SDG-13: Climate Action

15

Abstract

SDG-13, Climate Action, aims to adapt to climate change by mitigating adverse effects and keeping the temperature rise below 1.5° by the end of this century and prepare low-carbon development plans. Investing in adaptation is critical for limiting the adverse effects of climate change on human society. Every efficient policy for combating climate change, on the other hand, must decrease emissions to prevent future warming while also adapting to the unavoidable effects of climate change. This chapter presents the business models of 52 companies and use cases that employ emerging technologies and create value in SDG-13. We should highlight that one use case can be related to more than one SDG and it can make use of multiple emerging technologies.

Keywords

Sustainable development goals · Business models · Climate action · Sustainability.

The impact of climate change have been felt and experienced by many countries for many years. Today, greenhouse gas (GHG) is 50% higher than the levels in 1990. Global warming has caused climate change for a long time, and these irreversible changes threaten all countries if the countries around the world do not act. Economic losses caused by natural events due to this climate change are at the level of hundreds of billions of dollars. The nations aim to prevent permanent changes to be experienced in the climate system and to prevent economic losses due to this change. In this direction, the United Nations funds developing countries under SDG-13 to adapt to climate change and prepare low-carbon development plans (United Nations 2021a). The work carried out to support sensitive areas within the scope of Goal 13 also helps to achieve other goals. It is aimed to keep the global temperature change below 1.5° with the work to be carried out within the framework of this purpose. In addition, the carbon dioxide emission rate in 2030 should be reduced by 45% compared to 2010, and net-zero is targeted for 2050 (United Nations 2021a).

Climate change manifests itself in every way nature acts. In the middle of 2021, Germany suffered one of the most fatal and devastating natural disasters in its history by receiving record rainfalls in 100, 500 and even 1000 years in some regions ("European Floods Are Latest Sign of a Global Warming Crisis" 2021). Moreover, wildfires worldwide drew attention in 2021, especially in Siberia, Mediterranean countries and Canada. Despite the cold climate of the northern regions of Russia, Yakutia hit 39 °C and experienced the driest weather since 1888 and suffered

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record wildfires, causing massive amounts of smoke and abnormal temperature rise (Magnay 2021). Human losses, property damages, internal displacements, outages of healthy water and electricity, deforestation and high carbon releases indicate that humanity is still not ready to cope with frequent and abnormal climate-related disasters (Die Welt 2021). By 2030, the UN plans to cope with wild disasters in every country adaptively. Deaths, injuries, internal replacements or homelessness due to disasters should be reduced as much as possible (United Nations 2021b).

To achieve future goals of reducing climate change, national governments and international institutions need to establish new policies and plans with climate change measures included. Indicators of this targeted focus on decarbonisation strategies and the amount of greenhouse gas emissions (SDSN 2021). Contributor countries of the Paris Agreement on climate change prepared their nationally determined contributions (NDCs), which declare each country's plan on reducing GHG emissions and climate change impacts. In addition to NDCs, volunteer countries have begun to adopt new plans for protecting from the natural disasters caused by climate change, such as floods or cyclones (United Nations 2021c). However, some countries' declared targets are insufficient, meaning that they can be satisfied without the adoption of new policies. Also, another group of countries adopted policies that cannot satisfy the insufficient targets. This situation complicates the progress for the 2030 and 2050 targets. Therefore, the policies of the countries that make rapid progress should be imitated (Doni et al. 2020). Furthermore, policies must optimise benefits to different SDGs. For example, a regulation that bans fertiliser use totally to help climate action would decrease yields, and thus, it could increase poverty and hunger and contradict SDG 1 (no poverty) and SDG 2 (zero hunger). However, not having a policy that regulates fertiliser use could cause the overuse of fertilisers and damage the climate action (Campbell et al. 2018). Hence, the adoption of optimised policies is required to achieve the future targets of SDG 13. Also, revision of current policies and plans may be needed to strengthen the tools of governments against climate change. Figure 15.1 compiles the targets of SDG-13.

Climate change research in the built environment and related disciplines of transportation and utilities is still in its early stages. To plan effectively for the future, decision-makers require a significantly wider knowledge base. To accomplish this, academics and decision-makers must collaborate to generate this knowledge, which can then be used to develop effective climate change plans (EPSRC 2003). Some approaches, knowledge and skills are required to counteract climate change.

The course of adaptation necessitates adaptive management considering the evolving impacts of climate, the normative nature of risk tolerance and the tipping points between them (European Commission 2012; Wise et al. 2014). As emphasised by the UN, the importance of adaptation can be observed in the number of countries that have national adaptation plans and the financing of such plans. Recent reports identified six least developed countries that have already implemented a national adaptation plan, while a grand majority of developing countries are prioritising and implementing one. Furthermore, the mean annual finance for climate has been reported to be $48.7 billion between 2017 and 2018, which is an increase of 10% from 2015 to 2016. Most notably, the target of financial support for climate has started to shift from mitigation action to adaptation as more and more countries show increased support for adaptation (United Nations 2021c). The importance of creating reliable frameworks as measures of adaptive capacity has been emphasised both by researchers and policymakers (Solomon et al. 2007). However, there is no template for what this should contain due to adaptation's context-specific, process-based nature. Knowing how to adapt is deemed necessary to measure adaptive capacity, as it is highly related

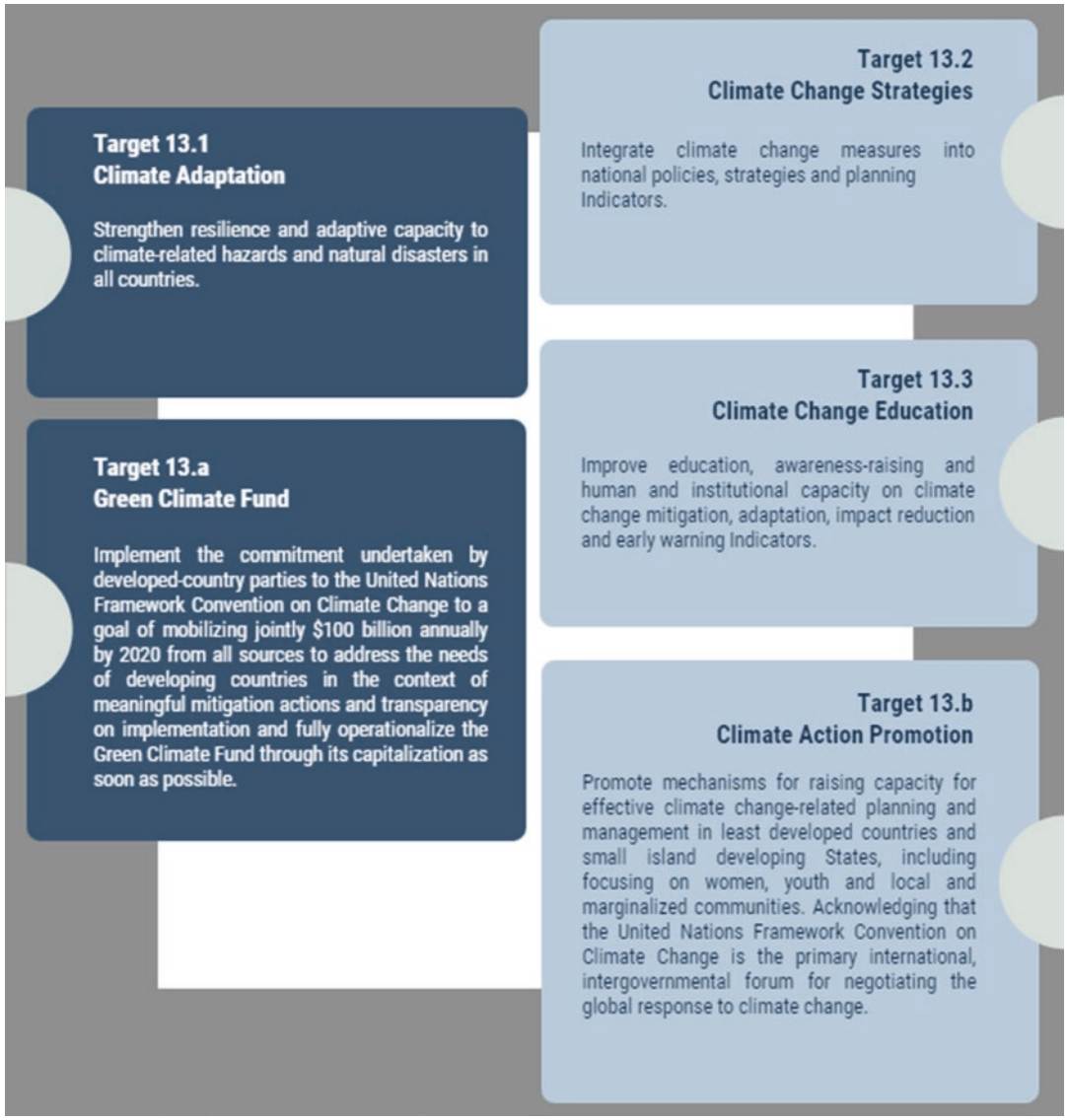

Fig. 15.1 Targets of SDG-13.(UNDP 2021)

to further deciding factors (Klein 2014). Learning is becoming more important in providing insights into what constitutes effective adaptation, which we define as improvements that minimise susceptibility to current and future climate change.

The United Nations Framework Convention on Climate Change (UNFCCC) is the international system for addressing climate change. The convention has been ratified by a large number of developing as well as developed countries such as the USA. The convention aims to "Prevent dangerous human interference in the climate system." In spite of the high amount of support for the convention worldwide, obtaining this goal is contentious (UNFCCC 2021).

The United Nations Framework Convention on Climate Change (UNFCCC) recognises the

influence of biological systems in determining when climate change should be ceased. Three fields of influence against which the conventional criteria of "dangerous interference" are tested are agricultural production, sustainable development and environmental response. Climate change must be ceased in a period that allows ecosystems to "adapt naturally, does not prevent sustainable development, as well as maintains agricultural productivity", according to the convention (UNFCCC 2021). In the light of the fact that sustainable development keeps productivity in agriculture and electricity, developed, least developed and developing island states should promote mechanisms to raise capacity for planning and management while incorporating women, youth and localised organisations and communities.

In the context of essential reductions by industrialised nations, the EU is committed to lowering greenhouse gas emissions by 80–95% below 1990 levels by 2050. Several goals are determined for decarbonisation by 2050. In the short-medium term, conventional fossil fuels such as coal and oil are planned to be replaced by low-emission fuels such as natural gas and hydrogen. Nuclear power is also a low-emission power technology and has a huge place in the long-term plans of the EU. Renewable energy sources are primarily preferred in diversified energy supply technologies. With all these energy supply plans, obtaining high-energy efficiency in the end-user area is also a crucial aim. Finally, carbon capturing systems are proposed in the long term to decrease the release of inevitably produced carbon gases into the atmosphere (European Commission 2012).

The time horizon in WEO-2019 is 2050, rather than 2040, as in previous editions, to reflect announcements by various governments to attain carbon neutrality by 2050 and to model the possibility for new technologies (such as hydrogen and renewable gases) to be deployed at scale. As a result of continued CO_2 emissions and advances in climate research, the interpretation of the climatic target included in the sustainable development scenario varies with time (IEA 2020).

Green Recovery's progress in biodiversity conservation, responsible production and climate action will be stronger by 2100 (90%, 94% and 84%, respectively) with a longer timescale and even more ambitious aims, with 12 out of 13 targets on track or improving (IEA 2020; Moallemi et al. 2020). The fossil-fuelled development path achieves the fastest improvements in socioeconomic indices, such as gross world product (GWP) per capita, by 2100 while fulfilling moderate (and occasionally even aggressive) aims. However, in fossil-fuelled development, human and economic development leads to a significant increase in the share of fossil fuels in the energy supply, driven by rising energy demand from high-energy-intensity industries and services. In almost all 10,000 realisations of the fossil-fuelled development route, reliance on fossil fuels results in high climate consequences from energy-related CO_2 emissions by 2100 (Moallemi et al. 2020).

In 2009, the World Energy Outlook published the 450 Scenario, a detailed energy transition scenario. The scenario was named after the CO_2 concentration of 450 parts per million (ppm), which was thought to be consistent with a 50% chance of keeping average global temperature rise below 2 degrees Celsius at the time (assuming that net-zero emissions were reached in 2100) (IEA 2020). More than half of the population in the region's major centres, where 1.2 billion new residents are predicted by 2050, live in low-lying coastal areas. As a result, more than 742 million urban dwellers are today exposed to several dangers caused by climate-related disasters, which pose a threat to infrastructure and communities (UNESCAP 2019).

Through their internal operations and supply chains, businesses are responsible for a large percentage of GHG emissions and resource use. Furthermore, items are frequently incorrectly disposed of and seldom enter a new life for future use due to a lack of end-of-use (EOU) planning.

This contributes to global waste, pollution and a depletion of fresh material supply. As a result, companies play a critical role in collaborating with governments to limit global warming below 1.5 °C and develop resilience to present and future climate change consequences. Top businesses are taking this responsibility seriously today, offering innovative solutions to cut emissions, minimise effects across the value chain, enhance climate resilience and raise climate awareness. This can be accomplished in a variety of ways, including the publication of a sustainability action plan, the procurement of low-carbon materials, the investment in on-site renewable energy, the purchase of renewable energy credits (RECs), the construction of net-zero factories and the return of products at the end of their useful lives (Bureau 2021).

Many of the adjustments required to establish a carbon-free world would have an initial cost on various economic sectors. When zero-carbon economy infrastructure is developed, and legislative incentives are implemented, high-carbon businesses are expected to lose market share throughout the transition. With the adoption of climate policies, a study by Malerba and Wiebe suggests that Germany will experience the highest job increase in the EU. However, some other countries worldwide, such as Japan and the USA, will have a higher increase of available jobs. The study also concluded that there is no correlation between poverty rates and proportional job increases. A country with a high portion of its population living in poverty may witness a high proportional job increase, while another country with similar population characteristics experiences a low proportional job increase. For example, Brazil experiences a high increase of 0.8%, and India experiences a low increase of 0.3% (Malerba and Wiebe 2021). Another study found that if the measures to restrict global warming to 2 °C become in charge, available jobs will increase 0.3% more compared to current measures (Montt et al. 2018). This study also found that Bulgaria, Indonesia and Taiwan will experience the highest proportional job increases of 0.9%. The study suggests that there will be 4.9 million new jobs created in China, one million in the USA and 1.3 million in India with the climate action measures. Since its economy relies mostly on fossil fuels and the industries that are expected to grow under climate action measures are not developed, the Middle East may experience job losses, unlike the rest of the world (Montt et al. 2018).

To reduce emissions, expenditure that belongs to individuals and the public must change. The government must develop new regulations that encourage individuals to spend their money in new ways, like using decarbonised heating for homes and using alternative modes of transportation such as electric automobiles and motorcycles. Simultaneously, changes in government expenditure and new fiscal incentives are required to spur the development of breakthrough zero-carbon technologies, improve building energy efficiency, modify farming methods and create sustainable energy grids.

Carbon emissions that originate from individuals or companies can be exposed to economic sanctions such as emission trading systems as well as carbon taxes. Even though this system can provide equal pay, low-incomers can be affected disproportionately by these measures (Abdallah et al. 2011). Favourably, this problem may be addressed by rebate programmes that return at least part of the collected earnings to lower-income individuals. Calculations of the precise future costs of adaptation generate a wide range of outcomes, as they are highly dependent on the level of future greenhouse gas emissions, how the climate system will respond to them in various locations and if they are effective. As a result, estimating the economic costs and benefits of adaptation is extremely challenging. However, adapting without attempts to mitigate climate change would be prohibitively expensive (Imperial College 2021).

According to the World Bank, developing countries can face economic damages of approximately 75–100 billion dollars per year because of the 2 °C warming until 2050. However, it is considered that these values are pretty low. In the

meantime, the UN Environment Programme (UNEP) estimates this loss can approach 280–500 billion dollars each year until 2050. If global warming continues to rise beyond this point, the costs of adapting will skyrocket (Fankhauser 2019; Olhoff et al. 2015; World Bank 2010).

According to the Intergovernmental Panel on Climate Change (IPCC), reducing global warming to 2 °C would lower yearly per capita global consumption growth by 0.06 percentage points relative to growth in a hypothetical future without climate change (Onencan et al. 2016). The Organisation for Economic Co-operation and Development (OECD), on the other hand, claims that if climate change is taken into consideration in reform and budgetary plans, this consideration will create a 1% and 2.8% increment to GDP in G20 nations for 2021 and 2050, respectively (Organisation for Economic Co-operation and Development 2017).

Investing in adaptation is critical for limiting the adverse effects of climate change on human society. Every efficient policy for combating climate change, on the other hand, must decrease emissions to prevent future warming while also adapting to the unavoidable effects of climate change. According to the Global Commission on Adaptation, climate change will affect people despite the most effective strategies. As a result, reducing emissions is "the best form of adaptation" (Global Commission on Adaptation 2019).

15.1 Companies and Use Cases

Table 15.1 presents the business models of 52 companies and use cases that employ emerging technologies and create value in SDG-13. We should highlight that one use case can be related to more than one SDG and it can make use of multiple emerging technologies. In the left column, we present the company name, the origin country, related SDGs and emerging technologies that are included. The companies and use cases are listed alphabetically.[1]

[1]For reference, you may click on the hyperlinks on the company names or follow the websites here (Accessed Online – 2.1.2022):

http://algaepro.no/; http://c-combinator.com/; http://flashforest.ca/; http://geopard.tech/; http://geyserbatteries.com/; http://mangomaterials.com/; http://spgroup.com.sg/; http://wingtra.com/; https://akercarboncapture.com/; https://biomemakers.com/; https://charmindustrial.com/; https://checkerspot.com/; https://deepbranch.com/technology/; https://emrod.energy/; https://en.vytal.org/; https://enervenue.com/; https://fullcyclebioplastics.com/; https://lignaenergy.se/; https://polyspectra.com/; https://poseidon.eco/; https://sadako.es/; https://seabenergy.com/; https://solarfoods.fi/; https://tech2impact.com/start-ups/utilis/; https://verv.energy/; https://www.aphea.bio/; https://www.bamomas.com/; https://www.bloomenergy.com/; https://www.bluenalu.com/about; https://www.business.att.com/products/multi-access-edge-computing.html; https://www.caire-solutions.com/; https://www.carbfix.com/; https://www.carbonclean.com/; https://www.carboncure.com/; https://www.climatedatahub.io/; https://www.clingsystems.com/; https://www.crowd4climate.org/; https://www.divergent3d.com/; https://www.freightfarms.com/greenery-s; https://www.ge.com/gas-power/future-of-energy/carbon-capture-storage; https://www.h2arvester.nl/?lang=en; https://www.harvest.london/; https://www.ibm.com/case-studies/energy-blockchain-labs-inc;https://www.meatable.com/; https://www.omniplytech.com/; https://www.ossia.com/; https://www.polybion.mx/materials/; https://www.raisegreen.com/; https://www.riversimple.com/; https://www.samsungsdi.com/business.html; https://www.space4good.com/; https://www.woodlandbiofuels.com/

Table 15.1 Companies and use cases in SDG-13

No	Company info	Value proposal (what?)	Value creation (how?)	Value capture
1	Aker Carbon Capture Norway 13 Carbon capture & storage	It is a company that provides modular carbon capture technology services to its customers.	They provide services to reduce the amount of CO_2 emissions caused by production facilities during production that spread to the atmosphere. This system, which has a modular structure, is delivered to the field to capture CO_2 in the regions where this service is needed.	An increase in the carbon tax will increase the production costs of many companies. By using this service, the amount of CO_2 emitted into the atmosphere during cement, bio/waste-to-energy, steel gas-to-power production can be reduced. This way, the amount of tax that companies have to pay due to CO_2 emissions is reduced. Thanks to this service, the negative environmental effects caused by production are also reduced.
2	AlgaePro Norway 13 Biotech & biomanufacturing, recycling	They use biowaste from municipal waste management, as well as carbon dioxide and waste heat from industrial sources, to develop microalgae in a circular bioeconomy.	They recycle biowaste from municipal waste management to grow microalgae in large ponds or a device named photobioreactor. The grown microalgae can be used as a sustainable feed in fish farms as they contain marine proteins and omega-3 fatty acids.	Savings are captured through low-cost microalgae use in fish farms and help in climate action through microalgae use as a sustainable feed in the fish farming sector.
3	Aphea.Bio Belgium 2, 13, 14, 15 Biotech & biomanufacturing	The company develops microorganisms that are beneficial for plant growth for reducing synthetic fertiliser application and controlling fungal diseases.	They look for microorganisms that are naturally existing and have desirable characteristics for promoting plant development and health. The component bacteria are then isolated and grown into pure colonies from the ambient samples.	Reduction of fertiliser applications and fungal diseases' control are obtained by developing agricultural biologicals. Yield and health of crops can be enhanced by using agricultural biologicals.

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Table 15.1 (continued)

No	Company info	Value proposal (what?)	Value creation (how?)	Value capture
4	AT&T USA 7, 9, 12, 13 5G, edge computing	It is a telecommunications company providing connectivity solutions and numerous other services.	AT&T Multi-Access Edge Computing (MEC) is a sophisticated traffic controller and data processor that is installed on-site. It connects certain devices to the cellular network and directs data flow according to business specifications. AT&T MEC may be designed to operate as a data bridge across cellular and landline networks since it is data smart.	The company moves computer capacity closer to the edge of the on-premises wireless network, allowing for near-real-time data processing. AT&T MEC, which is powered by AT&T 5G cellular connection, is a cost-effective approach to improve the capabilities of an existing private network via intelligent data routing and traffic prioritisation. Additionally, edge computing improvements and enhanced capacity to undertake data processing tasks, such as artificial intelligence (AI) and data analytics, cause devices to function more efficiently, resulting in lower GHG emissions.
5	Bamomas Finland 7, 13 AI, big data, energy storage, cloud computing, internet of things	Modern internet of things (IoT) connection and superior battery modelling enable a cloud-based intelligent battery management solution.	The system monitors the batteries' consumption, performance and condition in real time. Using IoT, real-time data may be accessible through the internet or a mobile dashboard. Regular reports, warnings and notifications are supplied, as well as system optimisation and big data. The solutions combine a contemporary cloud infrastructure with AI-powered battery modelling.	The company increases revenue by increasing battery longevity and guaranteeing operational continuity by adhering to maintenance recommendations.
6	Biome Makers USA 2, 13, 15 AI	It is an AI-based agricultural technology company that models soil functionality to improve arable soil productivity.	The company measures the crop quality and delivers agronomic insights such as disease risks, yield improvements and terroir characterisation to optimise farm operations.	Value is created by improving efficiency and sustainability and allowing the traceability of agricultural products by using AI.

7	Bloom Energy USA 7, 13 Hydrogen	It is a company that develops products that convert natural gas, biogas and/or hydrogen into electricity without a combustion process.	The fuel (hydrogen, natural gas or biogas) is converted into electricity by electrochemical methods without the combustion process by using the developed solid oxide fuel cell. The developed solid oxide fuel cell has a modular structure and can be scaled according to the customer's request.	Hydrogen technology provides more widespread use of renewable energy technologies. Thanks to this technology, increasing renewable energy systems provide an environmental value by reducing the amount of CO_2 emissions resulting from energy production.
8	BlueNalu USA 2, 13, 14 Cellular agriculture	It is a cell-cultured seafood company, satisfying the global appetite for seafood in a fresh, sustainable and humane way.	The company manufactures seafood using cellular agriculture technology and fish cells. Living cells are isolated from fish tissue, placed in culture media for proliferation, and are thus turned into seafood.	It can prevent overfishing, and thus, marine life can be restored and the amount of CO_2 absorption provided by the plants in the sea can be increased.
9	C-Combinator USA 13, 14, 15 Bioplastics, biotech & biomanufacturing	The company biomanufactures bioplastics, fertilisers and cosmetics from seaweed.	They've created a model for a cascading Sargassum seaweed biorefinery that can produce a variety of goods for agricultural, textile, personal care and cosmetics and bioplastics.	Environmental value is captured by reducing and balancing GHG emissions caused by fossil fuels or conventional plastics.
10	C:aire Austria 3, 11, 13 Biotech & biomanufacturing	It is a filter producer that eliminates unhealthy particles in the air with the help of bacteria.	Plants are grown on a statue-like filter. The unclean air that goes through the hole in the filter becomes purified and odourless, thanks to the degradation of unhealthy particles by bacteria that live in the soil under the plants.	The bacterium captures environmental value by degrading up to 98% of the target contaminants over time.

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Table 15.1 (continued)

No	Company info	Value proposal (what?)	Value creation (how?)	Value capture
11	Carbfix Iceland 13 Carbon capture & storage	It is a company that converts CO_2 into stone underground to give a natural and permanent storage option.	Carbon is naturally stored in large amounts in rocks. The company mimics and accelerates natural processes in which carbon dioxide is dissolved in water and reacts with reactive rock formations like basalts to generate stable minerals that serve as a long-term carbon sink. CO_2 is captured and permanently removed using the company's technique. The method offers a comprehensive carbon capture and injection solution, in which CO_2 dissolved in water – Sort of like sparkling water – Is pumped into the subsurface, where it combines with suitable rock formations to produce solid carbonate minerals via natural processes in approximately 2 years.	It provides safe underground storage of CO_2 with low investment costs. In this way, the amount of CO_2 released to nature is reduced.
12	Carbon Clean UK 9, 13 Carbon capture & storage	It is a company that provides solutions for carbon capture in a modular structure.	Classical carbon capture technology has been developed and modularised. Thanks to this modular structure, the application area of this technology has been expanded and it has been turned into a system suitable for small-medium or large scales, suitable for fast installation.	This technology provides value creation for carbon capture technology with its fast installation and scalability features. Thus, this technology becomes more accessible for many industries and users. By absorbing CO_2 from the atmosphere, it also reduces existing emission values, thus creating an environmental value.
13	Carbon Cure USA 13 Carbon capture & storage	It is a construction material firm that uses CO_2 in concrete production by using absorbed CO_2 from the atmosphere.	They source CO_2 from industrial production. The used CO_2 gas is collected, purified and distributed by established suppliers. The CO_2 delivered to the concrete plant is used and injected into the concrete mix. Injected CO_2 reacts with calcium ions, and as a result of this reaction, the concrete produced becomes stronger.	Concrete producers using this technology can produce high-quality, strong and more sustainable concrete. Concrete can be produced for green building applications, and value production is realised by developing the customer portfolio. Environmental value is captured by using CO_2 captured from the atmosphere.

14	Charm Industrial USA 13 Carbon capture & storage	The company uses plants to capture CO_2 from the atmosphere.	Their pyrolyzers break down biomass into bio-oil, a liquid rich in carbon but low in energy content. This bio-oil is then injected into EPA-regulated injection wells, where the bio-oil sinks and solidifies in place for permanent storage.	They convert biomass into a stable, carbon-rich liquid and then pump it deep underground. Environmental value is captured by removing CO_2 permanently from the atmosphere.
15	Checkerspot USA 13 Advanced materials, biotech & biomanufacturing	It is a biomanufactured advanced materials company for lightweight and high-performance applications.	Sustainable, superior performance advanced materials are obtained by designing and manufacturing convenient raw materials.	Environmental benefits are captured via low raw materials input, high durable, biodegradable and non-petroleum-based advanced materials.
16	Climate Data Hub USA 7, 13 AI, Datahubs	The platform provides rapid access to information about climate through data hubs and AI.	They're working on a dataset exploration and discovery tool that uses artificial intelligence, semantic search and intuitive visualisations to help technologists and data scientists quickly find relevant datasets, explore whitespace and see datasets in their geospatial, bioregional, social and economic contexts.	Environmental revenue is captured through the acceleration of the production of solutions for entrepreneurs and innovators via datahubs against the climate crisis.
17	Cling Systems Sweden 7, 13 Recycling	It is a global B2B market platform that enables the circularity of used rechargeable lithium batteries and their materials by connecting users, manufacturers and recyclers.	Their B2B used battery marketing platform connects workshops/battery dismantlers, recyclers, remanufacturers and OEMs. Used batteries are listed in the platform by used battery owners with all relevant data, verified buyers make bids to batteries or battery materials, the buyer, who proposed the highest price, places the order and cling ensures safe transport of sold goods.	The recyclability of lithium batteries is streamlined by establishing trusted and safe connections between users, manufacturers and recyclers. This way, enormous amounts of toxic lithium batteries can be safely transported and reused.

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Table 15.1 (continued)

No	Company info	Value proposal (what?)	Value creation (how?)	Value capture
18	Crowd4Climate Austria 7, 13 Crowdfunding	The platform provides a way to make an investment directly in solar energy and climate action projects.	People can select and invest in climate actions and sustainable energy projects that are selected based on ecological and social criteria by using the crowdfunding platform.	Environmental revenue through expansion of utilising renewable energy resources and decreasing greenhouse gases with a crowdfunding platform.
19	Deep Branch UK 13 Advanced materials	It is a carbon dioxide recycling company that uses microorganisms to convert clean CO_2 into high-quality products to enable global sustainable animal nutrition.	CO_2 is captured and converted into proton, a single-cell protein that has been optimised for animal feed. They collaborated with market-leading feed suppliers to create proton-based feeds.	Producing sustainable animal products with up to 60% fewer greenhouse gas emissions adds economic and environmental benefits. Proton-based feeds may be made with 90% reduced carbon intensity using locally obtained components.
20	Divergent Us 13 3D printing	It is a car manufacturing company that aims to develop fully 3D printed automobile production methods	Divergent adaptive production system (DAPS™) aims to transform auto manufacturing economic and environmental impact using a data-driven approach for designing and building vehicle structures	Part productions are optimised with 3D printing, reducing material waste, process length and complexity, so manufacturing operations consume less energy, leaving less carbon footprint. Automobile parts are also optimised to have the least material, reducing the weight of the vehicle and therefore carbon emission of the car
21	Emrod New Zealand 7, 11, 13 Advanced materials, wireless power transfer	They provide long-range wireless power transmission for electricity distribution companies.	Emrod's patented beam shaping, metamaterials and rectenna technologies are used to transport energy across vast distances utilising electromagnetic waves. Tele-energy is a technology that allows for safe, dependable and cost-effective long-range wireless energy transfer.	Monetary and business value is captured by reducing outage risks caused by wire damages and providing lower infrastructure deployment and maintenance time and costs. Remote locations in Africa, the Pacific Islands and other distant communities are supplied with affordable and sustainable energy to power schools and hospitals.
22	EnerVenue USA 7, 13 Energy storage, hydrogen	The company develops and provides metal-hydrogen batteries for heavy-duty energy storage problems with more affordable manufacturing solutions.	They propose affordable and durable energy storage solutions with metal-hydrogen batteries. Since the usage is limited with aerospace and military applications, the company aims to supply demilitarised, low-cost and safe product options.	Metal-hydrogen batteries' high cycle rate, durability, zero-maintenance cost, non-toxic and fire-free characteristics are both user and environmental friendly. Also, products are highly sustainable with a 99% recycling rate.

23	Flash Forest Canada 13, 15 Drones	It is a drone reforestation company that reforests the earth through UAV hardware, aerial mapping software, automation and biological seed-pod technology.	Drones, rather than people, reforest post-harvest or post-wildfire regions, which speeds up the process by ten times. They work with botanists to find optimum planting locations and give vital follow-up data on ecosystem health using multispectral mapping UAV technology.	Automation of the reforestation process by using drones in planting seeds decreases the time required for the regrowth of trees.
24	Freight Farms USA 7, 13 AI, soilless farming	It is a vertical hydroponic farm company designed and built entirely inside a shipping container.	The greenery S includes a cutting-edge controlled environment system that allows you to have complete control over the elements. Farmhand software employs IoT-connected sensors and auto-updating video feeds to provide full insight into the farm operation, allowing you to grow food 365 days a year.	Revenue is generated by employing artificial intelligence to build containers with improved plant quality, fewer resources, higher yields and 365 days of production.
25	Full Cycle Bioplastics USA 9, 13 Advanced materials, biotech & biomanufacturing, recycling	It is a biotechnology company that tackles plastic pollution and climate change by upcycling organic matter into a compostable alternative to oil-based plastics.	They generate polyhydroxyalkanoate (PHA) biopolymers from organic waste using bacteria-powered alchemy. PHA is a naturally occurring polymer with material properties similar to those of petroleum-derived polymers, making it a versatile, non-toxic and biodegradable alternative to oil-based plastics.	Revenue is captured through producing polyhydroxyalkanoate and then the production of highly adaptable, non-toxic and compostable products.
26	General Electric USA 13 3D printing, carbon capture and storage	It is a long-established company that provides solutions in energy technologies and carbon capture and storage (CCS) methods.	The company develops an advanced carbon capturing and storage facility with the collaboration of UC Berkeley. CCS knowledge of GE and 3D printing studies of UC Berkeley labs will be merged to actualise a fully 3D printed carbon capture facility.	The high raw material efficiency of 3D printed part manufacturing will lower the carbon footprint and eliminate the costs of conventional parts manufacturing methods in CCS facility installations.

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No	Company info	Value proposal (what?)	Value creation (how?)	Value capture
27	GeoPard Agriculture Germany 2, 13, 15 AI	It is a company that offers smart farming solutions based on AI for the discovery of the potential of agricultural areas and the improvement of agricultural decisions.	The multispectral analysis performed by AI-based algorithms displays the degree of absorption or reflection based on identified wavelengths to offer data on plant vitality, allowing users to see which crops are thriving and which are failing. It enables near-real-time field monitoring and condition evaluation.	The efficiency and sustainability of farming in fertilising, seeding and irrigation applications are increased with the assistance of AI-based prescription maps, thus helping the fight against the rise of carbon footprint resulting from conventional farming methods.
28	Geyser Batteries Finland 7, 13 Energy storage	The firm offers water-based electrolyte-based high-power heavy-duty energy storage technologies.	The batteries are made from common chemical components and use water as an electrolyte solvent. Due to the use of aqueous electrolytes, the batteries take less energy to manufacture than li-ion batteries and superconductors. Their batteries are built with a bipolar architecture that ensures consistent current density on electrodes.	Due to the use of an aqueous electrolyte in the manufacturing process, the batteries are carbon-neutral. Furthermore, their batteries can withstand over a million charge-discharge cycles, making them resilient and, as a result, producing less waste over time.
29	h2arvester Netherlands 7, 13 Autonomous vehicles, hydrogen	It is a circular energy model company manufacturing autonomously moving solar panels and hydrogen storage technologies for local and/or agricultural economies.	The company provides a comprehensive energy system of sun harvesting with autonomously moving PV matrices over arable fields and hydrogen generation for energy storage in fully independent rural microgrids.	Farmers can utilise their agricultural fields for sun harvesting, gain independence from the grid and sell excess power to other locals. Also, they can store energy in hydrogen form for sunless and windless days.
30	Harvest London UK 12, 13 Soilless farming	It is a soilless and vertical farming firm with the goal of producing sustainable food ingredients.	They farm in a controlled environment, ensuring that crops receive just the right amount of light, water, nutrients and humidity to grow. This enables year-round production of vegetables at a scale not achievable in fields, without the use of pesticides and with waste reduction at every stage.	They work directly with customers to produce herbs and vegetables that are hard to source locally in the UK. Thanks to the controlled system, the production efficiency increases, thus minimising the climate effects.

31	IBM Energy Blockchain Labs USA 7, 13 Big data, blockchain	It is a climate change-focused tool for monitoring and purchasing carbon credits in the green energy markets.	They established an efficient, transparent platform using Blockchain technology that allows high-emission firms to track their carbon footprints and satisfy regulations by purchasing carbon credits from low emitters.	It enables enterprises to fulfil government-mandated carbon emission reduction targets in a more effective manner, and as the organisation's usage of IBM Blockchain technology evolves, carbon asset creation timeframes and costs will decrease even more.
32	Ligna Energy Sweden 7, 13 Energy storage	It is an organic material-based battery manufacturing company that uses organic electronic polymers and biopolymers, which are used throughout the lifetime of the energy storage and then recycled and burned as biofuel.	The firm has been working on innovative electrical energy storage technologies and products. Forest waste materials and organic polymers are combined with a water-based electrolyte to create the battery technology.	The reuse of raw battery materials and the manufacture of organic products are used to generate revenue.
33	Mango Materials USA 13, 14, 15 Bioplastics, biotech & biomanufacturing	They create a naturally occurring biopolymer from waste biogas (methane) that is cost-effective when compared to traditional oil-based polymers.	They use methane captured at landfills, wastewater treatment plants or agricultural facilities. Methanotroph bacteria consume methane to produce PHA material. Then, they utilise this PHA as a raw material for their biodegradable YOPP BioPlastic material.	When left in the wild, YOPP BioPlastics contribute to the natural carbon cycle. After being decomposed by microorganisms, they do not leave behind microfibers or microplastics. Approximately the maritime environment, YOPP fibres biodegrade in 6 weeks.
34	Meatable Netherlands 2, 12, 13 Cellular agriculture	It is a company that produces animal-free meat with cellular agriculture technology.	To carry out meat production, a sample is taken from a cow or pig before production is made. Natural muscle and fat growth processes are then copied, and these products are produced. Then, these two products are mixed to produce meat.	It decreases the time required to produce meat from 3 years to 1 week. Environmental value is created by significantly reducing the amount of CO_2 produced in the meat production process.
35	Omniply Canada 7, 13 Flexible electronics & wearables	It is a flexible electronic production company for solar cells, smart packaging, automotive and the like.	Thin-film solar cells with great performance may now be readily incorporated into ordinary things, thanks to advances in technology.	Value is created via cost-effective, easy to integrate, lightweight and controllable technologies

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Table 15.1 (continued)

No	Company info	Value proposal (what?)	Value creation (how?)	Value capture
36	Ossia USA 7, 13 Wireless power transfer	The company manufactures equipment that charge multiple devices at the same time with wireless electricity transfer.	Cota revolutionises wireless power by reliably supplying remote, focused energy far devices. It automatically charges numerous devices without the need for human involvement, allowing for a more efficient and totally wire-free experience.	The ability to charge multiple devices at a distance reduces the amount of cable materials (plastics and copper) used, resulting in declined carbon emissions.
37	Polybion Mexico 6, 9, 12, 13 Advanced materials, biotech & biomanufacturing, recycling	It is a BioTechnology company that aims to develop substitutable alternative leather and organic foam material by recycling agroindustrial food waste with microorganisms.	The company recycles agroindustrial food waste and manufactures biomaterials that could substitute animal and synthetic leather and commonly used petroleum-derived synthetic polystyrene and polyurethane foam materials. The product, Fungicel, is a biomaterial that is capable of replacing synthetic foams in applications such as insulation and packaging.	Value is captured through keeping the CO_2 footprint and impact on the environment low, such as being plastic-free and animal-free. The manufacturing process is carbon-neutral, cost-efficient and circular.
38	polySpectra USA 13 Advanced materials, 3D printing	It is a 3D printing company that develops advanced printer filaments and prints' durable parts for medical and dental devices, aerospace components, automotive parts, robotics effectors and electrical connectors.	COR alpha, the company's superior 3D printer filament material, outperforms conventional 3D materials in terms of durability, application sectors and carbon footprint. The material's resilience might lead to it being used instead of traditional moulded plastics, which require lengthy manufacturing procedures. In addition, traditional production processes use more energy and have a bigger carbon impact.	PolySpectra COR alpha has less carbon footprint than ABS, nylon 6 and epoxy thermoset 3D printing materials. The rugged structure of the material constitutes a considerable substitution for even high-end demanding industries such as aerospace, medical and robotics and dispenses the need for energy- and time-consuming, unclean conventional moulding and CNC methods.
39	Poseidon Singapore 13 AI, blockchain	It uses AI and blockchain to analyse the carbon footprint of any product or service.	This company analyses the carbon footprint of any goods or service using AI and Blockchain and then processes carbon credits in small fractions to rebalance the product or service at point of sale.	Carbon credits have the ability to overcome the emissions gap and reach the 2 °C limit by pricing CO_2 emissions as well as environmental and social costs of products.

40	Raise Green USA 7, 13 Crowdfunding	It is a crowdfunding platform that gets funding for clean energy and off-grid power need projects.	Crowdfunding allows citizens to participate in renewable energy solutions such as solar energy applications.	Revenue is created via decreasing energy use, enhancing access to locally grown food and increasing energy battery and solar panel systems by supporting the projects.
41	Riversimple UK 11, 13 Hydrogen	It is a vehicle manufacturing company that produces hydrogen-powered cars.	The rasa is a water-emitting electric automobile that runs on hydrogen rather than batteries. The hydrogen is injected into a fuel cell, where it reacts with oxygen in the air to generate electricity. This electricity powers small, lightweight electric motors in each of the car's four wheels, giving it four-wheel drive.	Hydrogen-powered cars create value by shortening the fuel filling process compared to battery-powered electric vehicles, which is another environmentally friendly option. In addition, it creates environmental value by preventing the emission of CO_2 caused by internal combustion engine vehicles.
42	Sadako Technologies Spain 12, 13, 14, 15 AI, recycling, robotics	It is an AI-based waste segregation start-up for the waste and recycling industry.	Artificial intelligence (AI) algorithms can "see" things in highly complicated waste streams in real time, allowing robots to sort and manage waste flows and waste treatment plants to recover more and better from urban rubbish. They're pushing the frontiers of what can be recycled cost-effectively with AI.	With the company's technology, its products can distinguish between pet trays and pet bottles and learn to do this even better with feedback and AI. Further value is captured by improving the efficiency of recycling plants, reducing plastic manufacturing.
43	Samsung SDI South Korea 7, 13 Advanced materials, energy storage	The battery systems production company offers efficient battery solutions by developing advanced polymer-based materials and different types of configurations like cylindrical and prismatic.	With improved, high capacity, lightweight, slimness and cell arrangement, the number of utilised cells in the battery system decreases. The inclusion of Bluetooth to the battery pack allows customers to check residual battery, remaining mileage and other data on their smartphones while riding bicycles.	With a single charge of the battery, the available distance is around 7–80 km, and a single recharge costs 100 won. Because this is a non-fossil fuel mode of transportation, it has no carbon impact. It also offers a number of benefits, including being environmentally friendly and cost-effective and improving one's health, as well as allowing users to avoid traffic congestion and get some exercise by pedalling.

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Table 15.1 (continued)

No	Company info	Value proposal (what?)	Value creation (how?)	Value capture
44	SEAB Energy UK 7, 13 Recycling	It is an on-site containerised energy producer from waste through anaerobic digestion.	Flexibacter technology is designed to generate energy from food waste. The containerised anaerobic digesters produced are fully automatic and can be monitored remotely. The wastes are transferred to the system, and biogas production is realised, thanks to the processes performed here. Biogas is then used to fuel a combined heat and power (CHP) system engine to provide electricity and heat. Thanks to its built-in pasteurisation process, this system can process various feedstocks in a completely safe and odourless environment.	Flexibuster technology ensures that the garbage produced in the field is eliminated and this garbage is converted into a value, namely, energy. In this way, while protecting the environment, renewable energy is produced cost-effectively.
45	Solar Foods Finland 2, 12, 13 Bioech & biomanufacturing, cellular agriculture	It is a food tech company that develops solutions for food production, such as developing a bioprocess for Solein, a natural protein.	The method, also known as a bioprocess, takes a single bacterium and grows it by fermenting it. The microorganism is fed in the same way that a plant is nourished, except instead of water and fertiliser; it is fed just air and electricity. This is a 20-fold increase in efficiency over photosynthesis (and 200 times more than meat). Unlike traditional protein manufacturing, Solein requires only a fraction of the water found in the air to generate 1 kg.	Environmental value is captured by reducing the land and water used for food production. In this way, CO_2 emissions due to food production are also reduced.

46	SP Group Singapore 7, 9, 11, 13 Digital twins	In Singapore and Australia, the company owns and manages electricity and gas transmission and distribution operations, as well as sustainable energy solutions in Singapore and China.	Grid digital twin is a virtual depiction of the actual power grid assets and network that uses real-time and historical data to function. It consists of two main models. The asset twin can remotely monitor and analyse asset health and performance, allowing for early detection of possible grid threats. As a result, informed decisions on renewal and maintenance plans may be made. The network twin uses modelling and simulations to assess the grid's response to new demands (such as electric car charging) and distributed energy resources (such as solar photovoltaics and energy storage devices).	Improved network planning analysis and remote monitoring of asset status are key advantages of the grid digital twin, which saves labour resources by reducing the need for lengthy physical inspections. Because the grid digital twin gives a more holistic view of the grid, it may help with infrastructure design for a variety of purposes, such as installing electric car chargers and connecting solar PV and energy storage systems. GHG emissions would gradually drop as renewable energy sources and electric vehicles become more commonly used.
47	Space4Good Netherlands 9, 13 AI	They develop AI-based detection, estimation and prediction algorithms for events or states such as deforestation and fire by using satellite image data.	The portfolio of the company comprises detecting and predicting illegal logging activity, fire detection and risk assessments and monitoring groundwater storage. Time-series satellite image data is fed to custom AI algorithms of the company. Any visible disaster related to climate change such as floods or droughts can be monitored and predicted as well.	Disaster prediction and analysis suggest precautions for governments and people, so lives and valuables are protected. Detecting and predicting illegal deforestation and wildfires can trigger counter actions.
48	Utilis Israel 6, 9, 13 AI, spatial computing	Utilis transforms satellite-based synthetic aperture radar (SAR) data into large-scale decision-making tools.	The firm finds essential subsurface water near infrastructure such as water and sewer pipelines, motorways and railways, dams and embankments using microwave imaging from a satellite to assist estimate failure risk, mitigate before a break and limit water loss or pollution.	Emissions of carbon dioxide have decreased by 14,500 metric tonnes. By 2021, there will have been 36,000+ leaks discovered and validated, saving 9200 million gallons of potable water and 21,800 MWH of energy each year.

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Table 15.1 (continued)

No	Company info	Value proposal (what?)	Value creation (how?)	Value capture
49	Verv Energy UK 7, 13 AI, internet of things	Customers may acquire real-time power and energy statistics, as well as product usage data, from this firm, which helps them manage their energy consumption and waste more effectively and move closer to their net zero goals.	The Verv isolator incorporates Verv's high-resolution predictive energy insights and predictive maintenance technology, which identifies irregularities in the AC's performance. All of the data may be supplied to any NetZero or carbon monitoring reporting tool via APIs or directly from the platform. Each proposal is based on data-driven decision-making for maximising the use of air conditioning across a facility. It detects symptoms of component fatigue and locates defects that are occurring or about to occur using real-time monitoring.	EnergyGenius AI shows energy insights of the performance of the unit, how efficiently it is running and where and how energy and carbon reductions can be made. Using real-time monitoring, Verv can identify signs of component fatigue and locate faults that are occurring or are about to occur, in the utmost detail.
50	VYTAL Germany 12, 13 Advanced materials, recycling	It is a company that provides a digital reusable packaging system that offers people an affordable and sustainable alternative to disposable and plastic waste.	Their reusable containers can be purchased and used from participating system partners without payment. (the reusable system is smart and digital).	Containers are made from durable and recyclable materials and they are reused for food and beverage deliveries that reduce the carbon footprint.
51	Wingtra Switzerland 9, 13, 15 Drones	They create high-precision vertical take-off and landing (VTOL) drones that collect survey-grade aerial data and sell them.	Their drone WingtraOne can work in narrow spaces and rough terrain due to its VTOL design. Also, the VTOL design protects the camera from being scratched as the camera does not contact the ground. It can map eight times faster than a conventional multi-copter drone since it can carry a camera with higher-resolution and fly at roughly two times higher altitude than a multi-copter drone.	It helps climate change researchers in places that are hard to be inspected by humans, such as Antarctica, to analyse a wide area in a relatively short time. Also, it is used to investigate wildfires' consequences from the air. Furthermore, it is used by infrastructure and construction planners to map the construction zone to shorten the time needed by conventional mapping methods.

52	Woodland Biofuels Canada 7, 13 Biotech & biomanufacturing, recycling	It is an energy company that produces low-cost ethanol using waste biomass.	To produce ethanol, wastes such as forest industry wastes, agricultural waste, etc., which are continuous and abundant non-food wastes with low cost, are collected. Then, the gasification process of these collected organic wastes is carried out. After this process, catalysts and catalysed processes are carried out and distillation technology is used to purify the produced ethanol.	Value is created by decreasing the automobile fuel cost by using non-food waste biomass. Environmental value is captured by producing an alternative to gasoline.

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