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European forum of the software research community

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Cross-fertilization workshop report – v2

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Abstract:	This deliverable is the second of a set of deliverables describing the results from the three cross-fertilization workshops that are planned in the project, in both their public and private sessions. This is the result of task T2.1.
Keyword List:	Cross-fertilization, discussion Forum, workshop
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Table of Contents

List of Figures

Terms and abbreviations

AI	Artificial Intelligence
CSA	Coordination and Support Actions
DoA	Description of Action
EC	European Commission
GA	Grant Agreement to the project
KPI	Key Performance Indicator
SW	Software
R&D	Research and Development
ICT	Information and Communication Technologies
SWForum.eu	European Forum of the Software research community

Executive Summary

This deliverable is an extension of the results described in D2.1 (Cross-fertilization workshop report - v1), where we have reported about two other cross-fertilization workshops organised under the task T2.1. The main objective of the task T2.1 is to organize and deliver three workshops involving stakeholders from academia, industry and the public sector, representing different domains and application sectors. The workshops are important events to facilitate synergy-ignition among R&D EC funded projects, as well as a dissemination opportunity.

In this deliverable D2.2 (Cross-fertilization workshop report – v2) we present the WEGreen Workshop, co-hosted by SWForum.eu and HUB4CLOUD, on the topic of “Engineering Green and Sustainable Software in the Computing Continuum” [1], [2], [3].

1 Introduction

SWForum.eu aims to create a self-sustainable online forum that facilitates and encourages both researchers and practitioners as well as projects in software, digital infrastructure and cybersecurity to create intersections of expertise and a multidisciplinary approach to research and innovation [3]. This forum seeks to set in place the European research roadmap and offer cross-fertilisation of competencies to all other research and innovation areas.

SWForum.eu works to enhance the visibility and competitiveness of research and innovation in the field of software technologies, digital infrastructure and cybersecurity, especially European funded Research and Innovation Action (RIA) projects. Moreover, the project aims to introduce best practices and technology transfer opportunities to cross-synergise European excellence.

SWForum.eu project runs from 1 October 2020 through 31 March 2023. It is a CSA (Coordination and Support Action) project under the Horizon2020 program: H2020-ICT-2020-1/ CSA ICT-50-2020-1 Software Technologies, with 5 partners: Conceptivity, University of Oxford, Politecnico di Milano, Tecnalia, and Trust-IT Services.

The main objective of the SWForum.eu project is to raise awareness and strengthen the competitiveness of the European Software Industry - including the underlying digital infrastructures together with the needed security mechanisms - by facilitating a sustainable European Forum for stakeholders representing scientific researchers, service providers, software developers, operators and policy-makers relevant to software technologies, digital infrastructures and cybersecurity, where assets (products, services, technologies) can be shared, lessons learned, and policies developed, and facilitating engagement in the development of a set of research and innovation roadmaps for the Future Secure Digital Continuum through an online platform.

Within this context, SWForum.eu will promote EU cross-fertilization between the areas of software, digital infrastructures, and cybersecurity. This goal will be achieved by organizing a self-sustainable Forum (Objective 2 in the Grant Agreement) in the context of which workshops on specific cross-fertilization themes will be organized and will be driven toward the publication of joint papers, joint policy papers around the topics, the creation of new initiatives, and the launch of new ideas.

The aim is to create a living Forum that will involve, on a voluntary basis, individuals (researchers, industry representatives and end-users) interested in the future of EU research and innovation actions in the context of software technologies. In order to engage and increase stakeholder participation, SWForum.eu proposes to create a Fellowship programme, which will serve to maintain a fluid pool of experts from a balanced set of SWForum.eu target stakeholder groups. This group of high-profile, acknowledged experts in their respective domains will create an attractive “pull” effect on potential participants in these activities and events, as well as maintain a high level of excellence in the interactions within the Forum. In general, the Forum will contribute to the definition of the future European research roadmaps and will stay in touch with the EC to provide inputs, highlight needs from multiple stakeholders, and the like. SWForum.eu will promote the creation of this Forum, will drive it for the first period and, most importantly, it will drive the definition of a self-sustaining governance strategy and business model that will permit the sustainability of the organisation to survive beyond the end of the project.

So, SWForum.eu is considered as a:

- Unique opportunity for European software researchers to discuss topics, issues, trends, and concerns.
- Way to make our voices heard by developing recommendations to feed into policy-making decision processes.

- Professional online platform, namely for:
  - Identifying topical groups
  - Creating profiles
  - Developing discussion threads
  - Likes/ dislikes/ recommending

1.1 About this deliverable

The purpose of this deliverable is twofold: 1) report about the organization and execution of the cross-fertilization WEGreen workshop that we have held in the second period of the project and 2) reflect on lessons learnt in order to derive some valuable policy recommendations for the EC.

The presented WEGreen workshop [1] was supported by the European Commission under the programme H2020 by the projects SWForum.eu (Grant Agreement n. 957044) and HUB4CLOUD (Grant Agreement n. 101016673).

1.2 Document structure

This document is organized as follows:

- Section 2 presents the WEGreen workshop in terms of goals, organisation, theme, participants.
- Section 3 describes the execution of the workshop in particular, the keynote talks, position statements, discussion, and take away.
- Section 4 focuses on the achieved results, considerations and lessons learnt.
- Finally, Section 5 draws conclusions.

2 The WEGreen workshop @ GECON2022

2.1 Organisation

The WEGreen workshop was collocated with the GECON2022 conference on 15 September 2022 in Izola, Slovenia. It was organised with the support of both the SWForum.eu and HUB4CLOUD projects on the topic "Engineering Green and Sustainable Software in the Computing Continuum", and it was held as a hybrid event (Fig. 1).

Figure 1. WEGreen workshop 2022

This workshop focused on all issues concerning the engineering practices relevant to the creation and execution of green and sustainable software in the cloud continuum [1].

The workshop was organized in three main sessions (Keynotes, Position Statements, Wrap-up and Conclusion) of 1.5-hours total, held over a half-day (see the program below). More details about the execution are given in Section 3.

After a brief introduction to the SWForum.eu project, the first session featured two keynotes, each followed by questions and answers (Q&A). The next session was focused on two position statements and a discussion. Finally, the last session was a wrap-up and conclusion led by the Chairs.

Tuesday, 15 September 2022

10:30-10:35	Welcome (Program Chairs)
10:35-10:45	Introduction to SWForum (Juncal Alonso Ibarra, Tecnalia and SWForum.eu Coordinator)
10:45-11:00	**Keynote 1: Evaluate the environmental** - Download David Ekchajzer, Co-Founder of Hubblo, Member of Boavizta
11:00-11:15	Keynote 2: Ilias Iakovidis, Adviser at the European Commission, DG CONNECT
11:15-11:25	**Position Statement 1: Sustainability-Aware Software Architecting for the Future Cloud-** Download Vasilios Andrikopoulos, Assistant Professor at Rijksuniversiteit Groningen
11:25-11:35	**Position Statement 2: Sources of data center energy estimates -** Download David Mytton, CEO console.dev, researching sustainable computing at Oxford
11:35-11:50	Discussion of Position Statements (Moderator David Wallom)
11:50-12:00	Wrap-up and conclusion (Program Chairs)

2.2 Goals of the WEGreen workshop

The aim of the WEGreen workshop was to explore the major developments in the European Green ICT ecosystem including all areas from the application to the infrastructure [1]. The presentation of open source approaches was particularly welcomed.

Paying attention to sustainability and the environmental impact of products and processes is a normal and expected part of all activities [2]. We have seen national and international commitments around this; for example, the EC and many national governments are making commitments to be NetZero by 2050 and in many cases before then.

Information and Communications Technology (ICT) is an area that currently has one of the largest impacts and even now produces more CO_2 than the airline industry, one of the traditional high-profile emitters. This is not entirely unexpected with the pervasive nature of ICT in all parts of our professional and personal lives. As such, though, it is also an area where increases in efficiency or changes in practice could have a great impact by understanding all facets of the problem. This is especially true in the context of the new *computing continuum*, encompassing as it does the full range of devices and services from the personal and IoT, through the edge and into the cloud, as well as all the networking systems between them. This is a significant challenge, as making these complex systems requires agreement among different actors who only have the visibility and possibility to operate on parts of the overall system. For this reason, specific attention of the research community is required to find methodologies, methods, and tools to achieve real sustainability of software.

2.3 Participants

While we strongly encouraged in-presence participation, online attendees were admitted as well. There were 21 online participants, and 10 persons present at the workshop, for a total of 31 attendees.
The recording of the WEGreen workshop is available at the website of SWForum.eu upon login with a personal account (free to register).
(WEGreen - SWForum and HUB4CLOUD Workshop on Engineering Green and Sustainable Software in the Computing Continuum | SWForum.eu)

2.4 Theme

The workshop theme was chosen after an internal discussion in the SWForum.eu team, based also on the inputs received from the Project Officer. The topics of interest included, but were not limited to:

- Positive environmental impacts of the ICT space for business and the society;
- Energy consumption measurement & benchmarking
- Algorithmic efficiency
- Sustainability of Edge/Cloud computing application and data distribution & management
- Energy saving/aware applications/stacks/architectures
- Energy saving/aware system/hardware design
- Energy-aware management of data centres
- Energy-aware services of communications systems

Speculation on the potential sustainability of research results being produced in projects not specifically focusing on sustainability was also welcome.

2.5 Format and call for contribution

The workshop was opened to submission of contributions by experts in the community. We welcomed vision papers and research reports in the form of short abstracts (up to 5 pages in the LNCS format, available on the Springer website).

The workshop format was conceived to be interactive, and it was aimed at triggering a discussion and facilitating the creation of new initiatives.

All contributions had to be submitted using the EasyChair platform. Accepted papers were presented during the workshop. We proposed that the authors publish their papers in the workshop proceedings afterwards, hosted as part of the GECON'22 proceedings.

The important dates concerning submission and acceptance were as follows:

- Submission of contribution 7 August, 2022
- Notification of acceptance 10 August, 2022
- Camera ready paper 20 August, 2022
- Workshop 15 September, 2022

2.6 Keynote speakers

The keynote speakers were selected to ensure a good blend of different topics and a good geographical distribution. The choice fell on the following well-known speakers, who were able to cover in depth the workshop theme:

Keynote 1: Evaluate the environmental impact of ICT by David Ekchajzer, Founder of Hobblo, Member of Boavizta.

Bio: For the last two years, David has been working on the development of open methods, tools, and data to measure the environmental impacts of digital technology. In the academic context, he is working with mixed methods, combining social sciences and environmental assessment for a more global consideration of the environmental impacts. David is a co-founder of Hubblo where they help organizations to manage and reduce their digital impacts. He is also a member of Boavizta, an association that works to facilitate the consideration of these impacts.

Keynote 2: Sources of data center energy estimates by Ilias Iakovodis, Adviser at the European Commission, DG CONNECT

Bio: Dr. Iakovidis is currently an Adviser to DG Connect, coordinating the work related to Green digital transformation. In addition to work on improving the efficiency of the ICT sector, in particular datacentres, electronic communications and digital devices, he is also working on maximising the contribution of digital solutions (networks, technologies and applications) to accelerate the transition to circular economy, and, to support the sustainability goals in sectors such as energy networks, manufacturing, transport, and agri-food.

3 The workshop execution

3.1 Opening

The workshop started with a welcome and an introduction of the SWForum.eu project by Juncal Alonso Ibarra, from Tecnalia, who is the SWForum.eu coordinator.

She briefly introduced the three main goals of the project (Fig. 4):

- To create a sustainable forum for software practitioners that last for the duration of the project;
- To define a research roadmap in mainly 3 areas: software technologies, digital infrastructure, and cybersecurity.
- To prepare H2020 projects that are opened with the focus to the market, to understand how to address the market with respect to the technology.

Figure 2. The main objectives of the SWForum.eu project

The WEGreen workshop was coordinated by two program chairs:

- Elisabetta Di Nitto, Politecnico di Milano (Italy)
- David Wallom, University of Oxford (UK)

After the introduction, the workshop continued with keynote presentations as described in Section 3.2.

3.2 Keynote presentations

Keynote 1: Evaluate the environmental impact of ICT by David Ekchajzer

The first keynote, David Ekchajzer, started his talk on evaluating the environmental impact of ICT [2] by presenting what they have been dealing with recently, namely open-source products, engineering and consulting for evaluation of environmental impact of ICT, open R&D with more systemic consideration of impacts, as well as preparing open reports for public and private organisations (Fig. 5). Currently, they are building open data, methods and OS tools to ease the implementation of the evaluation of ICT open data. The main topics he touched upon are greenhouse emissions and the contribution of ICT to global warming. It is about 2,1% to 3,9% in 2022, but it will rise to 6-8% by 2025 (like the impact of transportation). [1]

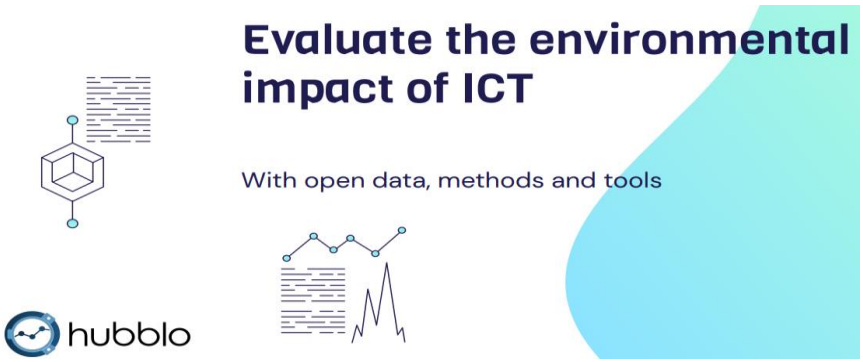

Figure 3. Presentation by David Ekchajzer, Founder of Hobblo, Member of Boavizta [1]

The speaker highlighted the importance of considering not only the impact of the various ICT devices, but also the impact of their manufacturing, transportation and waste.

Life Cycle Assessment

The keynote mentioned a well-known methodology called Life Cycle Assessment, which is defined by the ISO 14040/ 14044 standards and could guide us in evaluating gas emissions, mineral depletion, etc. He also described the multi-criteria analysis designed to be applied throughout the whole life cycle of the product.

However, the main issue with life cycle assessment is the lack of environmental data available and its transparency. As a whole, the ICT sector is not very transparent in terms of such data. Thus, at present it is hard to assess the impact of ICT and to implement life cycle assessment in the ICT context. This is the reason why open evaluations are so necessary, apart from the fact that this is democratic, and this is a requirement of the EU Green Deal. Moreover, there is a plan for how to perform environmental labelling at EU level as well as a requirement for the users to know how those labels are built and the users' rights to express their personal objections to them. Another motivation for such an open approach is the fact that the measurements usually are of poor quality. The keynote pointed out some projects which are trying to apply open life cycle evaluation, such as ADEME, SDIA, The Shift project, Green Software Foundation, the carbon transition Think Tank, and so forth.

Measuring the impacts of user terminals

Boavizta.org has recently built a platform that aggregates all manufacturing declarations and carbon impact of products declared by the manufacturer.

Measuring the impacts related to usage

An example of using a server was shown as well as the impact of its electricity consumption. In order to model power consumption, they consider different open source methodologies. In addition, they use a software sensor to estimate the power consumption for a given server, so that they allocate estimation of the power consumption of the server to a specific service.

Open source approach

They use an open source approach to build a database that aggregates power consumption (W) or CPU workload (%) data, and gathers more consumption profiles depending on different characteristics, utilizing *electricity map*, an open source tool that shows the carbon intensity per country.

Measuring the impact of manufacturing

The speaker presented a manufacturing example of *die size*, underlining that the most impactful part of such a manufacturing process is the engraving process (wafer). In this process, the

smaller the engraving, the more energy and resources are consumed. In this context, they have built an API that reports the characteristics of manufacturing, such as the CPU. Additionally, from the characteristics of the CPU they can infer the engraving impact and the overall impact of the manufacturing process.
As a concluding remark, the first keynote pointed out a useful framework to keep in mind whenever we would like to buy an ICT service, consisting of five steps:
1) refuse, 2) reduce, 3) reuse, 4) recycle, 5) return.

A couple of questions to the first keynote speaker followed.

Discussion

The discussion around this keynote centred around the existence of specific software tools for evaluating the environmental impact due to the usage of Cloud services. Unfortunately, these tools are not fully usable because they do not share openly the methodology used for the assessment and therefore measurements are not transparent.

Another discussion point concerned the importance of including in the impact computation all relevant aspects. For instance, referring to the Cloud case, we should consider also the impact of the chip manufacturing and we should assign the responsibility of all components resulting from the impact analysis to the right actors. In response to this point, the speaker highlighted that the application of a rigorous and transparent life-cycle assessment approach is an enabling factor that should be accompanied by a political decision-making process.

Keynote 2: The measures of Green Transition and Digital Transformation
Ilias Iakovidis acknowledged that today's focus is mostly on the conflicts, because they are measurable. For instance, the ICT footprint is >3% of the total greenhouse emissions, and electricity consumption is constantly increasing (currently being ~9%). So, in the context of the Green Transition we need to reduce energy consumption (Fig. 6).
However, measuring ICT impact is in fact, very difficult as it is basically a *materials* problem. In reality, 85% of the footprint is gone once the device has been produced, before even going to the market. In this respect, it is important how to measure it consistently and how it could be allocated. Electricity consumption will rise, but it will not increase at the same scale as CO_2 emissions, because it is not linearly correlated with it. As a matter of fact, the EU has the objective to reach Net Zero by 2030 within the scopes 2 and 3.

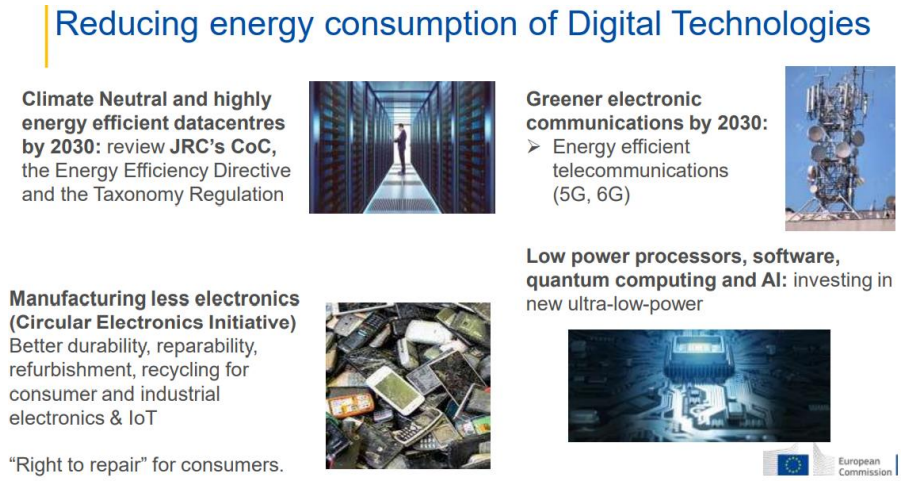

Figure 4. Reducing the energy consumption of Digital Technologies [1]

The EC has new initiatives such as the Digital Product Passport, which they would like to apply to some products, but not to ICT at the beginning. With respect to the material and CO_2 flow,

they track basically the material, subcomponents, and the product itself. Later on, this passport would give them a better view and allocations (Fig. 7).

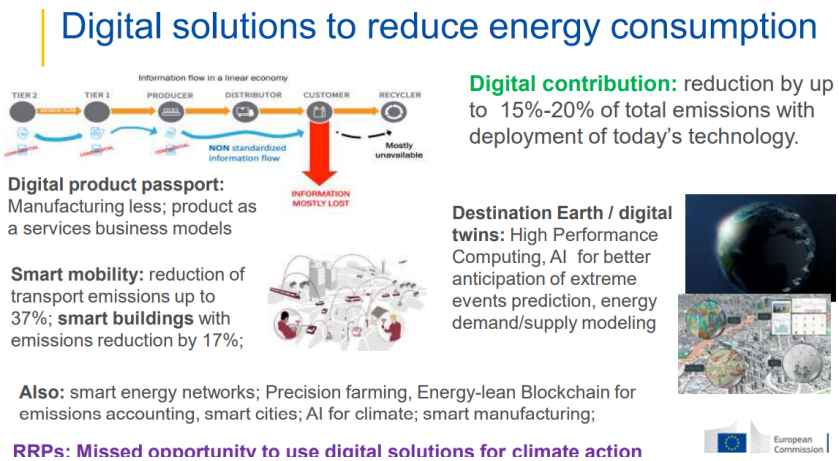

Figure 5. Digital solutions to reduce energy consumption [1]

After first presenting the big picture, the keynote speaker continued with the ICT problem, whereby he addressed the following topics considered important by the EU.

Green Deal and Digital Transition

These are the two biggest portfolios today in the EC and, taken together, are known as the "Twin Transition".

If we ask ourselves what the *end result* of the Green Transition will be, we could all answer this question. But do we know what the *aim* of the Digital Transition is? It is very important to look at it in the three-dimensional space of sustainability: Economy, Society, and Environment. The third dimension has been added recently as a very important one and there is a lot of space for improvement there. However, there is not enough scientific knowledge on how to look at these three dimensions together for digitalisation, and how to improve those three dimensions without avoiding doing it at the expense of one of them. So, there is a lot of focus on the conflicts, because there are a lot of measures (Fig. 8).

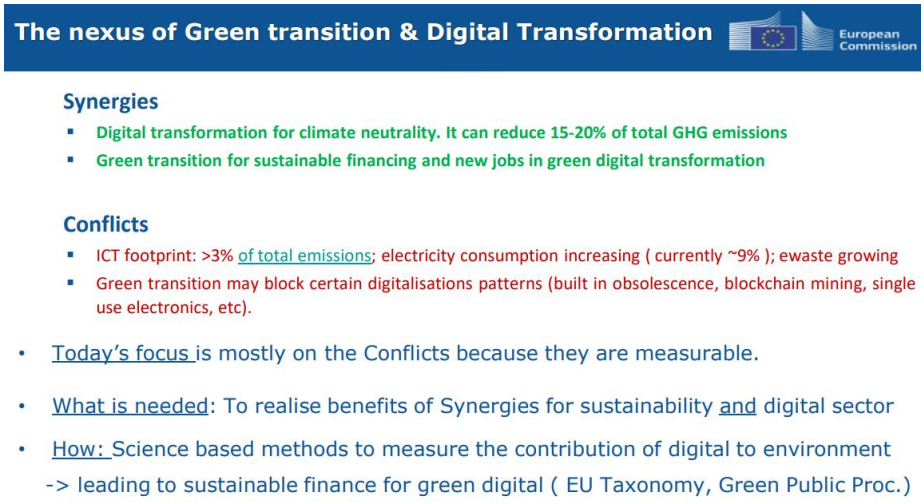

Figure 6. The nexus of Green Transition and Digital Transformation [1]

Regarding the life cycle methodology, there is a big conflict. Green is actually suffering from this digitalisation. It is difficult to measure synergy; but we need to start measuring enablement. However, instead of looking only at enablement, it is good to look also at emission reduction,

which we could achieve through smart use of software applications. There are two issues on the software side, as follows:

- What algorithmic optimisation will optimise process and power consumption with respect to running algorithms, especially machine learning and others?
- How to use the software in a smart way to reduce the consumption of any electricity-consuming smart device? There is a huge opportunity for improvement out there and that is what we still need to measure and scientifically explore.

In fact, what we can address in the ICT sector is firstly the **data centres**. There is an entire unit working at the Commission make all data centres in Europe Net 0 (neutral) by 2030 (Fig. 9).

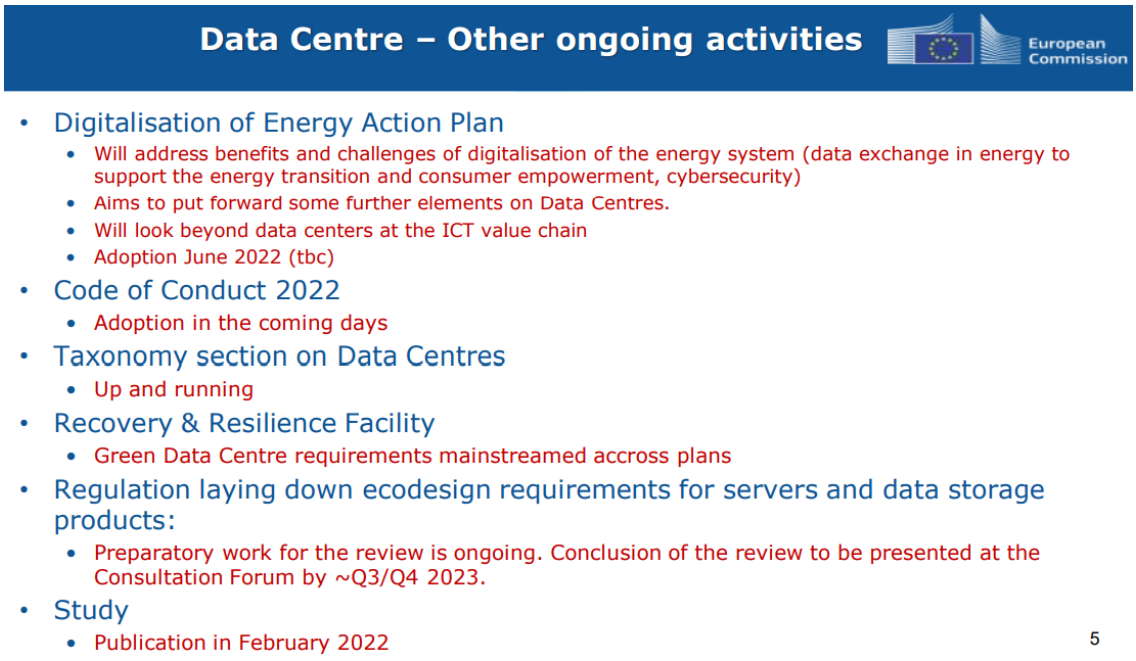

Figure 7. Data Centre as an ongoing activity [1]

Therefore, Europe has taken a commitment to help the data centres to become greener, which is very ambitious. The big data centres are not a problem. Rather, the real problem is represented by the smallest ones, which are often in the basements of the hospitals or local governments holding our medical records or passports, and which may not go to the big Cloud providers. On the other hand, there is a problem with the circularity of the electronics – and in Europe we are the worst in the world. So, we need to sensitise our public – for example, about delaying the acquisition of new mobile devices. If we renewed our mobile devices even only one year later, this would reduce emissions in Europe by millions of car lifetimes. This is an example of the huge impact we can have with better management of our end-user devices.

Much more can be done in the ICT sector. There are some estimates that today's footprint could be improved tenfold. So, the potential is out there for us to try to reach this goal.

Greening and saving energy on ICT level

Another initiative of the EC is the work on the Chips Act. They are looking at how to improve energy efficiency, but they still have much work to do together with the telecommunications sector.

The big objective is to reach 4% of the footprint of Europe and stabilize it, or even drive it down to 2-3% of total emissions. If we use, design, and govern the software properly, under very

special conditions, we could even capture more than 10%. So, there is a missed opportunity, and we are not yet sufficiently considering it. There are some estimates that whatever we are doing and enabling, we could still do 5-10 times better.

For example, there is a lot of software which is sitting at the 5G base-stations waiting to be put to sleep. In general, the Telecoms could be much more efficient if there were software that could understand when an electrical appliance needs to be switched on or off. There are possibilities for this type of reduction in mobility (as a service), precision farming, and so forth.

Therefore, there are many conditions under which ICT can have a net positive effect, and the aforementioned activities are being carried out at the Green-Digital Coalition in the EC (Fig. 10). Here they are looking at how to measure "software solutions". Knowing first what the solution is about, they then measure its footprint and enablement, in order to estimate the net effect. If the net effect is positive, then they provide this information (together with guidelines on how to keep it positive) to the financial, energy, mobility, agriculture, manufacturing, and smart cities sectors, as well as governments, to deploy the solutions under such conditions.

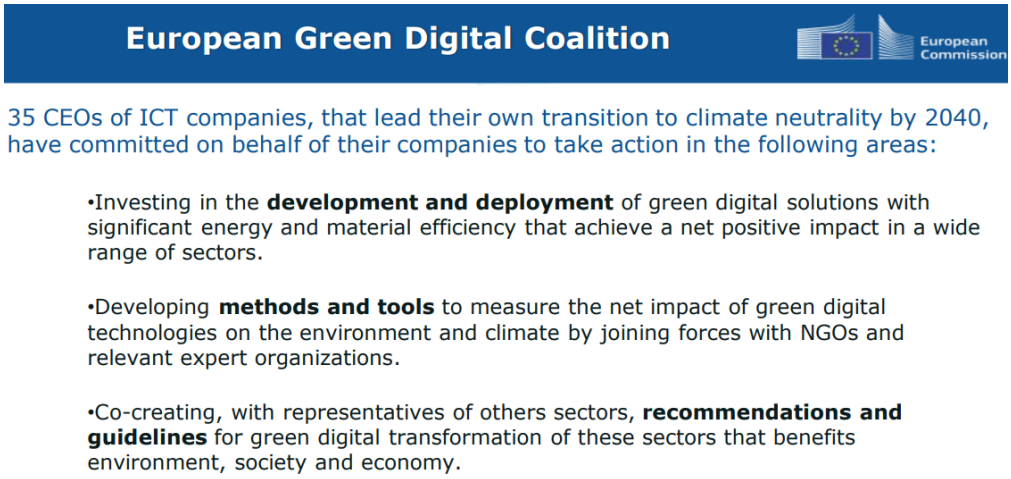

Figure 8. Green Digital Coalition [1]

In practice, every solution is a mix of technologies, with software being a significant part of the solution. The technologies may vary – telecoms, IoT sensors, etc. – but the software will make the difference in the optimisation process.

Among the interesting questions asked during the discussion after the Keynote 2 talk were the following:

How do you think we can correctly attribute scope 3 (emissions) to software?

It is becoming common practice for software vendors to offload their footprint by basically outsourcing their software to third parties. It is a difficult question regarding software, because it is a virtual entity. People usually think that when they run the software over something else, the emission is somebody's else responsibility.

There is a framework in the EU for measuring the sustainability of SMEs. However, the companies really do not understand well what they are asked for. So, there is also an educational process out there.

Are there some classes of process optimization? Is there something that software engineers can utilise?

We need to understand also how the hardware is positioned with respect to the emissions of information processing. It is very important to keep in mind the system as a whole and to bring into focus the system view and net effect.

Another remark concerned the fact that there is no actual modelling of resources like materials, nodes, energy, etc.

3.3 Position statements

Position statement 1: Sustainability-Aware Software Architecting for the Future Cloud by Vasilios Andrikopoulos, Assistant Professor at Rijksuniversiteit Groningen, SEARCH group.

Figure 9. The Sustainable Cloud project of the University of Groningen [1]

Vasilios Andrikopoulos talked about how to build sustainable software services that are operating in the Cloud. Their research group (Fig. 11) has worked extensively in the Energy Management field together with the University of Amsterdam. In this context, they are exploring sustainability as a multidimensional concern and they have introduced the **SAAFramework**, focusing on four aspects as follows (Fig. 12):

- Technical: How technically sustainable are software systems for the community?
- Social: What is the system's longevity? How long can the system live?
- Economic: How financially viable are the software systems?
- Environmental: What is the environmental impact of software systems?

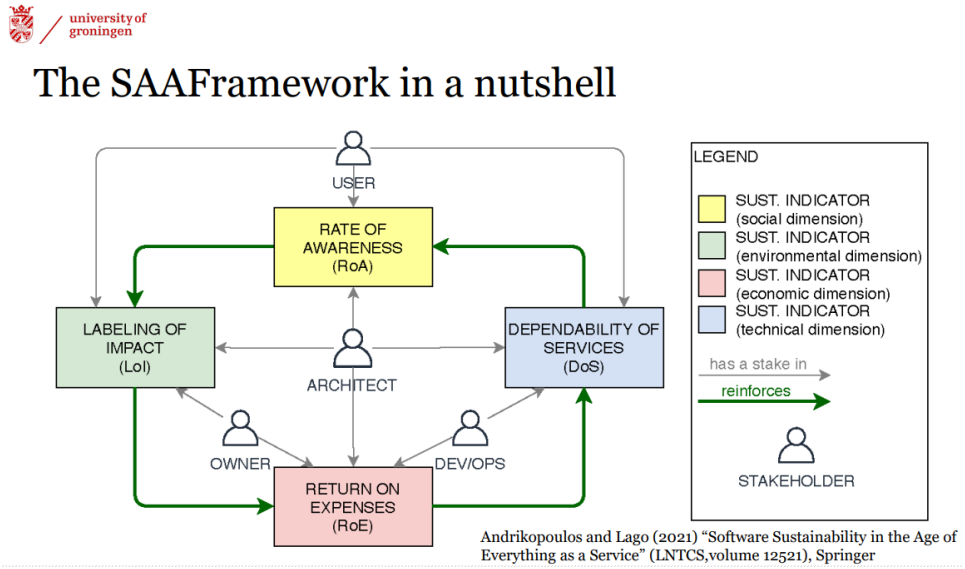

Figure 10. The SAAFramework in a nutshell [1]

This framework will be elaborated in the coming years as a way of guiding software architects. Based on it, people will be able to make decisions on how the software would look and how it would interact with the environment, users and other software systems before it is actually

implemented across these four dimensions. They identify a number of stakeholders, each with its own role. In particular, in this project they deal with SaaS providers.

The research group has also done prior work on how they document and support architectural matters. They are adding a set of indicators that allow them over time to understand how those indicators can work together in a positive relationship, and to understand the power efficiency of this return on expenses of the system.

The speaker presented the main propositions of their project as follows:

- To use SAAFramework to create self-sustaining systems that deliver sustainability across all three dimensions.
- Achieve this by indicators, having a positive feedback loop.
- Adopt different research methods to collect evidence about the sustainability of the system.

There was a brief discussion after the first position statement and one of the interesting questions was as follows:

Is this software actually hardware-dependent, and can this idea apply also to the Quantum?

The speaker explained that they are looking purely at the software, how it has been designed and eventually written. They do not have dependencies with other kinds of infrastructure like hardware. What they really build on is the relationship of the "offering as a service". They look at the capability to offer the fundamental assumption of the Cloud to the SaaS, together with the capability to outsource the infrastructure to third parties.

Position statement 2: Sources of data center energy estimates by David Mytton, CEO console developer, researching sustainable computing at Oxford University.

David Mytton presented their research paper and its main findings from 676 sources, 258 data centres energy estimates from 46 publications in the period 2007-2021 (Fig. 13). Here they sought original estimates with calculations, whereby they were trying to identify the challenges in methodology, as well as references.

They looked at three different methodologies: bottom-up, top-down, and extrapolation. They compared those methodologies and found significant differences in the range. The main thing that stands out from this is the willingness of researchers, and the availability of some of the data – shown cascading sources coming from 7 different publications.

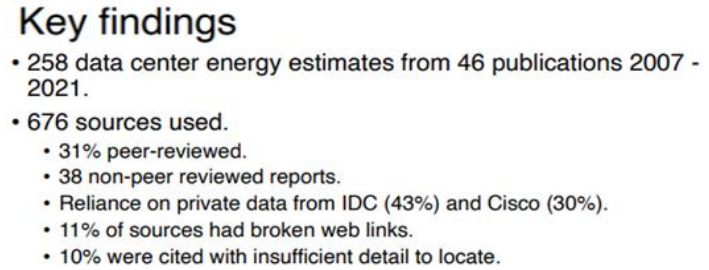

Figure 11. The key findings of the research paper [1]

The speaker also talked about the unexpected demand from data centres and battery systems that have resulted in delays for the UK grid (in West London) in providing new interconnection, and local connectivity to housing projects (Fig. 14). Then he pointed out the fact that the range of data is extreme and the challenge for researchers and organisations is also big in that respect.

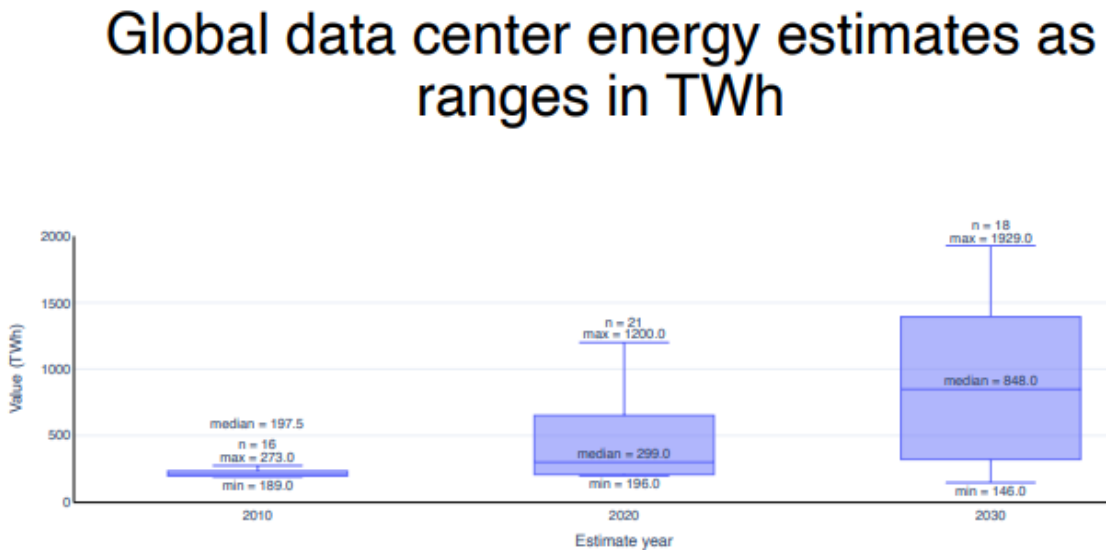

Figure 12. Global data centre energy estimates as ranges in TWh [1]

They provided several recommendations in the paper (Fig. 15) regarding the importance of the technology, the shift from Intel-based processing to architectures, and considerations in making predictions / projections into the future.

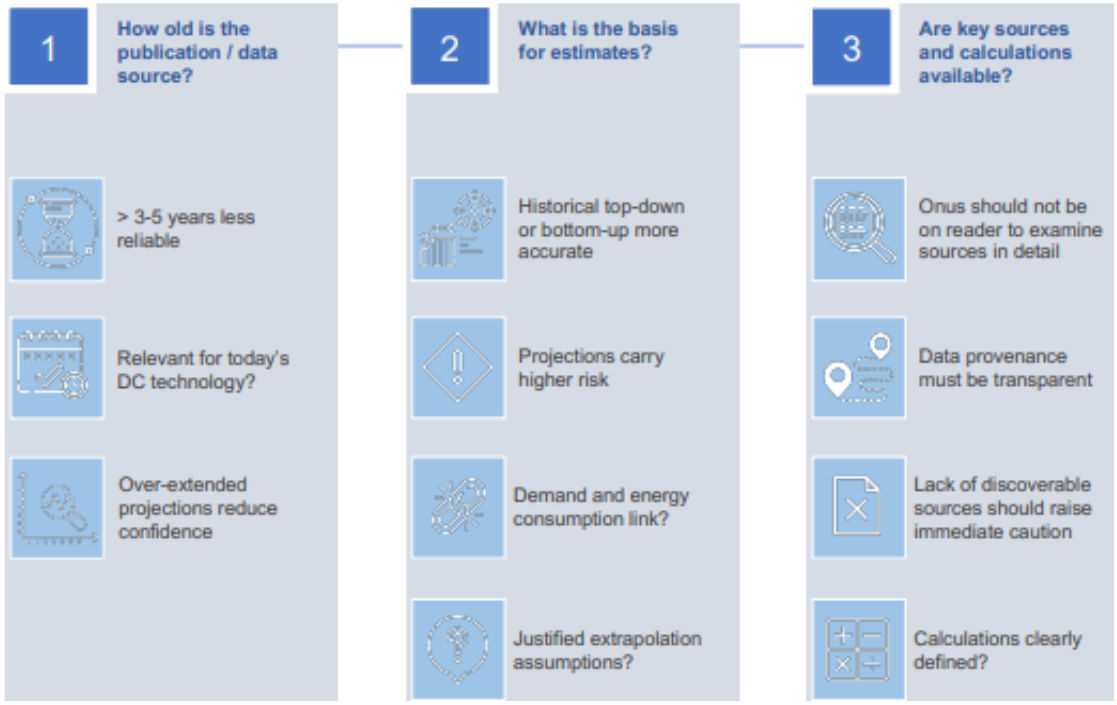

Figure 13. Some recommendations regarding the importance of the technology [1]

The Q&A after his presentation included a discussion concerning whether the estimates are based on simply multiplying the data or if other considerations entered into the estimates. Another discussion concerned how to make the consumer aware of who carries the principal responsibility, considering that at different times it may be the software provider, the hardware provider, or the connectivity provider. In general, how do we successfully *share* the responsibility to achieve the desired objective?

There were also comments that social value and people's experience is very important, although there remains a big issue of educating and measuring.

It was mentioned that France is the only country in the EU that has already introduced a law whereby Telecom consumers are to be informed about their footprint – that is, what they do on their mobile devices with their telecommunication services. It is interesting to contemplate the question: if we do provide such information on CO_2 emissions to consumers, what they could do with it? Firstly, it is better to make sure that it is correctly done before we measure it, and to make it clear to ourselves what kind of behaviour we want to stipulate.

It is also important to answer the question "Do we really have net positivity on both environmental and social issues?" In this regard, another initiative was mentioned called "Digital with purpose", which has been recently launched by the EC in Lisbon.

Further on, the speaker underlined that there have not been any serious studies performed so far on the relationship of the different dimensions of sustainability, trade-offs, and feedback loops with each other. Even if we take out the environmental issue, there are classical technical works on cost versus maintainability of a system, but what we are missing now is explicit modelling in this direction, collecting and monitoring data that stems from long-term projects, and looking at some mentioned studies on mobility versus virtual environment. Thus, the offered framework (Fig. 12) would allow us to look in any direction: technical, social, economic and environmental.

3.4 Discussion

After the two keynotes and the position statement presentations, the WEGreen workshop ended with a discussion on the capabilities in the mentioned multicriteria data analysis around software. All four speakers mentioned that the most important issue is the correct provenance of data and how we might achieve it in all of the different aspects of what we do.

Thinking about going beyond software, the principal challenges mentioned by the speakers were as follows:

- Data accessibility and availability
- Correct provenance of data

Additionally, one of the keynotes mentioned the regulatory agency BEREC (*Body of European Regulators for Electronic Communications*), which has its own set of national regulators. For the past year, they have been looking at how to estimate the footprint and how to drive it. Their major goals are as follows:

- How can they develop a code of conduct so that they can obtain sustainable financing to do something greener – it could be either fibre, or a different kind of software, or different technology, for example.
- What kind of numbers do they have to provide to consumers?

3.5 Main takeaways

The final conclusions and wrap-up concerned the most important things we could do in the next twelve months in the context of the findings of the WEGreen workshop [1]. The opinions expressed by the speakers are summarised in the following paragraphs.

One speaker said that, in the *short term*, he would move away from using data-related to energy-related consumption, because there is a no linear relationship between demand and energy consumption. In the *long term*, he would emphasise improving transparency. Customers asking for energy consumption data could provide a commercial incentive to do so. If that proves not to be sufficient, we could resort to legislative incentives to introduce transparency into some financial statements. There is a consistent reporting standard globally for financial analysis of companies, but such a standard does not exist for environmental impact. It is necessary to have consistent standards for transparency globally.

Another opinion was that it is of great importance to understand better the standardization landscape: What are the standards that evaluate the impact of software? Up to now, there was either a lack of them, or only a vaguely heuristic approach. But there is some movement now – for instance, Recommendation ITU-T L.1400 (*Overview and general principles of methodologies for assessing the environmental impact of information and communication technologies*), and the ongoing work in ETSI [2].

Can we standardize some of the thinking that we have just described during this workshop so that people can establish building blocks and progress further? Otherwise, one year from now we would just end up having the same discussion. The standards are important for developing our products and devices in a greener way. In this respect, we need to see how our development reflects standards, and if necessary, also make use of *de facto* standards.

In summary, monitoring and reporting, standardisation (both *de jura* and *de facto*) are really the most important needs going forward.

The research group of the University of Groningen would engage the stakeholders in the next months, trying to find actual cases, and taking care of the provenance of the data.

We should shift from the attributional way of accounting for impacts (where we try to account for the impact of each individual unit of service or production), to a consequential approach. This is an important shift because digitalisation involves a transformation of all of the other means of production, and we have to try to understand the *consequences* of this. We need to find a new way of thinking about the problem – thinking about the *consequences* of introducing new technologies, rather than looking myopically at individual details. Overall, it is necessary to use mixed methods, combining social sciences and environmental assessment for a more global consideration of the environmental impacts.

An interesting question at the end of the discussion was if there are any projects currently addressing standardisation, and if their results could be evident by the end of the Horizon Europe programme. According to our knowledge of the software projects being tracked by SWForum.eu, none are yet focused on this issue; and it may well provide an interesting topic for the JRC to consider supporting in the future.

Finally, the main takeaways from the discussion could be summarised in the following challenges:

- Greenhouse emissions and the ICT contribution
- Sustainable assessment of the footprint generated from software systems
- Standardisation of the evaluation methodologies for ICT environmental assessment
- Positive environmental impacts of the ICT space for business and society;
- Energy consumption measurement & benchmarking
- Algorithmic efficiency
- Energy saving applications
- Energy-aware management of data centres
- Energy-aware services of communications systems

4 Lessons learnt

From the experience gathered organizing the WEGreen workshop [1] we have understood that the blend of keynote speakers and open calls seems to work better than just an open call. This is the case, in particular, when the speakers are well-known. This confirms also that the research fellowship programme we have put in place as part of the project is a useful one, as it allows us to host well-known speakers even during live events.

5 Conclusions

The SWForum.eu workshops are providing a useful space for researchers, industry representatives, and end users to share their content, knowledge, and informed opinions on the most important software-related issues in the European Research Area. Contributors to the discussion groups can help to determine future directions for Software Technology in Europe. While the first two workshops have been useful for the support action to gain visibility and for the audience to solicit discussion around the important themes of open source and trustworthiness, as well as focusing on organizational reflections, at the WEGreen workshop, in particular, we discussed the following issues [1]:

- How to build Greener software systems?
- How to measure the environmental impact of software systems?
- What is the role of standardisation?
- What can be a sustainable model?

The software community as a whole could improve research on specialized tools for analysis software, tools for combining, analysing and visualising (in terms of reach, replicability, transparency) by promoting cooperation among multiple actors to create an integrated ecosystem.

The three pillars of SWForum.eu (digital infrastructures, software engineering and cybersecurity) were addressed by the challenges presented [3] and by the keynotes taking part in the SWForum.eu WEGreen workshop [1]:

- With the discussion on the ecosystem for analysis software we aimed at creating a community for building an infrastructure for integration and sharing of scientific workflows on top of shared software (engineering) data.
- With the discussion on Infrastructure as Code (IaC) cost and performance optimization we aimed at identifying the concepts, criteria, and tools relevant to these problems.
- With the discussion on the role of AI in the edge-to-cloud context we aimed at finding points of collaboration with other projects that work in the same field.

6 References

[1] “Presentation from the WEGreen workshop @ GECON 2022,” Izola, Slovenia, 2022.

[2] ETSI, “Energy efficiency and environmental aspects,” [Online]. Available: https://www.etsi.org/technologies/11-technologies-clusters/technologies/986-energy-efficiency. [Accessed 25 October 2022].

[3] E. Di Nitto et al., “Software Engineering for Services and Applications: Current and Future Challenges.,” 5 November 2017. [Online]. Available: https://eucloudclusters.files.wordpress.com/2017/11/se4sa-contribution-to-wp-2020-2027.pdf. [Accessed 25 October 2022].