IEMA Transforming the world to sustainability

IEMA Fellows Working Group on Disruptive Technologies & the Digital Economy

Thought Piece on Disruptive Technologies and Sustainability

Introduction

The world is undergoing immense change at an incredible pace. Climate change, population growth, threats to nature, resource concerns, and global development pressure, have all combined to create the ‘perfect storm of issues’[1]. Impacting on organisations, economic prosperity, communities, health and wellbeing, this perfect storm presents numerous risks and challenges for environment & sustainability professionals in supporting the transition to sustainability.

In parallel to this, the Fourth Industrial Revolution (4IR) is bringing an emerging fundamental shift in the way we live and work as a society; Much of which has yet to be understood and resolved. As disruptive technologies such as Artificial Intelligence (AI) are embedded by industries across the Internet of Things (IoT), data centres and cloud computing, they have the potential to lead to new business models, markets, products, and services.

This thought piece, the first in a planned series, has been drawn together by the IEMA Fellows Working Group on Disruptive Technologies & the Digital Economy. The document aims to demystify the landscape of disruptive technologies and their impact on the global transition to sustainability, and sends out a general call for action by environment and sustainability professionals, and the wider IEMA membership. To guide members towards the first steps they may take within their organisations in addressing this topic the thought piece is structured in 5 parts including:

1. Challenges for organisations;
2. The need for action;
3. Listing the technology;
4. Key actions for sustainability and environment professionals;
5. Annex A – Disruptive technologies.

1. Challenges for organisations

Many disruptive technologies present a challenge to traditional business models but also an opportunity for improved sustainability. By building greater understanding of emerging technologies, sustainability professionals will then have greater capacity to harness their impact to enable positive business transformations.

Taking the manufacturing industry as an example, the development of Additive Manufacturing, also known as 3D Printing, has been widely recognised as a transformative approach to industrial production that enables the creation of lighter, stronger parts and systems, with the potential to lower costs and be more energy efficient than conventional processes [2].

However, with the adoption of technology generally, e-waste has also continued to grow, rising from 49 million tonnes in 2016 to an estimated 60 million tons in 2021. Electronic devices which comprise toxic heavy metals like lead and mercury, can harm human health and the environment if uncontrolled at end of life. Combined with growing shortages of raw materials in the face of rising customer demand, and with research showing that mining copper and aluminium from ore costs 13 times more than recovering the metals through urban mining of e-waste, there is a strong case for enhanced e-recycling practices [3].

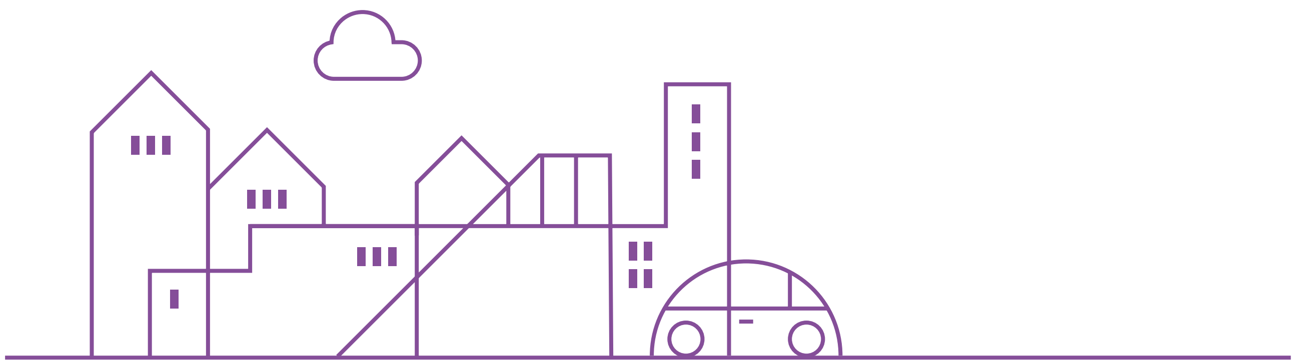
These imbalances are also apparent when considering the cognitive dissonance of the Information Communication Technology (ICT) sector which stands to play a crucial role in the field of Data Analytics for sustainability while continuing to suffer from the high carbon footprint of its data centres, despite ongoing efforts to correct these imbalances with renewable powered data centres [4]. As ICT companies such as BT work to move beyond these issues, virtualising data centres or opting for sustainable data centres in organisations (BT's centres use less energy and leverage free cooling for up to 95% of the year), this will help to drive energy efficiencies and carbon savings throughout organisations [5].

To resolve the sustainability challenge, environment and sustainability professionals urgently need to recognise that disruptive technonologies are the inevitable future. They need to avoid being left behind by working rapidly and collaboratively with all stakeholders to understand which disruptive technologies can best support transforming the world to sustainability.

Gaining this understanding may help to "open up" industries to technology solutions to achieve specific objectives such as carbon neutrality, so that exponential sustainable solutions can then be rolled out. A future IEMA communication in collaboration with IEMA policy networks will cover specific objectives and areas of focus in more detail.

The current challenges facing disruptive technologies are many and some are yet unknown, but they include:

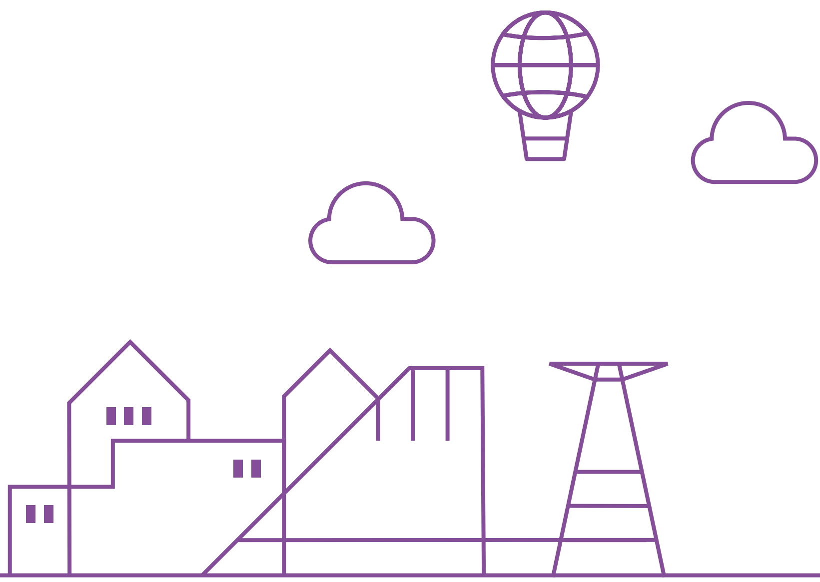
- Trust - We need to build trust in the technology and resolve issues of AI bias, ensuring data protection and digital ethics. To ensure the adoption of these technologies, they will need to be robust, secure and explainable, as public perception and understanding will be paramount;
- Accountability - With public trust behind these technologies, we will also require ongoing evaluation, industry standards, benchmarking and the wider regulation of disruptive technologies to ensure and maintain a high degree of performance and accountability;
- Systems change - We need to move towards a more open and collaborative information exchange model. However, the capacity and appetite needed for rolling out these information exchange technologies in a way that leaves no one behind will be considerable;
- Tech landscape planning - Multi-stakeholder engagement will be needed between finance professionals, sustainability professionals, technology companies and end-users if we are to ensure the setup of a viable long-term transition to a sustainable digital economy;
- Training - Training and investing in skills is needed to foster diversity of thinking, to enable employees to think differently and allow innovation to thrive particularly as these technologies change. It will allow organisations to keep up with available technologies and improve sustainability via behaviour change of key members of its workforce, such as engineers and programmers.



2. The need for action

Around the world, breakthrough innovators are already creating positive impact at scale by combining new mindsets, technologies and sustainable business models [6]. However, as we noted in the challenges above, these opportunities are also accompanied by a number of environmental and health risks.

The members of the IEMA Fellows Working Group on Disruptive Technologies & the Digital Economy are not technology experts, but they understand the value of disruptive technologies and the growing impact they are having on the economy, society and the environment. For this reason, they believe it is essential for sustainability professionals to be part of the debate to assess which technologies can best support the world's transformation to sustainability, and conversely, to identify sustainability issues associated with emerging disruptive technologies.



3. Listing the technology

Annex A highlights some of the 4IR technologies relevant for environment and sustainability professionals.

The technologies listed in the annex are often considered forming part of a group of fundamental or core technologies (e.g. AI, Internet of Things, Distributed Ledger Technologies and Big Data – therein marked as "Core Tech") but can be combined to form other technologies. Autonomous Vehicles for example, integrates several of these core technologies (e.g. AI, IoT and Big Data) and is listed here with further examples to help highlight the relevance of disruptive technologies to professionals. More comprehensive categorisations of disruptive technologies which go beyond the scope of this thought piece have already been set out by other leading organisations on this topic, be they Gartner [7] or PwC [8]. We therefore invite the reader to access these should they wish to find out more information about the technologies themselves.

Key values to abide by

Recent cases, highlighted in the media, have emphasised concern for the lack of values applied in development and implementation of technology.

For example, claims regarding the lack of ethnic diversity in datasets have led to reports that facial reconigition technology is unable to cope with black and ethnic minority faces, having been trained on predominantly white faces [9].

Avoiding this type of bias being "fed forward" into the use of technology means that a set of key values should be kept in in mind while implementing the key actions laid out in the next section.

They include the need to:

- Retain the spirit of collaboration to remain open and learn from others;
- Be mindful not to discriminate, when engaging with the technology, against someone because of age, disability, gender reassignment, marriage and civil partnership, pregnancy and maternity, race, religion or belief, sex or sexual orientation[10];
- Retain a high level of quality in data and process.

4. Key actions for sustainability and environment professionals

To enable the transformation to sustainability, IEMA has identified a list of core ingredients which include leadership, collaboration, innovation, systems thinking and skills.

With these core ingredients in mind, IEMA has set out some key actions that sustainability professionals, or their organisations, should look to integrate to ensure disruptive technologies can support a transformation towards sustainability.

These key actions include:

1. **Thinking about your business strategy (key market drivers in your industry and where the main opportunities and risks lie).** Assessing the business landscape will enable you to better understand how to disrupt yourself to remain ahead of the competition, and the impact that technologies could have in this regard to future proof and develop resilience to change.

2. **Developing a clear short term plan for upskilling management and board level professionals with enhanced technology and sustainability skills to help integrate relevant disruptive technologies & new collaborative business models within your organisation.** The systems and behavioural changes that are required within organisations, imply that professionals will need to rethink how they carry out their roles. Data collected during impact assessments for example, may need to be shared from one project to the next instead of remaining quarantined, to promote transition to sustainability at a wider scale. As technology evolves, professionals (and in particular audit qualified professionals) will therefore need to engage with IEMA and the IEMA Sustainability Skills Map [11], to assess what aspects of their work puts them in the "at risk" space and identify the upskilling they require in terms of technology and sustainability training to ensure they stay ahead of the curve.

3. **Creating or participating in forums with other stakeholders and technology providers to learn, discuss and explore new opportunities offered by disruptive technologies and innovators within your industry/sector.** Such forums are a chance to assess the impact of given technologies on productivity, access to services and markets, sustainable resource management, and overall resilience to issues such as climate change [12].

4. **Using your sustainability expertise to engage in multi-stakeholder debates with technology companies, finance professionals and your government representatives to ensure the setup of a suitable infrastructure for a sustainable digital economy.** Certain technologies are currently excluding key geographical marketing. It is essential that we make product passports and digital traceability through Distributed Ledger Technology and make storage platforms more widely available and affordable so that they can include organisations in developing countries. The United Nations confirm that currently subsidiaries of digital Multinational Enterprises (MNEs) are highly concentrated in developed countries, particularly the United States, whereas their presence in developing economies is marginal [13].

5. **Adopting a 'circular economy approach and whole systems thinking' when engaging in your organisation with 4IR and new technology.** To do so, you need to embed sustainability in the design phase of your work when engaging with technology (in line with ISO14001 environmental management system requirements), ensuring that you work across departments and organisations.

6. **Encouraging/investing in the use of data analytics and more open and collaborative cross sector data exchange models within your sector, and establishing the sustainability value of disruptive technologies.** New sources of data and analytical approaches, if applied responsibly, can support more efficient and evidence-based decision-making and can better measure progress towards sustainability. As we consider rebuilding the digital architecture of the way we do business, data analytics and data exchange will be integral to how we operate[14].

7. **Supporting a 'cyber security culture' that extends beyond information exchange when using technology.** The widescale adoption of disruptive technologies, mean that the cybersecurity culture should be expanded to enable the transition to sustainability. The cyber security culture should encourage the active support by organisations of collaborative technology initiatives that help to resolve the sustainability challenge, or adopt standards or regulations that support better performance and accountability.

This document was developed by the IEMA Fellows Working Group on Disruptive Technologies & the Digital Economy with significant editorial input from Marc Jourdan, IEMA Policy & Engagement Lead, and the IEMA Staff.

5. Annex A – Disruptive technologies

TECH	WHAT IS IT?
ARTIFICIAL INTELLIGENCE (AI) (CORE TECH)	AI applies "advanced analysis and logic-based techniques, including machine learning, to interpret events, support and automate decisions, and take action. Common definitions of AI focus on automation and, as a result, often fail to make clear the opportunities available to IT and organisations leaders. AI is technology that emulates human performance, typically by learning from it. It can augment humans, as it can classify information and make predictions faster and at higher volumes than humans can accomplish on their own" [15]. A direct example of its application in support of environmental sustainability is Microsoft's AI for Earth programme which puts Microsoft cloud and AI tools in the hands of individuals and organisations that are working to solve global environmental challenges. Some of the resources offered by the programme include the Land Cover Mapping API which leverages machine learning to provide high-resolution land cover information. Terrafuse, a partner organisation of AI for Earth, uses machine learning algorithms on the terrafuse.ai platform to create sophisticated climate-risk models. In partnership with Microsoft, terrafuse is combining historical data, existing wildfire simulations, and real-time satellite observations to create hyperlocal models of wildfire risk [16], an issue which is becoming more prevalent with climate change. Facing a limited amount of arable land, and a population that is expected to grow from 7.7 billion to nearly 10 billion by 2050, the agricultural sector faces the biggest challenge of producing enough food to eat, a challenge today but a potential crisis in the future. For this reason, AI is beginning to transform agriculture in important ways, including self-driving tractors that use GPS, satellite imagery, and AI solutions to plant more efficiently. As an example of this, Microsoft has partnered with the nonprofit International Crop Research Institute for Semi-Arid Tropics (ICRISAT) as part of AI for Earth to support continued development of AI solutions that focus on sustainable agriculture in developing parts of the world. The first pilot project carried out in India, led to the development of the AI Sowing App app which enable farmers to take advantage of the power of AI and rely on an App to increase yields by 30% more per hectare [17].

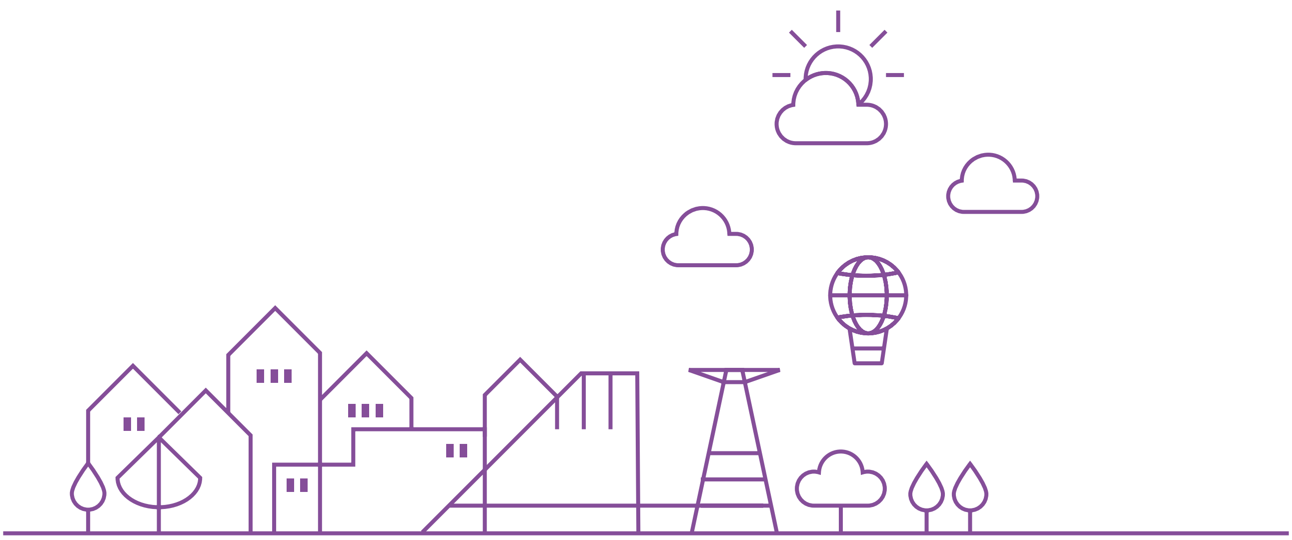
TECH	WHAT IS IT?
ADDITIVE MANUFACTURING (AM)	Additive manufacturing (AM) is fundamentally different from traditional manufacturing in that it is the closest to the 'bottom up' manufacturing process where a structure can be built into its designed shape using a 'layer-by-layer' approach rather than casting or forming by technologies such as forging or machining. AM is versatile, flexible, highly customisable and, as such, can suit most sectors of industrial production. Since the first patent granted in 1986 and the first 3D printing machine built in the late 1980s by 3D Systems, the market for AM industry grew significantly within the first decade ($1 billion US in 1997). AM has transitioned from rapid prototyping to functional prototyping. Today, it is used in all sectors of industries from space to toy to food, and represent a multi-billion dollar industry [18]. For sustainability professionals, AM has the potential to lower costs and be more resource and energy efficient than conventional processes. AM can allow the conversion of waste and by-products into products. Some material traditionally considered as waste can be upcycled to manufacture luxury products using AM. There are however limitations to what extent material can be recirculated due to quality and purity issues which could prevent recycling of the products when they reach their end-of-life. The greater the diversity in materials entering the recycling system then the greater the complexity of processes required during the recycling process, along with the potential for loss of value when materials cannot be separated. This highlights for the need for further research and development into AM technologies [19]. The main obstacle currently encountered in analysing the energy efficiency of AM is the variability of energy consumption between different 3D machines, which varies according to the materials, loads and patterns used. Research confirms that with comprehensive assessment methods based on sustainability metrics, this should help to assist the sustainable growth and innovation of AM, resulting in improved process results, minimised waste and environmental pollution [20].

TECH	WHAT IS IT?
AUTONOMOUS VEHICLES	An autonomous vehicle, also known as a driverless vehicle, can move and guide itself without human input. These vehicles can perceive what is going on in their surroundings and travel to different locations through a combination of sensors, cameras, radar and AI. Advanced control systems can interpret sensory information to detect obstacles and choose the most appropriate navigation path for the vehicle. Autonomous vehicles include unmanned aerial vehicles, also referred to as drones, which can be remotely controlled by working in conjunction with onboard sensors and GPS [21]. To help test and assess the impact of autonomous vehicles, Cranfield University has created a purpose built experimental facility for the rapid development of on and off highway, ground and airborne autonomous solutions, known as Multi User Environment for Autonomous Vehicle Innovation (MUEAVI). The facility includes vehicles, infrastructure, data, logistics, environment, sensors and their implementation and management. Working with clients including Nissan, or Jaguar Land Rover, MUEAVI helps to re-create urban and off road environments for the precise quantification of autonomous and semi-autonomous (ADAS equipped) vehicle performance. The facility also enables the recreation of real traffic situations faithfully in a controlled manner allowing rapid fault finding and systems development [22].
BIG DATA AND DATA ANALYTICS (CORE TECH)	Big data is high-volume, high-velocity and/or high-variety information assets that demand cost-effective, innovative forms of information processing that enable enhanced insight, decision making, and process automation which is made possible by fifth generation-enabled edge computing (otherwise known as 5G) [23]. Increasingly, "analytics" is used to describe statistical and mathematical data analysis that clusters, segments, scores and predicts what scenarios are most likely to happen. Whatever the use cases, analytics has moved deeper into the business vernacular. Analytics has garnered a growing interest from organisations and IT professionals looking to exploit huge mounds of internally generated and externally available data [24]. Big data analytics help to find patterns and generate insights from data otherwise unachievable by human means. Today, the entire data value chain from connected sensor networks to the dynamic management of data will soon be affected in 2020 by the anticipated worldwide commercial launch of 5G infrastructure.

TECH	WHAT IS IT?
BIG DATA AND DATA ANALYTICS (CORE TECH) continued...	Smart agriculture systems supported by 5G will play an important role in developing countries as populations grow and climate change continues to impact both arable and livestock faming. HD cameras attached to drones used to monitor crops across large farms or sensors placed in crop fields can help optimize growing and sustainable water management practices [25]. Despite faster connection speeds, there are anticipated infrastructure adaptation issues including an inevitable rise in infrastructure costs, as predicted by McKinsey [26]. For environment and sustainability professionals, this leaves open certain questions, such as whether current environmental research software and network applications which run on 3G infrastructure would run the risk of becoming outdated.
DISTRIBUTED LEDGER TECHNOLOGY (CORE TECH)	Distributed ledgers (known as a database that is consensually shared and synchronised across multiple sites, institutions or geographies) [27] use independent computers (referred to as nodes) to record, share and synchronize transactions in their respective electronic ledgers (instead of keeping data centralized as in a traditional ledger) [28]. One type of distributed ledger is blockchain. Gartner define blockchain as an expanding list of cryptographically signed, irrevocable transactional records shared by all participants in a network. Each record contains a time stamp and reference links to previous transactions. With this information, anyone with access rights can trace back a transactional event, at any point in its history, belonging to any participant. A blockchain is one architectural design of the broader concept of distributed ledgers. What this means is that blockchains promise transparent, tamper-proof and secure systems that can enable new business solutions, especially when combined with smart contracts. Within the energy sector, research indicates that blockchain technology could potentially help to enable the transition to future energy systems focused around three key principles: decarbonisation, decentralisation and digitalisation (thereby enabling the empowerment of consumers, pillars for both UK and EU policy). There are of course ongoing challenges facing the deployment of this technology, including the cost of information verification and data storage in continuously expanding ledgers [29]. Added to these hurdles, blockchain technologies can be disruptive for energy companies and face a large variety of challenges to achieve market penetration, including legal, regulatory and competition barriers. Despite these issues, the ability of blockchains to offer new solutions for empowering consumers and small renewable generators to play a more active role in the energy market, will continue to push further collaborations and trials, to fully assess whether the technology can reach its full potential and be adopted in the mainstream while supporting sustainability, both in the energy sector and in other industries [30].

TECH	WHAT IS IT?
IMMERSIVE TECHNOLOGY	Immersive technology is an integration of virtual content with the physical environment in a way that allows the user to engage naturally with the blended reality. In an immersive experience, the user accepts virtual elements of their environment as part of the whole, potentially becoming less conscious that those elements are not part of physical reality. **Immersive technologies include creations such as digital twins:** These are a virtual replication of some real-world object that connects to the object for information so that it can display its current status. An example of its application within the built environment, is the Digital Twin Hub (DT Hub). Created by the Centre for Digital Built Britain (CDBB) at Cambridge University, DT Hub is a collaborative web-enabled community for those who own, or who are developing, digital twins within the built environment. This development comes as infrastructure asset owners are increasingly looking to digital twins with aspirations of improving longer term commercial sustainability and resilience. The CDBB views that what distinguishes a digital twin from any other digital model is its connection to the physical twin. Based on data from the physical asset or system, a digital twin unlocks value principally by supporting improved decision making, which creates the opportunity for positive feedback into the physical twin. At the time of writing, the DT Hub steering group is looking to publish in the coming months the first set of agreed business values as part of its Digital Twin Roadmap. This will allow organisations looking to adopt or continue the development of Digital Twins to understand where the core value stems from in their models and what subsequent gains may look to be achieved [31]. **Other examples of immersive technologies include:** • *Virtual reality:* a digital environment that replaces the user's physical surroundings; • *Augmented reality:* digital content that is superimposed over a live stream of the physical environment; • *Mixed reality:* an integration of virtual content and the real-world environment that enables interaction among elements of both [32].

TECH	WHAT IS IT?
INTERNET OF THINGS (IOT) (CORE TECH)	"One of the three most impactful technological advancements we will see before 2030" (McKinsey, 2013 [33]) The Internet of things (IoT) is defined by the ITU as the global infrastructure for the information society, enabling advanced services by interconnecting (physical and virtual) things based on existing and evolving interoperable information and communication technologies [34]. IoT is therefore the concept of connecting any device with an on and off switch to the Internet (and/or to each other). In the consumer market, IoT technology is most synonymous with products pertaining to the concept of the "smart home", and can include everything from cellphones, coffee makers or even washing machines, providing access to information relating to these devices anywhere at any time [35].



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About IEMA

We are the worldwide alliance of environment and sustainability professionals. We believe there's a practical way to a bright future for everyone, and that our profession has a critical role to play.

Ours is an independent network of more than 15,000 people in over 100 countries, working together to make our businesses and organisations future-proof.

Belonging gives us each the knowledge, connections, recognition, support and opportunities we need to lead collective change, with IEMA's global sustainability standards as our benchmark.

By mobilising our expertise we will continue to challenge norms, influence governments, drive new kinds of enterprise, inspire communities and show how to achieve measurable change on a global scale. This is how we will realise our bold vision: transforming the world to sustainability.

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