CESAER

The strong and united voice of universities of science and technology in Europe

Leading by example

Boosting sustainability through good governance adopted by universities of science & technology

White paper

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Rooted in advanced engineering education and research, CESAER is an international association of leading specialised and comprehensive universities with a strong science and technology profile that advocate, learn from each other and inspire debates. Our Members champion excellence in higher education, training, research and innovation, contribute to knowledge societies for a sustainable future and deliver significant scientific, economic, social and societal impact.

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Letter by President

Over 1,500 volunteers and leaders from our Members have joined forces since 2020 to advance our collective thinking and efforts to boost the contributions of universities of Science & Technology (S&T) to ecological, economic and social sustainability.

This white paper concerns a conceptual synthesis along the overall objective of our Work Plan from 2022 to 2023, which is to advance the contribution of universities of S&T to knowledge societies for a sustainable future. This effort has been led by our Task Force Sustainability. In parallel, our association engaged externally together primarily with the International Sustainable Campus Network (ISCN), Science Europe and the University of Strathclyde, during our joint events at COP26 and COP27, and the related Call to Action.

This paper aims at inspiring and supporting universities and their leadership to act as agents of great changes and transformations, and to assume their role as autonomous players in society.

Universities of S&T contribute to sustainability in myriad of ways. Rather than attempting to present a comprehensive and detailed account of this rich diversity and the wide range of institutional good practices that come with it, in this white paper the writers *ad personam* summarise and synthesise such contributions. Thus, this document is not meant to be comprehensive nor prescriptive, but inspiring and supportive.

While acknowledging the great challenges our society is facing in relation to the pursuit of sustainability, and the grave consequences if we do not act swiftly and decisively enough, the synthesis provided in this white paper underlines the tremendous efforts from the community, both within our membership and beyond, that have been and are being undertaken. This ranges from how we can make our own campuses fully sustainable, to the contribution of our institutions and the students, academics and university professionals in our communities to help tackle local and global challenges such as those elaborated in the United Nations Sustainable Development Goals (UN SDGs).

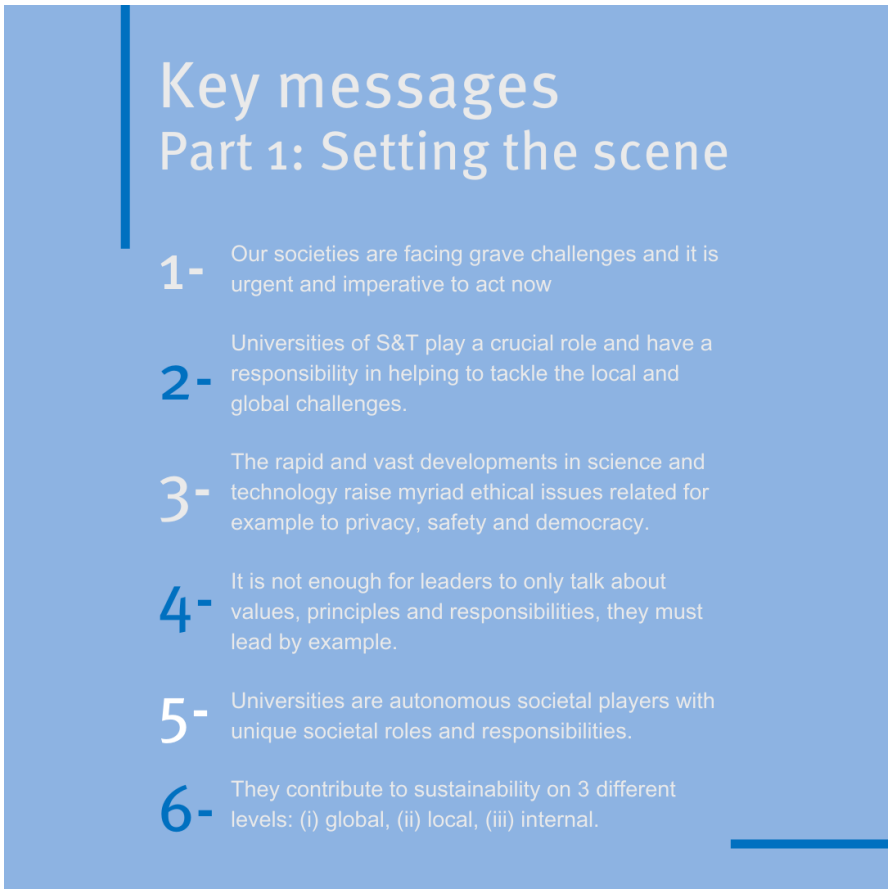
I thank the writers for their excellent work in preparing this paper. While clearly reiterating the urgency, it also reinforces my great hope for the future, and provides inspiration for how we can further boost our efforts, as leaders, individuals and as members of our communities.

Rik Van de Walle
President of CESAER
Rector of Ghent University

Executive summary

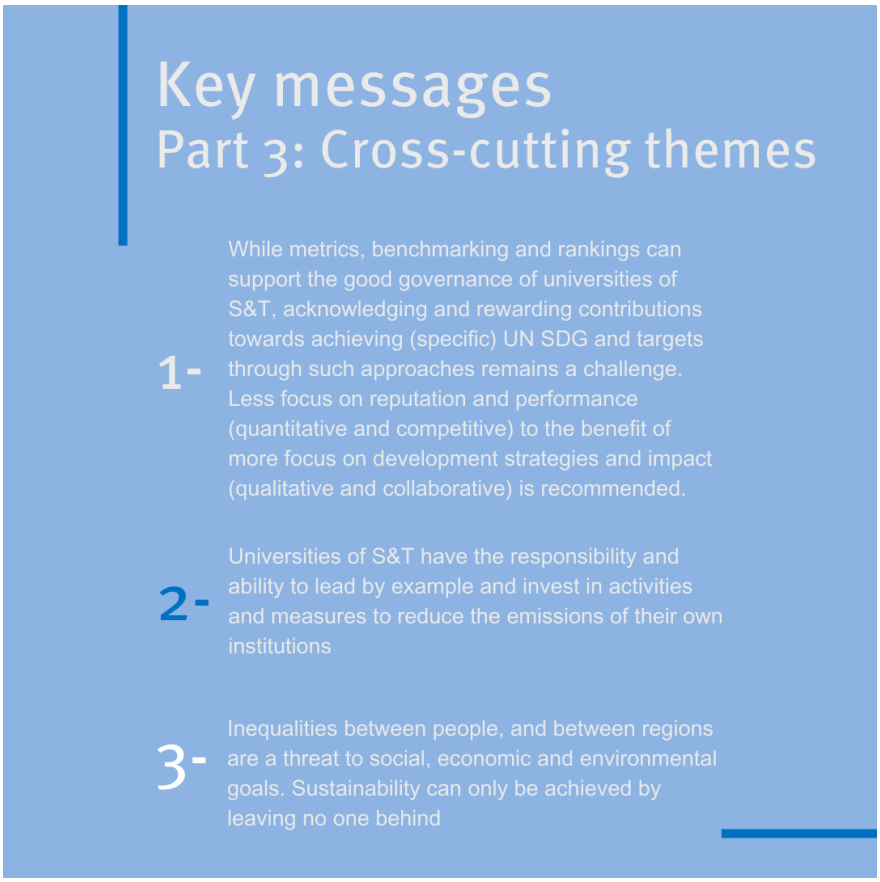
In this white paper, we explore key factors underpinning the good governance adopted by universities of S&T, enabling them to lead by example through contributions to sustainability. This paper is primarily intended for those involved in the leadership and governance of universities of S&T, to act as a guide for embedding good governance which contributes to sustainability. In this way, it can act as a tool to advance the implementation of our association's declaration 'Contributions of Universities of S&T to Sustainability'. The declaration stands as a formal commitment from the leaders of our Members when contributing to sustainability. A milestone while preparing the declaration, and upon which it builds, was the 2021 Call to Action where our association joined forces with the International Sustainable Campus Network (ISCN), Science Europe and the University of Strathclyde committing to support concrete actions to address the many challenges of global sustainability together.

In part 1 of this white paper, we set the scene by introducing key concepts, the 'what' (chapter 1 & chapter 2), 'why' (chapter 3) and 'how' universities of S&T contribute to sustainability (chapter 4).



In part 2, we focus on the contributions to sustainability within the knowledge triangle of research (chapter 6), learning & teaching (chapter 7) and innovation (chapter 8).

In part 3, we introduce three major cross-cutting themes for our association and its Members: measuring contributions (chapter 9), green campus (chapter 10) and equal opportunities and equity, diversity and inclusion (chapter 11). Those three themes are crucial for universities of S&T to be able to lead by example in their contribution to sustainability.



Good governance in universities of S&T involves a commitment to sustainability as a core value, and a willingness to invest time, resources, and expertise in creating a sustainable future for all. To provide concrete examples, we introduce a few best practice case studies from our Members.

In addition to leading by example, universities of S&T stand as beacons to provide inspiration for broader society. Universities of S&T should take a leadership role in providing for the new narrative to students, learners, researchers, other staff, and society, to safeguard commitment at all levels and promote a cultural of change within their universities.

We look forward to engaging with colleagues and friends on the findings presented in this white paper and to advance together when boosting the contributions of universities of S&T to sustainability.

Part 1: Setting the scene

Chapter 1: Pressing global challenges

The grave nature of the challenges facing our society, and the urgency for action, is clearer than ever. These local and global challenges include, among others, pandemics, conflicts, increasing social exclusion and wealth inequalities, climate change, pollution, biodiversity, and habitat loss. All of those endanger the future of humanity and planet Earth. The Covid-19 pandemic reinforced that human health and environmental well-being are strongly linked. It also underlined that, when faced with an emergency, our societies are capable of expedited and proactive collective action and global change.

Recent conflicts and crises, such as the Russian invasion of Ukraine, have not only created humanitarian crises and resulted in thousands of casualties, but also have shattered Europe's delicate equilibrium, and set off a sequence of events impacting many fundamental aspects of our wellbeing and security.

In addition, the frequency of major changes in weather patterns causing devastating natural catastrophes all over the globe such as droughts, storms, heatwaves, fires, and floods are increasingly impacting the most vulnerable communities. Global temperature increase has quickened and caused unmistakable and exponential change in our ecosystems since the 1980s. Summer of 2023 was one of the driest in Europe over the last 500 years, 2022 also recorded the warmest year on record in much of Western Europe and Asia. These record-breaking changes compounded the tensions in energy markets, transforming the way European countries source their energy. It is undeniable that climate change is having a direct and profound impact on people all over the world. It is even now being increasingly recognised as a threat to our health and survival. Reinvigorated action is hence urgently needed.

The knowledge triangle - research, education, and innovation - play crucial roles in helping to tackle these challenges, with universities of S&T as key generators of scientific knowledge, technology, and talent at their core. However, academics and academic institutions are confronted with multiple expectations from various stakeholders. They must create jobs and boost economic growth, safeguard academic freedom and institutional autonomy, assume social responsibility, and contribute to sustainability. Additionally, resilient universities risk being perceived as part of the 'exploiting elite' and serving vested (self-) interests. In societal terms, universities therefore need to show broader society that they actively contribute to tackling the local and global challenges of our time, to avoid being perceived as passive actors and to work together in dialogue with society to advance sustainable development.

While acknowledging that S&T has contributed to some of our current challenges, the solutions will also depend on developments in S&T. In this context and changing landscape, how should we understand the roles of universities of S&T in helping to tackle the local and global challenges of the twenty-first century, and how can they achieve the freedom and capacity needed to assume their responsibilities for supporting ecological, economic, and social sustainability? To answer these questions, it is helpful to first ensure that we have a shared understanding around the concept of sustainability.

Chapter 2: Definition of sustainability

Following the Millennium Development Goals (MDGs), the Resolution adopted by the UN General Assembly on 25 September 2015 and its seventeen SDGs and corresponding 169 targets constitute the most important narrative and relevant universally applicable guiding agenda "to end all forms of poverty, fight inequalities, tackle climate change and embed sustainable practices and principles in our societies, while ensuring that no one is left behind". The SDGs are (i) for all nations and organisations and we are all still developing them; (ii) comprehensive in embracing all the dimensions and the totality of sustainability, with a strong focus on human aspects, justice, inclusion, and equality for all; and (iii) underpinned by the two key principles of leaving no one behind and addressing the furthest behind first.

In order to better link the SDGs to research, education and innovation at universities, they were compiled into six action-focused transformations as (i) complementary and mutually-reinforcing approaches with a common vision and as (ii) modular building-blocks of SDGs' achievement:

1. Education, gender and inequality;
2. Health, well-being and demography;
3. Energy decarbonisation and sustainable industry;
4. Sustainable food, land, water and oceans;
5. Sustainable cities and communities;
6. Digital revolution for sustainable development.

The Covid-19 pandemic highlighted the continuing inequalities that exist, also in more wealthy parts of the world, through the different vulnerabilities of countries. The impossibility of containment within national borders reminded us of the inadequacy to attempt to tackle cross-border and global challenges through siloed and isolated approaches and demonstrated both the need for and the vast untapped potential that exist when we consider working together for the common good.

The staggering rise in 'Climate Emergencies' over the last twenty years, further raises the sense of urgency and need to act. The ambitious and welcome climate-related goal to decarbonise energy systems in Europe has been disturbed due to the war in Ukraine and the now overriding security-related goals to curtail the dependence on gas and petroleum imported from Russia.

In this white paper and departing from the autonomous role of academia in society, we thus do not primarily focus on the political agendas mentioned above, but rather on an action-oriented approach for universities of S&T as powerful engines and living labs for transformational sustainability aiming to deliver on the SDGs. Yet universities of S&T cannot and should not try to isolate themselves from the crises and unexpected developments of present times. Instead, universities of S&T should firmly engage with the broader community and show leadership, especially in times of crisis, by assuming responsibilities and acting proactively in deploying scientific knowledge, technology, and talent to resolutely and emphatically meet the challenges head on. To achieve this, there are several modes of contributions which we explore below.

Chapter 3: Values and ethical frameworks

The rapid and vast developments in science and technology (such as in artificial intelligence and quantum technology) raise a myriad of ethical issues related for example to privacy, safety, and security. This means that values can, will and should shape design. Design can then accommodate and help solve conflicting values and obligations, reducing the risk of moral overload. The intrinsic internal dimension to responsible research, education and innovation is, however also dependent on the broader political and societal contexts in terms of the academic freedoms and institutional autonomy granted to universities. It is therefore important to look at the way(s) in which a university deals with external pressures and challenges on key values.

There is a general decrease of trust in academia and political authorities. Issues of trust can then lead to effects on the safeguarding of academic freedom and the independence of universities. It is not enough for leaders to only talk about values, principles, and responsibilities. Universities must embed these throughout their institutions and staff to achieve a shared vision and conviction. Our experience shows us that there are a range of ways to strengthen values at the institutional level.

Above all, we must not shy away from difficult discussions around ethics and values, for example in misguided attempts to be ‘objective’ or treating all views the same, regardless of the values and ethics those views espouse. We must instead embrace those discussions as a natural and normal part of university life to continually reflect on what is right and wrong, and advance our understanding and implementation of values and ethics. This is particularly important for universities of S&T which act at the forefront of S&T where new areas can emerge at pace, such as in key technologies.

Chapter 4: Modes of contribution

As summarised in 1988 and reinforced in 2020 through the *Magna Charta Universitatum*, universities are autonomous societal players with unique societal roles and responsibilities. To assume these responsibilities, universities deploy a range of contributory methods, and here we highlight three in relation to sustainability.

4.1 Global contribution: Catalytic role of universities through cooperation with partners worldwide

By cooperating with partners worldwide, universities of S&T should seek to understand how diverse cultures and societies wish to integrate the scientific knowledge and technology contributed by universities of S&T in the most effective and appropriate manner. This provides an impetus for universities of S&T to establish and nurture direct sustained relationships with partners worldwide. Concretely, this could mean co-publications, sharing of students and staff, sharing of good practices, and a considerable level of collaboration with partners. Importantly, when engaging with global partners it is vital to consider the history and legacy of S&T, and actively consider decolonisation practices in support of restorative justice and reconciliation.

In the spirit of engaging with global partners, on 8 November 2021, at the twenty-sixth UN Climate Change Conference (COP26), our association together with like-minded partners organised a Symposium 'Science for Net-Zero Transition' and launched a joint call for collective global action to help tackle climate change by committing to reduce and transition to net-zero emissions. A year later, the partners reconvened and organised an event on 'Interdisciplinarity for the Net-Zero transition' underlining that only by acting together and globally, can the research system fully contribute to the goals of this transition.

Additionally, a systems engineering approach is needed to understand the unique interactions and trade-offs between industry, academia and broader society. Universities can play an important part in understanding the public policy, economic and societal consequences of deliberate or inadvertent challenges and propose concrete solutions to deliver for the common good. Particularly, universities of S&T can act as trusted partners, bridging and bringing together the different local, regional, European and global innovation ecosystems through cooperation and co-creation.

4.2 Local contribution: Catalytic role of universities on local and national responses

Universities play a catalytic role in stimulating the response of other potential contributors to the SDGs in their local and national environments at all levels including impact on governments and leaders of key civil society interests. The intellectual leadership and knowledge of universities, together with the respect they command as sources of scientific knowledge, technology, and talent, are crucially important in shaping the broader policy response and landscape.

Universities have significant relationships with their local, regional, and national governments in shaping responses to local and global challenges and are effective in informing and guiding the efforts of politicians, policymakers, and public servants. Moreover, through S&T communication and outreach they can raise considerable support within the public domain for sustainable development.

However, these leadership roles and responsibilities come with an imperative for universities of S&T to be proactive and vocal. Non-action and passivity (perceived or real) by universities of S&T is not only a missed opportunity for boosting activity but may slow down or even reverse progress if other actors wait for leadership which fails to materialise, or if they see the (perceived) inactivity of universities of S&T as a reason for inactivity themselves. The default for many societal actors is to neglect longer-term local and global challenges, often not because they do not want to act, but simply because it requires commitment of resources and efforts to also address longer-term priorities when swamped by immediate and short-term priorities. If players such as universities of S&T do not proactively help society to commence and sustain these actions, it is easy to default back to inaction.

4.3 Internal contribution: Sustainable university management and operation

In addition to acting as catalysts for activity in society from local to global levels, universities can and should also contribute to sustainability directly 'at home', on campus. The ISCN laid down a Sustainable Campus Charter and corresponding guidelines jointly developed with the

World Economic Forum's (WEF) Global University Leaders Forum (GULF). These outlined a comprehensive guidance for the sustainable management and operation of universities.

Chapter 5: Towards boosting contributions

We have now addressed the ‘what?’, ‘why?’ and ‘how?’ universities of S&T contribute to sustainability from their roles in the local, regional, national, and global contexts as well as their responsibilities ‘at home’.

Universities, especially those of S&T, combine the three methods of contribution along the full knowledge triangle, integrated and further elaborated under Research, Learning & Teaching, and Innovation in the second part of this paper.

In part 3 we introduce three cross-cutting themes which we believe, along the knowledge triangle, are essential for universities of S&T to lead by example and showcase good governance for sustainability: measuring contributions, green campus and equal opportunities, diversity, and inclusion.

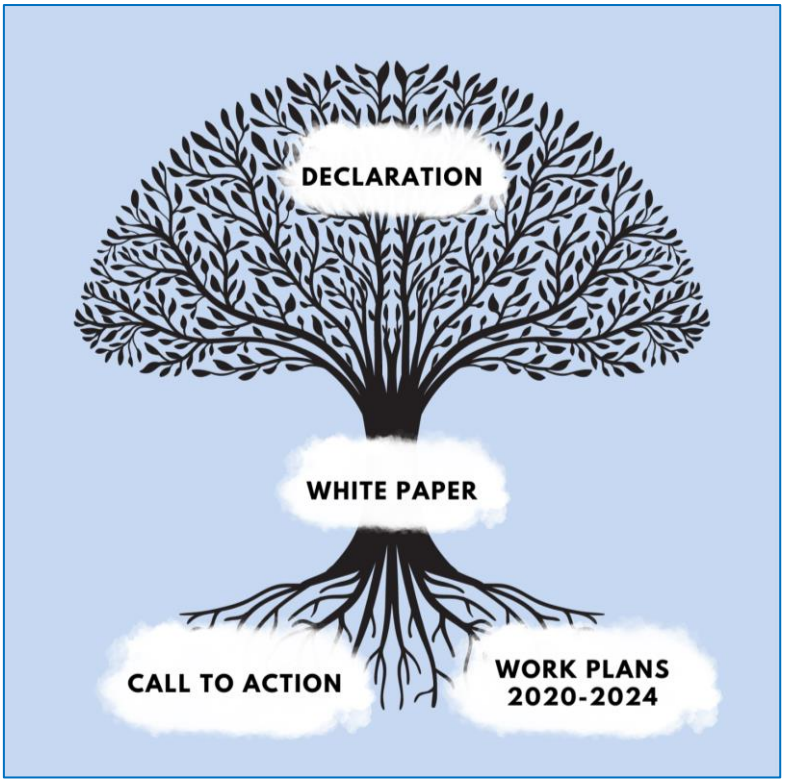


Figure 1: This white paper stems from our association’s two work plans from 2020 to 2024 and was also inspired by our 2021 joint Call to Action with the ISCN, Science Europe and the University of Strathclyde. The white paper is the underlying pillar and guiding document to our formal declaration which aims to boost the contributions our association and its Members make to sustainability.

Part 2: The knowledge triangle

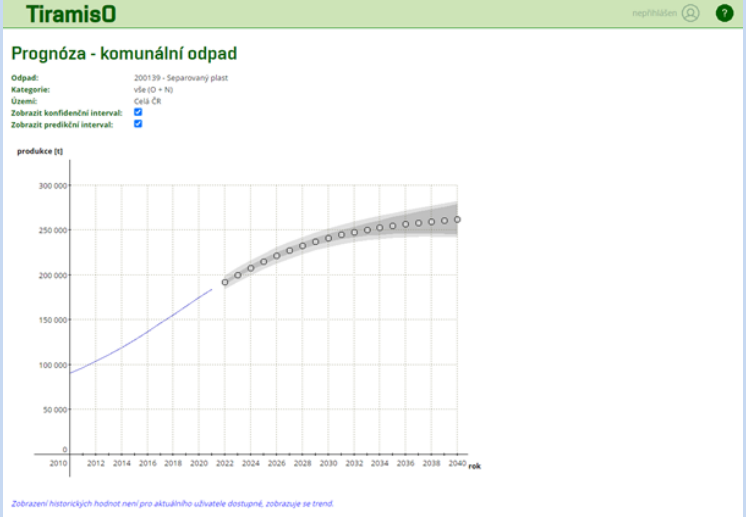
Chapter 6: Contribution of research

Ensuring a balanced and active approach to promoting openness in science & technology contributes to sustainability in a range of different ways. Open science represents a cultural change and is a global movement. Open science is understood as the scientific practice that aims to make scientific content, findings, and results (e.g., in the form of publications and research data) available to the widest possible number of recipients as early as possible in the research process in a quality-assured and reusable manner. Transparent and openly accessible knowledge is to be shared and further developed within collaborative research networks. As demonstrated by the Covid-19 pandemic and in the context of climate change, this approach to scientific practice helps to maximise the positive impact of S&T on society. Open science contributes to a more rapid spreading of findings (for example through greater citizen involvement), enables new insights to build on and more readily ensure that connections across disciplinary boundaries are discovered more quickly. The inter- and transdisciplinary evaluation of findings can lead to completely new insights and make critical interactions visible. In this way, knowledge gain is not only accelerated, but also qualitatively improved and broadened. However, the limits of openness must also be considered. There are legitimate reasons to constrain openness and access to specific scientific knowledge and technology, such as patient privacy or security considerations.

Open access to publications reduces the time needed to find research results, increases the reach of findings to new audiences, and helps to reduce duplication of research efforts. In the context of pandemics or climate change research, the time factor is especially crucial. When access to scientific knowledge increases, both in its reach and speed, societal players and policymakers are in a more favourable position to take up these findings and implement appropriate measures.

Scientific knowledge and technology should be considered in the broadest sense, including publications, data and other (digital) artefacts. Following the FAIR principles for data and software ensures the full impact of such outputs, by enabling their use and re-use in diverse contexts. This is especially important in climate change research, as collecting climate data is a time-consuming and expensive process.

Case study - Brno University of Technology (BUT)



Project name: Prognosis of waste production and determination of the composition of municipal waste – TIRSMZP719

Short description of the project: The TiramisO software, available from the website of the Ministry of the Environment, is a tool for forecasting of waste production in the Czech Republic for the period up to 2040. TiramisO is the result of the solution of the project TIRSMZP719. TiramisO was created to support the evaluation of the current state and the estimation of further development of waste management in the Czech Republic.

Impact: TiramisO software is a user-friendly tool for a long-term forecasting of waste production in the Czech Republic. The users of the software are the state administration, local governments, facility operators, investors and other entities involved in waste management. The software ensures a unified approach of all actors in waste management at different levels (national, regional, etc.). In addition to forecasting based on historical data, TiramisO also allows to model scenarios of expected changes in waste production in response to planned system changes.

Lessons learned: The project was created in close cooperation with the Ministry of the Environment of the Czech Republic. The software is thus adapted to real challenges arising from the valid legislation of the Czech Republic and the EU. Before the actual implementation of the software, it was necessary to develop a forecasting methodology with regard to the very specific form of the input data (short time series of historical data versus a long forecast for the future, error rate in the data, internal links of the system, etc.). This methodology is certified by the Ministry of the Environment.

Useful links: https://www.mzp.cz/cz/tiramiso_aplikace_prognozovani_odpadu
https://www.mzp.cz/C1257458002F0DC7/cz/tiramiso_aplikace_prognozovani_odpadu/$FILE/OODP-Metodika_prognoza-20220913.pdf
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6.1. Promote transparency and trust

Within the scientific community and beyond its boundaries, quality-assured findings can become a source of creativity and inspiration. Transparency in scientific results increases their likelihood to be noticed, understood and adopted by societal players such as business and industry. For example, this can contribute to the development and deployment of new and improved technologies to boost sustainability and counteract climate change. Policymakers can also benefit from this transparency, with the Covid pandemic having demonstrated that the process of scientific knowledge generation can directly inform political decision-making. If we can similarly succeed in transporting the findings from sustainability science and climate research into political decision-making, the race against time (e.g. to achieve the Paris Agreement goals) can be realised. Open science makes a vital contribution to this effort.

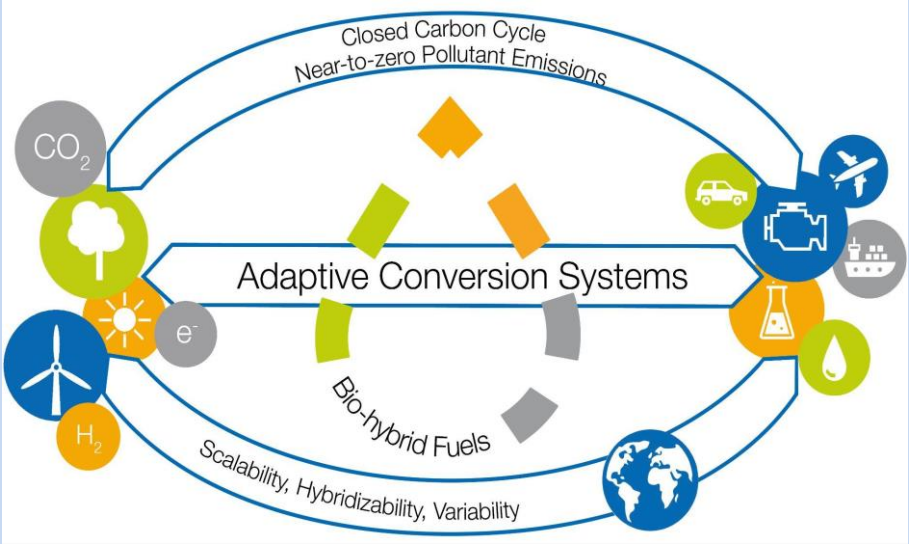
Engendering trust in S&T, especially in emerging key technologies, is vital for enabling their deployment and use for the benefit of society. This will help ensure that scientific results and evidence can benefit society more broadly. To achieve this, engagement with wider society is vital to ensure that non-specialists are engaged on an equal footing, not from the 'ivory tower'. Transparency is a key enabler for creating a shared understanding which underpins such efforts. In a particular example, citizen science projects actively involve citizens in the scientific endeavour and generate new knowledge and understanding. Citizen scientists can participate in multiple stages of the scientific process: developing the research question, designing the method, gathering and analysing data, and communicating the results. It thereby makes research and science more open to society, and more inclusive. At the same time, science gains credibility and trust through such collaborative efforts between specialist and non-specialist communities.

6.2 Promote cooperation, technology and knowledge transfer

Open access to publications breaks down barriers to international collaboration and facilitates global cooperation among scientists, especially between those at institutions which may not have access to many subscription-based journals due to their fees. Scientists at one end of the world can connect with their peers on another continent to make their work visible, thereby arriving at new insights.

Initiatives such as EOSC and GAIA-X are creating data spaces in Europe where scientists can collaborate, while adhering to FAIR principles. In this way, scientific communities can work together on data-intensive problems. For their part, companies can gain easier access to research data and thus more quickly develop application-oriented solutions to the challenge of climate change and achieving the SDGs.

Case study - RWTH Aachen University



Project name: EXC2186 “The Fuel Science Center (FSC) - Adaptive Conversion Systems for Renewable Energy and Carbon Sources”

Short description of the project: FSC aims to integrate renewable electricity with bio-based carbon feedstocks and CO2 to provide high-density liquid energy carriers (bio-hybrid fuels) which enable innovative engine concepts for highly efficient and clean combustion. With fundamental knowledge and novel scientific methodologies fossil fuels are replaced by adaptive production and propulsion systems under dynamic system boundaries.

Project partners: University of Alberta Edmonton, Alberta, Canada; University of California, Berkeley- Los Angeles - Santa Barbara, USA; Co-Optimization of Fuels & Engines (Co-Optima), Washington D.C., USA; Forschungszentrum Jülich; Max Planck Institute for Chemical Energy Conversion; Max-Planck-Institut für Kohlenforschung

Impact: FSC integrates natural, engineering, and social sciences to enhance interdisciplinary competences. Adaptive synthetic pathways are developed for bio-hybrid fuels using homogeneous, heterogeneous, bio-, and electro-catalysis. Experiments and simulations provide insights into combustion and catalysis. Modular, dynamic reactors produce high-yield bio-hybrid fuels. Engine concepts with energy conversion efficiencies above 50% and minimal emissions are developed. The dynamic cross-sectorial integration is evaluated on a system level regarding economic, environmental and social impacts.

Lessons learned: The key to successful, holistic research into a complex, cross-sectoral topic is the integration of all disciplinary competences in a dynamic team structure. Forward-integration occurs from fundamental science to the complex systems of fuel production, mobility, and transportation. Simultaneously, system-level information is propagated back by inverse methodologies. Thus, the integration of the research network as a structure-forming unit of the cooperating institutes at RWTH Aachen and the partner institutions is indispensable to create a world-leading scientific environment.

Useful links: www.fuelcenter.rwth-aachen.de

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6.3 Ensure a well-balanced approach to knowledge safety and security

From a scientific point of view, openness and cooperation with all global partners is crucial to help tackle local and global challenges. From a technological point of view, however, we should acknowledge increased global political and financial competition, and the reality of interference by some governments and businesses. This includes considerations around the concepts of ‘strategic autonomy & technological sovereignty’. In some scientific communities, it has been clear that ‘closedness’ is sometimes a must (e.g., due to patient privacy considerations) while for other communities openness has been seen as an unmitigated good. It is vital that universities of S&T do not take a passive stance on this issue and allow others to dictate what should be open or closed and when, but instead proactively lead this discussion on achieving the right balance. This is especially true for sensitive areas of research, such as those related to dual-use or surveillance capacity. This includes ensuring that knowledge safety and security measures are used by universities to comply with UN, EU and national law and regulations on export control. This also means the use of international sanctions to prevent sensitive technological knowledge being mobilised in the development of weapons of mass destruction; and military / or surveillance applications in countries where human rights are not respected. In addition to this compliance-focused approach, there are many grey areas where universities of S&T must not shy away from leading the discussion and shaping the policy landscape. We must not outsource decisions around the degree of openness to mitigate risks, but instead work with our communities to define, refine, and evolve how to approach and implement this balance. At its core, this process establishes an important framework for universities of S&T to pursue their societal roles and responsibilities and implement their values and missions.

Chapter 7: Contribution of learning and teaching

Traditional education has made substantial progress in analysing and understanding sustainability. It does not seem, however, to have made the necessary change to address today's increasingly complex challenges A more holistic approach to education is needed with a focus on changing people's mindsets, with values and consciousness as important leverage points for change. Indeed, universities of S&T do not only have the capacity to teach the science behind climate change and the technology to help solve global challenges. They also have the opportunity and responsibility to 'educate for sustainability' by influencing the minds of people and training the future leaders of the world.

An overarching challenge is that teaching activities are ascribed less value than contributions to research in the assessment of academics and academic institutions. In reality and as summarised by the Editor-in-Chief of *The Lancet*: "education is the vector that transmits to every new generation curiosity, passion, and commitment to reimagine the future, extend the limits of human possibility, and achieve a more just social world."

The UN SDGs, particularly SDG4 which is to 'ensure inclusive and equitable quality education and promote lifelong learning opportunities for all', highlights that education is both an end and a means towards tackling today's global challenges. Thus, education contributes to sustainability in a range of different ways.

7.1 Implement inter- and transdisciplinary programmes

To efficiently respond to the complexity of the current global challenges and contribute to sustainability, universities must address them in an interdisciplinary way by advocating cross-disciplinary research and education programmes that foster the rapid transformation of our societies required to address climate change and adaptation.

Sciences on their own cannot solve the grand challenges of the world. We need an approach that cuts across traditional disciplinary boundaries. In research and education, a commitment to support inter- and transdisciplinary collaboration should be emphasised.

Turning that ambition into reality is still more difficult than it ought to be. Interdisciplinarity is relatively well established in educational settings. However, recognition for these initiatives (for researchers, teachers, and students) is very important. Currently, in many educational settings, engagement in transdisciplinary teaching and research is all too often an additional contribution added on top of already busy agendas. Moreover, in the context of early-career paths, it can be difficult for employers to see the value in such interdisciplinary training, especially when measured against traditional career paths. This limits the scope of students and researchers to pursue an interdisciplinary career, and limits mobility between sectors. Therefore, more incentives in universities for interdisciplinary approaches are needed, such as rewards and credits assigned to students and researchers, combined with effective funding approaches.

Current examples of successful interdisciplinary approaches in learning and teaching include challenge based learning which concerns replacing existing modules through challenges. Tackling issues with objective-based learning may encounter certain obstacles such as (i) ensuring alignment of roles and responsibilities (maintaining all stakeholders commitments

and intensive coaching), (ii) lack of clarity of intended learning outcomes and (iii) lack of clarity of assessment criteria when assessment is organised along disciplinary boundaries (e.g. evidence shows that interdisciplinary research has consistently lower funding success than 'traditional' research, something that should be avoided in the context of learning and teaching). Objective-based learning is especially relevant as it allows for the exploration of socially relevant challenges and for collaboration with multiple stakeholders.

Some institutions also provide degrees dedicated to sustainability based on interdisciplinarity. This is an opportunity to address the pressing need for sustainability-based research, teaching, and innovation from a trans- and interdisciplinary perspective, fostering the links between education, research, and innovation.

Additionally, to comprehensively incorporate the sustainability agenda into teaching and learning, we cannot be confined to sustainability within institutions or student cohorts. Sustainability must be extended to include a university-wide holistic approach, engaging students, staff, and partners in all areas.

Case study - Leibniz Universität Hannover

Project name: Teaching Change - Education for Sustainable Development (ESD) in Teacher Training

Short description of the project: The Teaching Change projects aims at introducing and mainstreaming ESD in teacher training with the objective of empowering prospective teachers in their role as multipliers for change. In association with the Green Office and located at the Leibniz School of Education, the institution that connects the different courses of study, it seeks to establish ESD as a crosscutting principle.

Impact: The project develops teaching-learning-concepts on ESD and sustainability related topics. The concepts are co-designed and tested in practice with different lecturers, evaluated with students and then shared as open educational resources for other lecturers. The range of courses involved goes beyond the usual subjects of ESD (geography, citizenship education and biology), involving also e.g. special needs education, psychology, vocational teaching and drama classes. Ring lectures, key competence courses or didactic workshops provide interdisciplinary learning spaces for ESD across subjects.

Lessons learned: The project was designed to integrate ESD into existing study courses, paying respect to its crosscutting and interdisciplinary nature. Since ESD is more than just a topic (teaching ABOUT sustainability) but calls for a different learning culture (teaching AS sustainability), it became evident that integrating ESD successfully requires discussion and qualification on the principles of ESD of lecturers and experimental spaces to co-develop new teaching-learning approaches. With the need for a whole-institution-approach, the journey of implementing ESD takes time and effort - beyond one project.

Useful links: https://www.lse.uni-hannover.de/en/lse/projects/teachingchange

Main contact person: Timo Holthoff, Project Coordinator, Leibniz School of Education, Green Office.

7.2 Embed sustainability into curricular and extracurricular learning and teaching activities

Education also contributes to sustainability by enabling graduates to understand the challenges of our time, be able to communicate effectively about them, and apply sustainability in their fields of expertise. Students can learn about sustainability in three ways: curricula, co-curricula and hidden curricula.

Universities measure and increase the content on sustainability in the curricula by developing new sustainability-focused models and programmes, integrating sustainability content into existing programmes, offering university-wide courses on sustainability, and increasing the extent of sustainability learning outcomes in academic programmes. Additionally, they highlight and give visibility to courses that already integrate sustainability into their content.

Co-curricula, embeds sustainability in the entire student experience. Sustainability is part of recruitment criteria and orientation programmes. Sustainability is embraced by student clubs and societies and included in volunteering opportunities.

Hidden curricula enable students to learn about sustainability through the ways in which the university operates. An example can include a dashboard at the entrance of a building showing what energy that building uses, biodiversity tracking on campus, celebrating the link to nature, activities, and actions in the areas of sustainable transport, food sustainability initiatives and others.

7.3 Foster sustainability skills and competencies to help tackle global challenges.

Universities have a crucial role in fostering future leaders and teaching the right skills and competencies to tackle the pressing global challenges of our times. The impact from graduates and students can be one of the most powerful and effective ways for universities to give value to society, and it is the responsibility of the university to provide them with the necessary education for creating a better future. Sustainability is not only an academic pursuit, but an existential one, and universities have the societal responsibility of shaping the habits and behaviours of the next generations.

There is a need for transformation in the current higher education system and the overall institutional strategy of universities to meet society's needs through inter- and transdisciplinary approaches and challenge-based education and training (see above). Competences need to be redefined to accommodate these changes, providing learners and researchers with the right skills to work in inter- and transdisciplinary ways and settings. Student-centric learning needs to be taken seriously as it provides students ownership of the learning process, as well as the critical and transformational skills needed to contribute to society. Competences need to be redefined to accommodate the new skills necessary for the next generations, linking knowledge with agency to encourage younger generations to put their knowledge to good use. The European Entrepreneurship Competence Framework (2018) identifies the following key points to redefine competence and make students owners of their learning:

- importance of research competence
- entrepreneurial mindset
- intercultural, global understanding
- information, data and science literacy
- critical thinking and understanding of scientific methods
- responsibility in research, teaching and innovation

There are also unique human skills and competences that remain in high demand, even at a time when an increasing number of tasks are being done by artificial intelligence. In 'Robot-Proof: Higher Education in the Age of Artificial Intelligence', the author explores how learning and teaching can provide future generations with the right skills necessary to contribute to society which robots cannot achieve. Students will need (i) data literacy to manage the flow of big data (ii) technological literacy to understand the intricacies of artificial intelligence but also (iii) human literacy to function as human beings and navigate society. Universities of S&T have the capacity and responsibility to teach all these skills to their students.

Case study - University of Porto

Project name: Education for Sustainable Development (ESD@FEUP)

Short description of the project: The ESD@FEUP project intends to provide students with competencies that enable them to include in their practices, appropriate actions based on environmental, social and economic challenges. It also intends to be a catalyst for the integration of sustainable development in the FEUP's culture. It will last for 3 years.

Impact: To achieve the proposed goal, the project has the following actions: i) training of teachers, researchers and support staff in sustainability; ii) integration of ESD in selected courses; iii) transversal actions; and, iv) communication. It is expected by the end of the project that 80 teachers had been trained in the sustainability topic; 6500 students had received training related to sustainable development; 80% of students will be aware of the relevance of ESD in the engineering practice; 2 new courses related with sustainability will be offered.

Lessons learned: For the success of the project it is crucial the commitment of the whole academic community with the sustainable development. It's critical to motivate faculty for attending training related to sustainability and for the development of dedicated contents. To overcome this barrier, the project team consists of teaching staff, representing all departments of FEUP. It is expected that they influence their peers. So, the internal communication is a critical factor of the project. It is relevant to mention that this project is possible only because of the commitment and support of FEUP's leaders.

Useful links: https://paginas.fe.up.pt/~sustent/edsfeup/

https://paginas.fe.up.pt/~sustent/

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Chapter 8: Contribution of innovation

Innovation has been identified as a main driver for development and in the context of sustainability the focus is on the transformative power of disruptive innovation, creativity and collaboration between academic and non-academic partners. In that respect, knowledge and learning are key to enacting change and universities have a crucial role and effect on innovation and their ecosystems.

It is important to be aware of and engaged in the urgent process of transformation towards sustainability. A key question is: how do governments work with scientists to accelerate the adoption of innovative technologies for a more sustainable society? With the broader lens, looking at how we make sure our populations provide support for this shift and transformation towards a more sustainable society?

8.1 Strengthen the role of universities as drivers in responsible innovation ecosystems

Innovation is crucial for improving economic, environmental and social well-being. As the ecosystem changes, there is a growing necessity, not only to encourage more partnerships between industry and academia, but also to create new and more inclusive innovation ecosystems. The technology is only one element, going further with innovative technology, integrating it within society to become more sustainable is key. Trust in researchers and innovators must be upheld but more involvement of individuals, citizens and society at large is needed to co-create disruptive and responsible innovation for a sustainable future together.

When talking about innovation systems, there is a need to move from Science-Technology-Innovation (STI) activities (oriented at for example patents) towards Doing-Using-Interacting learning (DUI). There is a difference between (i) the important role of universities in innovation systems and (ii) their differing roles and approaches when it comes to ecosystems in terms of complex value propositions. There are different time horizons of universities (long term) compared to business (short term profit), which is also true for political cycles (short term election cycles).

Over the years, universities have been increasing their collaboration with industries when thinking about sustainability. Indeed, the private sector is a key actor in (i) sustainability, energy, and climate transition, (ii) generating and adopting innovations (technological and beyond), (iii) collaborating to identify solutions, and provide important opportunities for universities and scientists. There is also a strong emphasis on the key role of the private sector in terms of Corporate Social Responsibility (CSR) towards sustainability and changing business models.

However, the metaphor of a Triple Helix more or less invites proposals to extend the model, which moves beyond the state, industry and academia to instead involve all of society. In a discussion which focused on bringing society or the public back into the model as a fourth helix, Leydesdorff & Etzkowitz (2003) argued that the helices represent specialisation and codification in function systems which evolve from and within civil society.

8.2 Empower innovators and entrepreneurs as agents of change

Eco-innovation is a complex concept that requires a large skill set such as different types of engineering, scientific approaches and humanities to competently address it. By 2025, the World Economic Forum has forecasted that 50% of all employees will need to be reskilled in order to adapt to the current pressures and societal changes including the increased need to contribute to sustainable development. It is therefore necessary to think of sustainability in terms of the taught curricula within universities to provide added value broader skill sets for companies and society as a whole to better contribute to sustainable development. With the following list of skills we depart from the challenge-based orientation concerning the type of skills needed by engineers in the future to adapt to new pressures:

- Analytical thinking and innovation
- Proactive teaching and learning strategies
- Complex problem solving
- Critical thinking and analysis
- Creativity, originality and initiative
- Leadership and social influence
- Technology use, monitoring and control
- Technology design and programming
- Resilience, stress tolerance and flexibility
- Reasoning, problem solving and ideation.

There is a need to encourage growth learning and open mindsets at universities instead of fixed mindsets, viewing failure not as a limitation but as an opportunity to grow. This problem-based approach provides flexibility to develop different types of skills necessary to establish change through multi and trans-disciplinary approaches.

Navigating complex new ecosystems and fostering innovation at an institutional level while contributing and embedding sustainability requires integration of a systems thinking approach and design to address interplays and connectivity between economic, environmental, and social aspects. Opening and fostering systems change allows a move away from current linear mindsets, embedding problem-based learning within university curricula, encouraging, and collectively driving universities to be receptive to change.

Environmental trends are strongly driven by changing customer behaviour while business models are driven by environmental and social drivers. These have been enhanced and driven by the consequences of the Covid-19 pandemic. The pandemic also provided a renewed impetus to look at the whole supply chain (local vs global). Governments have acknowledged the importance of creating regional hubs and delivering collaboration and partnerships by also helping universities and industry to understand the importance of such partnerships. New business models are emerging based on shared experience and these developments can be enhanced by ensuring a permissive legislative landscape see.

While there are a range of promising examples and initiatives, the realignment towards a fully functioning system which fosters and encourages innovators and entrepreneurs to tackle complex challenges and navigate ecosystems still has much ground to cover (see position). A key question is how can we encourage this uptake, and how long will it take to change mindsets of the majority?

Case study - University of Twente

Project name: SHAREBOX

Short description of the project: To pave the way forward for more efficient processing and energy systems for the process industries, the SHAREBOX project develops a secure ICT platform for the flexible management of shared process resources. This will provide companies with robust and reliable information, needed to effectively and confidently share resources with other companies in a symbiotic ecosystem.

Project partners: University of Twente, University of Strathclyde, The North East of England Process Industry Cluster LBG, Eskisehir Sanayi Odasi, Guzman Global SL, Iberica de Suspensiones SL, Kerafrit SA, Keros Ceramica SL, Chemie Cluster Bayern GMBH, Universitat Politecnica de Catalunya, Dechema Gesellschaft fur Chemischetechnik und Biotechnologie, International Synergies LTD, University of Leeds, Zurcher Hochschule fur Angewandte Wissenschaften, Asociacion de Investigacion de las Industrias Ceramicas AICE.

Impact: 515.000 ton waste avoided from landfill, 635.500 tons of saved virgin resources, 1.38 million ton saved CO2, 53.85 million euros of additional sales, 14.12 million cost savings, 74 green jobs created, 4.45 million private investment triggered

Lessons learned: As a circular economy practice and business model, industrial symbiosis is the main enabler of sustainability in the process industry and it forms the basis of "hubs for circularity" as a regional development model. When companies exploit each other's waste (replacing primary resources), they can reduce costs, generate additional revenue, and significantly improve their environmental performance. The ICT tools developed under SHAREBOX help companies identify, assess and implement synergies when exchanging resources, forming symbiotic networks spanning a single industrial park or wider regions

Useful links: https://www.youtube.com/watch?v=IKh7g4LuKL4
https://circulareconomy.europa.eu/platform/en/good-practices/sharebox-secure-management-platform-shared-process-resources

https://cordis.europa.eu/project/id/680843

Main contact person: Devrim Murat Yazan, d.m.yazan@utwente.nl

8.3 Help to shape markets towards promoting innovation for the common good

While acknowledging that there is an ongoing discussions around limitations of the concept of green growth, there is evidence on the opportunities, drivers and policies for innovation-led sustainable growth. For example, the European Commission has been investigating ways to integrate sustainable financing to its financial planning in support of the European Green Deal, as well as developing its Green Taxonomy. This notably includes the Corporate Sustainability Reporting Directive (CSRD) to encourage companies to report and disclose their environmental impact. Following that movement, it is therefore important for governments to establish framework conditions favouring a contribution to sustainability and to ensure lower costs of sustainable goods for consumers.

The political landscape and the financial sector are both important in shaping markets to promote innovation for the common good in terms of (i) different investments and (ii) Green taxonomy but (iii) also looking at how ‘corona-funds’ (e.g. the Recovery and Resilience Facilty of the European Union) are pumped into ‘dirty’ sectors and industries. Issues faced include companies departing from strong economic positions to include social and environmental sustainability leaving little space of manoeuvre. Without appropriate safeguards, endorsement and support, companies will struggle to maintain the balance of being economically competitive, alongside showing their commitment and desire to adopt sustainable and socially progressive principles and practices.

It is also important to encourage companies to seek opportunities in the green market, pushing for more innovation and tackling social and environmental challenges. In addition to fostering the next generation of innovators with a growth mindset, universities have an important role to act as ‘anchor institutions’ in innovation ecosystems, therefore being pivotal in creating and bringing about the change in narrative.

Part 3: Cross-cutting themes

Chapter 9: Measure contributions

9.1 Ranking agencies' approach towards measuring sustainability

Any contributions of universities were, are, and will be measured along the expectation patterns placed on them. The triggers to measure their contributions to sustainability derive from various sources, such as (i) the expectations from students and learners, (ii) more complex expectation patterns of funders, (iii) a need to increasingly measure impact instead of performance, (iv) digitalisation and rapidly emerging key technologies, (v) a different geopolitical order, and (vi) the pressing local and global challenges. Thereby, the key performance indicators from the paradigm of the New Public Management fall short to measure the contribution of universities to sustainability and that is why we need to move from traditional to progressive metrics over the next generation(s).

Major ranking systems now gather and process institutional data and provide corresponding services to universities. Prominent examples include the THE University Impact Rankings, the QS Sustainability University Rankings, the University of Indonesia GreenMetric and Sustainability Tracking, Assessment & Rating System (STARS), but also other ranking systems are developing such assessment tools. The ranking typically occurs along keyword searches optimised through machine-learning components (e.g. SciVal) or (i) publication data (particularly the abstract and citation database SCOPUS from Elsevier) and (ii) institutional data from universities collected by periodic surveys or gathered from websites.

Through their (mainly) quantitative methods, they focus primarily on (i) the stakeholder engagement and reputation building (external process-orientation) and (ii) the performance of universities, such as the excellence of the research, education and innovation of universities (internal result-orientation). The measuring of (i) internal process allowing for the realisation of institutional development and of benchmarking (internal process-orientation) and of (ii) the contribution to achieving (specific) UN SDGs and targets, as well as the broader impact of helping to tackle the local and global challenges remains complex.

Another major challenge for universities concerns the definition and measurement of their ecological footprint, taking into consideration the full supply chain for all that is produced and consumed by the estate, workforce and student populations and promoting sustainable global employment practices throughout the supply chain. These efforts in sustainable university management and operations are tentatively measured by ranking systems as well, for instance by analysing policy papers, sustainability reports or internal guidelines.

The welcome shift away from the undue focus on reputation and performance (quantitative and competitive) to increasing focusing on development strategies and impact (qualitative and collaborative) is now being explored, also along more qualitative methodologies, including case studies. However, it is important to emphasise that the ranking's methods of measuring universities' contributions were recently developed and are a constantly evolving domain.

Importantly, the situation described above for universities aligns with considerable costs for buying data on other universities for benchmarking purposes and related services, with high administrative burden when completing surveys and updating institutional data. Essentially, universities (i) collect institutional data and often deliver this for free to (commercial) third parties; (ii) develop algorithms and machine-learning components and often deliver them for free; and then (iii) pay the third parties to get back insights around the university's reputation, impact and performance to be able to benchmark against others. In this context, it is important to remind universities that ownership of the data is theirs, and as such the data can be used for alternative purposes rather than feeding into ranking agencies' databases.

9.2 Promote a holistic approach of measuring contributions

We advise universities to re-orientate their focus and effort towards a comprehensive, consistent and coherent approach, covering all purposes when measuring their contributions to sustainability:

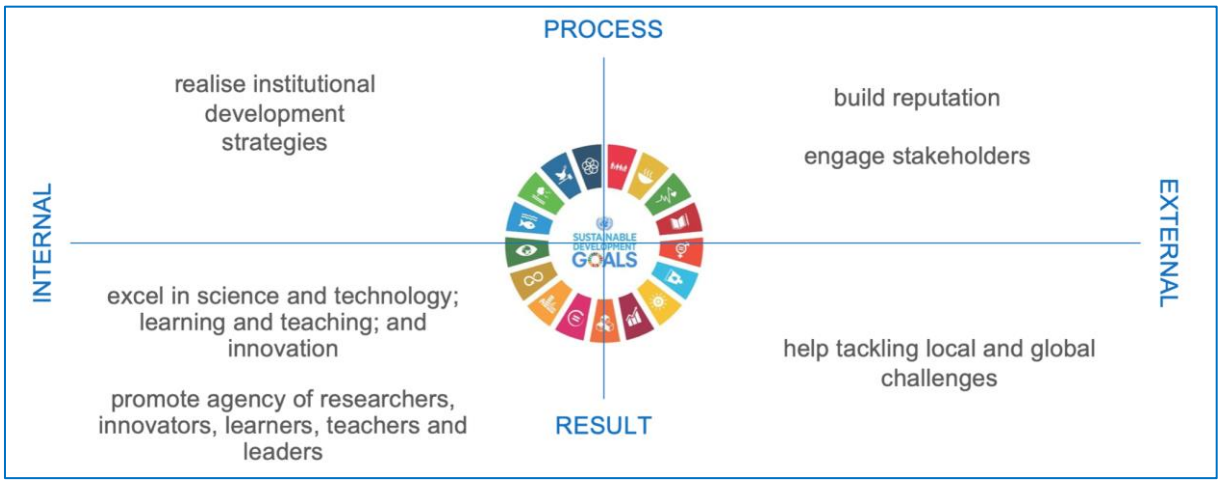


Figure 2: Purposes of measuring contribution of universities to sustainability in a holistic approach

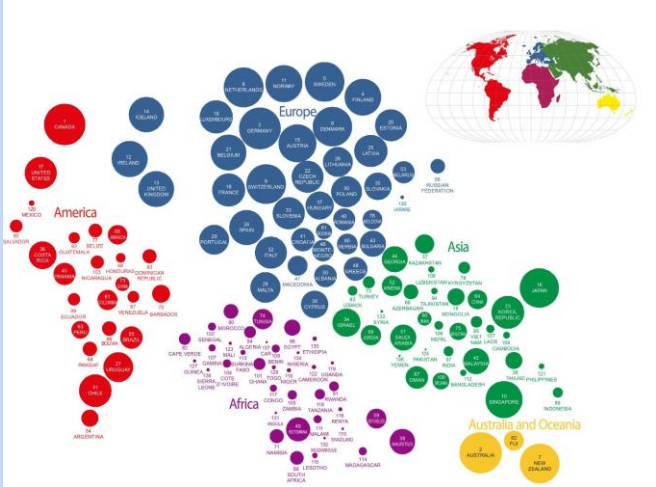
Universities are encouraged to move away from an approach that specifically targets influencing ranking systems towards advocating for a holistic vision of their contributions to sustainability. This new vision summarised conceptually above in Figure 2, covers measuring universities contributions through their processes, as well as their results, and on both internal and external elements. Measuring universities' contributions to sustainability should reflect the commitment as laid out in the present white paper and its adjoining declaration. This will not only enable universities to measure, monitor and report on their contributions to sustainability, but also empower them to release unprecedented strengths, to act as autonomous agents of great change and transformation, and help them to advance the evolving idea of a university of S&T.

9.3 Place our association as a proactive partner of ranking agencies and a key element of stakeholder organisations

Moreover, a true partnership approach is needed to standardise such institutional data, add meaningful meta-data, and reduce the administrative burden and additional costs to (commercial) third parties.

We therefore conclude this chapter by advising universities and their stakeholder organisations to work through CESAER with the European Commission on the European Higher Education Sector Observatory. As such, universities and stakeholder organisations can invoke fair retention rights on their institutional data, algorithms and machine-learning components and connect this data with the European Open Science Cloud (EOSC). These platforms, initiatives, and data portals could provide much needed help to develop a common ground for measuring the contribution of universities to sustainability in a meaningful, holistic and collective way.

Case study - National Technical University of Ukraine - Igor Sikorsky Kyiv Polytechnic Institute



Project name: Quantitative Assessment and Analysis of Sustainable Development of World Countries and Regions of Ukraine in Context of Quality and Security of Human Life

Short description of the project: A quantitative assessment of the development state of 136 world countries and 27 regions of Ukraine is carried out annually (since 2006) from the standpoint of the sustainable development concept in the space of three dimensions: economic, ecological, and social-institutional, taking into account the impact of a set of global and regional threats. Original mathematical models and methods are used.

Project partners: National Academy of Sciences of Ukraine, Ministry of Education and Science of Ukraine, International Science Council, World Data System, Committee on Data for Science and Technology etc.

Impact: The methodologies, reports, and recommendations are shared with international partners and central/local authorities in Ukraine responsible for socio-economic development. Annual research improves decision-making effectiveness, supports strategic and tactical planning, and fosters a new way of thinking among the population, allowing Ukraine to realise its potential for sustainable development.

Lessons learned: Our project faced challenges in organising work with high-level experts and finding reliable data sources and their verification. We learned to prioritise building strong relationships with experts and stakeholders, streamline data collection and verification for accuracy, and communicate and collaborate clearly within our team. These lessons have equipped us with tools and knowledge to improve our approach and achieve greater success in future projects.

Useful links: http://wdc.org.ua/en/sustainable-development/reports
http://sdi.wdc.org.ua/main/

Main contact person: Kostiantyn Yefremov, k.yefremov@wdc.org.ua

Chapter 10: Green campus

Leading by example when contributing to sustainability signifies that universities of S&T have the responsibility to create impact not only externally but also internally, notably by reducing the ecological footprint of their activities and greening their campuses.

In addition, universities should have clear and transparent policies and procedures for sustainability initiatives and should regularly report on progress and results to the broader community and beyond. The involvement of the entire university community, from faculty and professional services to students, staff and alumni, is needed to mobilise every individual. University leadership and administrations' full commitment implies leveraging internal resources and focusing on a university's own operations.

10.1 Example: Reduce the ecological footprint of universities

We provide here a list of examples of activities universities of S&T can and should put into place to reduce their ecological footprint by reducing their greenhouse emissions or even achieving net-zero emissions:

- calculate, monitor and evaluate the ecological footprint and emissions;
- develop and realise goals and targets to reduce them;
- dedicate university funds to initiatives and actions related to sustainability;
- recruit and employ staff that specialise in and are dedicated to sustainability;
- promote sustainable global employment practices throughout the supply chain, e.g. not supporting child labour, forced labour, unacceptable employment conditions, contracts and practices;
- develop CO2-neutral and circular economy derived buildings;
- promote sustainable mobility;
- reduce water consumption;
- improve the energy balance;
- manage waste sustainably;
- ensure green procurement of products and services;
- reduce the dependence on international travel making use of and advocating for virtual engagement where possible and, where international travel is needed, seeking the most sustainable modes of travel available;
- improving the environmental performance of facilities

10.2 Example: providing for a healthy and thriving local (living) environment.

The commitment of universities of S&T to the conservation and preservation of natural spaces goes beyond merely maintaining picturesque landscapes. These institutions are actively contributing to ecological sustainability, preserving local biodiversity, and serving as beacons of environmental responsibility. Through research, education, and practical conservation initiatives, universities are demonstrating that the preservation of natural spaces is a vital component of their broader commitment to sustainability. These activities include the following examples:

- Implementing comprehensive biodiversity action plans such as the identification of native plant and animal species, habitat restoration, and measures to reduce invasive species. Indeed, many university campuses boast diverse ecosystems, including woodlands, wetlands, and meadows;
- Employing sustainable landscaping practices and moving away from traditional landscaping practices that rely heavily on chemical fertilizers and pesticides;
- Designating proportions of one's campus as wildlife habitats or natural reserves (primarily for large-campus universities). These areas are managed with minimal human intervention to allow ecosystems to thrive naturally;
- Involving students in restoration projects, awareness raising, wildlife surveys and habitat monitoring.

Case study - Universidad Politécnica de Madrid (UPM)

Project name: UPM decarbonization and energy efficiency

Short description of the project: The UPM decarbonization and energy efficiency project included:

- Replacement of the entire lighting system of the University by LED lamps
- Installation of photovoltaic panels
- Building's Climatic isolation
- Launch of a vehicle purchasing policy that requires Hybrid or Full Electric engines
- Improvement and renovation of air conditioning systems
- Electricity supply contracts 100% renewable

Project partners: CESAER, International Sustainable Campus Network (ISCN), University Global Coalition (UGC), Sustainable Development Solutions Network (SDSN), Spanish Network for Sustainable Development (Red Española para el Desarrollo Sostenible - REDS)

Impact: From 2017 to 2020, the University's carbon footprint has been reduced by 82%, mainly due to the inclusion of new contracting requirements from our energy providers in environmental matters. The greatest impact in terms of energy efficiency is foreseen for the years 2023 and following, in which it is estimated that electricity consumption will decrease throughout the campus by 26% in 2023, thanks to the improvements made in LED and air conditioning and the promotion of Self-consumption with Photovoltaic energy.

Lessons learned: A positive impact on decarbonization can be profitable and followed by economic savings in the medium and long term. In order to achieve quick impact to neutralise the effects of the energy crisis, a very aligned cross-area task force has to work together, designing new procedures that can boost the change. Regular ways of implementation that could be the most efficient ones for a normal context may be inappropriate as speed of implementation makes the difference.

Useful links:https://sostenibilidad.upm.es/plan-de-sostenibilidad-ambiental/ https://sostenibilidad.upm.es/huella-de-carbono-de-la-universidad-politecnica-de-madrid-2019-2020/ and https://sostenibilidad.upm.es/consumos-2021/ https://sostenibilidad.upm.es/eps01-la-upm-continua-reduciendo-su-huella-de-carbono/

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Chapter 11: Equal opportunities and equity, diversity and inclusion

Inequalities between people, and between regions, threaten social, economic and environmental goals. We cannot achieve sustainable development and make the planet better for all if some are excluded from the chance for a better life as laid down in SDG 5 'Achieve gender equality and empower all women and girls' and SDG 10 'Reduce inequality within and among countries'. Likewise, we need to ensure that our populations remain supportive of both technological and social innovations. This requires an understanding of the concerns of diverse publics, as well as knowledge on how to translate that understanding into inclusive social and technological innovation that leaves no one behind.

Thus, equality policies are eminently important for achieving the UN SDGs. For universities of S&T, this means a dual agenda of reconsidering who is involved in the development of new scientific knowledge and technologies, and what and how research is done. Universities have several roles in relation to diversity: (i) recruitment, (ii) operations and governance of the university through policies and plans, (iii) wider outreach and empowerment in society and (iv) in research and innovation. In other words, the role of universities of S&T goes beyond the passive act of selecting students and staff from as diverse backgrounds as possible. Universities of S&T have an active role to play in ensuring and encouraging diversity in students and staff by empowering people in society, engaging people of all backgrounds and leaving no one behind. A focus must be placed on the inclusion and acceptance of staff and students from disadvantaged backgrounds, in accordance with the *leave no one behind* and the *furthest behind first* principles of the UN Agenda 2030.

Universities are well advised to consciously promote equal opportunities for all genders and the promotion of Equity, Diversity and Inclusion (EDI) among students and staff must be consciously pursued (see also our EDI Declaration). These goals can only be achieved through a transformative process that is fully supported, and often initiated, by committed leadership and whose progress is monitored and adapted as necessary.

11.1 Promote Gender Equality Plans (GEP) and Diversity Plans (DP)

The European Commission has established criteria for gender equality that cover minimum procedural requirements and are an eligibility criterion in Horizon Europe. These criteria require a Gender Equality Plan (GEP) that secures high level commitment, dedicated resources including gender and diversity expertise, data collection and monitoring, as well as specific training. These GEP also meet the targets of SDG 5 and cover (i) the recruitment and career progression of women, including equal pay measures and tackling consequences of Covid-19; (ii) measures against gender-based violence, including sexual harassment; (iii) Work-Life-Balance and organisational culture; and (iv) women careers and gender balance in decision making.

It is necessary to consider categories of discrimination other than gender. This includes intersecting social factors like race, age, ethnicity, sexual orientation, social and economic status, ability etc. Gender equality issues as well as the mandate to increase inclusion and diversity should not be seen as a burden, rather as a great opportunity for our institutions.

The set-up, implementation and evaluation of Diversity Plans (DPs) thereby help universities to (i) respect the value of diversity brought by students and staff to the institution, learn from

diverse approaches and views and offer a helping hand to those in need; and (ii) promote openness and critical thinking with students and staff, empowering them to act as guardians of what is true and what is not. The biggest hurdles to true inclusion have been extensively researched and outlined, e.g. lack of concrete responsibility, lack of knowledge, subtle exclusion (e.g. implicit bias, unconscious bias, non-events), and lack of progress.

Universities thus are advised to assume responsibility through DPs with concrete tasks at different hierarchical levels. Measurable goals and regular reviews of goals of achievement are important requisites in doing so. The lack of knowledge can be addressed through training. Likewise, awareness raising via training is an essential tool to combat implicit bias that causes unequal treatment and exclusion. Boosting progress can be addressed through measures such as quotas. Austria's example shows that mandatory quotas for decision-making bodies led to a sharp increase in the proportion of women in university leadership.

11.2 Put forward women leaders and other underrepresented leaders as role models

Due to persistently effective gender stereotypes in many countries, girls entering into STEM education remains an issue. Targeted measures must be taken to combat these prejudices. Women role models have proven to be crucial. These role models have two distinct qualities: one being encouragement for new generations to pursue a career within STEM subjects; another is to act as trailblazers for students and staff during their time at university.

Interventions with role models are found to have a positive and significant effect on the enjoyment of mathematics, the importance attached to mathematics, as well as on expectations of success in mathematics and girls' aspirations in STEM. In addition, sessions with role models significantly reinforce the positive impact of expectations of success on STEM choices. Thus, women role models are an incentive for the next generation of girls to look up to someone opening pathways that may have appeared closed at first. Moreover, role models counter existing stereotypes around STEM careers. While much focus has been placed on girls and women, similar efforts can, and should, be expanded to cover all underrepresented groups.

11.3 Go into schools to boost interest for STEM

Offerings for underrepresented groups, including girls and women are an important measure for increasing the proportion of women in STEM. We need to support local, national and global efforts to encourage underrepresented groups in STEM subjects with in- and out-of-school programs. It is important to offer workshops that encourage underrepresented groups to maintain their interest in STEM subjects and to take into account the context, not only the content. This can be done through a variety of different means:

- talking about the exciting careers that can be had within maths, science, computer science and engineering. If young women don't know the opportunities available to them in maths and science, they may think it was a mistake to pursue STEM studies.
- showing that there does not have to be any difference in achievement between different genders, backgrounds, etc.

- emphasising that possible achievement gaps are often due to lower support and self-confidence in underrepresented groups rather than differences in aptitude.

11.4 Broaden from a gendered approach to an inclusive one considering all aspects of EDI.

Gender affects what we do, and how we do it - including the interactions we have with other people, the research we do, and the designs we create, and for whom. The same is true for non-binary considerations and intersecting social factors such as age, ability, educational background, ethnicity, race, geographic location, sexuality, social and economic status etc. The needs of people and their requirements are rather specific depending on the context, and their adaptation to and use of systems are transient and hard to foresee. This must be considered when performing research and innovation.

It is important to understand that this research does not necessarily focus on the differences between genders. According to a report published by the European Commission, the integration of the gender dimension involves questioning gender norms and stereotypes, rethinking standards and reference models and examining the needs, attitudes and behaviours of all genders. Yet researchers and engineers should not consider gender in isolation. Equally important is to understand that intersecting social categories combine to inform individuals' identities and experiences.

Collections of case studies covering science, health & medicine, engineering and environment are available, as well as literature reviews for entire subject areas like robotics, human-computer-interaction, mobility and energy to support researchers and foster the necessary interdisciplinary and transdisciplinary research.

Case study - University of Strathclyde

Project name: IGNITE Network+

Short description of the project: The IGNITE Network+ [Innovation and Growth Needs Inclusion and engagement of all Talent in Energy] is a four-year funded UK Research and Innovation EPSRC project which was established in September 2022 with £1.25m funding to tackle the lack of diversity in the energy research sector. It aims to support sustainable, abundant, clean and equitable energy for all, by harnessing the talents of energy researchers from all backgrounds.

Project partners: The network is led by the University of Strathclyde with partners Imperial College London, the University of Manchester, the University of Nottingham, the University of Bristol, Queen's University Belfast and Brunel University London.

Impact: The network builds on the previous work of the STEM Equals project which was focused on creating more inclusive STEM communities for women and LGBT people in both academia and in industry. Example outputs include the launch of StrathPride (Strathclyde University's LGBTQI+ staff and PGR network), launch of a cross-faculty Women in Science and Engineering Committee, funding 11 collaborative projects (£60,000) led by women at Strathclyde University, organisation of the See Yourself in STEM project, a reciprocal mentoring programme and LGBTQI+ awareness training for senior leaders at the University of Strathclyde.

Lessons learned: The current lack of diversity in energy researchers stems not from a lack of interest, talent or ambition in underrepresented individuals, but from systemic inequalities in UK systems and institutions. The IGNITE Network+ will address diversity issues by:

- collecting data that can expose systemic inequality;
- designing, testing and implementing disruptive initiatives;
- monitoring the success of interventions and activities;
- dentifying, disseminating and encouraging good practice.

Useful links: https://www.ignitenetplus.ac.uk/

https://www.stemequals.ac.uk

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Part 4: Conclusion

Throughout this paper, we have demonstrated the crucial roles universities of S&T are having and can have when contributing to sustainability through research, education and innovation, as well as through measuring their contributions, greening their own campuses and upholding and defending key values such as EDI. While acknowledging the substantial achievements by many universities already to date, heightened contributions to sustainability can only be achieved through (continued) transformative reform, fully supported and often initiated by committed leadership. Progress should be measured, monitored and adapted as needed. Contributing to sustainability and making changes will require adapting the way universities of S&T approach education, research and innovation within their institutions.

Considering all the areas outlined in this paper, the authors are convinced that action must be fully supported, and instigated, by committed leadership at universities. Universities of S&T have a responsibility, through good governance, to lead by example for a more sustainable world.

Leadership is needed to disseminate the new narrative among students, learners, researchers, staff and society, to safeguard commitment at all levels and to promote cultural change within universities. We commend and promote universities as autonomous agents of great transformation towards ecological, economic and social sustainability.

Additionally, to increase societal impact, the authors of this paper would like to recall and encourage university leaders to look even more beyond the walls of their own institutions and advance local and global engagement along SDG17 ‘Strengthen the means of implementation and revitalise the Global Partnership for Sustainable Development’.

To advance efforts in this area, we encourage leaders at universities of S&T and beyond to reflect on: What they see as the role of their leadership in promoting a culture of change towards contributing to sustainability? What are the mechanisms that their university has or should put in place to assess and reward contributions to sustainability, helping to ensure this becomes integrated into everyday operation, acknowledged and rewarded accordingly?

We would like to finish with a concrete example within sustainability: the net-zero transition. What is your role in ensuring that your institution helps lead the urgent societal need for transformation towards net-zero? Most countries have committed to net-zero by 2050, how much earlier do you believe your operations could be fully net-zero and do you have the implementation strategy in place to realise this ambition?

Additional resources

Many references were provided throughout the white paper with links directly to relevant resoruces. Below we provide additional resources for the interested reader.

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