



Crypto Valley



NEXT STEP:

# SUSTAINABLE AI

## How Can Blockchain Help?

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## Foreword

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Dear Readers,

It is with great pleasure that we present to you our latest report on the topic of sustainable Artificial Intelligence (AI) written by the Crypto Valley Association's Sustainability Working Group. Artificial Intelligence (AI) has emerged as a powerful force reshaping our world, permeating innumerable aspects of our lives, from healthcare, to transportation, to finance and business and many more. As AI continues to advance at an unprecedented pace, it becomes imperative for us to critically examine its ethical, sustainability, and social implications.

As Switzerland's leading blockchain community, we are committed to fostering innovation, collaboration, and sustainable development in the digital era. Hence, we could not leave the topic of evolving AI unaddressed, especially as the use of blockchain can reduce some of the inherent risks of artificial intelligence.

Within the pages of this report, you will find a comprehensive exploration of three critical areas of AI sustainability: the ethical use of AI; green AI; and democratic/open-source AI. These areas represent crucial dimensions that shall demand our attention and collective action. By addressing the ethical implications of AI, minimizing its environmental footprint, and promoting inclusivity through open-source approaches, we can ensure that AI technologies serve the greater good.

We would like to extend our heartfelt appreciation to the CVA Sustainability Working Group, led by dedicated experts in the field, for spearheading this report. Their diligent efforts and thoughtful analysis have shaped the report into a valuable resource for policymakers, industry leaders, and individuals seeking to navigate the complex landscape of AI sustainability. Additionally, we express our gratitude to the CVA Startup Working Group, whose contribution to this initiative ensured representation of the thriving ecosystem of blockchain and AI-enabled startups within our network.

In closing, we encourage you to immerse yourself in the wealth of knowledge, insights, and recommendations presented in this report. An exciting collective journey awaits us: by harnessing the transformative potential of blockchain in tandem with AI, we can build a future where sustainability and responsible innovation can flourish hand in hand.

Sincerely,  
Emi Lorincz  
President, CVA Board of Directors

## Opening Remarks from the Authors

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*AI has traversed a significant journey, but it is with the advent of ChatGPT that a truly remarkable revolution has been ignited. It has bridged the divide between AI and humanity, reshaping our perceptions of this powerful technology. Hand in hand with blockchain technology, AI spearheads a profound technological revolution. While there may be those who exploit these advancements for less noble ends; we hold the true power. It is our conscious choice to embrace and wield these transformative technologies. My hope is that this document will kindle vibrant conversations, ignite curiosity, and empower others to actively participate, forging a path toward a more sustainable society.*

Maja Kehic, CMO at DeepSquare



*The increase in awareness of the last months of the general public concerning the capabilities of AI is impressive. Tools like ChatpGPT are now known by a relatively big chunk of the population and not just by a bunch of technologists. In parallell, an increasing number of concerns have been raised to make sure that AI ultimately benefits people and the planet. Similar to every technology, AI is not inherently positive or negative, its outcome ultimately depends on how AI is being used by humans.*

Michele Soavi, CSO at ImpactScope



*Like any other exponential technology, artificial intelligence has been growing slowly for a few decades, just to be on the verge of abrupt expansion now. It is in these times that sustainability topics need to be brought to the forefront, not later. We hope this report will enable constructive conversations between product teams, investors, regulators and other stakeholders about how to make AI ethical, green and open-source from the get-go.*

Carmen Cucul, Healthcare Consultant



## Executive Summary

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The interest in AI increased exponentially in the last months with the **launch of ChatGPT**, a chatbot developed by OpenAI and released in November 2022. Although significant improvements are still required, the impact of ChatGPT and similar tools are becoming more and more clear, also outside of the AI community.

AI tools will undeniably **impact our lifestyles and economies** in the coming decades, if not earlier. Process automation may lead to a radical change in the job market, resulting in a replacement effect – by the substitution of many jobs and tasks replacing human labor with AI processes. AI-related jobs to manage and maintain the infrastructure may counterbalance some of this effect but with a much lesser magnitude. Process automation may significantly impact lifestyle as well, contributing to the increase of free time available due to the increasing number of tasks potentially performed by a machine. There is an increasing need for organizations and individuals to understand AI's potential impact on their lives and their business.

Similarly to every technology of new introduction, its impact is neither positive nor negative but it depends on how the technology is used. The objective of the present report is to preliminarily explore the **potential impact of AI from a sustainability perspective in connection to the use of blockchain**. The report is mainly based on the review of the topic performed in the first half of 2023 as well as a survey proposed to the members of the CVA and associated networks. Furthermore, the **RESTART framework** is proposed to ensure the ethical use of AI. Last but not least, a compendium of blockchain-based, AI-focused CVA member organizations is introduced to illustrate the current landscape of products and services springing at the intersection of AI, blockchain and sustainability.

The following conclusions have been derived concerning the need to create a sustainable AI. Firstly, the importance of **providing open-source software** to make sure that the advantages of AI are harvested by humanity and are not concentrated in the hands of a few companies or individuals. Secondly, the importance of thinking through concerning the **goals to reach with the use of AI** – RESTART framework offers the possibility to support such requirements. This is necessary to avoid the unintended consequences that AI may lead to, such as job loss or mental problems arising from AI predominance. Thirdly, the need of laying the foundations for a **green AI**, with a focus on creating efficient software, limiting the use of energy and the generation of electronic waste. These conclusions are expanded at the end of the report and consider the potential development of the project with further publications or applied research.

## Content Overview

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The ability to understand the sustainability implications of AI and the intersection with Blockchain requires **at first to provide background information** needed in order to understand its potential implications. As this report is prepared by the Crypto Valley Association (CVA), our focus is on providing a deeper understanding of AI, rather than Blockchain (as we assume that readers have at least a general understanding of Blockchain technology). **In the second step, we detail the requirements for an ethical, green and democratic AI** and the potential support provided by Blockchain. As such, use cases, results of a survey and a framework are provided to help reflect and support the reader in understanding the implications for their industry.

In Chapter 1, *The Uptake of Artificial Intelligence*, we **define AI**, its key terminology, history and development lifecycle to establish a common reference framework. We conclude this chapter by looking at the benefits and challenges of AI and where we (and our survey responders) think the technology is headed in the next 5-10 years. This section can be skipped by readers who are well-versed in the AI topic.

In Chapter 2, *Ethical AI: How to Use AI Ethically* we make the case that AI models should be designed from the start with an **ethical goal** in mind. We bring the most important characteristics of such models into **a simple framework** (RESTART) and show that blockchain technology can act as a strong enabler of AI models designed with ethical use in mind. Lastly, we illustrate how AI and blockchain can work together for an ethical goal through a deep dive into the healthcare industry.

Chapter 3, *Green AI: Sustainable use of data infrastructure* considers the **energy requirements** associated with the use of AI tools, with the objective of promoting an energy-efficient use of such tools and avoiding negative publicity from the general public regarding their environmental footprint - as it has been the case with Bitcoin. It concludes with a use-case concerning how AI and blockchain can be used to improve the carbon offsetting industry.

in Chapter 4, *Open-source AI: Democratizing the Creation of AI Models*, we make the case for why **AI should be accessible to everyone** independently from their geographical location, income or technological knowledge. Similarly to the other chapters, we explore how blockchain can support such a requirement for a more inclusive AI and bring concrete examples of existing companies and initiatives working with this objective.

Chapter 5 includes the **conclusion and potential development** opportunities for the research. Last but not least, and after the acknowledgements in Chapter 6, **a compendium of blockchain-based**, AI-focused CVA member organizations illustrate the current landscape of products and services springing at the intersection of AI, blockchain and sustainability. These organizations are active in a wide range of domains, such as blockchain data analytics, gaming, online marketing, financial services, data centers etc.

Note: The views expressed in this report are those of co-authors alone, they do not reflect the opinion of CVA nor of their respective employees. The compendium is based on desk research conducted by this report's co-authors and is not exhaustive, nor does it represent an endorsement of selected organizations.

# 1. The Uptake of AI

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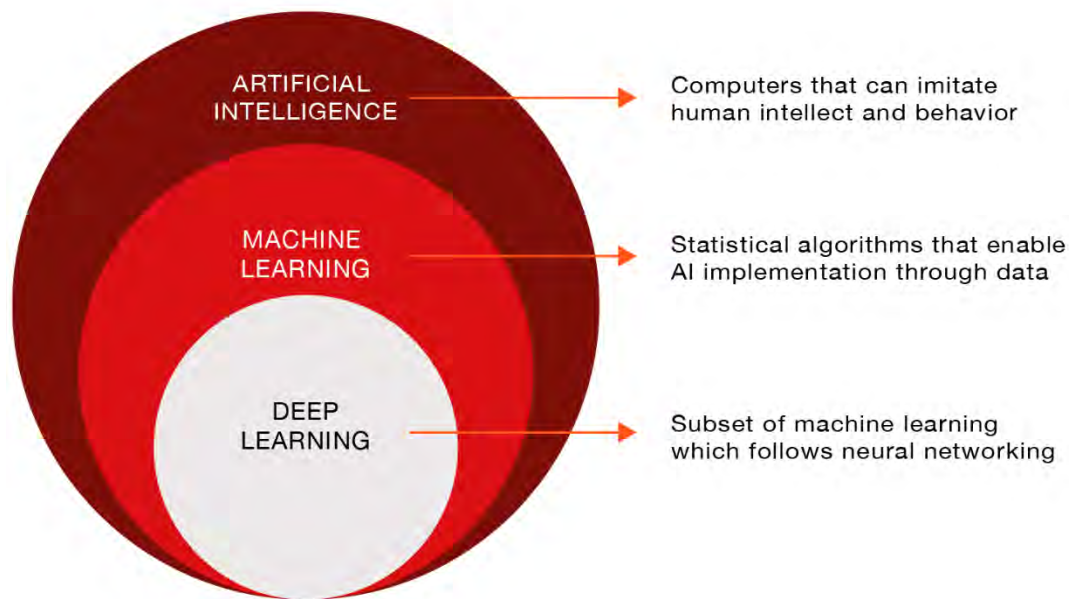
## 1.1 What is AI

We asked AI itself what it thinks AI means. OpenAI's [ChatGPT](#) responded the following: “AI, short for Artificial Intelligence, refers to the development of computer systems that can perform tasks that typically require human intelligence, such as visual perception, speech recognition, decision-making, and natural language processing. AI is achieved through various techniques, including machine learning, deep learning, neural networks, natural language processing, and computer vision. These techniques enable machines to analyze large amounts of data, recognize patterns, and make decisions based on that analysis”.

The definition above has potentially introduced many new terms and with them, some confusion. Therefore, we found it relevant to include a short taxonomy. We will be referencing these terms several times throughout this report:

- **Machine Learning (ML):** is a technique, approach, or process for implementing AI which involves parsing massive amounts of data, learning from that data, and making predictions based on that ([Becominghuman.ai](#)). ML is used in AI, not the other way around.
- **Deep Learning (DL):** is a subset of machine learning that involves the artificial neural network (see below). DL uses multiple layers to progressively extract higher-level features from the raw input. For example, in image processing, lower layers may identify edges, while higher layers may identify the concepts relevant to a human such as digits or letters or faces. ([Wikipedia](#))
- **Artificial Neural Networks (ANN):** are computing systems inspired by the biological neural networks that constitute human brains. They use several layers of mathematical processing (units) in an attempt to simulate the network of neurons that make up a human brain so that the computer will be able to learn things and make decisions in a human-like manner. ([Forbes](#))
- **Natural Language Processing (NLP):** is a technique that enables computers to analyse and understand human language, both written and spoken, in much the same way human beings can ([Investopedia](#)).
- **Computer Vision (CV):** is to images what NLP is to words. It is a technique to transform visual images into descriptions of the world that make sense to thought processes and can elicit appropriate action from the part of computers ([Wikipedia](#)).

Here is how you can think of some of the above terms from a visual perspective:

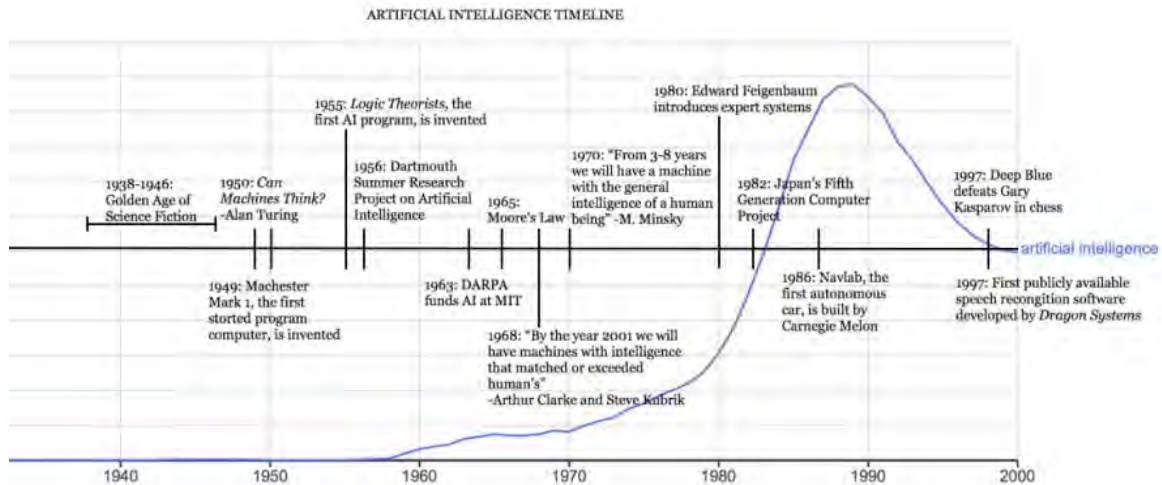


Source: <https://becominghuman.ai/how-are-deep-learning-artificial-intelligence-and-machine-learning-related-be44f11172cf>

## 1.2 History and AI Examples

The evolution of AI epitomizes the words of Ernest Hemingway from his 1926 novel, *The Sun Also Rises*, - "At first it happened *gradually and then suddenly*." AI entered the imagination of the public more than 100 years ago. It began with the "heartless" Tin man from *The Wizard of Oz* and flourished in *Star Trek* where advanced androids like Commander Data and helpful holographic AIs like the Emergency Medical Hologram were part of life as usual on *The Enterprise*.

In 1950 Alan Turing, a young British polymath released a paper called [Computing Machinery and Intelligence](#) in which he discussed how to build intelligent machines and how to test their intelligence. Unfortunately, the computing machines became powerful enough and cheap enough to support such complex undertakings only in the 1980s, after several embryonic, mostly government-funded experiments in the preceding decades. Below is a more detailed chart of AI's origins.



Source: <https://sitn.hms.harvard.edu/flash/2017/history-artificial-intelligence/>

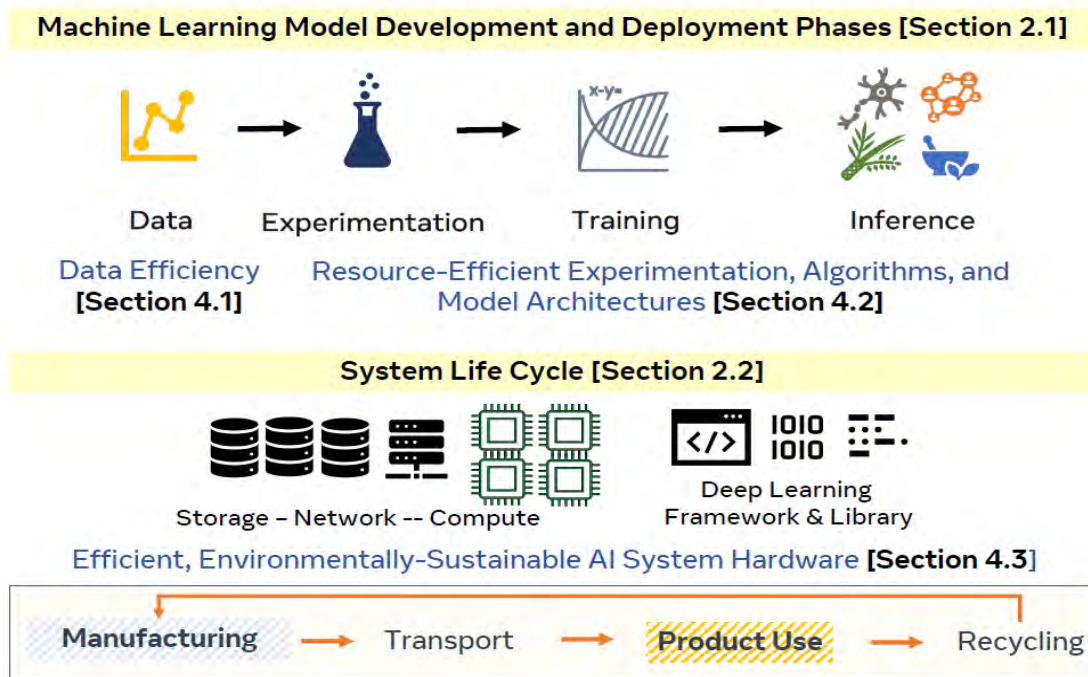
A major breakthrough for AI came at the turn of the 21st century. In 1997, reigning world chess champion and grandmaster Gary Kasparov was [defeated](#) by IBM's Deep Blue, a chess-playing computer program. In the same year, Windows operating system was upgraded with [Dragon NaturallySpeaking](#) v1.0, a speech recognition software using NLP and text analytics. So far **AI was narrow and specific**, meaning it could operate a distinct task without the ability to extrapolate its process to other tasks automatically. Think of Siri from Apple, Alexa from Amazon, Cortana from Microsoft, IBM's Watson, content recommendation algorithms based on our past behavior, self-driving car's software, and face recognition tools - these are all [considered Artificial Narrow Intelligence \(ANI\)](#).

The last several years have seen the evolution of AI from narrow and specific to general and contextual (i.e. ability to execute a broad range of tasks at par with a human being or even better). While **Artificial General Intelligence (AGI)** and **Artificial Super Intelligence (ASI)** are not yet fully here, the road is being paved by companies such as [OpenAI](#), [DeepMind](#) and [Anthropic](#). OpenAI's [ChatGPT](#) was launched to the general public on November 30th, 2022. In less than two months the application reached 100 million users, which is staggering considering it took Facebook 4 years and Instagram 2 years to reach the same target. [GPT-4](#) version was launched in March 2023, and by many, it is the closest to the general AI concept we got so far. According to [Vice](#), GPT-4 could get into top universities as it successfully passed standardized exams such as SAT or GRE.

While the world awaits AGI and ASI to evolve (which is an area of deep concern, as we discuss later in this report), the world is busy experimenting with **generative AI**. [Generative AI](#) is AI that can create new content including audio, code, images, text, simulations, and videos (as opposed to previous models which are more focused on delivering clean data outputs). For example, Github's [Copilot](#) already writes 40% of the code for those developers who used it; Stability AI is offering open-source [stable diffusion](#) solutions for text-to-image and text-to-video conversions; Google and Apple have [embedded](#) generative AI for app developers and anyone can become their own interior designer with the use of [Interiorai](#)'s image-to-image conversion technology.

## 1.3 AI's Lifecycle

Knowing a bit better what AI is and how it has been applied in some real-world use cases, let's now see how an AI model is created. The following AI lifecycle management approach is commonly used across the research community. It will help us better understand AI, and also put some of the later discussions in context:



Source: Carole-Jean Wu et al., "Sustainable AI: Environmental Implications, Challenges and Opportunities", arXiv:2111.00364v2 [cs.LG], 2022

As the framework above shows, there are **two layers in the process of AI development**. The first covers the mechanics of creating the AI model/algorithm. It contains phases such as data collection and structuring, hypotheses definition/experimentation, model training and its inference with the real world (continuous training). The second layer reflects the infrastructure required to operate the respective AI model/algorithm, with critical components such as data storage hardware & software as well as DL frameworks & libraries. The sections below will make reference to some of these components when providing examples of how blockchain can help AI's sustainable development.

## 1.4 AI in the Future

Where do we think AI is headed in the next 5-10 years? To answer this question, during the March-May 2023 period, **we surveyed CVA's members** and associated networks and here are the results: Out of 66 respondents, 88% believe that AI's role will increase in the medium term, to become a critical data & technology pillar for society. Our position, as CVA's Sustainability Working Group, is aligned with the outcomes of the survey. This assumes however that stakeholders (including regulators) will identify ways to enable a sustainable development of AI which is based on ethical goals, efficient / green use of infrastructure and open-source models.

If indeed, AI ends up becoming a fundamental part of human life in the future, it will have to synergize well with other transformative technological phenomena, such as quantum computing, 3D/4D printing, brain-computer interfaces, Web 3.0 to name a few. Can quantum computing help AI become greener (e.g. use more effectively its data infrastructure)? Will AI be able to improve the functioning of synthetic, 3D-printed organs in human bodies? Will humans, via their digital avatars get better experiences or even a new, more prosperous life in an AI-powered Web 3.0? All these are questions which will find answers in the next 5-10 years.

## 1.5 Benefits of AI

Given that 77% of our responders in the survey said they hold a positive or very positive view of AI, let us briefly mention some of its benefits. We will reference some of them in subsequent chapters of this report.

**(1) Increased economic productivity:** use of AI can tremendously accelerate automation of production lines and agricultural crops, making the output more abundant at lower costs. AI can also ensure that the right goods & services are being offered in the market, through better demand forecasting (which is what [Amazon](#) and many other online retailers already do). Increased productivity was AI's top-rated benefit in our recent survey, with 86% of respondents in agreement.

**(2) Better prevention and/or cure of diseases:** Especially in rare diseases, AI can crunch multi-country medical registries to help physicians diagnose patients faster and more accurately than they would alone, given the scarcity of such patient populations in their own practice. AI-driven algorithms can help physicians decide on the optimal mix of treatment for a specific patient and/or identify early which patients are at higher risk to have their disease returning (relapsing), as mentioned in a literature review [published](#) in 2022. This has been the second most important benefit area for AI in our survey, with 80% of respondents identifying it as such.

**(3) Reduction of social inequalities and poverty:** Increased productivity, coupled with better supply-demand matching through AI should lead to cheaper (or even free) access to products & services for many. Think of [Hopper](#) which finds cheap flights for you or [Arx](#) which uses AI to help developers build affordable houses. And by facilitating access to complex information, AI can democratize learning and personal development with the likes of [ChatGPT](#) or [Semantic Scholar](#).

**(4) A safer world:** cyber-attacks have increased by 38% in 2022 compared to 2021, according to CheckPoint Research's [report](#). But luckily so did AI-based [tools](#) to combat it. And when it comes to autonomous vehicles (of which self-driving cars are [projected](#) to reach 60 million units by 2030) a major consideration is how to ensure they don't collide. AI is put to good use here too, with examples such as MIT's [VISTA 2.0](#) open-source simulator helping the nascent industry keep

our roads clean. Last but not least, a safer world with AI is also one where [climate change](#) can be better forecasted and calamities such as earthquakes or wildfires earlier detected.

**(5) Better quality of life:** The past couple of years have brought us, the consumer, endless AI-driven applications which enrich our lives. From [maps](#) and navigation systems to improve our travelling experience, [text editors](#) and autocorrect programs to help us with that university paper, search and recommendations engines to spare us time shopping online, chatbots who (not always!) answer our questions without needing to queue for customer service, [digital assistants](#) to organize our calendars and take notes in meetings, personal trainers who know exactly what we had for breakfast and won't let us sleep until we have made those 10 thousand steps ... the list of useful AI-powered apps is endless. 32% of survey respondents also agreed, placing quality of life as AI's third most important benefit.

## 1.6 Challenges with AI

In March 2023 Elon Musk, CEO of Tesla, Twitter and SpaceX (also co-founder of OpenAI), together with thousands of others signed an [open letter](#) urging for a six-month pause in the development of AI models that are more powerful than current [GPT-4](#) (GPT stands for Generative Pre-Trained Transformers).



*Recent months have seen AI labs locked in an out-of-control race to develop and deploy ever more powerful digital minds that no one – not even their creators – can understand, predict, or reliably control. [...] Powerful AI systems should be developed only once we are confident that their effects will be positive and their risks will be manageable*



Despite some level of controversy around methodology or claims made in this letter, it is well understood that AI will bring along challenges and areas of short and long-term concern. Some of them are summarized below.

### 1. Short term: loss / alteration of jobs, more bias and discrimination, LAWs

A paper [published](#) in March 2023 by researchers from OpenAI, OpenResearch and the University of Pennsylvania has concluded that “around 80% of the U.S. workforce could have at least 10% of their work tasks affected by the introduction of LLMs (Large Language Models, such as GPTs), while approximately 19% of workers may see at least 50% of their tasks impacted.” The occupations with the highest exposure include mathematicians, writers, web designers, accountants, journalists, legal secretaries, and clinical data managers. In time, the **labor market** will adjust to the impact brought by AI and new types of jobs will emerge, as was the case with the internet.

**Bias and discrimination in decision-making** might also be exacerbated in the short term, due to relatively low diversity of AI model datasets (mostly western-based) and insufficient controls to identify / eliminate [bias and deep fakes](#). Some [examples](#) of areas where biased AI models create discrimination or false positives/negatives are access to healthcare, recruitment / candidate selection, insurance premium calculation, and risk of recidivism.

Last but not least, a very worrisome trend is the use of **LAWs (Lethal Autonomous Weapons)** in recent wars such as [Libya](#) and [Ukraine](#). LAWs (also called slaughter bots or killer robots) are

weapons that can identify and kill targets with the help of AI but with no human intervention. The Future of Life Institute has a [dedicated page](#) and a [pledge](#) on this topic.

## 2. Long-term: Superintelligence beyond human cognition & control, addictions

Back in 2015, Elon Musk, Stephen Hawking, together with several other high-ranked scientists and researchers, raised for the first time [concerns](#) regarding the spread of AI beyond human abilities and control. More recently, The Future of Life Institute [argues](#) that AI “*could potentially undergo recursive self-improvement, triggering an intelligence explosion leaving human intellect far behind.*” Letting **AI become superintelligent** (i.e. performing better than human intellect at all cognitive tasks) might be the biggest event in human history but “*it might also be the last, unless we learn to align the goals of the AI with ours [before it becomes superintelligent](#)*”).

The European Union is also working on defining and regulating AI [since 2018](#). In the “[Regulatory framework proposal on artificial intelligence](#)”, the European Commission [defines](#) 4 levels of risk related to AI: Unacceptable risk, High risk, Limited risk and Minimal or no risk. **Unacceptable risk** is outright banned: “*All AI systems considered a clear threat to the safety, livelihoods and rights of people will be banned, from social scoring by governments to toys using voice assistance that encourages dangerous behavior*”. Other governments and regions of the world might follow suit (meanwhile Italy temporarily banned the use of ChatGPT altogether, in April 2023 over privacy concerns).

A subtler longer-term effect of giving humans highly intelligent tools is the threat of us **developing addictions** that make us unable to **perform life-securing tasks independently**. We have seen it with the rise of smartphones: two decades after their invention hardly anyone knows anymore how to orient themselves in a new city without a phone's GPS, and we all have a hard time multiplying 57 by 2.5 in our head. AI-powered tools might make the next generation incapable of independently processing data or writing creative content as ours is to do administrative tasks done by our smartphones today.



*Humans will have to learn new restraint. [...] Strong cultural norms, rather than legal enforcement, will be necessary to contain our societal reliance on machines as arbiters of reality.*



Wrote Henry Kissinger (who turns 100 this year) in his [latest article](#) about AI.

Concluding, the potential benefits of AI are enormous, particularly concerning what AI-driven models can bring to society, especially in terms of a more productive economy, better healthcare, and higher quality of life for all. A slower, more controlled, fair, and sustainable AI evolution is a priority over rushing things in the name of technological advancement or business opportunities.

## 2. Ethical AI: How to Use AI Ethically

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Given AI's potential to enhance human productivity, but at the same time to carve its own life free of human control,- an important consideration towards AI's long-term sustainability should be its ethical goals and use.

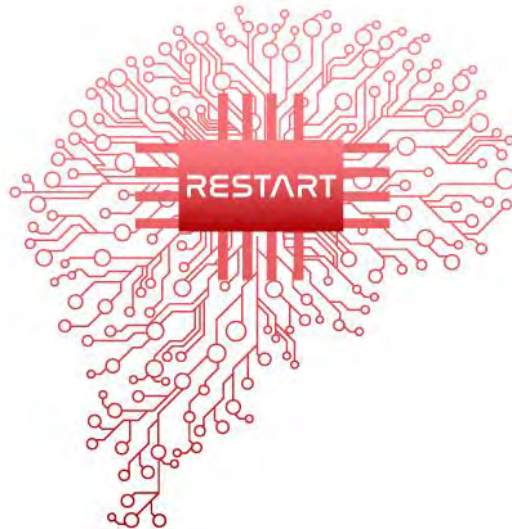
### 2.1 Key Considerations for Setting Ethical Goals and Use of AI: the RESTART Framework

Ethics can be an abstract and all-encompassing theme, therefore we tried to narrow it down to the most important principles and values when it comes to AI development and usage. In the process, we created an easy-to-remember framework based on the RESTART acronym to provide preliminary guidance for sustainable implementation of AI solutions:

- a. **Restrainability:** at all times AI should ensure that humans maintain their freedom of choice and a “*legal sovereign*” status. In other words, development & use of AI should be restrained within the limits imposed by humans, be it for how they take decisions or for what they perceive as being allowed. Humans should act as the ultimate guardians against uncontrolled expansion of AI, when and if needed. Without restrainability, AI risks becoming autocratic.
- b. **Effectiveness:** Given its core task of processing huge amounts of data, AI must ensure optimal use of resources/infrastructure (e.g. energy consumption). According to a [2021 study](#), AI models can consume more than 1 GWh of energy just to be trained, which can [translate](#) into millions of dollars in electricity costs alone. More on AI's effectiveness in resource utilization is covered later in this report. Without effectiveness, AI will not be sustainable.
- c. **Security:** needless to say, that any AI model/algorithm should pay special attention to the way the data it uses will be protected. Handling PII (Personal Identifiable Information) is particularly well regulated around the world as 134 out of 194 countries have put legislation in place to ensure data protection and data privacy (e.g. [GDPR](#) in EU, [APPI](#) in Japan etc.).
- d. **Transparency:** one of the most important characteristics of an AI model/algorithm should be that it is explainable and auditable. This means anyone with a legitimate interest to learn how the model has been created, trained, and deployed should be able to receive such information. At the other end of “transparency” should be a clear framework of who *cannot* see the data and why (e.g. cyber criminals, violation of human rights etc.) and how results were obtained (i.e. explainable AI).
- e. **Accessibility:** Democratizing contribution of the general public to an AI model creation might seem like a “nice-to-have” technical characteristic. However, from an ethical point of view, it is of utmost importance that AI is opened up for anyone interested to contribute independently from their income and technological knowledge.
- f. **Representativity:** There are almost 8 billion people in the world, who speak 7.000 languages and produce daily almost 1.000 Petabytes of data. AI should reflect such

diversity and inclusion in terms of its dataset composition, research questions / hypotheses and inference environments. Without representativity, data will be of low quality and so will the AI built on top of it (e.g., garbage in - garbage out). This, by the way, is a problem many data & analytics fields seem to have, for example in [healthcare](#).

- g. **Trust:** any new technology that uses sophisticated processes to transform our personal data into insights that shape our decision-making needs to be trusted first. In the context of AI, trust can be recognized in users' confidence that models have been built thoroughly, that bias has been controlled/eliminated, and that results are correct and reliable.



We ran a survey, asking CVA members and associated networks which of the above ethical considerations they think are the most important when it comes to the use of AI (up to 3 choices). Based on 66 answers, here are the results:

1. Transparency - 62%
2. Trust - 59%
3. Security - 59%
4. Restrainability -50%
5. Representativity -38%
6. Effectiveness -23%
7. Accessibility -17%

Over the longer term, considerations such as representativity, effectiveness and accessibility will become critical as AI evolves in its lifecycle. To test the completeness of the RESTART framework, we asked ChatGPT on the same matter and 8 ethical considerations were returned: Fairness & Bias, Privacy, Transparency, Accountability, Safety & Security, Human Control, Social Impact, Ethical Governance. Positively, there is a significant overlap between humans and what has been inferred by AI.

## 2.2 How Can Blockchain Technology Support an Ethical Use of AI

Using our RESTART framework above, we introduce a few examples of how blockchain technology (and its several prominent use cases) can support an ethical use of AI. Many other areas of complementarity are being proposed later in this report. A fine line exists between the three main themes of this report: ethical, green democratic AI. Therefore, we limit our recommendations to the main ones:

### (1) Transparency & trust

Transactions run on a public blockchain are executed through smart contracts which are visible on its ledger: anyone can see components of their respective transactions, such as the parties (i.e. addresses), time of execution, block validators or other details. This means that if an AI model or AI-powered application were to be developed on a public blockchain, anyone could theoretically start an audit trail to test, for example, the validity of a data source (e.g. identify deep fake in data sources) or the authenticity of the LLM used. Blockchain offers the opportunity to bring traceability and understandability to AI and help to overcome the black box problem of AI (i.e. not knowing how the decision process of AI is taking place).

### (2) Restrainability and security through distributed & balanced power

Two major characteristics of blockchain make it particularly useful in the quest to keep AI within the ultimate control of humans, yet outside of the purview of a select few: a decentralized network of validators and advanced applications of game theory. The former can ensure better filtering of AI input and output (e.g. identify deep fakes, eliminating or not approving their release). The latter can ensure that bad actors are punished and that no one becomes too dominant in data ownership (a recurring pattern in Web 2.0).

### (3) Representativity with inclusion of new, blockchain-native data sources

Due to its ethos and inherent characteristics, blockchain has been increasingly used by populations or in geographic regions which are generally under-represented in western, English-speaking datasets currently used by AI models. Think of Latin American or African families who use blockchain for remittances outside of the traditional banking system. Or villagers in South East Asia who play blockchain-based games to earn money and lift up from poverty. These new data sources, which are native to the blockchain world, are slowly entering the big data lakes and bringing a more varied and representative view of culture, ethnicity, gender, belief systems and needs.

In our survey, the CVA members and community at large concluded that transparency (61% of votes), trust (54%) and security (44%) are the 3 most important areas where blockchain, as a technology layer can help AI, as a data layer, to achieve its goals ethically and sustainably.

## 2.3 Use Case: Pharmaceutical/Healthcare Industry

Pharmaceutical industry has always been a **data-driven sector**. In order for one medicinal product / drug to hit the market [approximately 5 million molecules](#) had to be researched and dropped, and roughly [2.5 billion USD](#) spent in the process. And once a drug is on the market, another several hundred million USD are spent to collect real-world evidence of how it actually performs in patients, outside of controlled clinical trials. In addition, with the advent of non-medicinal interventions to support the drug (such as health monitoring devices, self-management apps for

patients, and decision-making support tools for doctors) a new range of data emerges for collection and processing in the pharmaceutical space.

AI has entered the industry from the back door, but it's quietly gaining traction and visibility. In R&D, AI can accelerate drug discovery processes, identify eligible patients for trials, and optimize clinical trial operations. In the commercial / downstream space, some of the common use cases for AI are algorithms to diagnose rare diseases or predict disease progression, decision support tools for doctors to make the best treatment choice for their patients, or algorithms trained in Customer Relationship Management (CRM) data to provide pharma representatives insights for next best action with their customers.

However, the pharmaceutical industry is also one of the most **regulated**, and thus risk-aware sectors out there. Letting machines access sensitive health data and making recommendations that can be life-saving (or threatening) for patients is surely a high risk-area in this industry. As a consequence, many pharma companies have developed frameworks for the ethical use of AI.

**Specific ethical considerations for AI used in medical/clinical care**

Many pharmaceutical / healthcare providers ground their ethical considerations to use AI models in two established strategies: how they pursue data, digital and technology innovation and what they pledged in their Sustainable Development Plans for [SDGs](#). Using our RESTART framework, we combined the public information available in annual reports and press releases into the table below.

Overall, what seems to be very important in the pharmaceutical / healthcare domain is that Health Care Professionals (HCPs) remain in control of their medical / clinical decision-making and that patients are well aware of and protected against the risks of AI. If all required safety nets are in place, the use of AI could actually improve the quality of data modelling and accelerate progress in medical care.

<b>RESTART Attribute</b>	<b>Support of AI and Blockchain</b>
<b>Restrainability</b>	<ul style="list-style-type: none"> <li>- HCPs are the ultimate decision-makers, AI provides support</li> <li>- Patients should be informed of AI limitations</li> <li>- Patients are encouraged to discuss AI findings with their HCP</li> </ul>
<b>Effectiveness</b>	<ul style="list-style-type: none"> <li>- AI models should use minimal energy for data processing</li> <li>- AI model supports net-zero emissions pledge in healthcare</li> </ul>
<b>Security</b>	<ul style="list-style-type: none"> <li>- Secure collection, storage and transfer of patient data</li> <li>- Limit the use and sharing of patient data to intended purpose</li> <li>- Ensure highest privacy levels for patient data used in AI</li> </ul>
<b>Transparency</b>	<ul style="list-style-type: none"> <li>- AI risks are explained to patients, HCPs, and other stakeholders</li> <li>- AI model dev't needs to be documented &amp; auditable</li> <li>- AI data governance and permission levels are defined</li> </ul>
<b>Accessibility</b>	<ul style="list-style-type: none"> <li>- Open-source code should be used as much as possible</li> <li>- AI models peer-reviewed for scientific accuracy</li> </ul>
<b>Representativity</b>	<ul style="list-style-type: none"> <li>- Data sources are varied and inclusive in terms of age, gender, race, ethnicity and social determinants of health</li> </ul>

### Trust

- Best ML & software engineering practices used
- Independent tests on similar user groups yield same results
- Clinical trials demonstrate safety & efficacy of the AI system

### Examples of AI-driven, blockchain-based applications in medical/clinical care

Blockchain technology is decentralized, trustless, immutable, and well-encrypted, which makes it an ideal candidate to support AI-driven models and applications for medical/clinical care. We present a few application domains where blockchain can help the ethical use of AI.

One group of applications are **AI algorithms to diagnose diseases or improve disease management**. Such applications are usually decision-support tools for healthcare professionals to decide on the right diagnosis or treatment regimen for a specific patient. Think of [IBM Watson Health](#) (as an early prominent example) or the more recent work at [Hadley Labs](#) around community-driven AI models to improve COVID-19 diagnosis, treatment of dermatological / skin diseases and research in open genomics. Another group of applications are the ones supporting **decentralised medical data storage & sharing** such as Harvard Medical School startup [Nebula Genomics](#), which uses [blockchain](#) to store data from users' genetic test kits and [partnered](#) with [Longgenesis](#) to use AI to run life data economics research on their combined datasets. [Patientory](#), [E-HCert](#) and [Digipharm](#) are other examples of blockchain in healthcare which enable patients to control their own data as they participate in clinical trials or value-based healthcare projects and receive AI-generated insights in return. Last but not least, blockchain-based AI-driven platforms can **increase efficiency of drug research & development**. Some examples include [Insilico Medicine](#), which uses AI to create an entirely new AI-driven drug discovery pipeline (with early successes in COVID-19 and fibrosis indications) and [Smart Omix](#), a decentralised blockchain-based research platform helping researchers prototype, revise and launch mobile studies as well as collect patient data via wearable devices.

Concluding this chapter, we found [the words](#) of Garri Zmudze, managing partner at LongeVC, as highly illustrative of the **sympiotic relationship between AI and blockchain** when it comes to sustainability in healthcare / pharmaceutical industry: *“Without blockchain, artificial intelligence lacks the ethically sourced and protected biomedical data it needs to find new solutions. Without artificial intelligence, the vast amounts of data protected by blockchain remain secure but unusable for research. Progress happens when these innovations work together, just as critical public health initiatives of past decades succeeded thanks to the advent of the World Wide Web”..*

## 3. Green AI: Sustainable Use of Data Infrastructure

### 3.1 Introduction to AI's Energy Consumption and Carbon Emissions

AI is rapidly transforming various industries, from healthcare to finance to transportation, with its ability to automate and improve decision-making processes. However, this advancement comes at a cost - the **significant carbon footprint of AI**. The energy consumption of AI has become a growing concern, as it requires massive amounts of energy to train and run complex models. According to a 2019 [report](#) by University of Massachusetts, Amherst, training a single AI model can emit as much carbon as 5 cars over their entire lifetime, more than 300 tons of carbon dioxide equivalent. Different solutions are being developed for AI solutions or computer science in general (e.g. [Green Software Foundation](#)) to develop efficient coding standards that limit the number of required computations.

#### Common carbon footprint benchmarks

in lbs of CO2 equivalent

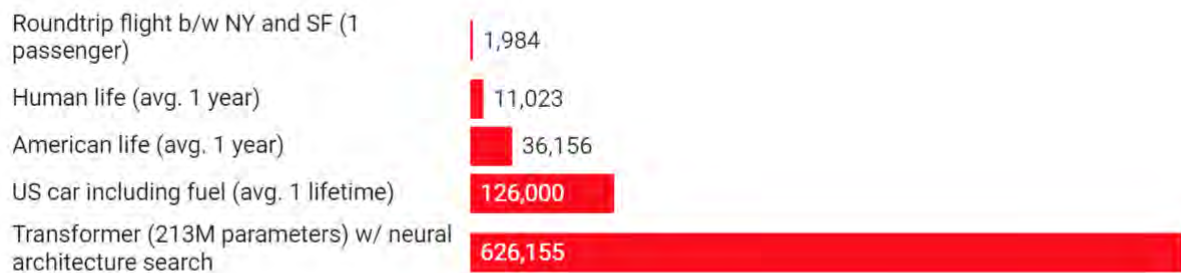


Chart: MIT Technology Review • Source: Strubell et al. • Created with Datawrapper

AI models require a lot of energy to learn and improve their accuracy. The **training process** involves large amounts of data and complex calculations, which are usually performed on powerful computers or specialized chips known as Graphics Processing Units (GPUs) or other accelerators. These devices consume a considerable amount of energy and generate heat, which further increases their energy consumption. As AI applications become more widespread, the energy demand and carbon emissions of AI are expected to grow significantly.

#### What can be done?

Researchers are working on various techniques to reduce the energy consumption of AI, one of which is the **optimization of the computation process**. For instance, researchers from MIT and IBM Research have developed a technique that reduces the energy consumption of DL. The technique involves selectively ignoring calculations that have a minimal impact on the final output. This leads to significant energy savings without affecting the accuracy of the model. Moreover, another technique involves developing energy-efficient hardware, such as Field-Programmable Gate Arrays (FPGAs) or Application-Specific Integrated Circuits (ASICs), which can perform AI computations more efficiently than traditional CPUs or GPUs.

However, reducing the carbon footprint of AI also requires a shift towards **sustainable energy sources**. For instance, Google has [pledged](#) to use 100% renewable energy for its global operations, including its data centers, to reduce its carbon footprint. Other tech companies, including Microsoft and Amazon, are also investing in renewable energy sources, such as wind and solar power, to power their operations. This shift towards renewable energy can also benefit smaller organizations that use AI by enabling them to offset their carbon emissions and promote a greener environment.

AI's energy consumption and carbon emissions are becoming a growing concern, as its applications become more widespread. Researchers and tech companies are working towards developing techniques and solutions to reduce the environmental impact of AI. By optimising the computation process, developing energy-efficient hardware, and shifting towards renewable energy sources the carbon footprint of AI can be significantly reduced.

### How big is the problem?

The carbon footprint of AI is becoming clearer as researchers and companies gain a better understanding of its environmental impact. New findings from OpenAI suggest that the energy efficiency of AI models is improving rapidly, with energy use doubling every 2.4 years, compared to the computational power doubling every 3.4 months. However, AI's total energy consumption is still increasing due to the rapid growth in demand for AI services.

To put things into perspective, Hugging Face [reports](#) that BLOOM's training led to 25 tons of CO<sub>2</sub> emissions, which doubled to 50 tons when considering manufacturing, computing infrastructure, and energy for running the model. BLOOM, trained on a French nuclear-powered supercomputer, has lower emissions than other LLMs of the same size trained in areas relying on fossil fuels. After launch, BLOOM emitted around 19 kg of CO<sub>2</sub> per day, equivalent to driving an average new car for 54 miles. OpenAI's GPT-3 and Meta's OPT were estimated to emit over 500 and 75 tons of CO<sub>2</sub>, respectively, during training. GPT-3's high emissions are partly due to older, less efficient hardware. However, accurate figures are uncertain as there's no standardised way to measure CO<sub>2</sub> emissions, with estimates based on external data or limited information from the companies. A [study](#) found that training an off-the-shelf AI language-processing system generated almost a ton of carbon emissions, equivalent to a roundtrip flight between New York and San Francisco for one person. Building and training the AI system from scratch can produce up to 35 tons of emissions, depending on the power source, which is twice the amount an average American exhales over their lifetime. In the future, the increase in the usage of AI models could lead to an exponential increase in carbon emissions.

<b>Consumption</b>	<b>CO<sub>2</sub>e (lbs)</b>
Air travel, 1 passenger, NY↔SF	1984
Human life, avg, 1 year	11,023
American life, avg, 1 year	36,156
Car, avg incl. fuel, 1 lifetime	126,000
<b>Training one model (GPU)</b>	
NLP pipeline (parsing, SRL)	39
w/ tuning & experimentation	78,468
Transformer (big)	192
w/ neural architecture search	626,155

Table 1: Estimated CO<sub>2</sub> emissions from training common NLP models, compared to familiar consumption.<sup>1</sup>

Source: <https://arxiv.org/pdf/1906.02243.pdf>

## 3.2 Towards a Sustainable AI Infrastructure

### **Sustainable high-performance computing**

[DeepSquare](#), a Zug based project and CVA member, is dedicated to integrating sustainability and mitigate the environmental impact of computing resources. Their vision encompasses the integration of cutting-edge technologies to minimize electrical consumption by leveraging renewable energy sources and new cooling approaches. Additionally, while DeepSquare's primary focus is not infrastructure deployment, their key mission lies in democratizing access to supercomputing resources. They achieve this by building a platform that aggregates underutilized compute resources, making them readily available to end users on-demand with an intuitive user interface. Nevertheless, the team has gone a step further by developing a blueprint for sustainable clusters, enabling others to adopt eco-friendly practices when it comes to their supercomputing infrastructure. This innovative approach paves the way for a more sustainable computing landscape, demonstrating their commitment to addressing environmental concerns while empowering users with unprecedented computing capabilities.

The company promotes Immersion Cooling, a method that involves submerging electronic devices in a thermally conductive and electrically resistant liquid that is 1.200 times more effective at capturing heat than air. The heat collected through immersion cooling can be efficiently exchanged using a straightforward liquid-to-liquid heat exchanger. This recovered heat can then be repurposed for heating applications or utilised in industrial processes. Even though the project is focused on delivering a platform that seamlessly interconnects users with a grid of distributed supercomputing resources, they have deployed two PoC of High-Performance Computing (HPC) clusters in Switzerland.

This is a demonstration that sustainable HPC is possible. For example, the cluster in Basel is placed in residential buildings and is connected to the existing heating system. This pilot project proves that providing heat to a residential building from the “waste” heat generated by HPC clusters can be established as a standard in Smart Cities. The system developed in a [pilot project](#) executed in partnership with IBW (Industrielle Werke Basel) is currently able to produce approximately 5 kW of heat supply to be used in a residential building in Basel – cutting the fossil fuel consumption of the 3-story townhouse, in an old building standard, by half.

### **Blockchain-based solutions to carbon offsetting**

Regarding blockchain, different methodologies and tools are being developed to calculate its carbon footprint, particularly considering the significant energy requirement for the consensus process in Bitcoin, with a carbon footprint of several hundred kgs of CO<sub>2</sub> for transactions. The amount is variable but comparable to 1 million Visa transactions. [ImpactScope](#), a Geneva-based CVA member, has been developing methodologies and tools to calculate the carbon footprint of each transaction for the main blockchains. As what is not measured, cannot be managed.

The ImpactScope tools allow for calculating carbon emissions associated with each transaction or wallet. Depending on the type of blockchain and the public data available, different methodologies have been created to perform the task. For example, by calculating the carbon emissions associated with each wallet based on the count of transactions. Similarly, by allocating carbon emissions depending on the transaction fees paid for each transaction out of total transaction fees paid in the blockchain. Real-time data about energy consumption of Bitcoin, can

be obtained, for example from sources such as the [Cambridge Bitcoin Energy Consumption Index](#) or the [Bitcoin Energy Consumption Index](#). It is expected that similar tools will have to be developed to increase the ability to understand and measure the carbon footprint of different AI applications.

### 3.3 How Can Blockchain Technology Help a Green AI

Several articles suggest that blockchain technology can help make AI more sustainable by reducing its carbon footprint and enabling transparency and accountability in the use of energy resources. As mentioned before, blockchain is a distributed ledger technology that allows secure and transparent tracking of data and transactions, making it an ideal match for AI. Here are a few areas where blockchain technology can help:

#### **(1) Blockchain-based energy marketplaces**

According to a study published in the Journal of Cleaner Production, blockchain can facilitate the implementation of green algorithms that prioritise energy-efficient computing and reduce the environmental impact of AI. This can be achieved by creating a [blockchain-based energy marketplace](#) that allows users to trade energy resources in real time and incentivizes the use of renewable energy sources.

#### **(2) Tracking energy usage and emissions**

An article from [Forbes](#) highlights the potential of AI and blockchain in achieving sustainability goals. The combination of AI and blockchain can provide real-time data on energy consumption, emissions, and resource usage, enabling organisations to make informed decisions that reduce their carbon footprint. Moreover, blockchain can ensure the transparency and accountability of data and transactions, enabling stakeholders to track the use of energy resources and verify their sustainability credentials.

#### **(3) Decentralized energy management**

OpenMind [proposes](#) the use of blockchain and AI to create a decentralised energy system that allows individuals and communities to manage their energy resources and reduce their dependence on centralised energy providers. The system relies on AI-powered energy management systems that optimise energy usage based on individual needs and preferences, while blockchain ensures secure and transparent tracking of energy transactions. DZone [explains](#) how blockchain can transform AI by enabling the secure and transparent sharing of data and models across different organisations and stakeholders. This can facilitate collaboration and innovation in the development of sustainable AI solutions, while ensuring the protection of data privacy and security.

### 3.4 Use Case: Blockchain-Based Carbon Offsetting Industry

Reduction of carbon emissions is a priority required to limit the increase of the temperature of the earth on the planet by 1.5 degrees Celsius. To reach such an objective, an increasing number of initiatives are being implemented to reduce carbon emissions. Among them, the most significant initiative concerns carbon offsetting aiming at supporting companies to reduce their carbon footprint emissions by investing in projects that reduce or store CO<sub>2</sub>.

Blockchain can support the process of CO<sub>2</sub> offsetting, given the qualities of traceability, transparency and trust that it can provide. AI has the potential to enhance the qualities of the

blockchain to perform such processes and create financial and sustainable value. Using the RESTART framework, the following requirements have been identified for the carbon offsetting industry as well as opportunities associated with the use of blockchain and AI.

<b>RESTART attribute</b>	<b>Support of AI and blockchain</b>
<b>Restrainability</b>	<ul style="list-style-type: none"> <li>- Ability to emit carbon credits limited to projects that respect qualitative standard</li> <li>- AI supports the identification of suitable areas to maximize CO2 sequestration potential</li> <li>- Blockchain for audit trail of decision-making process</li> </ul>
<b>Effectiveness</b>	<ul style="list-style-type: none"> <li>- AI suggesting resource management strategy to minimize CO2 emissions</li> <li>- Smart contracts send red flags if required conditions are not met</li> </ul>
<b>Security</b>	<ul style="list-style-type: none"> <li>- AI identifying security breaches for unusual patterns</li> <li>- Smart contracts automatically enforce remediation</li> <li>- Blockchain infrastructure easing remediation</li> </ul>
<b>Transparency</b>	<ul style="list-style-type: none"> <li>- Blockchain visible to the public (e.g. reforestation) with data modified only by pre-determined stakeholders</li> <li>- AI support in reforestation process built with explainable AI principles</li> </ul>
<b>Accessibility</b>	<ul style="list-style-type: none"> <li>- Technological solutions used should not limit the use to experts</li> </ul>
<b>Representativity</b>	<ul style="list-style-type: none"> <li>- Carbon offset products with a broad variety in geography and type of products</li> <li>- Blockchain maintains official records of offsetting projects and AI proposes ideal mix of projects to improve biodiversity</li> </ul>
<b>Trust</b>	<ul style="list-style-type: none"> <li>- Blockchain as the single source of truth</li> <li>- AI proposing tokenomics models leading to the desired behaviour</li> </ul>

## 4 / Open-source AI: Democratizing the Creation of AI Models

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### 4.1 Benefits of Democratizing AI Models

AI has traditionally been inaccessible to many due to its complexity and cost. Democratizing AI is about making it accessible and affordable to a broader range of people and organizations, enabling them to benefit from its capabilities. **Open-sourcing pre-trained AI models** contribute to sustainability by reducing duplicated efforts and promoting resource sharing. By providing access to existing models, researchers and developers can build upon them while saving time, effort, and computing resources. This democratizes access to AI technology and reduces the overall energy consumption associated with training new models. Open-source models also encourage collaboration, allowing the AI community to improve model efficiency and optimize performance.

Sharing pre-trained models fosters transparency and the adoption of best practices for sustainable AI development. The AI community can analyze, assess, and share methods for environmentally friendly AI, pushing the field towards more sustainable solutions. Additionally, open-source models enable smaller organizations and academic institutions to access advanced AI models without expensive hardware or extensive training processes, which enables more democratized access to knowledge. By openly sharing models and techniques, valuable insights and best practices can be disseminated, leading to more efficient and sustainable AI implementations.

Lastly, open-source pre-trained models often require less training time to fine-tune for specific tasks, reducing energy consumption and carbon emissions. Open source AI models break down barriers to knowledge by making cutting-edge AI technologies accessible to a wider audience. This democratization ensures that individuals and organizations, regardless of their financial or resource constraints, can benefit from the latest advancements in AI. By leveling the playing field, open source models enable a more inclusive and diverse community of developers and researchers to contribute to sustainable AI solutions. By openly sharing code and documentation, open source initiatives enable learners to gain hands-on experience and deepen their understanding of sustainable AI practices. This knowledge transfer contributes to building a skilled workforce that can drive sustainable AI development in the long term.

Generative AI models, such as those used for NLP, image synthesis, or music generation, can particularly benefit from open-sourcing pre-trained models from a sustainability perspective. These models are often computationally demanding and require significant training time and resources, leading to higher energy consumption and carbon emissions.

## 4.2 How to Democratize AI Models

Here are a few ways in which AI models could be made more open-source and accessible:

### (1) Pre-trained AI models

One way to democratize AI is by providing access to pre-trained models. These models have been trained on large datasets and can perform tasks such as image recognition, NLP, and speech recognition. Several organizations and projects have successfully democratized AI by providing access to pre-trained models. For example, [Hugging Face](#) has developed the popular Transformers library, which provides access to numerous pre-trained models for natural language processing tasks. These models, such as BERT, GPT-3, and T5, can be fine-tuned for various applications, including sentiment analysis, summarization, and translation. [NVIDIA's NGC](#) is a hub for GPU-optimized software, including pre-trained models for image recognition, NLP, and speech recognition. They offer models such as EfficientNet for image classification and BERT for NLP, which can be fine-tuned and deployed across industries. [TensorFlow Hub](#) is a repository of reusable ML models developed by Google. It offers a wide range of pre-trained models for image recognition, text classification, and other tasks, making it easier for developers to integrate AI into their applications.

### (2) Cloud-based platforms

Cloud-based platforms provide a cost-effective way for organizations to build and deploy AI applications. These platforms provide tools for data preparation, model training, and deployment, making it easier for non-experts to build AI applications. For example, iSquare platform, built by Swiss AI pioneer [SquareFactory](#), offers specialized development, consulting, and research services to help companies build AI models. They provide an intuitive and cost-effective platform for training these models. Furthermore, deploying models is made easy, quick, and affordable

through the iSquare SaaS platform. Another example is [Openfabric](#), harnessing the power of blockchain, advanced cryptography, and novel infrastructure to create a new foundation for AI apps, companies can be more efficient with their AI. By optimizing software layer, and combining it with sustainable compute platforms, such as DeepSquare's, companies can reach higher sustainability standards while championing AI solutions.

### **(3) Open-source tools**

Open-source tools like TensorFlow and [PyTorch](#) promote sustainability in AI by making it easier for researchers and developers to build and share models. With large and active communities contributing to their development, these tools become more accessible and powerful. This collaborative approach reduces the need for redundant work and the consumption of resources, as developers can leverage pre-existing models and tools.

### **(4) AI education**

Another way to democratize AI is by providing education and training on AI. This can be done through online courses, workshops, and hackathons. The goal is to make AI more accessible to people from different backgrounds and skill levels.

### **(5) Fairness and transparency**

Finally, democratizing AI also means ensuring fairness and transparency in its use. This can be achieved by developing algorithms that are free from bias and by ensuring that AI systems are transparent in their decision-making process.

In conclusion, democratizing AI is about making it accessible and affordable to a broader range of people and organizations. By providing access to pre-trained models, cloud-based platforms, open-source tools, education and training, and ensuring fairness and transparency, AI can become a tool for everyone, not just a select few.

## **4.3 How Can blockchain Technology Help Democratize AI**

AI has the potential to revolutionize the world and improve our daily lives, but it is currently dominated by a small number of tech giants, making it inaccessible to most people. Blockchain, on the other hand, is a decentralized technology that can empower individuals and small organizations by democratizing access to data and eliminating the need for intermediaries. By combining blockchain and AI, a more democratic and equitable AI ecosystem can be created.

### **(1) Data ownership**

Currently, data is dominated by a few large corporations, which can afford to collect, store, and process large amounts of data. By using blockchain, data can be owned and controlled by individuals and small organizations, who can decide whether or not to share their data with others. This can make AI development more democratic, as it provides access to a wider range of data sources.

One example of democratizing data access using blockchain technology is Ocean Protocol. [Ocean Protocol](#) is an open-source, decentralized platform that enables individuals and organizations to share, monetize, and collaborate on data and AI services. By providing a secure and transparent way for data providers and consumers to connect, it promotes a more equitable data ecosystem. This empowers smaller organizations and individuals to contribute and benefit from AI development.

Another example is [SingularityNET](#), an open-source, decentralized marketplace for AI services built on top of the Ethereum blockchain. It allows AI developers to monetize their models and algorithms, while users can access and utilize these AI services. By creating a decentralized network of AI service providers, SingularityNET enables more democratic access to AI resources and fosters collaboration among developers.

## **(2) Data privacy**

Data privacy is a major concern in AI development, as large corporations often collect and use personal data without the owner's consent. Blockchain can help address this issue by providing a decentralized platform for data storage and processing, where users have control over their own data and can decide who can access it.

[Oasis Labs](#) is a privacy-focused blockchain platform that enables the development of scalable and secure applications. Their platform leverages secure computing techniques, allowing users to maintain control over their data while still enabling data to be used for AI development. By providing privacy-preserving smart contracts, Oasis Labs ensures data privacy and control for users in the AI ecosystem. [Fetch.ai](#) is a decentralized platform that combines blockchain and AI to create an intelligent infrastructure for data sharing and processing. Their Autonomous Economic Agents (AEAs) are capable of securely sharing and processing data without compromising privacy. These AEAs can collaborate, negotiate, and make decisions on behalf of their users, ensuring that data privacy is maintained throughout the AI development process.

## **(3) Smart contracts**

Blockchain can be used to implement smart contracts as are self-executing agreements that can automate processes and reduce the need for intermediaries. This can make AI development more efficient and cost-effective, as it eliminates the need for intermediaries and can speed up the development process.

## **(4) Decentralized marketplaces**

Decentralized marketplaces for AI development can be built on top of blockchain, where individuals and small organizations can buy and sell AI models, data, and services. This can make AI development more accessible and affordable to a wider range of people, as it provides a platform for smaller players to compete with larger corporations.

## **(5) Transparency**

Blockchain can provide a clear audit trail of data and AI models. This can help increase trust in AI, as users can verify the source and quality of the data and models used in AI development.

In conclusion, blockchain has the potential to democratize AI by providing a decentralized platform for data ownership, data privacy, smart contracts, decentralized marketplaces, and transparency. By combining blockchain and AI, a more democratic and equitable AI ecosystem can be created, where individuals and small organizations have greater access to data and can compete on a more level playing field with larger corporations.

## 5. Conclusion

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The work performed within the Sustainability Working Group (WG) at CVA allowed the identification of main opportunities and requirements associated with the possibility of leveraging AI and blockchain to create sustainable outcomes. Firstly, **open source AI** can be used by as many people as possible independently from their location, income or technological knowledge and not be concentrated in the hands of a minority. Secondly, there is a need to develop AI solutions where the output and outcomes are well thought out to **avoid unintended consequences**. The RESTART framework has been proposed in the working group to avoid such a problem. Finally, we identified the need to **consider the energy requirements of AI** solutions with the objective of creating efficient software and limiting e-waste generation.

For future developments, the **Sustainability WG at CVA is exploring how to move forward with the research** on the topic in different potential ways (e.g. publication of a paper or starting of an applied research project). With this objective in mind, different types of collaboration and partnerships are being considered.

## 6. Acknowledgments

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## 7. Compendium: CVA Members Active in AI and Blockchain

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As of June 2023, Crypto Valley Association had more than 200 corporate members. In order to create this compendium, we conducted a preliminary scan of the entire CVA membership database. We filtered for organizations that offer products and/or services at the intersection of blockchain and AI, with a second criterion of aiming for a sustainability-related goal, either now or in the future.

We are presenting our findings below, per category, with the hope that this compendium will give our readers a better sense of what is possible at the intersection of the three domains while also providing concrete examples from the CVA's own network. Please note that we have not conducted thorough due diligence on any of these companies, and we are not endorsing any of the products or services mentioned below. Our selection might be incomplete.

### **Blockchain analytics**

1. <https://www.chainalysis.com/>: is a blockchain data analytics and forensic investigation tool. Their AI-enriched data platform powers investigation, compliance, and risk management tools
2. <https://www.elliptic.co/>: is a crypto forensics and risk management startup. They recently partnered with MIT AI Lab to label blockchain data for better tracking of illicit usage
3. <https://santiment.net/>: uses AI algorithms to understand behaviours in blockchain / digital asset world based on social media, crowd sentiment and other on and off-chain indicators. Produces signals and context for traders and investors with both free and paid subscription plans
4. <https://whaleanalytica.com/>: uses AI algorithms to define fair market value of Web3.0 assets such as metaverse property, NFTs (non-fungible tokens) etc. Supports the activity of DAOs (decentralized autonomous organisations) and other investors in web 3.0 space

### **Data centers / infrastructure**

1. <https://www.bitkern.com/en/>: high-performance data centers based on AI and blockchain-technology to serve institutional clients including crypto miners. Their goal is to use surplus energy and utilize it for technological progress & increased efficiency
2. <https://deepsquare.io/>: a platform to seamlessly interconnect users with decentralized supercomputing resources. Sustainability is achieved through the use of renewable energy sources and making their services accessible to small businesses, researchers and academic institutions
3. <https://sesterce.com/>: data centers providing computing power to blockchain & AI industries. They focus on using 100% green energy and by shutting down energy consumption when not needed, they help stabilize the grid and reduce costs.

### **Gaming & Creative industries**

1. <https://www.augmento.com/>: is an image-to-AR generator app. The base product/package is free, and the company plans to introduce AI-enabled services in the future (such as AI/AR 3D modeling, AI driven personalization, advanced analytics etc.).
2. <https://dexgamelabs.swiss/>: Blockchain and AI technology-based gaming developed platform. The company has developed software that assists with next-generation decentralized game development. It has features for game exchange, esports gaming and more.
3. <https://www.legacynetwork.io/>: is a startup offering gamified personal development through AI and blockchain technology. The planned educational App aims to cover content for mindfulness, empathy and discipline as well as build a network of learners that can support each other grow.

### **Marketing & Financial services**

1. <https://www.profila.com/>: a platform where consumers can interact with brands and be paid for their attention in blockchain-native tokens. AI is used in different projects, such as Profila's [partnership](#) with University of Luzern to educate / support users with privacy-related questions.
2. <https://www.rubinstein-schmiedel.com/>: fintech company providing fully automated AI trading and investment services to professional investors in a range of asset classes including digital/crypto-assets, equities, commodities, etc.

### **Product and software development**

1. <https://www.bitstory.ai/>: provides AI-driven forecasting and modeling tools/algorithms to help businesses make data-driven decisions in areas such as manufacturing, IoT, business forecasting.
2. <https://www.superhow.com/>: a Lithuanian-based company that designs and develops technology products using emerging technologies, mostly blockchain and AI. Key research and prototype areas are transaction processing, e-health, digital identity protection, supply chain.
3. <https://impactscope.com/>: helps organizations deploy web3 tools to measure, verify and amplify their impact. ImpactScope uses AI tools to monitor and verify the impact created (e.g. identification of greenwashing).

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