-ros-simplifying-ros-2-development-with-a-graphical-interface

[20] https://alma-ai.eu

[21] http://dl.dfki.de

5.3.3 Rheinland-Pfälzische Technische Universität Kaiserslautern-Landau (RPTU)

Exploitation plan The results of the projects will be integrated into the lectures of the embedded systems study programme. It is planned to incorporate aspects of the SustainML results into the open-source platforms and tools (e.g. open-source HW platforms and DRAMSys), which have already found wide-spread acceptance in the research community and industry. Additionally, the HW exploration framework developed will help researchers to exploit the HW architectures better for achieving a much lower energy consumption. Thus, new research orientations and new fields in the widely researched area of DNN will be enabled using such an open-source HW platform exploration framework. At RPTU the proposed project will be closely associated with the newly approved "Sustainable Embedded AI" initiative from the industrial Carl Zeiss Foundation (approved in Oct. 2021).

Target group / audience / stakeholders The target group of RPTU are HW developers/designers and HW engineers that handle multiple HW architectures and implementations for ML applications.

Expected results / impact We expect that the SustainML project's framework and especially the HW exploration and generation framework for different ML architectures will become a reference for all AI/ML accelerator users and will help to drive future developments in the AI community and industry. The results stored in an open database for various HW platforms will help HW designers to judge and to weigh the different disadvantages and advantages of each HW architecture approach. Thus, it will give HW developers concrete measures at hand to deal with the classical trade-offs performance vs. energy efficiency and this will finally lead to a much more sustainable usage of ML applications, as they can be executed on the most energy saving (carbon footprint) HW platform.

5.3.4 University of Copenhagen (KU)

Exploitation plan KU intends to disseminate the research carried out in the project as publications in high impact machine learning venues, such as the International Conference on Neural Information Processing Systems (NeurIPS), ICML and Journal of Machine Learning Research (JMLR). KU will aim to organize a neural network architecture search (NAS) benchmarking competition in one of the major conferences based on the energy consumption optimized framework developed as part of SustainML, to further interest in sustainable ML. KU will communicate the research to the broader public to garner interest in sustainable ML. The research in the SustainML project will help KU to progress in their sustainability action goals.

5.3.5 National Institute for Research in Digital Science and Technology (INRIA)

Exploitation plan The ExSitu research group at INRIA Paris-Saclay intends to disseminate project findings through scientific conferences (CHI, UIST, IUI, CSCW), journals (TOCHI, TIIS), and networking events (e.g., special sessions on conferences and summer schools). We will facilitate the exchange of knowledge across Europe through personal exchanges that will allow for close collaboration with various partners. Furthermore, we intend to generalize our findings and make them available to the larger research community by creating and distributing online tutorials that explain our method, allowing other AI researchers to use this type of human-computer collaboration approach (D4.2).

Target group / audience / stakeholders The target group of INRIA are ML experts that plan, select and build ML applications as part of their daily work.

Expected results / impact Publication and interactive systems that:

- Develop a better understanding of how users plan, search for, and select ML models.

- Identify the relevant characteristics of a ML project in terms of constraints and context.
- Develop new interactive methods for users to express and refine these characteristics using a human-computer partnership approach.
- Develop new explainability approaches that intelligent systems can use to suggest and expose the trade-offs of alternative ML models in a context-dependent manner.
- Design new interactive visualizations to explore the design space of ML models with multiple competing objectives, including AI-waste minimization.

5.3.6 IBM Research GmbH

Exploitation plan IBM Watson is one of the most recognized AI brands with the broad public and thanks to IBM Watson Studio, IBM was recently also recognized as a Leader in the 2021 Gartner Magic Quadrant among experts and practitioners in Data Science and Machine Learning. IBM Watson Studio is a software platform for building, running and managing AI models using open-source code or visual modeling and which provides tools for data scientists, application developers and subject matter experts to collaborate and scale up data workflows across the cloud. IBM Watson studio like other IBM cloud offerings include Trusted AI technologies based on open-source projects developed at IBM Research, including tools for AI lifecycle governance (AI FactSheets 360), algorithms to detect and remove bias in models (AI Fairness 360), and a toolkit for explainable AI (AI Explainability 360).

We envisage that several developments of SustainML could be built into tools that could eventually be offered to and used by data science and machine learning practitioners through the IBM Watson offerings, like the IBM Watson Studio or IBM Maximo platforms. As for the mentioned Trusted AI technologies currently in IBM Watson Studio, their integration could also be done by integrating open-source projects resulting from SustainML. In particular, we imagine that users of the IBM's platforms could deeply appreciate and benefit from an implementation of the functionalities provided by WP3 that would complement the current machine learning pipelines with a tool to easily and explicitly optimize the energy footprint and associated cost training and deployment costs. Conversely, the deployment of energy consumption optimized ML tools into a global data science platform like IBM Watson Studio would be a great dissemination vector for some of the results of SustainML.

5.3.7 UPMEM

Exploitation plan UPMEM plans to promote its PIM enabled DRAM to the AI industry, highlighting its benefits of acceleration and energy saving. One of the major factors for adoption of the UPMEM PIM architecture in the AI industry is its integration to a fully-fledged recognised framework. The PIM architecture imposes constraints in the algorithm development that require specific attention in order to make full benefit of the specificities of the technology. Removing this heavy development constraint in addition to specializing UPMEM's product towards better AI calculation will be determinant in driving future success of the technology in this most important sector of computing. The SustainML project is expected to develop a framework that will enable easier integration of AI/ML accelerators into existing software stacks, providing a reference for companies and researchers who wish to use accelerators in their applications without requiring months of investigation and optimization ahead of it.

Target group / audience / stakeholders The target group is the AI industry, specifically those interested in using AI/ML accelerators for image recognition, recommendation models, and deep learning models for genomics. The stakeholders are companies and researchers who are interested in adopting AI/ML accelerators and can benefit from the integration to a recognised framework. By developing a framework that makes it easier for companies and researchers to use AI/ML accelerators, the SustainML project is expected to attract a wider audience of stakeholders to the technology.

Expected results / impact UPMEM expects that the SustainML project's framework will become a reference for all AI/ML accelerator users and will help drive future sales in the AI industry. The framework will remove the heavy development constraint for algorithm development, making it easier for companies and researchers to adopt accelerators like PIM technology. By specializing UPMEM's product towards better AI calculation and integrating it with the framework developed within the SustainML project, UPMEM's product is expected to become more attractive to the target audience of the AI industry. This is expected to result in increased adoption and sales of PIM technology in the AI industry, driving future success and growth in this important sector of computing.