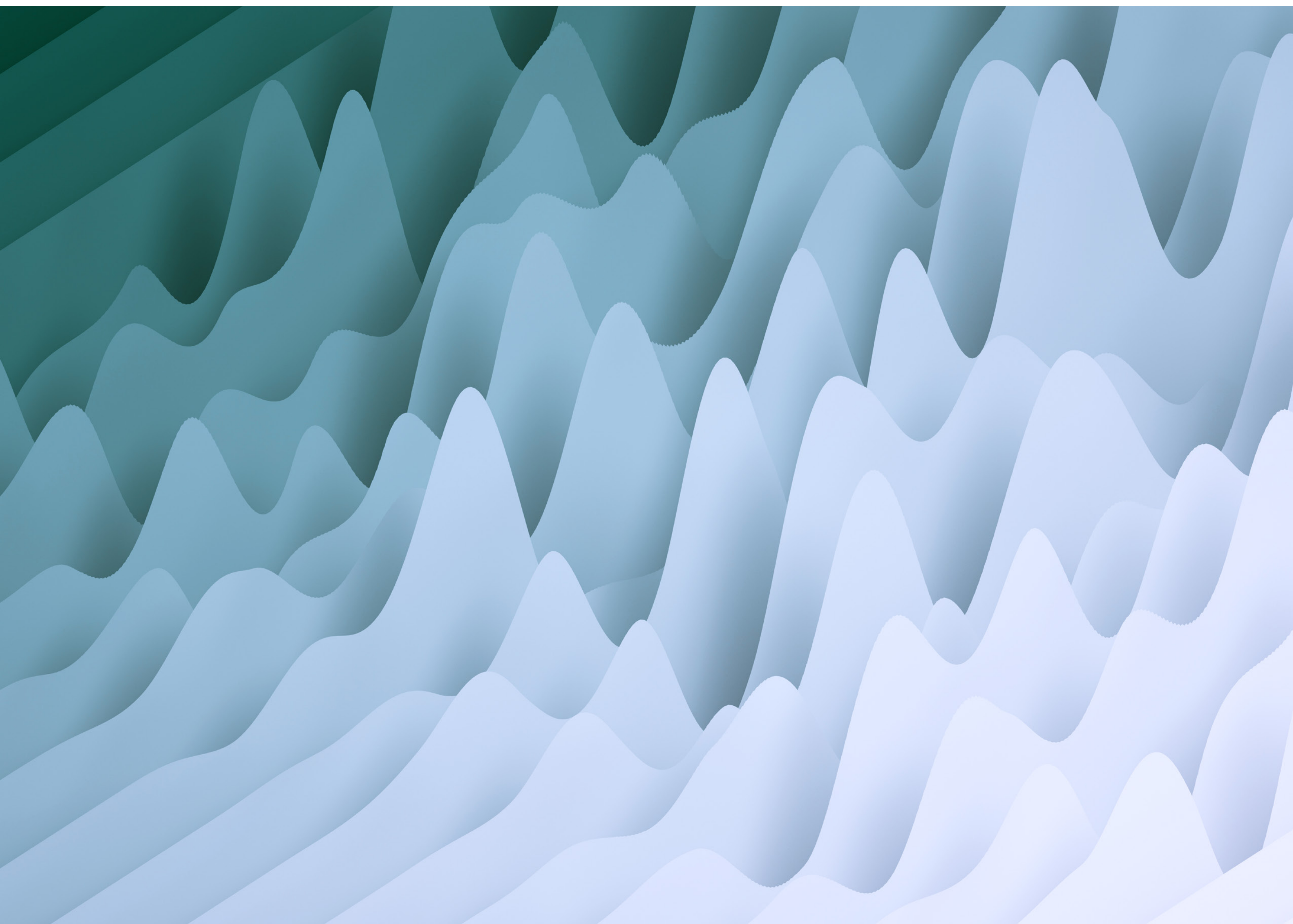
SYSTEMIQ

initiative for applied artificial intelligence

How to leverage AI to support the European Green Deal



„Leveraging AI for the European Green Deal must be done from an ecosystem perspective. We need policies targeted at the scaled application of AI for the EGD implementation."

Matthias Ballweg
Director Mobility and Policy
SYSTEMIQ

"We should use AI as much as we can to tackle the most important challenge of our times - Climate Change"

Andreas Liebl
Managing Director
UnternehmerTUM and appliedAI

Introduction

"Using AI to fight climate change" Peter Koerte, Chief Technology and Strategy Officer, Siemens AG

Among the many challenges that societies across the globe face in these turbulent times, climate change remains the most pressing. It threatens our very existence on this planet, and with it all areas of our social and economic order.

But there are also reasons to be optimistic about our ability to confront this challenge. On the one hand, there is a growing readiness to take collaborative and at times bold action to limit climate change, on all levels from local to global. In this respect, the goal to limit global warning to 1,5°C serves as a shared point of reference. Among those leading the way towards this goal is the European Union, with its recently announced European Green Deal that sets out to make Europe the world's first climate-neutral continent by 2050.

On the other hand – and here I speak from the point of view of a global technology company with experience in many areas that contribute to the fight against climate change – there is a great number of technological solutions that can help us win this fight. We ourselves are committed to reach CO2-neutrality by 2030. And the purpose of our technologies is also to help our suppliers, our customers, and our partners to reduce their CO2 emissions. Among these technologies we put a specific focus on AI-based technologies, for a simple reason: so far, we have only started to tap its potential to fight against climate change. With AI, there is much more we can do here – and we must do it.

This is why I am grateful to the authors of this White Paper. Not only because it gives a masterly overview of the many ways in which AI can help the fight against climate change. Even more importantly, it describes the requirements that are needed to use the potential of AI even better. Part of these is human-centered AI (HCAI), meaning AI being designed in a user-centric way, seamlessly integrating into our daily lives. One example are digital companions that enable people to make better decisions in our work. And finally, this White Paper suggests starting thinking in ecosystems – nobody can do it alone, and collaboration is key. In particular, policy makers are key. That is also why the White Paper suggests five policy interventions the EU should integrate into the European Green Deal to enlist the potential of AI for its success.

We at Siemens are prepared to lead the way bringing sustainability and business opportunities together. We do that with our customers and partners, identifying and exploring new ideas every day. AI is one of the key technologies here, and at our AI Lab, for example, we pursue novel AI-applications, especially in the realms of sustainability. But not just that. The AI Lab also provides a space where we test new approaches of running innovation projects. Part of this is cooperating with the One Young World community. We do that without hierarchies, self-guided, but with a common purpose. And there is no better purpose for than the one we all share – the fight against climate change.

No doubt, what you have here is an important contribution for anyone who wants to understand the key mechanisms and levers for AI to tackle climate change. Enjoy reading it.

1. A sustainability and AI agenda for Europe must be treated jointly

Economic incentives, regulatory frameworks, global value chains and consumer behaviour are currently not set up to limit global warming[1] or reach the UN Sustainable Development Goals[2]. To change this, the European Green Deal (EGD) marks an unprecedented effort of EU policy-making. It aims to combine the reduction of environmental pressures with economic growth and societal well-being - through a profound transformation of the current economic system. Multiple aspects will need to be harnessed to master this challenge: new types of cross-industry collaboration, far-reaching policy changes across the EU's member states, untested ways of living and working, and the application of innovative technologies and solutions.

The complexity of the EGD implementation and its possible ripple effects across the globe cannot be underestimated. The System Change Compass[3], crafted by SYSTEMIQ and the Club of Rome, provides guidance on how best to expedite the process. It outlines the key system challenges the EGD needs to address to meet societal needs while not overstepping our planetary boundaries. To do this, the current organisational model must move from being focused on economic activities to being organised around economic ecosystems that are holistic in scope and demonstrate a direct link to natural capital and the planetary boundaries (see figure 1). The key economic ecosystems defined in the System Change Compass include mobility, healthy food, consumer goods, and built environment - all representing a societal need; and circular materials, nature-based solutions, energy, and information and processing - which support the societal needs. Aiming at solving ecosystem challenges helps to move from a consumption-based perspective to a more systemic, needs-based perspective. The core idea is simple: people don't need products and services; they need their societal needs to be met. So, for example, they don't need cars, but mobility; they don't need refrigerators, but fresh and healthy food; they don't need house ownership, but high-quality, affordable and safe living space. To support this perspective, various investment opportunities, that are allocated to one particular economic ecosystem, exist. For example, in the mobility ecosystem car-and ride-sharing models, in the circular materials ecosystem additive manufacturing, in the healthy food ecosystem urban agriculture - and many more (cf. appendix 1 for the entire presentation of investment opportunities per economic ecosystem).

[1] Intergovernmental Panel on Climate Change 2022: Mitigation of Climate Change

[2] United Nations n.d.: Sustainable Development Goals

[3] SYSTEMIQ & Club of Rome 2020: A System Change Compass

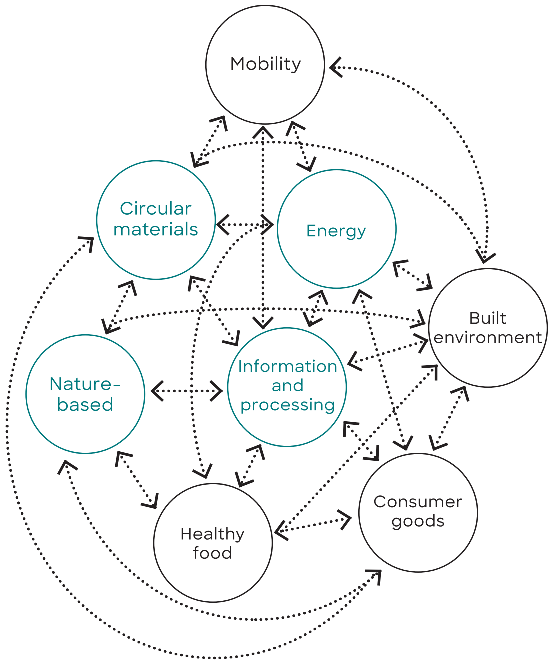
Figure 1: Systems map[4]

Four economic ecosystems meeting a specific societal need:

- Healthy food
- Housing
- Mobility
- Consumer goods

Four economic ecosystems supporting the other economic ecosystems in their delivery of societal needs:

- Nature based
- Energy
- Circular materials
- Information and processing



The economic ecosystem information and processing is defined as a key supporting ecosystem in the systems map, required to meet the goals of a low-carbon, resource-efficient economy. Artificial Intelligence[5] (AI) is part of this ecosystem and provides a powerful toolset that offers a multitude of new and often disruptive opportunities to save resources as well as reduce carbon emissions. Such AI tools could provide some of the needed solutions to reach the goals of the EGD. However, the use of AI to contain planetary boundaries is still scarce in comparison to non-environmentally related AI, due to inadequate economic incentives and a lack of conducive policy tools, among other reasons. Hence, AI for EGD applications must be delivered as part of a holistic solution and be supported by conducive legal, financial, technical and infrastructural measures. Simultaneously, European values, such as respecting human rights or freedom, must be assured when applying technologies.

The European Union (EU) already developed a sound body of AI policy and is currently in the midst of a policy process for regulating and supporting AI. This ambition is guided by combining the safeguarding of fundamental rights whilst leveraging the technology's potential. In doing so, the European Commission has published, next to a White Paper[6] and a Coordinated Plan[7] on AI, the so-called AI Act[8], a proposal for a new regulatory AI policy framework in the beginning of 2021. The proposal clusters AI cases based on their respective risk levels (unacceptable, high, and low or minimal risk) and sets forth different rule stringencies depending on these risk levels. To more effectively make the EU's AI vision a reality, our position paper urges European decision-makers to take an opportunity-based perspective for the development of future AI regulation, further boosting potential benefits and decreasing risks for the improvement of EGD-related solutions. We outline the key requirements to enable large-scale, effective use of AI for environmental impacts and link these to key policy interventions. Herein, our paper also maps out where the current proposed policy framework falls short of supporting AI's potential.

[4] SYSTEMIQ & Club of Rome 2020: A System Change Compass

[5] We use the terms Artificial Intelligence (AI) and Machine Learning (ML) interchangeably in this paper

[6] European Commission (2020): On Artificial Intelligence - A European approach to excellence and trust

[7] European Commission (2021): Coordinated Plan on Artificial Intelligence 2021

[8] European Commission (2021): Proposal for a Regulation of the European Parliament and of the Council – Laying Down Harmonised Rules on Artificial Intelligence (Artificial Intelligence Act) and Amending Certain Union Legislative Acts

The dual role of AI for the EGD implementation: addressing the negative environmental footprint of AI

Harnessing AI for EGD implementation ("AI for EGD") cannot be done without acknowledging and addressing AI's inherent environmental footprint ("green AI"). We refer to this as the dual role the technology plays towards environmental challenges: While entailing potential to address many of these challenges, AI is also a driver of them. The global carbon footprint of the ICT sector is estimated to be responsible for over 2%[9] of all emissions already today and is expected to quadruple in the next years. Additionally, these numbers do not even capture the full environmental footprint: material extraction for the production of microelectronic and ICT components additionally contribute to negative environmental impacts[10].

While there are several solution pathways to reduce AI's environmental footprint (such as utilising more efficient models and training methods but also energy-efficient, specialised hardware[11], scaling renewable energy for green data centers, adopting circular strategies to reduce e-waste and related resource consumption), it will take many years to significantly abate the environmental challenges of AI.

This means that in any case, it is essential to assess whether a given AI application aimed at EGD implementation contributes to a net positive impact. Life-cycle-analysis tools or the recently published indicator set for assessing the sustainability of AI systems[12] will help to answer such questions, but large-scale research on the impact of AI for EGD is still in its infancy.

This paper acknowledges the dual role of AI for the environment and integrates these risks into the policy interventions.

Digitalisation affects energy consumtion via: (Source: Lange, Pohl & Santarius 2020)

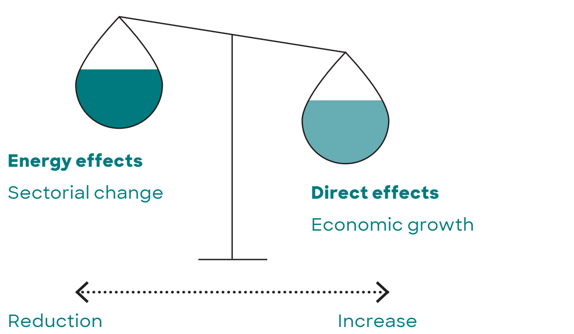
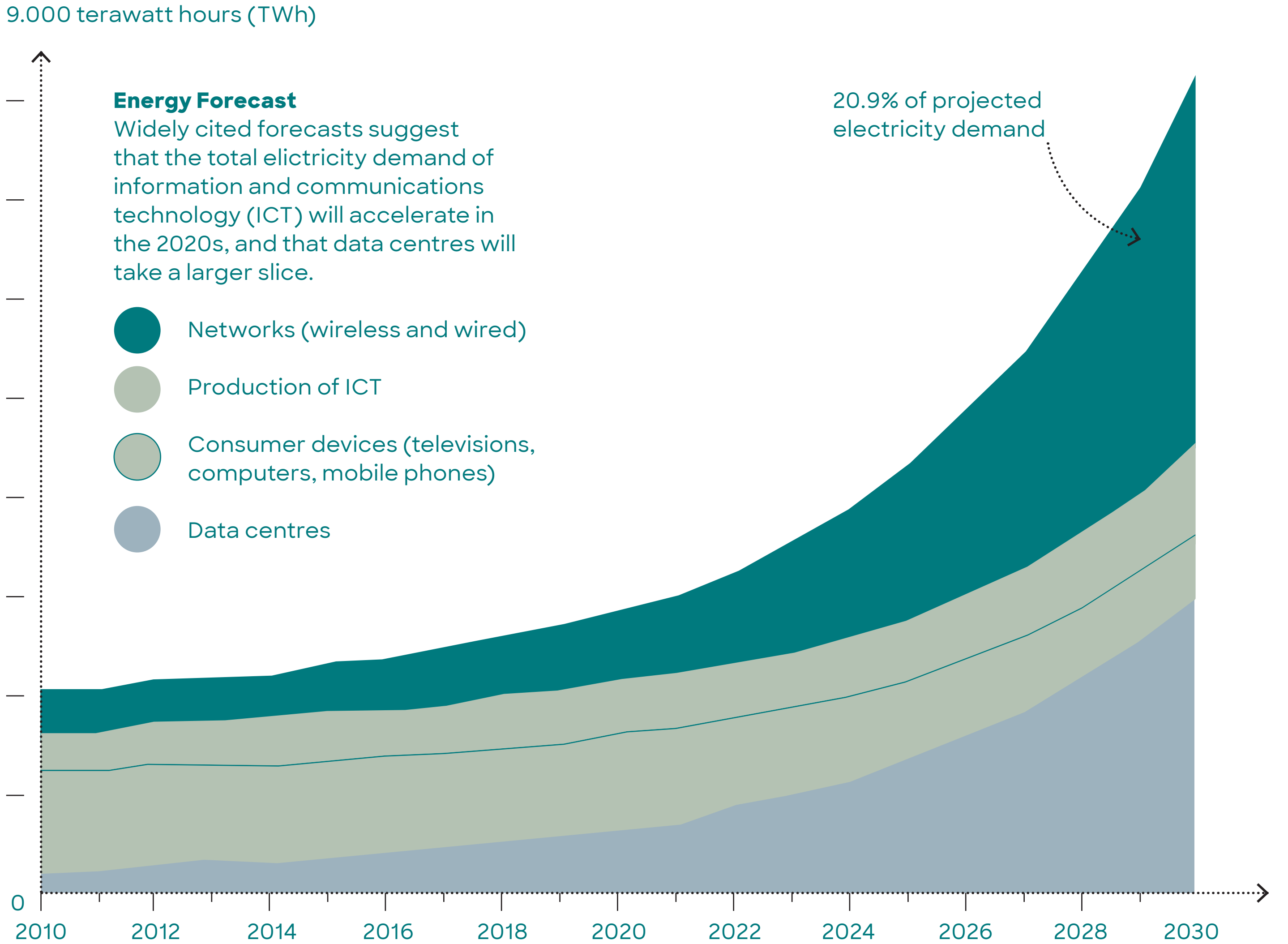


Figure 2: ICT energy consumption[13]



[9] Informations and communications technology industry, 2018 data

[10] ibd

[11] For example, the EU Chips Act integrated the development of energy-efficient chips as one key aspect

[12] IÖW (2021): Nachhaltigkeitskriterien für künstliche Intelligenz

[13] Andrae, A. S., & Edler, T. (2015). On global electricity usage of communication technology: trends to 2030. Challenges, 6(1), 117-157.

2. How to drive impact – learning from 20 AI cases that boost the EU Green Deal

Figure 3: AI capabilities overview from appliedAI Initiative

1
Computer Vision
Computer vision processes visual data like images or videos with the aim of understanding their underlying semantics. By doing so, respective AI models can perform image segmentation, object recognition and tracking, image classification, emotion recognition, or 3D reconstruction.

2
Computer Vision
Computer audition can interpret audio signals to perform audio-based sentiment analysis, speech-to-text conversion, sound similarity assessment, or source separation.

3
Computer Linguistics
Computer linguistic or natural language processing (NLP) systems process, interpret, and render text as well as speech. Examples are relation extraction, sentiment analysis, text classification, entity recognition, conversational systems, or translation.

4
Control
AI's robotics and control capability analyzes, interprets, and learns from data that stems from physical systems (e.g., IoT devices like smart meters) and aims to control these systems. Robotics and control is applied in mobile robotics, control optimization, high-definition mapping and localization, advanced drones, collaborative robotics, or user-adaptive control automation.

AI CAPABILITIES

5
Forecasting
Forecasting describes the estimation of future events and conditions on a continuous scale. Examples include predicting the likelihood of certain events, time-series forecasting, or dependency-based forecasting.

6
Discovery
Discovery processes large amounts of data to find patterns and 'logical' relationships, e.g., through anomaly or outlier detection, association analysis, segmentation and clustering, causal inference, or correlation analysis.

7
Planning
Planning searches for optimal solutions to problems with large solutions spaces. Examples are logistics planning, planning and scheduling, policy development and strategic agents, or cooperative multi-agent systems.

8
Creation
Creation describes, in general, the generation of data based on input samples. The data types include, amongst others, audio or visual data and examples are AI augmented engineering, style transfer, image generation and manipulation, audio generation, or text generation and summarization.

As described in chapter 1, AI can be an enabler for many investment opportunities related to a resource-efficient, low-carbon economy. To specify AI's green potential, this chapter introduces important characteristics of AI (chapter 2.1) and, based on the analysis of 20 AI for EGD use cases, derives solution archetypes that describe how AI can achieve impact in the EGD context (chapter 2.2).

2.1 Four guiding principles to unlock AI's full potential

In general, a common definition describes AI as machines performing cognitive functions that are typically associated with humans[14]. Performing such cognitive functions typically requires that an AI application learns from data and, subsequently, uses the trained model for inference (i.e., obtaining the actual results). The following eight AI capabilities (figure 3) structure and describe how AI performs cognitive functions:

The presented AI capabilities promise far-reaching potential. But their success in practice depends on four guiding principles that are essential for AI to unfold its impact potential.

1.
AI is an unprecedented, powerful toolset - and depends on various technological requirements: As mentioned above, AI can be described as a powerful toolset that lets us tackle massively complex tasks and build applications that weren't possible before, e.g., to reduce environmental pressures. However, the effective deployment of AI heavily depends on multiple technological requirements. On one hand, the AI itself must meet certain technological requirements like a particular level of accuracy or speed. On the other hand, the integrated solution that is built around the AI model (i.e., the entire AI application) depends on, e.g., sensors to collect input data or the underlying infrastructure. Hence, to unlock the full power of AI, specific technological requirements must be fulfilled (cf. chapter 3).

2.
AI relies on high-quality data: When building and applying AI models, data is the most important resource since the trained AI model relies on and reflects the input data it was fed with. Observations that are not included in the training data cannot be considered in model training. In parallel, new methods for (virtual) data generation serve as alternative sources. In any case, training data must be representative, correct, balanced, timely, as well as sufficiently reflect context and granularity. Poor training data quality inevitably leads to poor model performance. We derive which data requirements the deployment of AI for EGD requires in particular in chapter 3 (cf. data requirements).

3.
AI requires human (inter)action: AI alone will not make the difference we wish for: First, humans use their skills to develop and implement AI systems as well as their human-machine interfaces to set the goals of AI systems and to enable them to achieve their predefined goals in a safe way. Second, widespread acceptance as well as sufficient understanding of AI on user, society, and organisation level are key to drive broad adoption of the solutions. In a nutshell, AI is the tool that delivers exceptional value if developed, implemented, accepted, and adopted by humans. Actively shaping the quickly evolving field of human-machine interaction will be a key success factor.

4.
AI is only relevant when applied at scale: AI at a research, prototype or even small application level is very different from an AI application that is professionally deployed at scale in thousands or millions of instances. Many challenges only arise at this level of scaled implementation, especially for the comparatively small European AI startups. For example, application providers tend to only integrate solutions developed by large technology suppliers if these suppliers provide a trusted, accepted, and stable technological backbone for scaled applications (e.g., for controlling energy grids or traffic). Scale is key for AI to deliver the desired impact. Hence, it is also crucial that all derived requirements and interventions are thought, applicable, and effective at scale.

Acknowledging these guiding principles as a baseline for making AI applications impactful enables us to take an integrated and opportunity-based view on AI for EGD without losing sight of the mammoth task our society and economy are currently facing. Consequently, we derive technological, data, skills, and business requirements based on the above presented guiding principles in section three.

[14] Rai, A., P. Constantinides, and S. Sarker, "Next-Generation Digital Plat forms: Toward Human-AI Hybrid", Management Information Systems Quarterly, 43(1), 2019, pp. iii-ix.

2.2 Extracting insights from 20 AI for EGD use cases

To make the concept of AI for EGD more tangible, we compiled a use case library that contains 20 AI for EGD applications, mainly based on Rolnick et al.'s[15] extensive overview of how AI can be used to tackle climate change. To develop this use case library (see appendix 2), we chose the most important and promising existing AI applications and mapped them to the economic ecosystems as well as their investment opportunities. Note that we do not include use cases from information and processing since AI itself is part of it. Moreover, as we take a systemic perspective, our use cases do not focus on individuals or their human-machine interactions. Therefore, AI systems that act as "digital companions", do not play a major role in our use case selection. We analysed the 20 AI for EGD use cases in detail and, for better readability, present detailed descriptions as one-pagers in appendix 2. Please note that our use case selection is non-representative as well as non-exhaustive.

The use case analysis suggests that the AI capabilities computer vision, control, forecasting, discovery, and planning are key enabling capabilities for the EGD. Amongst them, control is currently one of the least mature and production-ready technologies and will increasingly harness its potential in the future. For all other capabilities, the technologies and/or models are sufficiently advanced but many implementation challenges exist (see chapter 3). Moreover, creation and computer linguistics also play a role, whereas none of our 20 use cases deploys the computer audition capability. Please note that, since our use case selection is non-representative as well as non-exhaustive, this cannot be translated into generally applicable insights regarding the AI capabilities' importance for AI for EGD use cases.

Synthesising and structuring the AI capabilities and the 20 most promising use cases in the seven economic ecosystems (as mentioned, excluding information and processing) shows that four main solution archetypes can be derived across the ecosystems. Please note that the solution archetypes are not entirely "mece", also since since the use cases themselves are non-exhaustive:

1.
Matching supply and demand: The better the matching, the more efficient the system. AI can be used for most complex predictions of both supply and demand as well as for real-time matching. This could be used to significantly level out peak demand as well as reduce buffer and waste.

Example use cases include the reduction of food waste or the forecasting of energy demand and supply (cf. AI for EGD use case library).

2.
Autonomous systems: Most complex systems can be controlled (autonomously) by AI to perform better than human-programmed systems. Either this is done centrally or decentrally in a multi-agent collaborative setting. Experiences from industrial settings show savings/ gains of up to 40% (and sometimes even higher) in AI-controlled dynamic systems.

Related use cases are the dynamic traffic management in cities or controlling smart grids (cf. AI for EGD use case library).

3.
Decision support for optimization and efficiency: Systems can run more efficiently and with less interruptions or failures (e.g., harmful leakages) through individual optimizations and detected anomalies that indicate potential malfunctions or failures in a way no human could do. Applications lead to reduced resource usage and waste.

Examples for use cases are the reduction of food waste or the monitoring of emissions (cf. AI for EGD use case library).

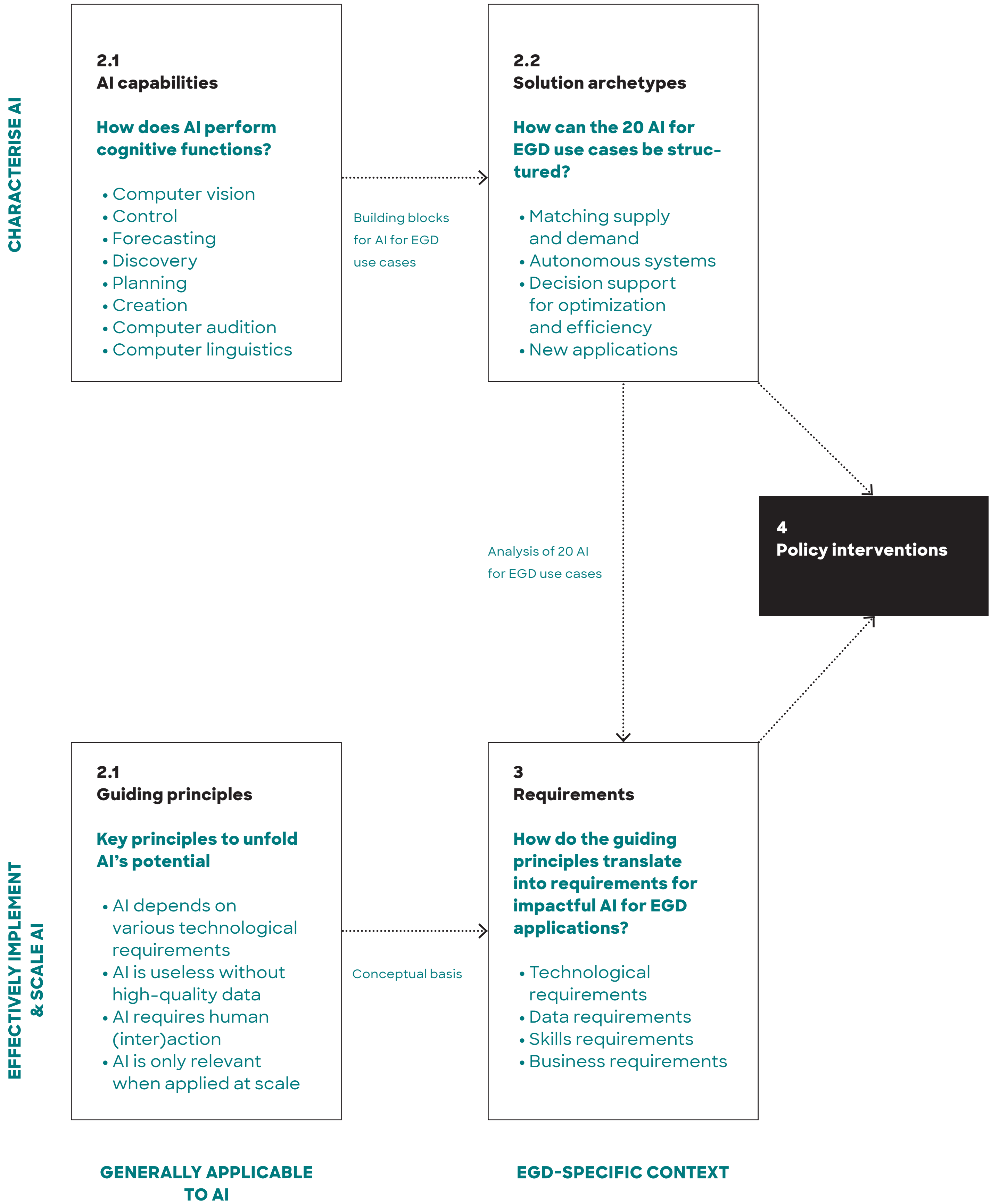
4.
New applications: AI can be used to develop applications that do not yet exist and potentially would not be possible without AI.

Use cases include the management of fusion reactor's magnetic fields or generative and algorithmic design (cf. AI for EGD use case library).

The following figure provides an overview of the 20 use cases. From the center to the left column, we cluster the use cases into their economic ecosystems of the System Change Compass: energy, mobility, built environment, healthy food, nature-based, and consumer goods. From the center to the right column, we map the 20 use cases to their corresponding solution archetypes. Note that every use case belongs to one particular ecosystem and can incorporate more than one solution archetype.

[15] Rolnick et al. (2019): Tackling Climate Change with Machine Learning

Figure 4: Overview of the paper's methodology

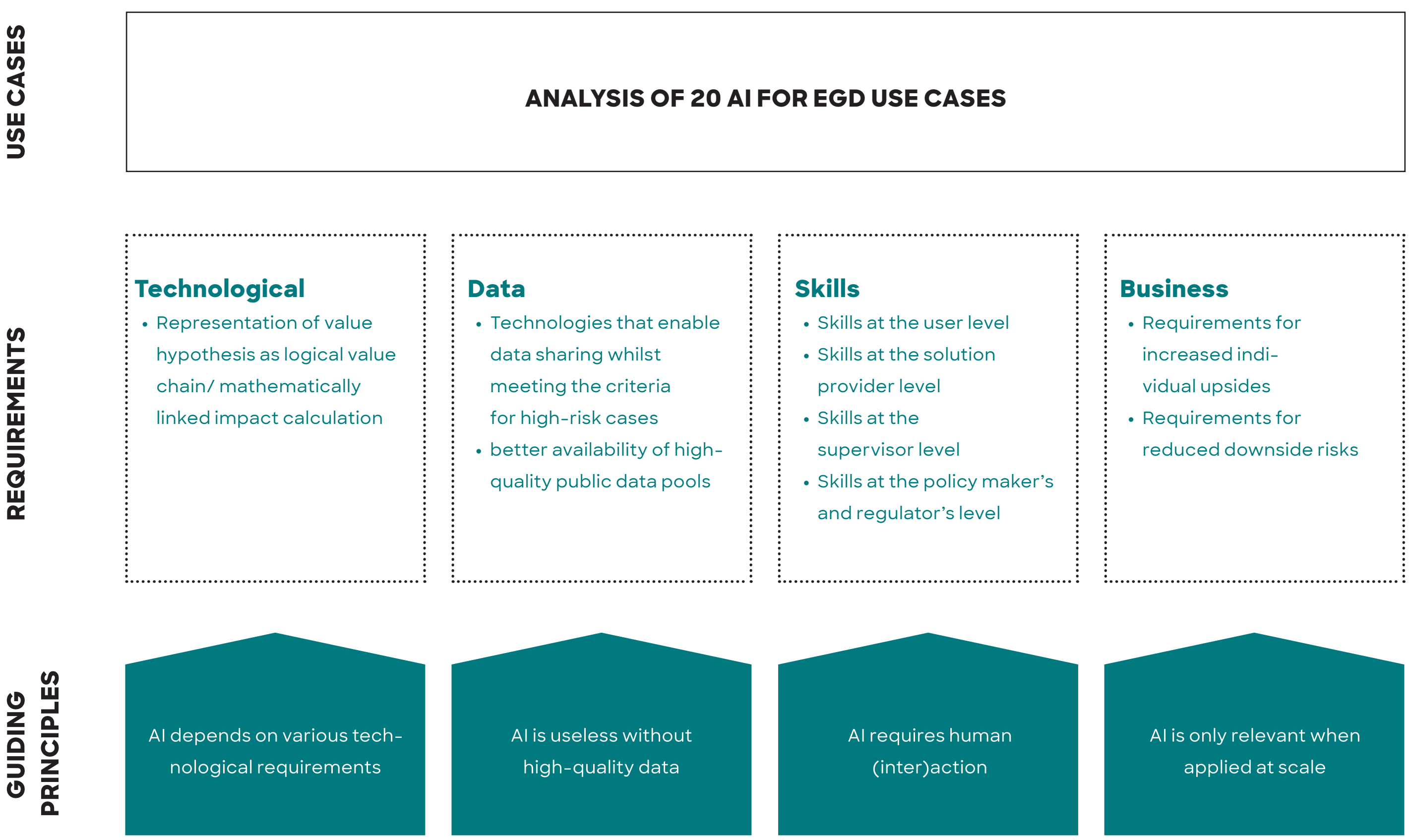


3. Technological, data and skills requirements to scale AI for EGD

As the European Commission's proposed AI Act acknowledges, impact is being achieved only when AI is applied professionally and at scale. Combining the guiding principles with the solution archetypes that were derived from the relevant AI use cases for supporting the EGD, a set of requirements can be extracted. These requirements combine the necessary systemic perspective with the specifics of successful application of AI technology and need to be fulfilled for implementing the EGD.

Not meeting these requirements will significantly risk or even hinder the adoption of the outlined AI use cases. At the date of publication, these requirements are not met. Throughout the following, we provide guidance on who should play a role in fulfilling the requirements.

Figure 5. Requirements



Technological requirements

As outlined by the first guiding principle in chapter 2, unlocking AI's full potential requires fulfilling a multitude of technological requirements. To begin with, most use cases and especially high-risk applications as defined by the European Commission's proposed AI Act require the fulfilment of certain criteria. Yet, AI adopters struggle with fulfilling these criteria and (applied) research does not offer sufficiently mature approaches.

- Reliability: Describes the AI model's consistency of outputs for similar inference tasks even with varying input data.
- Interpretability: Refers to the model's explainability of its outputs as well as the functioning of the model itself.
- Accuracy: Describes the model output's accuracy including the correct reflection of the reality.
- Reproducibility: Describes the ability to reproduce the output ex-post including the requirements towards the data availability.

Besides fulfilling these criteria imposed by EU policy, our analysis reveals that many AI for EGD use cases require the effective deployment of reliable and at scale, ready-to-use technologies:

- M2M (Machine to Machine) Communication: The communication between different agents, senors, or devices to exchange information, even in open environments like cities or buildings
- AI@edge: The (continued) deployment and application of single models on multiple local devices which need to run stable and energy-efficient even if conditions change.
- Multi Agent Systems: The ability of multiple agents to collaborate and achieve a common goal together even if individual systems experience sub-optimal consequences
- Human centered AI (HCAI): The design of AI use cases that interact closely with humans in a user-centric way to ensure that the application delivers actual value to the user as well as that the user has a basic understanding of the application and can interpret its outputs. In most cases, HCAI also requires fulfilling the above mentioned high-risk criteria.

Many tech companies and especially the large cloud solution providers are working on technology solutions that can meet these criteria – but there is still a long way to go and significant investment required. It remains unclear to what extent and how fast Europe's solution providers will be able to develop and adopt such future solutions, mainly due to the lack of existing providers that are significant enough to invest on a globally competitive level. To be specific, we are not aware of any startup or tech company from Europe that one could consider a global leader. To overcome this challenge and successfully develop AI applications that deploy the above technologies and fulfil the above criteria, simulations, training or learning environments, as well as experimental approaches (significantly more sophisticated than current regulatory sandboxes) are needed. Throughout R&D, the EU should stick to its 'standardisation before regulation' approach to ensure a high level of efficiency as well as systematically support building European AI champions.

Data requirements

As the second guiding principle outlined in chapter 2 explains, the underlying data determines large parts of the AI application's performance. Therefore, high quality training and test data as well as data for application must be available according to the application-specific requirements. The analysis of the selected use cases and solution archetypes reveals that this requires combining data from various sources. Hence, effective data sharing approaches that ensure a high level of privacy and the demanded criteria for high-risk cases as defined in the EU's AI Act (e.g., high data quality, completeness, free of error) must be implemented in the future. While many requirements introduced by regulators are very difficult or even impossible to implement today, such approaches will entail combinations of both technologies like homomorphic encryption or differential privacy as well as behavioural, economic, and regulatory mechanisms:

- Federated learning: Describes a system where multiple parties that own private and often sensitive data collectively train a model without revealing their data to any third party.
- Homomorphic encryption: This cryptographic technology allows for performing calculations directly on encrypted data. Also AI models can be trained and used based on homomorphically encrypted data sets, which enables the use of cloud services whilst ensuring that the cloud provider does not have access to the actual, unencrypted data.
- Differential privacy: Adding noise to particular data points or model weights ensures so-called plausible deniability such that distinguishing between actual and perturbed data is impossible. Differential privacy can be used to, e.g., perturb data sets or trained model parameters (i.e., weights) in federated learning setups.
- Anonymization and pseudonymization: Both approaches make sure that there is no link between data entries and particular individuals, companies, or organisations.
- Incentives for data sharing: Individuals and organisations can be rewarded for contributing private data to an AI application (e.g., financially or through gamification).
- Obligation to share data: Some cases might even require data owners to share their (anonymised/pseudonymised) data, e.g., when an incentive-based approach does not prove effective.
- R&D GDPR exceptions beyond existing ones: Temporary R&D licences that lift particular GDPR restrictions in clearly defined, experimental environments beyond research exemptions as AI systems are still learning and evolving in productive application environments.
- Common interpretation: EU's national supervising authorities should have a common understanding of data-sharing related aspects to ensure international interoperability and standardisation within the EU.

Besides the above approaches that improve access to private training data, better availability of high quality public data pools will further facilitate the development of impactful AI for EGD applications.

Skill requirements

As we outline in chapter 2, requirements for unleashing AI's full potential for the EGD in practice go beyond technological and data aspects. Rather, humans need skills at various levels:

- Skills at the user level: The actual target user of an AI application must be willing to use the AI. Achieving this demands a certain level of understanding and knowledge of how existing AI applications are working and how potential future applications might work in general.
- Skills at the solution provider level: Domain experts and AI developers require the technical skills and expert knowledge to develop and improve AI applications.
- Skills at the supervisor level: Application-specific supervisory authorities (e.g., cities or smart grid operators) must be aware of the technological AI basics, potential use cases, risks, and opportunities to be able to allow for and manage the development of impactful AI for EGD applications.

Skills at the policy maker and regulator level: Policy makers must understand AI basics and be aware of how AI can generate value to design policies that create an enabling environment for the development and use of impactful AI for EGD applications.

Overall, the harm caused by the rather negative or risk-focused connotation when talking about AI in Europe must not be underestimated. Regardless of the skill level, if people mainly associate AI with risk, they stay tech-averse and remain reluctant to apply new AI applications. Consequently, upskilling initiatives need to also focus on conveying positive pictures of a potential future (as we can influence society's perception only by actively shaping the journey – not by inactivity).

Business requirements

Organisations require a clear and strong business incentive to implement, operate, and ultimately scale AI for EGD use cases: Individual upsides (not ecosystem benefits) need to outweigh downside risks that come with the regulation.

Requirements for increased individual upsides

- Direct financial return and new business models
- Access to earmarked AI for EGD financial support: Many AI for EGD applications require large investments for their development, making it difficult yet impossible for a lot of organisations to harness AI for EGD's potential. To overcome this challenge, financial as well as technical R&D support is crucial and needs to be accessible..
- Access to learning and upskilling for existing employees and to talent pools for new employees

Requirements for reduced downside risks

- Tools, benchmarks, and practical standards that support organisations in achieving compliance with regulation and that are approved by regulators
- Digital sovereignty: For achieving the goals of the EGD, European Startups will play a key role. Consequently, small innovative EU businesses that provide AI solutions closely related to critical infrastructure (e.g., energy system) require a high degree of legal certainty (especially regarding liability) or a moratorium (?) of certain parts of the AI ACT. They cannot cover that risk at small stages of the business. To ensure growth of European startups to central contributors to the EGD and to maintain Europe'S digital sovereignty, the EU should support these EU-based businesses. The recent announcement of a 10bn fund will not solve it alone
- Q&A sections with fast and reliable guidance for companies (esp. SMEs that cannot afford specialist lawyers)
- Extensive experimentation and learning options (not only in research but also in first years of application)
- Clear as well as commercially viable mechanisms and mature technologies for secure data sharing. This will make it easier for businesses to develop AI for EGD applications, drastically decrease legal uncertainties and risks, as well as improve innovativeness and the time to market for new AI applications

4. The right policy interventions to scale AI for EGD

The European Commission intends to make Europe a hub for trustworthy and excellent AI - in practice, not only in theory. To do sothe Commission has developed a new AI Act and a Coordinated Plan on AI. These documents contain a wealth of tools and mechanisms that the Commission plans to implement to ensure that the EU leverages the potentials of AI - for economy, society and the environment. In this context, the AI Act has fuelled discussions in the AI community: one criticism is that the act takes a risk-based approach to AI rather than an opportunity-based one, which hinders unleashing the potential that AI could have for the EGD implementation. But the regulation is not the only policy intervention put forward by the European Commission to support AI: it also plans to significantly increase EU investment in AI[16]. And already today, there are various Horizon projects (EU funded research consortiums) that work on the potential of AI for EGD. Despite all

Figure 6. Overview of suggested policy interventions.

POLICY INTERVENTIONS TO ENABLE AI FOR EGD

Derived from...	Policy recommendation
Tech-nology	• Strong European solutions: Enable EU businesses to become global champions • Large-scale testing beyond sandboxes: Provide experimentation environments to pilot AI applications in large-scale, real-world scenarios
Data	• Implement an efficient market for AI for EGD-related data in the EU
Skills	• Shift society's AI mindset to an opportunity-based one: Educate society in AI's potential as well as managing and understanding its risks
Business	• Adopt the new AI policy framework but provide administrative support for EGD cases • Earmark AI funding to EGD implementation
Generic	• Build a pioneer coalition of EU member states that adopts AI for EGD strategies • Create standardised CO2 assessment methodologies for AI applications to support carbon footprint transparency

these efforts and intentions, the EU is still not providing the needed conducive framework conditions to scale AI cases by fulfilling the technological, data, skills, and business requirements outlined in chapter 3. Moreover, the upcoming regulation might even hinder promising applications from being developed and scaled. Therefore, we propose that EU policy for AI adopts a slightly different perspective: from a risk-based approach to an opportunity-based approach. A complementary set of policy interventions should aim to a) reduce the risks that are associated with AI to b) support the potentials of AI for the EGD implementation. We derive and outline eight policy interventions that should be a part of this policy approach.

1. Strong European solutions: Enable EU businesses to become global champions

As outlined in the above chapter on technological requirements, various puzzle pieces (i.e., technologies and criteria) must be further developed to successfully deploy AI for EGD applications. As this challenge is unlikely to be solved in the EU's current AI champion landscape, new players that successfully combine the latest AI research with business innovation and that can provide these puzzle pieces for the technological transformation are needed and existing ones must evolve. This notion is already included in the EU's "Ecosystem of excellence" vision[17], but still lacks effectiveness in practice: It is crucial that these "puzzle piece" solutions are technologically mature, commercially viable, and scalable. Moreover, the global pace of development is extremely fast, which makes it necessary to thoroughly test, continuously improve, and quickly deliver market-ready solutions. Eventually, innovative organisations with the right mindset and skills rather than research institutions or projects must be in the forefront when tackling the challenge. In this context, Biontech's COVID-19 vaccine development serves as a positive example: The company's leadership and integration into its innovation ecosystem have been crucial in achieving the development speed and success.

The EU has various levers to strengthen the technological capability of existing businesses as well as enable new businesses to become global champions. As an example, the EU should build its own startup incubators and competitions. To ensure that startups can succeed more, the EU should increasingly contract startups' solutions in its public procurement. Moreover, it should invest in developing a European Machine Learning operations (ML-Ops) framework with trustworthy and state-of-the-art AI tools.

[16] ttps://ec.europa.eu/newsroom/dae/redirection/document/75787

[17] European Commission (2020): White Paper on Artificial Intelligence - A European approach to excellence and trust.

2. Large-scale testing beyond sandboxes: Provide experimentation environments to pilot AI applications in large-scale, real-world scenarios

Testing environments are essential to develop new AI technologies and applications, but sandboxes should not only be set up to ensure data privacy compliance: in the case of AI for EGD use cases, next to compliance with data privacy rules, experiments should also provide a first indication of the potential environmental impact, shed light on possible monetary incentive structures, set the stage for multi-stakeholder cooperations (e.g., between innovators, public institutions and large companies) and pilot innovative business models. More technically, experimentation environments could also be used to assess and improve the AI application's performance in real-world environments or the applicability, performance, as well as effectiveness of data sharing approaches. However, the creation of siloed and very restricted sandboxing environments to test AI applications for EGD purposes often falls short of the required testing and learning purposes to deploy applications in a real-life environment. In addition, the set-up of sandboxes, as framed by the EU's proposed AI policy framework[18], already require time-intensive procedures (e.g. testing plan, adhering to implementing acts, application procedure)[19]. Sandboxes - or what should rather be large-scale simulations/testing environments - can provide actual value for AI innovation at system level, if they allow for scalability, funding for the experimentation fields is secured, and they are set up as European lighthouses for specific ecosystems attracting global talent and organisations. The European Commission should ensure that the sandbox provisions proposed in the policy framework and respective implementing acts allow for such controlled environments without overly constraining the establishment of sandboxes in member states. A good example is the sandbox implemented in Norway, which is led by the national data protection authority and accompanies four AI companies with the goal to ensure compliance with GDPR regulations and other ethical AI practises[20].

We call on AI companies, environmental organisations, and other interested stakeholders to actively innovate and shape the policy process. The European Commission should establish effective feedback loops integrated with simulation / testing environments and strive to incorporate respective insights when adopting its AI policy as well as adopt additional interventions and support mechanisms. With the right mix of policies, AI systems have an immense potential to support the EGD ambitions.

3. Implement an efficient market for AI for EGD-related data in the EU

Today, data is too complex and risky to share, such that there is no efficient market for trading and accessing data in the EU yet. To create the required enabling conditions for a data market to arise, simplification, international standardisation (e.g., avoid having various GDPR requirements), and sufficient risk reduction are necessary. Data flow between organisations needs to be facilitated by providing an effective data infrastructure. Besides, respective monitoring mechanisms that ensure fair and secure trading far beyond the currently existing mechanisms need to be established.
Next to further advancing, and accelerating the implementation of its GAIA-X[21] initiative, the EU could trigger the development of a data market by starting with data that is relevant for AI for EGD applications. To do so, public European organisations should be incentivised or even forced to provide their existing data that supports the creation of EGD use cases (e.g., the European Space Agency (ESA) could open-source its satellite data).

[18] The European Commission's intention to allow for sand boxes and the significance it places on these testing envi ronments in the AI policy framework indicates large potential for AI innovation. Especially the European AI Board can help to share learnings and support collaboration. Focus should, however, be put on ensuring that the scalability of these sandboxes is feasible.

[19] https://eur-lex.europa.eu/resource.html?uri=cellar:e0649735-a372-11eb-9585-01aa75ed71a1.0001.02/DOC_1&format=PDF

[20] https://www.datatilsynet.no/en/regulations-and-tools/sandbox-for-artificial-intelligence/

[21] https://www.gaia-x.eu/

Further, we urge the EU to thoroughly assess the implications of every regulatory proposition related to data sharing for its implementability also in distributed AI applications. Specifically, requirements like "free of error," "complete," or "full reproducibility incl. storage of training data" can act as a substantial hurdle for distributed AI applications which are essential for the AI for EGD use cases and should be redesigned.

4. Shift society's AI mindset to an opportunity-based one: Educate society in AI's potential as well as managing and understanding its risks

As of today, AI evokes mixed associations, often focusing on risks rather than opportunities. This connotation is also reflected in the EU's current risk-based rather than opportunity-based approach. But, as outlined in the previous chapters, AI is an unprecedented and disruptive toolset that will allow us to work on applications that were not possible before and which are essential for tackling climate change as well as reaching EGD goals. Businesses' as well as society's enthusiasm and will to shape are key factors for the success of such AI applications and should be sparked and fueled.

Therefore, the EU should invest in a mindset shift: Without neglecting but effectively managing its risks, AI should be associated mainly with its potential. To achieve this, the EU should support AI applications that solve complex problems that society can easily relate to (e.g., cancer recognition) and communicate the applications' successes. Besides, while the AI Act or the Digital Education Action Plan[22] already emphasise the importance of technological awareness and skill development, the EU should invest in training and upskilling initiatives and communication plans to educate the society about the potential of AI and how its risks can be handled. In a nutshell, the EU, which is home to brilliant engineers and innovators and has access to the powerful toolset provided by AI, should focus on how to ensure that the resulting potential is used as effectively as possible.

5. Adopt the new AI policy framework but provide administrative support for EGD cases

The proposed European AI Act represents a landmark policy to regulate AI in Europe - with potential trickle-down effects across the globe. The aim of the European Commission to make the EU an AI hub of trust and excellence is a noteworthy ambition - the policy adoption process can, however, be expected to be lengthy. The challenge that European policy-makers have to solve now is to adequately manage data privacy, systemic, and ethical risks without overly policing AI innovators. This challenge becomes especially relevant for AI applications with value creations that go beyond cost reduction or process optimization: especially the development of those applications that can contribute to solving the grand challenges of our society (i.e., carbon and resource-intensive industries putting our climate and environmental ecosystems under irreversible pressures) should be supported. Several AI for EGD applications fulfil the EU's high risk criteria, especially those that belong to the mobility and energy ecosystems (but also in other ecosystems like food and built environment) and are therefore subject to the use case-based risk assessment proposed in the framework. This assessment does lengthen the development time of AI applications and increases its costs and risks. Hence, the barrier for companies to provide such applications (often developed under challenging circumstances without clear business cases) will become bigger.

[22] European Commission (2020): Digital Education Action Plan (2021-2027)

While the EU does provide an exception (Article 47) for applications in the environmental protection area (market roll out can happen before the conformity assessment if deemed appropriate by a member state surveillance authority), the conformity assessment still represents a possible barrier for AI innovators[23]. We therefore recommend that AI applications with a clear and proven positive environmental impact (e.g., shown in a pilot project, case study or scientific assessment) should be supported in this process.n. This should help to lower the barrier for AI innovators to deploy such applications by providing bureaucratic support (e.g., help with document submissions or access to legal advice), as well as fast-tracked processes and simple access to funding during this process. We recommend that the European Commission specifically highlights the need to ensure that AI for EGD applications (if possible with clear examples of the relevant EGD high-risk assessments) are rolled out at scale in the AI policy framework and also translates this need into a clear action point.

A further challenge for the European Commission is that some of the data-related high-risk requirements (such as data to be representative, complete, unbiased, and free-of-error or the limits on AI applications with distributed data and without central storage possibilities) inhibit the development and application of potentially impactful AI systems for environmental protection (for example, traffic optimization can never be complete or free of biases because there will always be new situations in the real world). The ongoing process of discussion and adopting the proposed AI policy framework should incorporate solutions to this challenge, such as defining standardised tests and requirements that decide on whether an application achieves unbiased outputs. In addition, the European Commission should actively provide tools or benchmarks that help organisations to comply with regulation similarly to what UK[24], Singapore[25] or the US[26] are providing. As an example, the EU's AI Watch[27] might be well suited to support the development of such tools or benchmarks.

In addition, especially the proposed EU regulatory framework's reproducibility requirement poses significant challenges to AI use cases for EGD purposes that are initiated by multi-stakeholder consortiums: As an example, in a federated learning setup where multiple parties own training data, there is no central entity that could prove the AI model's reproducibility without accessing the federated data pools (i.e., centralising the data). Since, as mentioned above, federated learning use cases show potential for EGD-related deployment, policy should cater for and enable multi-stakeholder use cases.

6. Earmark AI funding to EGD implementation

A portion of European funding for AI should be clearly earmarked to EGD use cases: many of the AI applications that can help to implement the European Green Deal currently lack a clear business case and incentives for stakeholders (AI developers, users, and data owners) to develop them, use the applications, and share data to train the AI models. Funding and investments for R&D, large-scale testing environments, required infrastructure, green data centers, data sharing incentives and the provision of high-quality public data could help to leapfrog the rather nascent status of AI EGD use cases to a more mature state.

[23] The current AI policy framework notes that the 'right for environmental protection' should be considered and also weighted against possible harm that the AI system could create. This sentence showcases that the EU has already considered this trade off. Further, the proposal states that "[...] any market surveillance authority may authorise the placing on the market or putting into service of specific high-risk AI systems within the territory of the Member State concerned, for exceptional reasons of public security or the protection of life and health of persons, environmental pro tection and the protection of key industrial and infrastruc tural assets." This authorisation is only temporary while the system undergoes the risk assessment. This Article 47 is a great addition to the proposal - but it lacks a concrete solution on how to support AI for EGD innovations during the conformity assessment procedures.

[24] https://ico.org.uk/about-the-ico/news-and-events/news-and-blogs/2021/07/new-toolkit-launched-to-help-organisations-using-ai/

[25] https://www.pdpc.gov.sg/-/media/files/pdpc/pdf-files/resource-for-organisation/ai/sgisago.pdf

[26] NIST Benchmarks on Face Recognition

[27] https://knowledge4policy.ec.europa.eu/ai-watch_en

The EU already today invests a large amount of finances in AI and further funding availability is already planned (e.g., as part of the Digital Europe Programme or the Recovery and Resilience Facility, and also together with the European Investment Bank). To ensure that these EU funds support the development and implementation of AI applications that help to meet societal needs, the EU should earmark parts of these funds specifically to EGD use cases (e.g., as done in the Recovery and Resilience Facility where 37% of funds are earmarked for the green transition[28]). This could help to reduce the high initial development costs and develop structures for business incentives. In the future, AI cases for EGD can be expected to have strong business cases, not only due to increased funding opportunities, but especially because higher carbon prices and environmental taxes will increasingly bolster the business case for companies (AI developers and users).

7. Build a pioneer coalition of EU member states that adopts AI for EGD strategies

Fostering a concerted approach among member states to tackling the role of AI for the EGD can help to turn the EU's AI plan and EGD targets into reality. Currently, European countries have very different approaches to AI, and especially to AI for EGD. Even though the EU's intentions of a twin transition are clear, there are various countries that have not stated their attempt to utilise AI for the EGD goals. In fact, eight countries do not mention the relation between AI and sustainability topics in their AI strategies yet[29]. On the contrary, other member states with AI strategies have highlighted the possible opportunities for EGD areas. For example, the German government has explicitly stated their intention to harness AI for environmental challenges, and in this context has set aside a significant amount of funding[30]. In comparison to other European countries, Germany's AI for EGD approach is therefore progressive, but it is still only a start to a large-scale roll out of AI for EGD. In light of the EGD, progressive member countries would benefit from a collaborative approach to developing and scaling AI applications for energy, mobility, food, buildings and circular materials.

Starting such a harmonised approach with the leading AI countries in the EU could help to create ripple-effects and subsequently lead to a learning and collaboration environment, making the EU overall well-placed to advance AI applications for climate change mitigation and resource efficiency. The European Commission could be an initiator for such a pioneer coalition (for example as part of the European AI Alliance), facilitating and acting as a hub for possible knowledge sharing and collaboration opportunities.

8. Create standardised CO2 assessment methodologies for AI applications to support carbon footprint transparency

Similar to other products and services[31], AI models will increasingly need to provide transparency on their carbon footprint. The carbon emission challenge of AI often makes newspaper headlines - and as shown on page eight and nine, this is not without a reason. An increased focus on the carbon footprint (and other environmental problems) of AI solutions can help to drive solutions for it, for example by increasing pressure for governments to provide funding for green data centers, urging researchers to develop energy-efficient AI nodes, or by conducting cost-benefit analysis (including environmental costs) when building new AI models. At the moment, no standardised CO2 assessment methodologies for AI applications is commonly used, but research in this field is emerging.

[28] https://ec.europa.eu/info/business-economy-euro/recovery-coronavirus/recovery-and-resilience-facility_en

[29] https://www.europarl.europa.eu/RegData/etudes/STUD/2021/662906/IPOL_STU(2021)662906_EN.pdf

[30] https://www.z-u-g.org/aufgaben/ki-leuchttuerme/

[31] https://www.washingtonpost.com/climate-solutions/2021/06/17/carbon-footprint-emissions-label/

The EU should support, fund and guide an initiative to quickly align on a common carbon footprint calculation and include carbon footprint transparency based on a standardised and easy-to-use methodology as a voluntary measure in its AI framework[32]. For example, the German government stated in its AI strategy that it will support a systematic approach for environmental impact measurement (positive and negative) of AI applications. Carbon footprint transparency can help to increase knowledge on the overall system benefits of an AI application and, herethrough, the potential for fast-tracked high-risk approval. AI applications for EGD will only be able to scale if these negative impacts are made transparent and manageable. In addition, carbon footprint information will help to reduce societal doubts about the technology, potentially contribute to renewable energy roll-out through investments and will help to make AI fit for a low-carbon economy.

[32] Several papers and initiatives have addressed this issue, see for example IÖW 2021, Henderson et al. 2020, Anthony, Kanding & Selvan 2020, or the Machine Learning Emissions Calculator.

[33] At the moment, the AI policy framework proposal outlines that AI providers should be encouraged to voluntarily com mit to conduct environmental sustainability assessments, but the disclosure specifics are not detailed. In the future, it should be considered to oblige AI providers to report the carbon footprint of AI applications. Such information will also depend upon the availability of high-quality data - an open-access database for environmental sustainability assessments of software, potentially safeguarded by an independent institution and commissioned by EU policy, could help to provide such data needs.

Aligning different stakeholders on AI Policy

This paper was written by SYSTEMIQ, a company dedicated to the fulfilment of the Paris Agreement and a just ecological transformation of our resource intensive economy , and appliedAI, Germany's largest AI initiative with the vision to shape Europe's innovative power in AI. The discussions that took place to shape the content and policy recommendations were therefore an adequate representation of the different stakes and interests involved in the formulation of a conducive policy environment to scale AI - and in this case, AI for EGD.

The following aspects especially provoked intense discussions and - as a result - helped to approach on a common vision of the things that need to happen in the EU now and that work for different stakeholders:

1.
Amount of red tape: As mentioned by appliedAI, for an AI system provider, the amount of bureaucratic work should be kept at a minimum. While SYSTEMIQ understood this, it was also voiced that some red tape is essential to ensure data protection rights are upheld and to avoid any risks. In light of the wider goal to strengthen AI for EGD cases, we agreed that EGD cases should be supported during their risk assessments and any other required process steps, to ensure that lengthy approval processes do not hinder scaling of the environmentally beneficial situation.

2.
Data privacy: In aspect 1) the essence of this is already hinted at - both parties agreed that data privacy should not be jeopardised just because a solution could bring about systemic environmental benefits. However, it is also key to recognise that without solving our climate crisis and other ecological challenges, humanity will not be able to safely live on this planet. It is therefore essential to ensure timely support for approval processes to, on the one hand, harness the potential of promising AI EGD solutions whilst, on the other hand, not sacrificing privacy.

3.
Multi-stakeholder initiatives: At the moment, AI policy demands one organisation/stakeholder to be in charge. However, this can prove to be very challenging in light of sustainability transformation initiatives that are often steered and supported through a variety of diverse stakeholders. Creating sustainable visions forces us to think in ecosystems with value beyond single stakeholder benefits. We aligned on addressing this by demanding policy processes that cater for the specific needs of multi-stakeholder use cases.

4.
Green AI: AI systems are often criticised for their inherent high energy usage and potential e-waste. We discussed this problem intensively in the beginning because there are two angles to this: on the one hand, it can be expected that renewable energy will solve large parts of this problem, on the other hand utilising AI systems could exacerbate pressures on the energy system. While we do not think that this problem should hinder the development, implementation and scaling of AI solutions, we aligned on the need to develop a standardised method for calculating AI's carbon footprint that could act similar to the Product Environmental Footprints that the EU is currently developing, as well as the need to ensure green infrastructure (e.g. renewable energy) is available to power AI systems

Appendix 1

Figure 7. Economic ecosystems and their investment opportunities.

50+ nascent investable champions offer exciting growth opportunities and are needed to achieve the EGD

HEALTHY FOOD

- Organic food and beverages
- Regenerative agriculture
- Sustainable aqua-culture and fishing
- Reduce and valorise food waste
- Urban agriculture
- Product reformulation for nutritious food
- Alternative proteins

BUILT ENVIRONMENT

- Smart urban planning
- Rethink built envi-ronment ownership
- Repurpose underutilized buildings
- Retrofit existing buildings
- Fluid and sufficiency-oriented space management
- Circular and net-zero housing

MOBILITY

- Fast charging infrastructure
- High speed railway infrastructure
- Modern and adapted transit infrastructure
- Car- and ride-sharing models
- End-of-life management for cars
- Electric and autonomous vehicles
- Infrastructure to improve traffic flow and AV adoption
- Green aviation
- Green shipping
- Walking/cycling infrastructure

CONSUMER GOODS

- Product-as-a-Service models
- Maintenance and value retention in products
- Peer-to-peer product sharing platforms

NATURE BASED

- Restoration of degraded land and coasts
- Smart forest management
- Urban greening
- Systems for paid ecosystem services
- Seaweed
- Marine and land-based envi-ronmental protection areas
- Ecotourism

ENERGY

- Renewable power generation
- Energy storage
- Hydrogen economy
- Smart metering and (point-of-use) energy management
- Grid integration and technologies
- Production of low-carbon gaseous and liquid fuels (transition technology only)
- Carbon capture infra-structure (transition technology only)

CIRCULAR MATERIALS

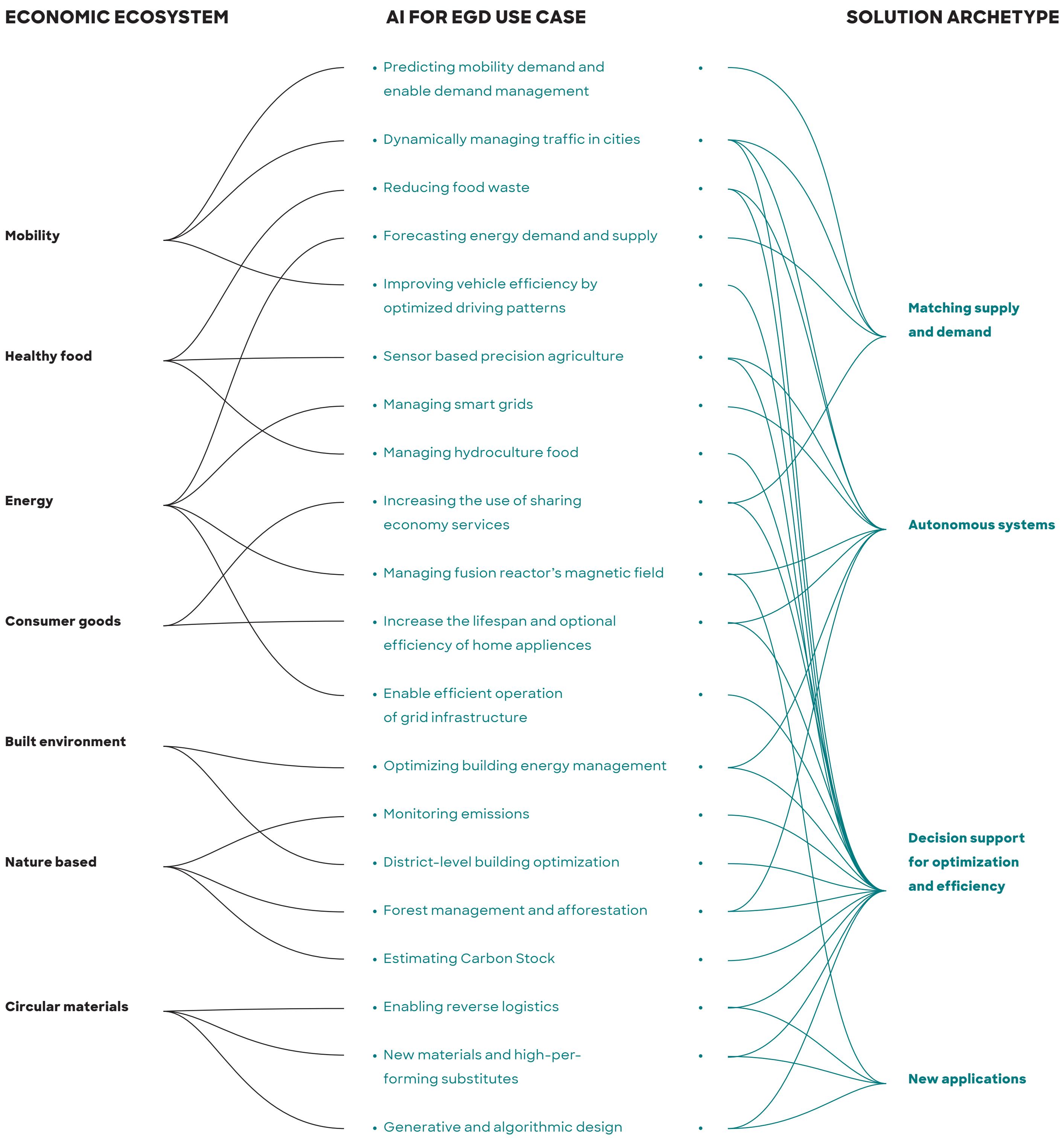
- Localised and distributed value chain systems
- Asset recovery systems and reverse logistics
- Markets for secondary materials
- High-value material recycling
- Materials-as-a-Service models
- New materials and high-per-forming substitutes
- Additive manufacturing

INFORMATION AND PROCESSING

- Distributed manufacturing
- High-speed digital infrastructure
- Digital material information and tracking systems
- Data generation, processing, and protection
- Artificial Intelligence for societal challenges

Appendix 2

Figure 8: Overview of AI for EGD use cases and their economic ecosystems as well as solution archetypes.



Energy

EGD Pillar: Supply clean, affordable and secure energy

FORECASTING ENERGY DEMAND AND SUPPLY

AI Application Name
Forecasting energy demand and supply

Economic Ecosystem
Energy

Investment opportunities
Smart metering and (point-of-use) energy management; Renewable power generation

Use case description

What does it do and what are the benefits (high level) for whom? What is the system failure that it aims to overcome?

- Accurately predict consumer behaviour (demand) and volatile energy source availability (supply: e.g., wind, solar) both short and medium term
- Basis for real-time electricity scheduling (grid operators) and longer-term system planning (energy suppliers)
- Enable the transition to fully relying on renewable energy by allowing for effective management of volatile renewable sources
- short term: decrease reliance on polluting standby energy generation and manage variable sources
- long term: determine when and where plants should be operated/built

Environmental Potential
Reduce dependency on energy based on carbon-intensive sources and enable the transition towards renewable generation

Real life examples
Sensewaves: Load and local generation forecast
Nectaware and Dexter: Load forecasting

AI Component

- Prediction: Implicitly or explicitly identify dependencies between input features and supply/demand (i.e., dependent variable) to deliver an accurate forecast for energy demand and supply. Forecast is based on historic data and identified patterns.
- Computer vision: Image recognition (e.g., remote sensing) to recognise local weather conditions
- Discovery: identify yet unknown connections / dependencies between energy supply and demand

Solution Archetype
Matching supply and demand

Special Requirements

Selected requirements beyond the standard ones to apply and scale solution in Europe

- Tech: Interpretability/Explainability of recommendations and predictions, Causal AI to find causal relationships, potential requirements from high risk classification of EU
- Data: Decentral data to be used to train central models (federation), AI@Edge, Data Sharing of anonymised / pseudonymised data, Bias Reduction (Demand and Supply might be human-made and do not necessarily reflect real need at any point in time)
- Business: Autonomous systems and data sharing must be as easily available as possible and combined with incentives to ensure participation of individuals

MANAGING SMART GRIDS

AI Application Name
Managing smart grids

Economic Ecosystem
Energy

Investment opportunities
Smart metering and (point-of-use) energy management; Grid integration and technologies

Use case description
What does it do and what are the benefits (high level) for whom? What is the system failure that it aims to overcome?

- Improve process of electricity scheduling and dispatching in smart grids with highly volatile energy sources and load by, e.g., automating or delivering insights on how to simplify or approach power system optimization
- Increased efficiency, degree of automation, and quality of power system operation. Required for more volatile supply AND demand
- Scheduling and dispatch processes must improve significantly to be able to integrate more renewable energy sources as well as more decentral consumers (like electric vehicles)

Environmental Potential
Indirect GHG emission reduction potential: Enable the system to fully rely on renewables

Real life examples
Bluwave-ai: SaaS-based AI-powered grid energy optimisation platform that predicts electricity demand to improve system stability

AI Component

- Planning and Search: Autonomous multi-agent system
- Control: centralised control with reacting agents to optimise energy grid utilisation

Solution Archetype
Autonomous systems

Special Requirements
Selected requirements beyond the standard ones to apply and scale solution in Europe

- Tech: Multi-Agent systems, 100% reliability, Demand/Supply Prediction, Pot. Distributed Ledger, high liability but high potential gains, Interpretability, Reproducibility, potential high risk classification
- Data: AI@edge, Anonymization/GDPR Compliance (Data Ownership), Federated Data pools or data sharing mechanisms, Realtime data availability, Complex policy structures to create fair market with old and new structures in parallel (similar to autonomous driving)
- Skills: Autonomous system. Skills at infrastructure supervisory authority required
- Business: Macro-level economic benefits must be translated into micro-level benefits (i.e., for individual players) to ensure viable and fast smart grid scaling

ENABLE EFFICIENT OPERATION OF GRID INFRASTRUCTURE

AI Application Name
Enable efficient operation of grid infrastructure

Economic Ecosystem
Energy

Investment opportunities
Production of low-carbon gaseous and liquid fuels (transition technology only); Hydrogen economy

Use case description

What does it do and what are the benefits (high level) for whom? What is the system failure that it aims to overcome?

- Enable efficient operation of grid infrastructure by preventing avoidable losses throughout energy transport through detecting anomalies and identifying optimization potential
- Minimise transport-related energy waste and emissions (i.e., reduce cost)
- Grid optimization potentials and maintenance needs often remain undetected for too long since detection is complex

Environmental Potential
Directly (e.g., gas leaks) and indirectly (e.g., increased electricity transportation efficiency) decrease GHG emissions

Real life examples
Capterio: AI-enabled software that optimises grid infrastructure operation

AI Component

- Planning: Recommendations for grid infrastructure optimizations through time-series analyses
- Discovery & Forecasting: Anomaly detection to avoid leakages and enable predictive maintenance

Solution Archetype
Decision support for optimization and efficiency

Special Requirements

Selected requirements beyond the standard ones to apply and scale solution in Europe

- Tech: explainability, reproducibility, potential high risk classification
- Data: potentially data sharing
- Skills: Awareness of technologies, use cases and potential application partners in companies
- Business:
- Provide R&D or investment incentives
- Manage liability and regulatory hurdles in relevant markets (esp. for critical infrastructure like energy grid or water supply etc. to minimise business hurdles whilst maximising the EU’s digital sovereignty)

MANAGING FUSION REACTOR'S MAGNETIC FIELD

AI Application Name
Managing fusion reactor's magnetic field

Economic Ecosystem
Energy

Investment opportunities
Renewable power generation

Use case description

What does it do and what are the benefits (high level) for whom? What is the system failure that it aims to overcome?

- Based on simulated or experimental data, AI can help in understanding how plasma evolves and, on that basis, explore ways to control and design components of fusion reactors. Moreover, AI can support the discovery of new materials used in fusion reactors.
- In doing so, AI can accelerate R&D on nuclear fusion and, thereby, contribute to generating cleaner energy.
- Relying on nuclear fission generates significantly more radioactive waste than fusion.

Environmental Potential
Nuclear fusion is expected to produce safe and carbon-free energy on a commercial scale, using only hydrogen as input.

Real life examples
AI models can predict impending plasma disruptions with high accuracy within milliseconds. This enables effective preventive measures to stabilise the plasma.[34,35]

AI Component

- Control (Reinforcement Learning): Manage the magnetic field and fusion reaction
- Discovery: Identify new materials (e.g., for heat transport, superconduction, etc.)
- Creation: Design components

Solution Archetype
Autonomous systems; New applications

Special Requirements

Selected requirements beyond the standard ones to apply and scale solution in Europe

- Tech: explainability, reproducibility, potential high risk classification, stability of the AI system
- Skills: Set of new skills for all players in the supply chain from new materials (e.g., for superconduction) to design (e.g., heat exchangers)
- Business: Subsidies to reduce R&D invest

[34] AI Business 2020: It takes brains to build a sun: The role of AI in nuclear fusion

[35] SciTechDaily 2021: Faster Fusion Reactor Calculations Thanks to AI

Mobility

EGD Pillar: Accelerating the shift to sustainable and smart mobility

PREDICTING MOBILITY DEMAND AND ENABLE DEMAND MANAGEMENT

AI Application Name
Predicting mobility demand and enable demand management

Economic Ecosystem
Mobility

Investment opportunities
Car- and ride-sharing models; Fast charging infrastructure; Modern and adapted transit infrastructure; Electric and autonomous vehicles; Infrastructure to improve traffic flow and AV adoption; Walking/cycling infrastructure

Use case description

What does it do and what are the benefits (high level) for whom? What is the system failure that it aims to overcome?

- AI can understand mobility patterns to predict origin-destination demand
- This allows for redesigning mobility in cities and rural areas with more individualised mobility services to improve the operational efficiency of transport modes. Moreover, it enables better alignment of service offering with movement patterns (i.e., demand)
- Mobility infrastructure is not built and used in the most efficient way, which negatively affects traffic flow

Environmental Potential
Mitigate climate change by reducing GHG emissions through increased mobility efficiency

Real life examples
Downtown.AI: analyses, maps, and predicts the movement of entire cities' populations

AI Component
- Discovery: Identify patterns in Movements
- Forecasting: Predict future traffic based on historic traffic data

Solution Archetype
Matching supply and demand

Special Requirements

Selected requirements beyond the standard ones to apply and scale solution in Europe

- Tech: Explainability, Non-Discrimination
- Data: Data sharing, Anonymization / Pseudonymization, federated learning or data access rights to understand movement patterns and highly frequented start-end patterns. Combination with data on public infrastructure (Multimodality), Bias Reduction
- Business: Incentivise individuals for (anonymously) sharing their movement data

DYNAMICALLY MANAGING TRAFFIC IN CITIES

AI Application Name
Dynamically managing traffic in cities

Economic Ecosystem
Mobility

Investment opportunities
Car- and ride-sharing models

Use case description

What does it do and what are the benefits (high level) for whom? What is the system failure that it aims to overcome?

- AI can help in optimising traffic flow by identifying optimal routes for passenger transport (public and private) as well as freight transport in cities.
- More optimal routes increase transportation efficiency and, therefore, decrease travel cost, time, and emissions or electricity demand.
- Yet, there is only very little systemic routing in cities, causing traffic jams, more emissions or electricity demand, and longer travel time.

Environmental Potential
Less emissions or electricity demand caused by inner-city traffic

Real life examples
Alibaba City Brain: traffic management service in Kuala Lumpur

AI Component

- Planning and Optimization: Identify routing optimisations that improve traffic flow on overall system-level
- Control (Reinforcement Learning): control routing and traffic management systems based on system-level optimisations

Solution Archetype
Autonomous systems; Decision support for optimization and efficiency

Special Requirements

Selected requirements beyond the standard ones to apply and scale solution in Europe

- Tech: Autonomous multi-agent system or centralised control with reacting agents to optimise energy grid utilisation
- Data: Edge, Agents, Complex policy structures to create fair market with old and new structures in parallel (similar to autonomous driving)
- Skills: Planners and city representatives need to embed data first approaches in their daily work. Cities as “supervisory authorities”
- Business: Incentivise open APIs and real time communication of systems

IMPROVING VEHICLE EFFICIENCY BY OPTIMISED DRIVING PATTERNS

AI Application Name
Improving vehicle efficiency by optimised driving patterns

Economic Ecosystem
Mobility

Investment opportunities
Electric and autonomous vehicles

Use case description

What does it do and what are the benefits (high level) for whom? What is the system failure that it aims to overcome?

- AI can identify optimal driving patterns.
- These insights can be directly translated into steering AVs and into more general guidelines for manual driving. Both increases operational efficiency and, thus, customer satisfaction
- The current interplay of vehicles rules out opportunities for increasing driving efficiency. A systemic approach can increase efficiency.

Environmental Potential
Increased driving efficiency leads to reduced carbon emissions or electricity consumption through vehicles.

Real life examples
Autonomous vehicles (AVs) have the potential to increase energy efficiency by 4 to 10%

AI Component

- Control (Reinforcement learning): Learn efficient driving patterns, e.g., via agent-based approach
- Forecasting: Predicting energy demand of a vehicle helps to adjust battery charging and discharging strategy (e.g. in hybrid vehicles)
- Planning: Optimised charging along the travel route by accurately predicting energy demand.

Solution Archetype
Decision support for optimization and efficiency

Special Requirements

Selected requirements beyond the standard ones to apply and scale solution in Europe

- Tech: M2M Communication, Cyber Security, Reproducibility, Explainability
- Data: Drivers data, information about environment and potentially other participants

Built environment

EGD Pillar: Building and renovating in an energy and resource efficient way

DISTRICT-LEVEL BUILDING OPTIMIZATION

AI Application Name
District-level building optimization

Economic Ecosystem
Built environment

Investment opportunities
Smart urban planning; Repurpose underutilised buildings; Retrofit existing buildings

Use case description

What does it do and what are the benefits (high level) for whom? What is the system failure that it aims to overcome?

- Urban building energy models (UBEMs) provide information on energy use of all buildings within a district
- District-level energy information allows to provide load flexibility, enable optimization, predict retrofitting potential, or plan and operate district heating and cooling
- Optimise energy consumption on district-level

Environmental Potential
Reduce energy consumption and enable transition to using renewable energy through demand side management

Real life examples
Buildings' operational energy consumption accounts for up to 80-90% of their total life cycle energy use. Given that 68% of the world's population is expected to live in cities by 2050, optimising energy consumption on district-level is essential for achieving net zero.

AI Component

- Planning and optimization: complex energy use optimization based on variety of building and district parameters
- Forecasting: Predict building retrofitting potential

Solution Archetype
Decision support for optimization and efficiency

Special Requirements

Selected requirements beyond the standard ones to apply and scale solution in Europe

- Tech: Ethically aligned, bias reduction ("utopian" future, not reality), explainability
- Data: Incentives for data sharing, Anonymization / Pseudonymization, Data on public infrastructure
- Skills: Citizens and data owners need to understand how systems work and what the AI role is
- Business: New business models for construction / building operation industry

OPTIMISING BUILDING ENERGY MANAGEMENT

AI Application Name
Optimising building energy management

Economic Ecosystem
Built environment

Investment opportunities
Circular and net-zero housing

Use case description

What does it do and what are the benefits (high level) for whom? What is the system failure that it aims to overcome?

- For specific buildings, AI can forecast the energy demand, evaluate building design, and assess operation strategies by understanding the building's physical behaviour and characteristics.
- Increased energy efficiency leads to reduced cost and less carbon intensive operation
- Due to various complexities, building energy management is traditionally being done rather manually and rule-based.

Environmental Potential
Increased building energy efficiency reduces the building's energy consumption and, therefore, its carbon footprint.

Real life examples
GridEdge: reduces buildings' energy demand through efficiency savings as well as improved operations and control

AI Component

- Control: Operatively control the building's energy system
- Planning and Optimization: Based on usage patterns, optimise energy management
- Computer Vision: Vision-based detection of materials and energy optimization potential (e.g., regarding insulation)
- Forecasting: Forecasting the building's energy demand helps grid operation

Solution Archetype
Autonomous systems; Decision support for optimization and efficiency

Special Requirements

Selected requirements beyond the standard ones to apply and scale solution in Europe

- Tech: Stability, liability, standardisation
- Data: Anonymization, data sharing
- Skills: Awareness of possibilities/use cases, partners
- Business: Subsidise initial investments to reduce entry barriers

Healthy food

EGD Pillar: From ‘Farm to Fork’: a fair, healthy and environmentally friendly food system

SENSOR-BASED PRECISION AGRICULTURE

AI Application Name	Economic Ecosystem	Investment opportunities
Sensor-based precision agriculture	Healthy food	Regenerative agriculture

Use case description

What does it do and what are the benefits (high level) for whom? What is the system failure that it aims to overcome?

- AI can help in identifying and delivering what land and crops need in order to achieve optimal efficiency.
- Benefits through increased efficiency are manifold and range from less water usage via increased crop health to automation.
- Traditional agriculture approaches are mainly based on making farmland more uniform and predictable instead of working with the natural heterogeneity of land and crops

Environmental Potential

Decreased resource consumption (e.g., water or fertiliser), better ecosystem health, and reduced emissions

Real life examples

Farmers Edge: Provides AI-based precision farming solutions

AI Component

- Control: Control agricultural (sub)systems based on inputs from sensors
- Computer vision: Understand and act on image data delivered through drones
- Optimization and Planning: Optimise use of fertiliser and water consumption
- Forecasting: Predict irrigation demand or expected crop yield

Solution Archetype

Autonomous systems; Decision support for optimization and efficiency

Special Requirements

Selected requirements beyond the standard ones to apply and scale solution in Europe

- Tech: Transfer learning, AI@edge, autonomous systems with high stability / robustness, explainability
- Data: Data sharing (satellites, local data from farmers, etc.)
- Skills: Upskilling of farmers and supervisory authorities about AI-powered / data driven applications
- Business: Stricter regulation as well as shifted customer behaviour / incentive schemes

REDUCING FOOD WASTE

AI Application Name
Reducing food waste

Economic Ecosystem
Healthy food

Investment opportunities
Reduce and valorise food waste

Use case description

What does it do and what are the benefits (high level) for whom? What is the system failure that it aims to overcome?

- Provide information on how to reduce food loss, e.g., by improving demand forecasting, controlling food quantity and quality, optimising logistics, or improving refrigeration systems.
- Increased efficiency in food production and consumption (also leads to cost reduction and increased revenues)
- Reduce the high quantity of food loss

Environmental Potential
Decrease emissions throughout the food supply chain (from production to transport) and avoid emissions for surplus food

Real life examples
Tomra: Identify non-uniform produce and sort it according to its highest and best use

AI Component

- Discovery: Identify clusters and patterns
- Forecasting: Understand market trends to forecast expected food demand
- Control (Reinforcement learning): Decrease energy consumption of cooling systems by predicting and optimising the power usage effectiveness (PUE)
- Computer Vision: Classify and detect food, assess its quality, and count food

Solution Archetype
Matching supply and demand; Autonomous systems; Decision support for optimization and efficiency

Special Requirements

Selected requirements beyond the standard ones to apply and scale solution in Europe

- Tech: Explainability
- Data: Data (ideally from customers to producers) to be shared. Digitalization of the whole supply chain
- Skills: Create willingness to share data

MANAGING HYDROCULTURE FOOD

AI Application Name
Managing hydroculture food

Economic Ecosystem
Healthy food

Investment opportunities
Urban agriculture

Use case description

What does it do and what are the benefits (high level) for whom? What is the system failure that it aims to overcome?

- Analyse the production of food grown in hydroculture (often in vertical farming applications) to identify optimization potential
- Increased efficiency (energy and resource use) for hydroculture food production. New and growing markets offer growth potential for businesses
- Support the transition from entirely traditional, soil-based food production to a mix of both soil-based and more efficient hydroculture-based food production

Environmental Potential
Hydroculture promises significant decreases in land use, carbon emissions, and water use

Real life examples
infarm: Micro vertical farms for supermarkets

AI Component

- Optimization and planning: Optimise the farming process (e.g., define optimal nutrients/minerals input)
- Computer Vision: Detect plant health and ripeness
- Forecasting: Predict harvest time

Solution Archetype
Decision support for optimization and efficiency

Special Requirements

Selected requirements beyond the standard ones to apply and scale solution in Europe

- Skills: Educate people to understand options and benefits

Nature-based

EGD Pillar: Increasing the EU's climate ambition for 2030 and 2050; Preserving and restoring ecosystems and biodiversity

PREDICTING MOBILITY DEMAND AND ENABLE DEMAND MANAGEMENT

AI Application Name
Monitoring emissions

Economic Ecosystem
Nature-based

Investment opportunities
Smart forest management; Systems for paid ecosystem services

Use case description

What does it do and what are the benefits (high level) for whom? What is the system failure that it aims to overcome?

- Use data from remote sensing images to detect GHG emissions (not only CO2) in real-time
- Knowing the location, time, and quantity of emissions allows introducing effective regulation or incentive schemes. It also enables businesses to more efficiently manage their activities
- Emission monitoring is still hardly standardised and inaccurate. However, to be able to effectively manage emissions, precise measurement is essential.

Environmental Potential
Emission monitoring enables the design of more effective policy interventions and the actual enforcement of emission reduction regulation

Real life examples
Climate TRACE: A coalition of businesses, NGOs, and universities that uses remote sensing and AI to measure GHG emissions from anthropogenic activities

AI Component

- Computer vision: Use image data from remote sensing applications (e.g., satellites) to detect emissions
- Discovery: Identify patterns to derive insights into natural ecosystems' emissions and emissions caused by humans
- Forecasting: Accurately predict future emissions to enable the design of more coordinated interventions

Solution Archetype
Decision support for optimization and efficiency

Special Requirements

Selected requirements beyond the standard ones to apply and scale solution in Europe

- Tech: Edge sensors
- Skills: Knowledge about sensor management

ESTIMATING CARBON STOCK

AI Application Name
Estimating Carbon Stock

Economic Ecosystem
Nature-based

Investment opportunities
Smart forest management; Systems for paid ecosystem services; Marine and land-based environmental protection areas

Use case description
What does it do and what are the benefits (high level) for whom? What is the system failure that it aims to overcome?
- Via remote sensing, AI can estimate the carbon stock stored in forests (in above-ground biomass) and peatlands
- Convenient identification of changes in carbon stock allows for acting on them
- Quantifying the stored carbon enables more effective land management.

Environmental Potential
- Improved data on carbon stocks allows for better carbon management globally
- More accurate carbon offsets

Real life examples
One third of total carbon reduction potential stems from improved land management and agriculture

AI Component
- Computer vision: Feature extraction from remote sensing data
- Forecasting:
  - Forecast carbon stock based on extracted features
  - Predict outcome from LiDAR devices mounted on UAVs based on broadly available satellite data

Solution Archetype
Decision support for optimization and efficiency

Special Requirements
Selected requirements beyond the standard ones to apply and scale solution in Europe
- Tech: Improve LiDAR data availability and ensure its equal distribution across regions and seasons
- Data: Increase LiDAR data availability, generated by UAVs
- Business: Subsidies to reduce R&D investment

FOREST MANAGEMENT AND AFFORESTATION

AI Application Name
Forest management and afforestation

Economic Ecosystem
Nature-based

Investment opportunities
Restoration of degraded land and coasts; Smart forest management

Use case description

What does it do and what are the benefits (high level) for whom? What is the system failure that it aims to overcome?

- Provide information that helps tackling deforestation and enabling afforestation
- Increase the health of ecosystems and the volume of stored CO2 by decreasing deforestation, preserving forest health, and fostering afforestation (also in previously arid zones like deserts).
- Healthy forests play an essential role in ensuring the health of natural ecosystems. However, this potential is not used to a sufficient extent - rather, deforestation activities around the world put ecosystem health at risk.

Environmental Potential
Forests provide important carbon storage and contribute significantly to maintaining ecosystem health.

Real life examples
Dendra Systems: Automated drone afforestation
NXC: Forest monitoring via remote sensing
Ororatech: Wildfire detection and forest monitoring via remote sensing

AI Component

- Computer vision: identify appropriate afforestation sites, monitor tree health, determine carbon stored in forests, provide (preventive) information on forest fires, detecting illegal deforestation
- Control: Operate drones that autonomously plant trees

Solution Archetype
Autonomous systems; Decision support for optimization and efficiency

Special Requirements

Selected requirements beyond the standard ones to apply and scale solution in Europe

- Tech: reliability, autonomous systems with high stability / robustness
- Data: data sharing or pretrained models would allow for better tools for everyone
- Skills: Upskilling of farmers / managers about ai powered autonomous systems

Consumer Goods

EGD Pillar: Mobilising industry for a clean and circular economy

INCREASE THE LIFESPAN AND OPERATIONAL EFFICIENCY OF HOME APPLIANCES[36,37]

AI Application Name
Increase the lifespan and operational efficiency of home appliances

Economic Ecosystem
Consumer goods

Investment opportunities
Product-as-a-Service models; Maintenance and value retention in products

Use case description

What does it do and what are the benefits (high level) for whom? What is the system failure that it aims to overcome?

- AI can extend the life cycle and operational efficiency of home appliances by…
  - improving their operation (by providing information on how to use them, e.g., by virtual assistants like chatbots)
  - automating their operation
  - providing predictive information on maintenance needs
- Increases the material and energy efficiency and decreases operation cost as well as need for new devices. This can also improve customer experiences and, therefore, increase revenues.
- Operation optimisation / automation can reduce inappropriate operation and predictive maintenance can enable longevity

Environmental Potential
Increased operational efficiency decreases energy use and increased life cycles reduce material use

Real life examples
LG provides precision washing without any human guesswork by using AI models that select the optimal wash cycle for each load

AI Component

- Control: Automate the operation of home appliances and / or provide information on how to appropriately use them
- Forecasting: Predict maintenance needs
- Computer linguistics: Understand user questions and appropriately react to them

Solution Archetype
Autonomous systems; Decision support for optimization and efficiency

Special Requirements

Selected requirements beyond the standard ones to apply and scale solution in Europe

- Data: Enable privacy-preserving data sharing to increase the amount of available training data
- Skills: Educate consumers to appropriately understand and act on information provided by AI models

[36] Ferreira, Luis & Bulut, Barış & Oliveira, André & Landeck, Jorge & Teixeira, Nuno & Morgado, Nuno & Sousa, Orlando. (2021). Predictive Maintenance of home appliances: Focus on Washing Machines. 10.1109/IECON48115.2021.9589642.

[37] The Consumer Goods Forum and IBM (2019): AI in Consumer Goods (Whitepaper).

INCREASING THE USE OF SHARING ECONOMY SERVICES[38]

AI Application Name
Increasing the use of sharing economy services

Economic Ecosystem
Consumer goods

Investment opportunities
Peer-to-peer product sharing platforms

Use case description

What does it do and what are the benefits (high level) for whom? What is the system failure that it aims to overcome?

- Provide information on how to increase the use of sharing economy products by asset and price matching, demand forecasting, as well as understanding participant preferences and attitudes
- Improved sharing economy services can increase the revenue for asset owners whilst offering better experiences for asset users.
- Improving sharing economy offerings can increase the usage of underused assets and, in doing so, alleviate overconsumption, pollution, and poverty.

Environmental Potential
The sharing economy has the potential to improve material efficiency by increasing asset use. This, in turn, reduces resource use. Thus, improving sharing economy services, further reduces resource use as well as emissions from producing and transporting assets.

Real life examples
Airbnb: Price tips support efficient service pricing

AI Component

- Forecasting: Predict the expected demand for specific assets in future periods
- Forecasting: Forecast optimal suggestions for asset users and efficient prices for asset owners
- Discovery: Analyse past sharing economy data to gain insights into participant preferences and attitudes

Solution Archetype
Matching supply and demand; Decision support for optimization and efficiency

Special Requirements

Selected requirements beyond the standard ones to apply and scale solution in Europe

- Tech: explainability, reproducibility, high reliability
- Data: anonymization/pseudonymization
- Skills: Participants require basic understanding of AI to interpret outputs

[38] Chen, Ying & Prentice, Catherine & Weaven, Scott & Hsiao, Aaron. (2021). A systematic literature review of AI in the sharing economy. Journal of Global Scholars of Marketing Science. 1-18. 10.1080/21639159.2020.1808850.

Circular Materials

EGD Pillar: Mobilising industry for a clean and circular economy

ENABLING REVERSE LOGISTICS[39]

AI Application Name
Enabling reverse logistics

Economic Ecosystem
Circular materials

Investment opportunities
Asset recovery systems and reverse logistics

Use case description

What does it do and what are the benefits (high level) for whom? What is the system failure that it aims to overcome?

- Provides information on how to set up, run, and optimise reverse logistic functions (namely network design, collection, warehousing, and processing)
- Consumer goods producers can more easily and conveniently use the potential of reverse logistics as well as access new markets and business models
- Can accelerate the transition from a linear to a circular economy

Environmental Potential
By enabling the transition to a circular economy, the use case can reduce the use of virgin material

Real life examples
Optoro: Delivers AI-based software that supports in deciding on how to process returned items
Stuffstr: AI-based pricing of returned products

AI Component

- Planning and Discovery: Determine optimal number and location of collection points, depots, as well as processing facilities
- Forecasting: Determine best use (recycling, disposal, reselling, refurbishing, repairing, etc.) for specific product
- Computer vision: Sorting and visual assessment of returned products

Solution Archetype
Decision support for optimization and efficiency; New applications

Special Requirements

Selected requirements beyond the standard ones to apply and scale solution in Europe

- Tech: Explainability, reproducibility, AI@edge
- Data: Data sharing schemes between supply and recycling chain partners
- Skills: Basic knowledge of users about the AI systems, their application, and the interpretation of results

[39] Wilson, M., Paschen, J., & Pitt, L. (2021). The circular economy meets artificial intelli gence (AI): understanding the opportunities of AI for reverse logistics. Management of Environmental Quality: An International Journal.

NEW MATERIALS AND HIGH-PERFORMING SUBSTITUTES

AI Application Name
New materials and high-performing substitutes

Economic Ecosystem
Circular materials

Investment opportunities
New materials and high-performing substitutes

Use case description

What does it do and what are the benefits (high level) for whom? What is the system failure that it aims to overcome?

- Identify new material compositions and transform carbon-intensive industrial production processes
- AI has the potential to accelerate material science to identify better materials and optimise conventional production processes to make them less environmentally harmful
- As of today, many materials are either by themselves or in their production environmentally harmful but still in use on a large scale

Environmental Potential
AI can help in identifying greener materials as well as production processes for carbon-intensive materials that are used on a large scale.

Real life examples
Element AI analyzes production processes using AI to identify optimization potential

AI Component

- Creation: Generate new material structures with specific target characteristics
- Discovery: Transform conventional, carbon-intensive industrial production processes to cleaner ones

Solution Archetype
Decision support for optimization and efficiency; New applications

Special Requirements

Selected requirements beyond the standard ones to apply and scale solution in Europe

- Tech: Improve generative AI models
- Data: Provide public data sets containing material structures and data on industrial production processes
- Skills: Foster cooperation between material scientists, AI engineers, and industry
- Business: R&D incentives

GENERATIVE AND ALGORITHMIC DESIGN

AI Application Name
Generative and algorithmic design

Economic Ecosystem
Circular materials

Investment opportunities
Additive manufacturing

Use case description

What does it do and what are the benefits (high level) for whom? What is the system failure that it aims to overcome?

- Identify designs and structures that tend to be more complex and material-efficient
- Cost reduction (through increased material efficiency) and new business models for component manufacturers as well as designers
- In practice, more efficient structures and designs that require less material are not being broadly identified and used

Environmental Potential
Minimise material use

Real life examples
Hyperganic: Develops an AI-based, algorithmic design engine that optimises components for 3D printing

AI Component
Creation: Generate complex and highly material-efficient structures and designs using AI

Solution Archetype
Decision support for optimization

Special Requirements

Selected requirements beyond the standard ones to apply and scale solution in Europe

- Tech: Improve generative models; high reliability to avoid material failure
- Skills: Awareness of generative design benefits at manufacturing companies

Authors

Dr. Andreas Liebl, Managing Director of UnternehmerTUM, is responsible for the appliedAI initiative. With 50 partners, the initiative is driving the adoption of AI in Germany. He serves as expert regarding innovation and commercialization in the Global Partnership on AI next to other advisory roles. Before joining UnternehmerTUM, he worked for McKinsey for five years and did his PhD at the Technical University of Munich.

Matthias Ballweg leads EU policy and mobility at SYSTEMIQ – a globally active “”System Change Company”” driving the shift towards a sustainable economy. He is jointly responsible with the World Economic Forum for the Circular Cars Initiative and he is architect of further coalitions, like the battery passport consortium. He is co-author of several influential studies on green recovery and the European Green Deal amongst others the “System Change Compass” with the Club of Rome. Previously, he was Vice President and Head of Strategy at MAN Truck & Bus, where his responsibilities included all topics related to the future of mobility in passenger and freight transport.
He holds a doctorate from TU Munich, is a startup founder, father of 4 and Chairman of the Oberland Section of the German Alpine Club - the second largest sports club in Germany.

Marie Wehinger is an Associate at SYSTEMIQ’s circular materials platform. She has signficiant experience in driving multi-stakeholder collaboration for a circular economy and EU policy and has been focusing on the mobility and fashion industry. Previously to joining SYSTEMIQ, Marie co-founded a peer-to-peer clothing rental startup. She holds a Bsc in Business Administration from the LMU Munich and a Msc in Sustainability & Innovation Management from the Technical University Berlin.

As part of SYSTEMIQ and the Energy Transitions Commission, **Timon Rückel** develops data-driven and industry-backed models that simulate the decarbonisation pathways of hard-to-abate industries. Before joining SYSTEMIQ, he finsihed his Honours degree in Finance and Information Management at TUM and conducted research in the domains of Deep Generative Learning as well as Cryptography.

About appliedAI

appliedAI is Europe's largest initiative for the application of leading-edge, trustworthy AI technology, with the vision of shaping Europe's innovative power in AI. appliedAI was formed as an objective, reliable initiative that acts both as enabler and innovator. Based on our ecosystem, we promote value creation by helping to build global AI champions.

You can find more information about appliedAI at: www.appliedai.de

About SYSTEMIQ

SYSTEMIQ was founded in 2016 and employs around 300 sustainability experts worldwide. Our expertise and the goal of our work are the socially sustainable transformation of the economy and the sustainable development of projects to mitigate environmental and climate damage. These can be projects to combat plastic in the ocean, to create businesses for the protection of the rainforest or to advance the battery passport.

You can find more information about SYSTEMIQ at: https://www.systemiq.earth

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SYSTEMIQ

initiative for applied artificial intelligence

appliedAI Initiative GmbH
August-Everding-Straße 25
81671 Munich
Germany
www.appliedai.de

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