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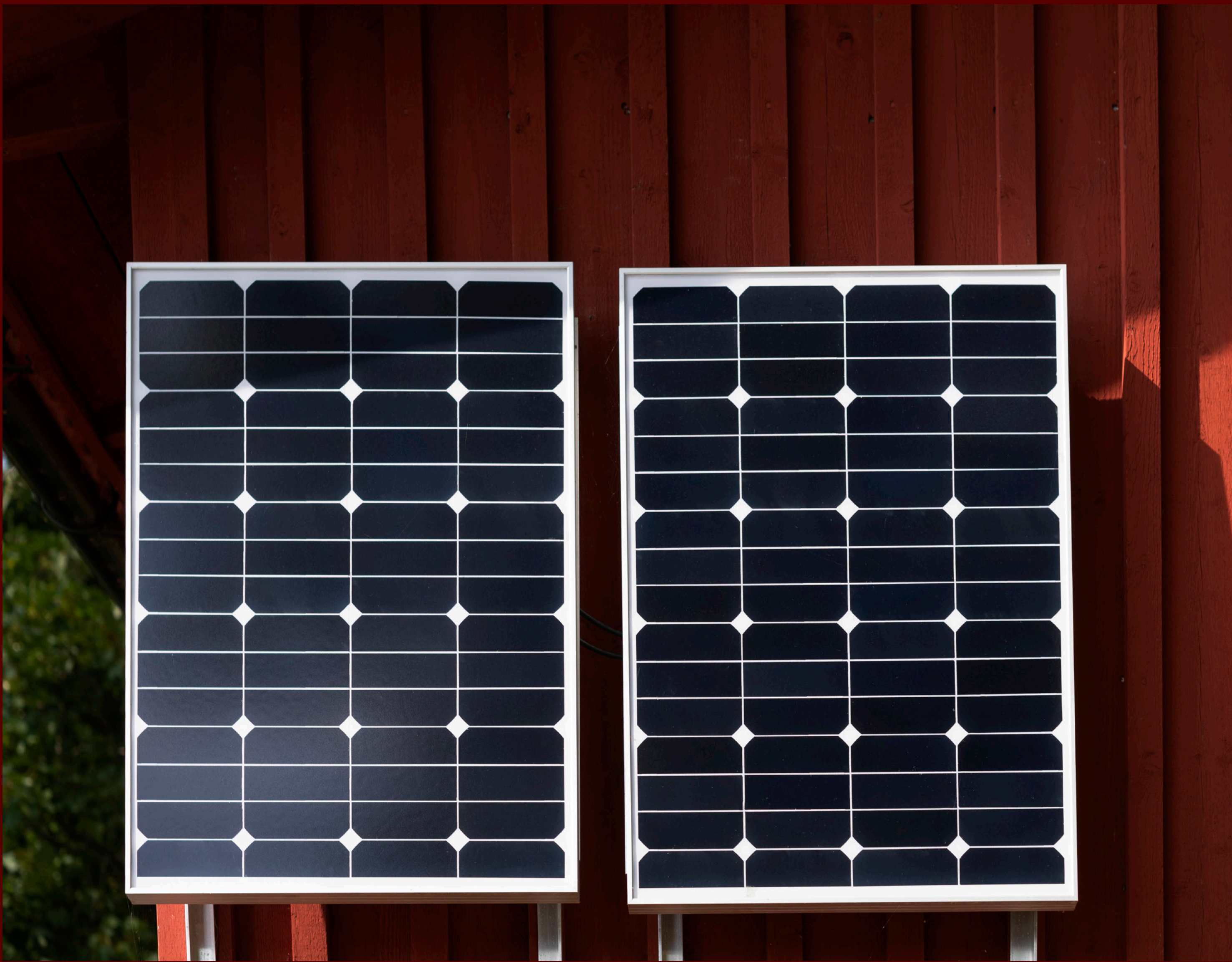

Whitepaper

Renewable Energy

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The SDGs as an Investment Theme

The United Nations (UN) Sustainable Development Goals (SDGs) were adopted by all UN member states in 2015. The SDGs represent a shared blueprint for global peace and prosperity towards 2030. The 17 goals highlight how ending poverty and conflicts can be realized alongside strategies that improve health and education, reduce inequality, contribute to economic growth while safeguarding natural habitats, oceans and tackling climate change [1, 2]. However, Figure 1 shows that the progress towards achieving the SDG targets has been insufficient. According to a recent SDG report, most targets do only have a fair progress, and are not on track to achieve the 2030 agenda [3].

The SDGs provide a common target and language for sustainable development and facilitates business opportunities when finance flows towards sustainable projects. The UN Roadmap for SDG investing calls on the financial industry to disclose and incorporate long-term risk into investment decision making, implement sustainable investing strategies, scale up green financial instruments, as well as measuring and reporting on impact [4]. According to the Business and Sustainable Development Commission, achieving the SDG opens market opportunities in four economic systems: Food and agriculture; cities; energy and materials; health and well-being [5]. Estimates show that a USD 12 trillion market value could be opened by 2030 if the SDGs are realized, creating 380 million jobs in the process [6]. An estimate by The World Business Council for Sustainable Development (WBCSD) of the distribution of these investment themes, is found in Figure 2.

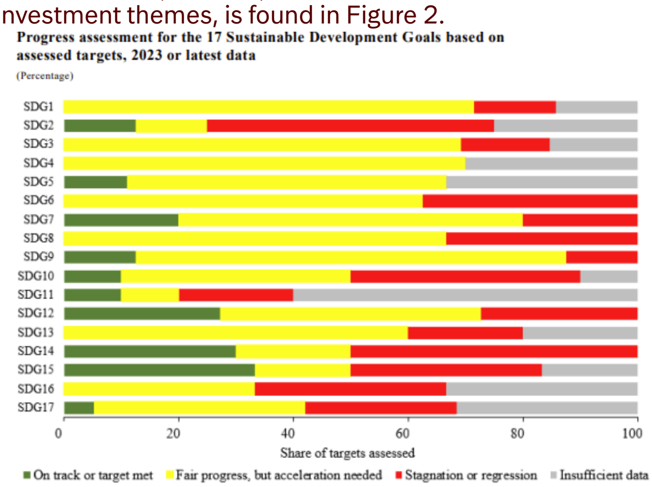


Figure 1: Share of targets assessed according to a SDGs report of 2023 [3]

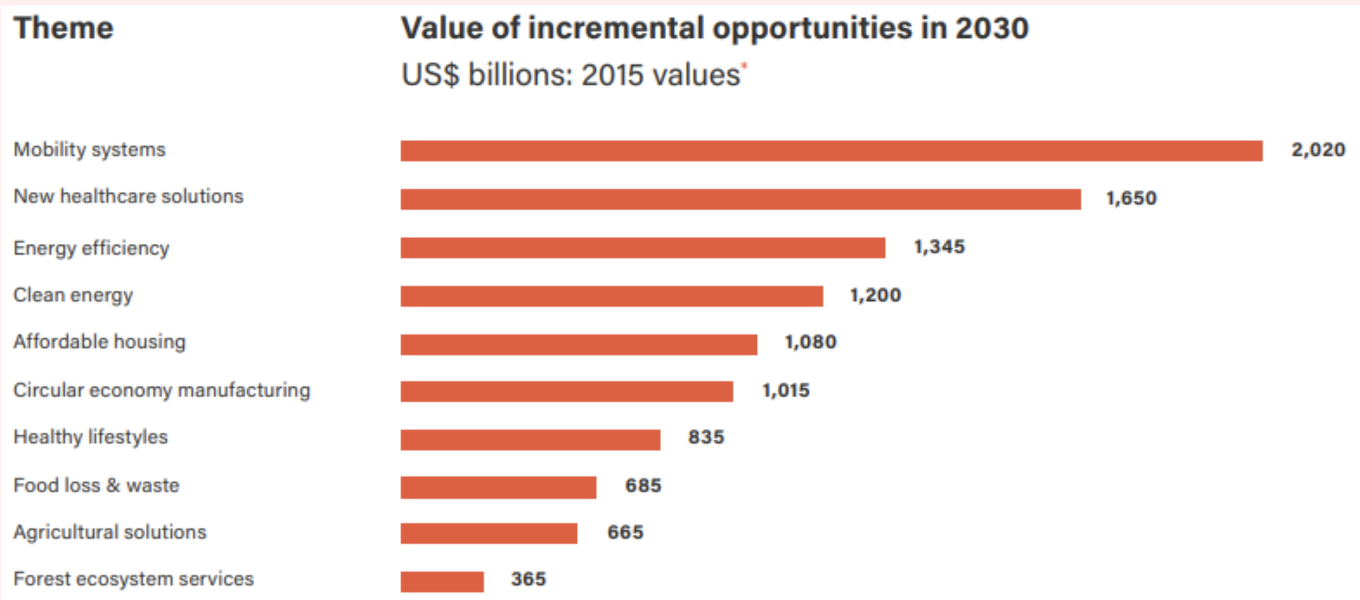


Figure 2: The 12 largest business themes in world economy heading for the SDGs. Source: Business and Sustainable Development Commission [6].

Solutions Theme: Renewable Energy

Climate change poses major threats to the future, such as rising temperatures, environmental degradation, natural disasters, extreme weather events, rising sea levels, and more [2] [7] [8] [9]. Demonstrating the seriousness of climate change, the 2015-2020 period marked the highest temperatures of human history and the Intergovernmental Panel on Climate Change (IPCC) argues that CO2 emissions must be reduced by 45 percent from 2010 levels by 2030, to limit the global temperature increase to 1.5 °C from pre-industrial levels [10]. In this context, the recent IPCC AR6 synthesis report revealed that the world is close to not accomplish such a target [11] However, there might still be hope, as the International Renewable energy Agency (IRENA) emphasizes that the 1.5 °C scenario could be achieved if renewables, alongside other mitigating contributors, supply more than 82 percent of total final energy consumption by 2050 [12]

Policymakers and the public increasingly agree about focusing on renewable energy to reduce CO2 emissions and achieve Paris Agreement´s goals [13]. Renewable energy is energy derived from natural sources and could be replenished at a higher rate than consumed [14]. These energy technologies hold great potential in resolving global energy crises due to their infinite supply and ability to mitigate the adverse effects of the climate crisis [15]. Consequently, the positive outcomes strengthen the outlook for renewable energy as an attractive investment segment.

Main SDGs Linked to Solutions Theme

13 CLIMATE ACTION

Take urgent action to combat climate change and its impacts
Strengthen resilience and adaptive capacity to climate-related hazards and natural disasters in all countries; Integrate climate change measures into national policies, strategies, and planning; Improve education, awareness-raising and human and institutional capacity on climate change mitigation, adaptation, impact reduction and early warning [16].

7 AFFORDABLE AND CLEAN ENERGY

Ensure access to affordable, reliable, sustainable and modern energy for all
Increase substantially the share of renewable energy in the global energy mix; double the global rate of improvement in energy efficiency; enhance international cooperation to facilitate access to clean energy research and technology, including renewable energy, energy efficiency and advanced and cleaner fossil-fuel technology, and promote investment in energy infrastructure and clean energy technology; expand infrastructure and upgrade technology for supplying modern and sustainable energy services for all in developing countries [17].

There are many linkages to other SDGs, which will be described in the subsequent sub-categories. Other relevant SDGs with crossovers will be described in different thematic whitepapers.

Investment Potential in Renewables Towards 2050

The rise of renewables is the single important necessity to achieve net-zero emissions by 2050, according to a wide range of leading forecasts and models developed by organizations such as Intergovernmental Panel on Climate Change (IPCC), BloombergNEF (BNEF), International Energy Agency (IEA) and International Renewable Energy Agency (IRENA). While scenarios and models vary in terms of how to achieve GHG emission mitigation and adaptation, the models are consistent regarding the benefits of increased solar and wind energy generation. Technology efficiency, reasonable energy storage, economies of scale, expertise and the development of a mature market will all accelerate such demand.

The Paris Agreement commitments have redirected financial flows towards climate mitigation and adaptation measures. For the first time, investments in low-carbon energy technologies have surpassed those in fossil fuels; exceeding USD 1 trillion in 2022, a 19 percent increase from 2021 levels and a 70 percent increase from pre-pandemic levels in 2019 [18]. In the forthcoming decades, the scale of such investments will continue to grow. According to IRENA's World Energy Transition Outlook, investments amounting to USD 150 trillion will be required by 2050 to scale up renewable power generation, electrify end-use sectors and deploy the technologies required to meet the 1.5°C target [12]. With such a substantial amount, the financial resources allocated by the public sector to support the transition are insufficient and hence, investments from the private sector will be crucial [19].

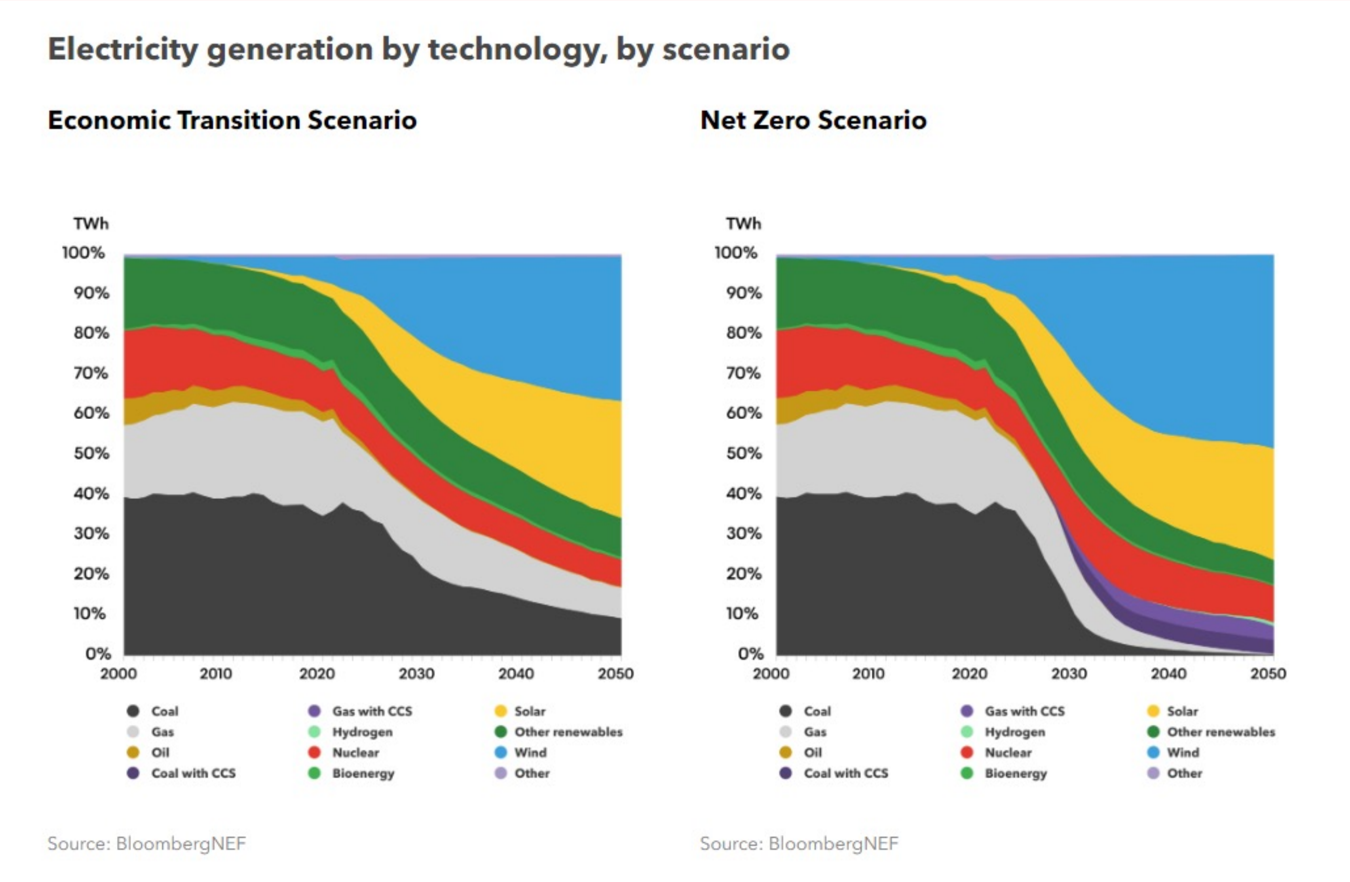


Figure 3: Historical and scenario modelled global electricity generation mix for different technologies. Source: BNEF [20].

The weight of renewables versus fossil fuels scales quite differently when considering today's energy system, as only a small fraction of global primary energy is derived from renewables, as demonstrated in Figure 3. However, as the figure indicates, a rapidly accelerating uptake of renewables in electricity production from 2000 is estimated [20]. The main drivers for such an increase are political regulations, financial development, and significant cost reductions for renewable technology [21] [22]. Also, for the future, financial investments in clean energy will continue to be a lifeline for transitioning economies along with new technologies to emerging and developing countries [18].

The overall global energy system needs a significant shift to achieve net zero emissions. The illustration of how primary energy consumption has changed since year 1800 is illustrated in Figure 4. While renewables have expanded exponentially, it started from miniscule levels compared to fossil-based sources.

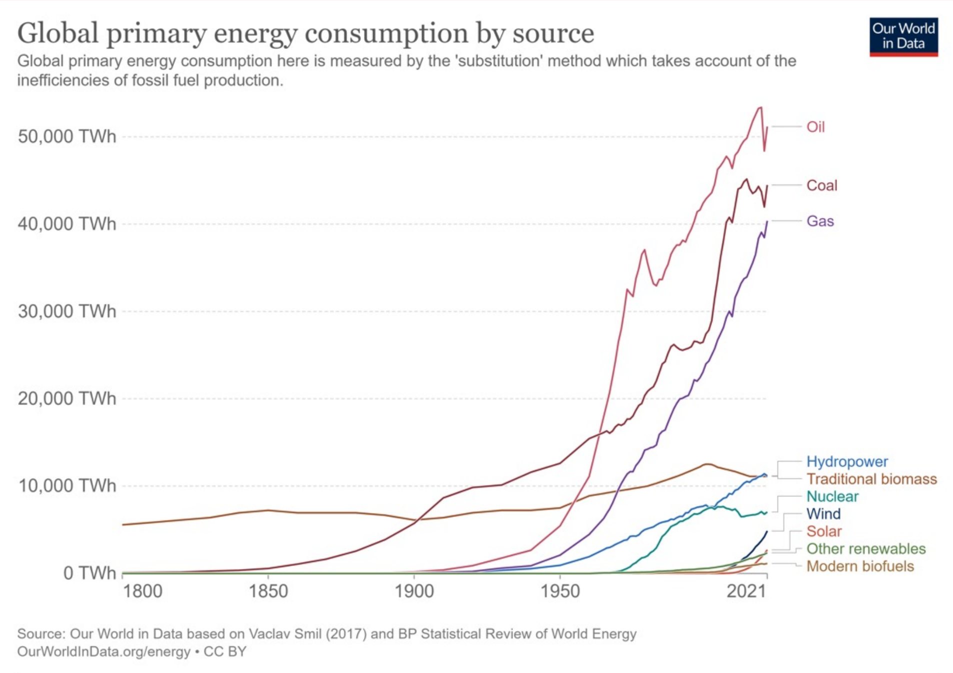


Figure 4: How the world's energy system has changed since the 1800s.

Despite the dominance of fossil fuels in the broader energy system, investments are on a trajectory to shift the trend. While global investments in clean energy have slightly increased from 2018 to 2020, Figure 5 demonstrates a pronounced trend the last couple of years.

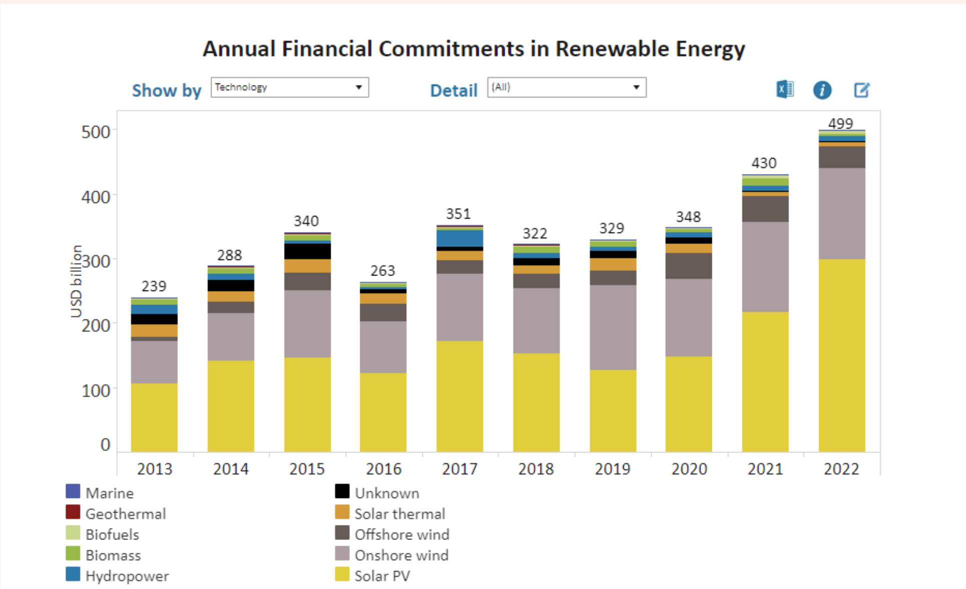


Figure 5: Global trends in renewable energy investments show that solar and wind energy has dominated the share of new investments in renewables since 2013. Source: IRENA [12].

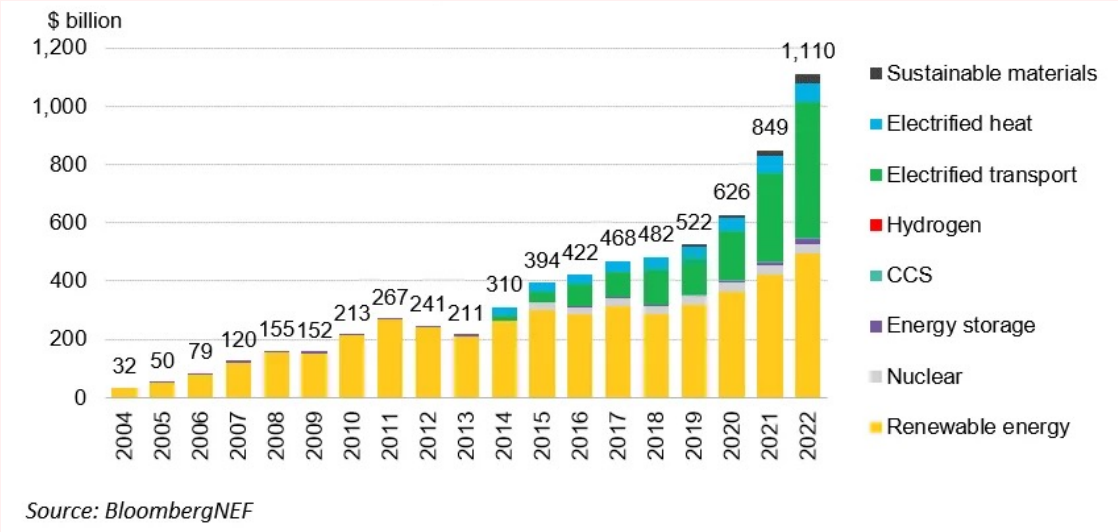


Figure 6: Global investment in energy transition by sector, of which renewables and electric transport is most notable. Source: BNEF [24].

Figure 6 demonstrates how renewable investments have been complemented with supporting infrastructure investments since 2004. Investments in electrification, energy storage, carbon capture and storage (CCS) and hydrogen have all increased notably. Accordingly, the transition to net zero transmission does not only consider clean energy production, but it also requires changes in upstream and downstream clean energy production sites and electrifications. However, clean electricity production serves as a prerequisite in electrification of the transportation sector. For instance, despite electric vehicles (EVs) non-tailpipe emissions, the pollution from its electricity production must be considered to reduce life cycle emissions [25].

A positive takeaway from IEA's graph in Figure 7 is the considerable investments in energy efficiency in parallel with investments in renewables. The most environmentally friendly energy is non-consumed or not produced energy. Additionally, the win-win nature of energy efficiency is measurable in monetary savings. Hence, companies and nations that prioritize energy efficient solutions and upgrading of distribution systems, will experience instantly reduced electricity consumption and monetary savings.

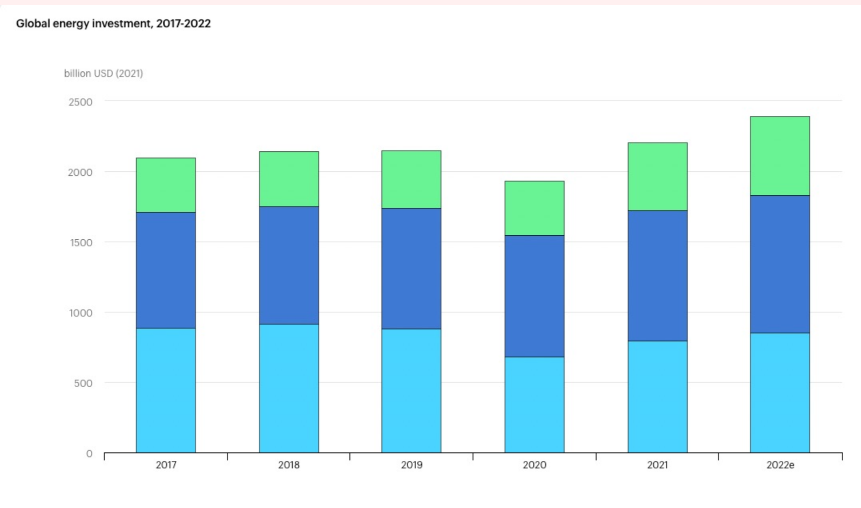


Figure 7: IEA's overview of global investment in clean energy and efficiency and share in total investment, measured in USD billion (left axis) and per cent of total energy investments (right axis) from 2017-2022. Source: IEA [26].

Scenario analysis could predict future trends and outcomes of energy production and could give valuable insight towards informed investments decisions. A scenario analysis by IRENA is given in Figure 8, which highlights how CO2 levels potentially evolve towards 2050. The first scenario is a baseline scenario, which recognizes business along today's trajectory without extra efforts for emission mitigation. In this scenario, emissions are expected to increase at a rate of 0.7 percent per year by 2050, resulting in a likely temperature rise of 3 °C or more by the end of the century. However, there are several efforts that have mitigated these effects, in line with the increased deployment of clean energy technology. The planned energy scenario demonstrates outcomes of the government's current energy plans, targets and polices, as the Nationally Determined Contributions (NDCs) from the Paris Agreement. NDCs refers to the emission mitigating efforts by each country [27]. The last scenario of Figure 7, namely the transforming energy scenario, illustrates a controlled shift of the entire energy system, where ambitious, yet realistic, transformations towards renewable energy sources and efficacy are considered. In conclusion, the combined tools of increasing the renewables' share in energy production, energy efficiency and a change in fuel compositions, lead to various reductions of emission, as demonstrated in Figure 7. Such valuable insight highlights the importance of transforming the energy sector to realize the Net Zero Scenario (NZS).

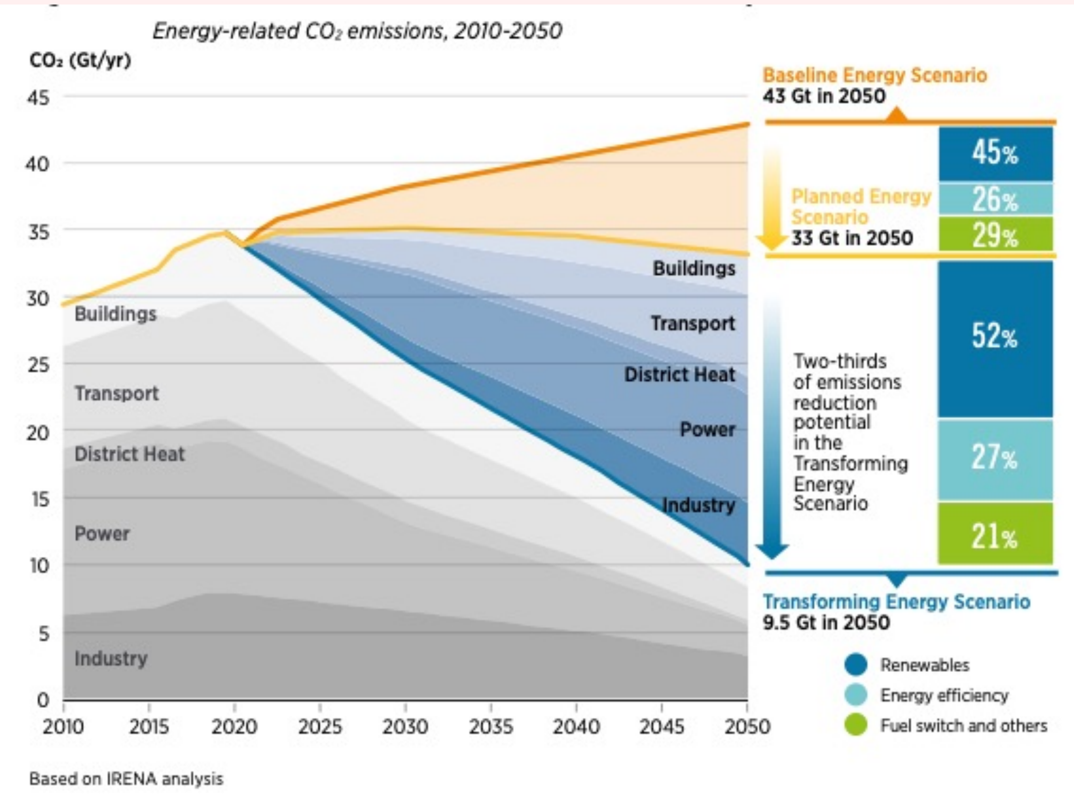


Figure 8: A scenario analysis by IRENA, demonstrating different CO2 outcomes [28]

Supporting Laws and Regulations

The European green deal and sustainable finance

To transform the European economy, the European Green Deal was presented by the European Commission in December 2019. As a part of the ambiguous plan and in compliance with the Paris Agreement, initiatives on Sustainable Finance were further introduced [29]. Sustainable finance focuses on integrating environmental, social and governance (ESG) considerations into financial investment decisions, leading to long-term investments in sustainable activities. In this manner, Sustainable Finance has a key role in ensuring policy objectives outlined in the European Green Deal [30].

To facilitate Sustainable Finance, the EU Commission announced a Sustainable Finance Action Plan (SFAP) for financing sustainable growth [31]. The SFAP is built on recommendations from the High-Level Expert Group (HLEG) on sustainable finance and outlines a comprehensive strategy to further connect finance with sustainability. The SFAP has three objectives.

(1) Reorient capital flows towards sustainable investments.
(2) Manage financial risks stemming from climate change, environmental degradation, and social issues, and
(3) Foster transparency and long-termism in financial and economic activity.

Based on the SFAP, the EU has put in place a Sustainable Financial framework to obtain the objective of Sustainable Finance [32]. The framework consists of three building blocks:

1

A classification system under the EU Taxonomy

The EU Taxonomy is a classification system that defines what is qualified sustainable in terms of economic activities. The taxonomy is developed by the Technical Expert Group (TEG), which was established by the European Commission to guide financing sustainable growth.

2

Disclosures under the Sustainable Finance Disclosure Regulation (SFDR) and Corporate Sustainability Reporting Directive (CSRD)

The objective of SFDR and CSRD is to improve transparency in the market for sustainable investment products, prevent greenwashing, and increase transparency regarding sustainability claims by sustainability disclosure. SFDR requirements cover a broad range of Environmental, Social, and Governance (ESG) metrics to define the disclosure requirements for selling financial products. CSRD provides a framework regarding reporting of non-financial data.

3

Investment tools under the EU climate benchmarks

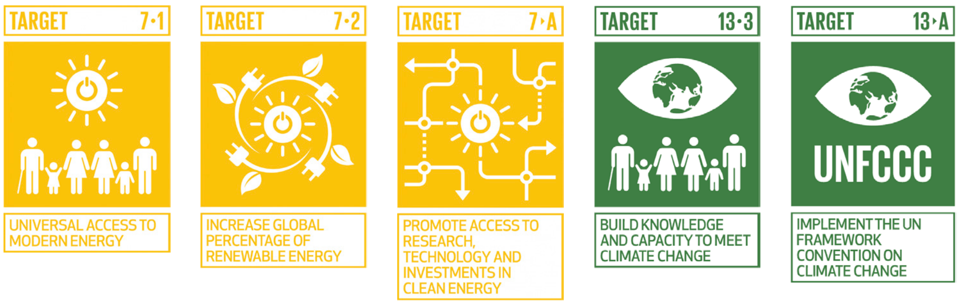
The investment tools include benchmarks, standards, and labels, that aim to facilitate financial market participants that try to align their investments strategies with the EU's environmental objectives).

Sub-themes

The transition toward a 100 per cent Renewable Energy System requires the utilization of new technologies and energy sources, which includes incremental energy efficiency improvements, and deployment of variable renewable energy sources [33]. This whitepaper includes four central sub-themes that are fundamental for renewable energy expansion: renewable energy technologies; energy storage; distribution; and efficiency. This section will determine the sub-themes with their potential and link their contribution to the SDG targets.

1. Renewable Technologies

Examples of key SDG Targets



Given the limited reserves of fossil fuels and the increasing level of energy consumption, it is not possible to solely rely on fossil fuels as an energy source [13]. This reality, in addition to the necessity of decarbonization, has moved the trend towards an increased reliance on renewable resources [33] [34]. However, to achieve a fossil-fuel free energy generation by 2050, renewable energy production will need to be increased 6 to 8-fold if energy demand is held constant [2]. Such ambitious expansion requires the utilization of various technologies that could harness energy from renewable sources. In this context, the utilization of solar energy, wind energy, hydropower, geothermal energy, marine energy, and bioenergy becomes evident, which will be further elaborated in this section [35] [14].

Wind Energy

Wind power generation has grown rapidly as it is one of the most predominant sources of power generation in the NZS [36] [37] [38]. This technology harnesses kinetic energy of moving air, by using large wind turbines located on land (onshore) or in sea- or freshwater (offshore) [14]. The benefits of wind power are further evident: It provides carbon- and pollution- free electricity and has potential to supply energy that exceed the electricity demand [39] [38]. Still, offshore wind accounts for less than 7 percent of the total cumulative onshore and offshore global wind capacity [40]. To achieve NZS, it is therefore required an average expansion of wind generation to approximately 17 percent per year during the 2023-2030 period [36]. The drivers for such an expansion will be R&D, supportive policies and diminishing costs [37]. For instance, the levelized cost of electricity (LCOE) for wind has fallen 60 percent the last decade, as new technology provides improved projections of both wind resources and wind turbine operating conditions [19] [39]. Moreover, LCOE for wind is projected to be significantly lower than the average LCOE of all fossil fuel generation by 2040 [39]. As costs continue to decrease, and technology advances, wind power will become one of the world's most important sources of energy [40].

Solar Energy

Solar energy stands out as the most abundant and readily available resource, having a vital role in reducing the energy reliance on fossil fuels [41] [14]. This technology converts sunlight into energy, either as electricity through photovoltaics and concentrated solar power, or in the form of solar heat through thermal technologies [41]. While solar photovoltaics (PV) technologies promise higher energy efficiency at lower costs, the main advantage of concentrated solar power is its ability to store thermal energy and delay electricity production, which makes it a predictable and reliable energy resource [42].

Solar energy production has experienced the highest growth in EU, signifying its great potential [41]. Based on current market trends, solar energy could potentially meet 20 percent of EU's electricity demand by 2040. Hence, EU initiatives aim to bring over 320 GW of solar photovoltaic by 2025 and nearly 600 GW by 2030. Additionally, the EU supports research and innovation projects that contribute to reducing the cost and increase the efficiency of solar energy technologies [42]. Consequently, the cost of solar power has decreased by 82 percent over the last decade, and the LCOE is further expected to decrease from 10 eurosCent/kWh in 2024 to 6.77 eurosCent/kWh in 2040 for all PV systems [43] [41]. Such cost reduction has boosted the demand for solar energy, making it one of the most competitive electricity generation technologies [43]. Also, new solar photovoltaics technologies promise higher energy conversion from sunlight and more energy efficiency [42]. The combination of lower costs and enhanced technologies results in increased deployment of solar energy.

Hydropower

Hydropower stands as the world's largest source of renewable electricity today and is expected to retain this position towards 2030 [44]. This technology harnesses the energy of water moving from higher to lower elevations and can be generated from both reservoirs and rivers [14]. Hydropower is designed to be relatively cost-effective, as it reduces losses in power generation [45]. Moreover, it is a reliable source of energy, as it enables power providers to meet peak demands and respond to a growing energy demand [44] [46].

However, as generation capacity of hydropower is still increasing, optimizing hydropower generation crucial from an economic and environmental point of view [45] [40]. Globally, there is a substantial profitable hydropower potential amounting to 5.27 PWh yr–1 [47]. As Europe's hydropower potential is extremely exploited, most new hydropower projects will be built in the Global South, where many of the world's major free-flowing rivers are located [47] [44]. Looking ahead, the optimized hydropower system is therefore expected to play a key role in the transition to a decarbonized energy system [47] [48]

Geothermal Energy

Geothermal energy (GE) is increasingly recognized as an option that could contribute to achieve the Paris Agreement target [49]. Geothermal energy is based on heat flux from the earth's core and consists of two main applications: power and heat production [49] [50]. Among renewable resources, geothermal energy is relatively reliable because of its independence from seasonal, climatic, and geographical conditions [50].

Geothermal energy holds significant potential, as an abundant renewable energy source [50]. Projections indicate that geothermal power production could increase to approximately 100–210 TWh/yr by 2050. Such advancements could eliminate more than 1 billion tons of CO2 by 2050 [49]. In this respect, EU pays special attention to geothermal energy, as attested by the €90 million granted for R&D on its technology between 2014 and 2018. Moreover, according to some estimates, the European geothermal energy investment market, including both supply and demand side, is projected to be worth about 160–210 billion USD per year by mid-century [49]

Ocean, Wave and Tidal Energy (marine energy)

Marine energy systems are still at an early stage of development, where prototypes on wave and tidal devices are being explored. The technology uses kinetic and thermal energy of seawater to produce electricity or heat [14]. Marine energy technology is less polluting and more efficient compared to other renewable sources and has a secure supply of energy [51].

The theoretical potential for ocean energy is above the present human energy requirements [14] [52]. Even though the current installed global capacity is 512 MW annually, the potential production ranges from 45 000 terawatt-hours (TWh) to well above 130 000 TWh annually [53]([52]). To achieve a sustainable development of tidal energy, an annual generation growth of 23 percent is required through 2030. However, the growth in ocean energy has been slower than expected, as these projects tend to be expensive, due to their inability for achieving economies of scale [51]. Despite the high costs, investors and institutions are showing high interest in marine energy as more resources are allocated to develop its technology and increase the installed capacity [52].

Bioenergy

Biomass is a clean, renewable energy source, since its initial energy sources, i.e., plants and algae, can be managed sustainably and can regrow in a relatively short time [54]. Bioenergy could be categorized as "traditional-" and "modern" biomass. Traditional technologies refer to the combustion of biomass in such forms as wood, animal waste and traditional charcoal. On the other hand, modern bioenergy technologies consist of liquid biofuels produced from bagasse and other plants, bio-refineries, among others [55]. The key advantage of bioenergy is that it is flexible, available, and can reduce waste issues [56].

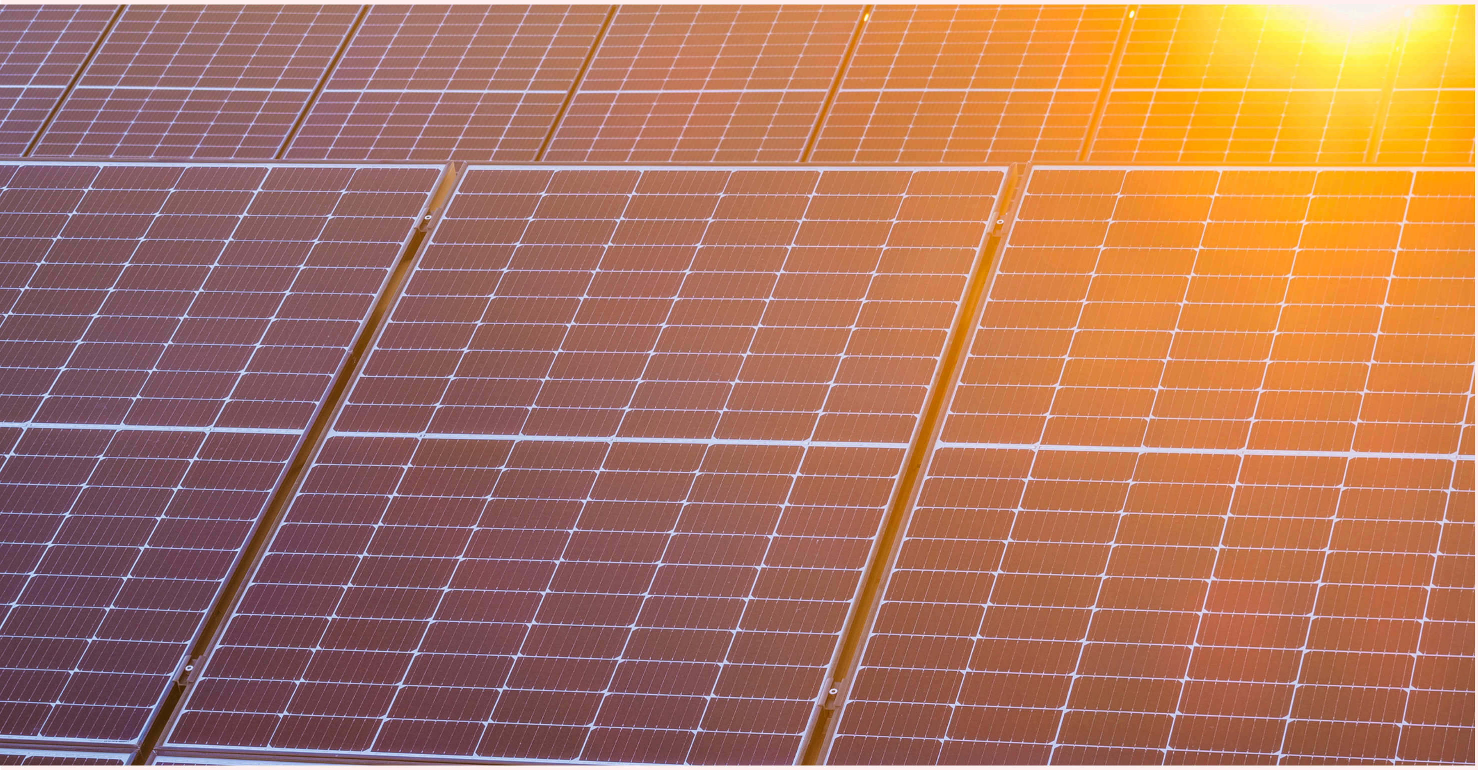
Bioenergy continues to be the main source of renewable energy in the EU, with a share of almost 60 percent [40]. The heating and cooling sector is the largest consumers, utilizing approximately 75 percen of bioenergy [57]. However, more efforts are needed to accelerate modern bioenergy deployment to get on track with the Net Zero Scenario , which calls for an eight percent annual increase between 2022 and 2030 [56]. Such increase could help diversify energy supply and thereby balance other renewable sources [57].

Shortcomings for renewable energy production

Even though renewable energy technology would help the world accelerate towards a Net zero Scenario, there are some mentionable shortcomings that need to be addressed as negative environmental repercussions could occur when expanding renewable energy generation. The general hydropower has a deep interaction with the environment and its expansion might cause damage as it displaces people and changes the natural river flow, which affect livelihoods and crops [48]. Also, bioenergy should only be used in limited applications, given potential negative environmental impacts related to large-scale increases in forest and bioenergy plantations [14]. However, if the resources are utilized carefully, their benefits will still exceed the potential damages.

Renewable Technologies

Solutions Company Highlight: Nextracker

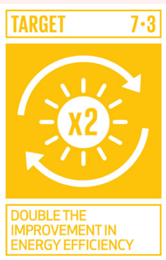


About

Nextracker is the number-one global solar tracker and software provider for ground-mounted and distributed solar projects, with an average market share of 30 percent the last seven years [58]. Their technology enables solar panels to track the sun's movements at different angles, and thus, enable them to capture more solar energy. Consequently, the objective of their solutions is to deliver more flexible solutions and achieve premium performance and maximum energy output across a broad range of projects sites and weather conditions.

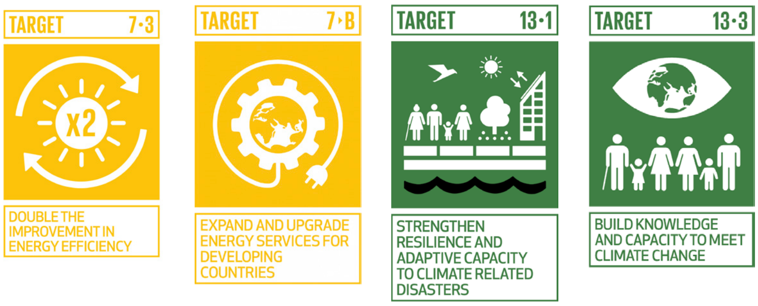
Impact on SDG Targets

Nextracker has installed over 75 GW of smart solar trackers and therefore saved over 108 metric tons of CO2 emissions annually [58]. Hence, the company contributes to SDG 7 regarding increased renewable share and energy efficiency. Their company also impacts SDG 12, by optimizing the efficiency of natural resources. Lastly, SDG 13 on climate mitigation and adaptation is achieved through its climate resilient solar optimization systems.



2. Energy Storage

Examples of key SDG Targets



To achieve a 100 percent share of variable renewable energy sources and to bridge the gap between the dynamically changing supply and demand, long-term energy storage systems (ESS) are necessary [33] [59]. An ESS is a system that converts energy, usually in the form of electricity, into another form of energy that can be reserved in a storage medium and then converted back to electricity when needed [60]. The demand for flexibility in the electricity system will increase significantly in all EU countries, increasing from 11% of total EU electricity demand in in 2021 to 24 percent in 2030, and further rising to 30 percentby 2050 [61]. Consequently, energy storage is crucial to provide the necessary flexibility, stability, and reliability of energy, especially when renewable energy production increases and energy system changes [33] [62].

Energy Carriers

An energy carrier is a transmitter of energy and enables storage and transmission of energy over time [63]. Energy carriers are created from primary sources of energy, and include hydrogen, electricity, fuel, coal, wood, and natural gas [64] [63] [65] . Hydrogen stands out, because of its high energy density and because it can store and supply large amounts of energy per unit mass without generating CO_2 emissions. Consequently, it holds potential for being a reliable energy carrier in the energy transition and projections estimate that hydrogen should account for 5–10 percent of total energy in 2050 under the Paris Agreement [66] [67] . The production processes of hydro energy are widely investigated, which enables converting several waste materials into valuable alternative fuels or chemicals. However, the costs for these processes are high [33]. In this context, solar energy is going to play a crucial role as it enables solar-to-hydrogen possibilities, as a means of achieving a clean energy carrier [68]

Storage technologies

The implementation of an energy storage system depends on the site, sources of electrical energy, and its associated costs and the environmental impacts [60]. There are different technologies for storing energy, such as thermal-, electric-, mechanical- or chemical energy storage [69]. In this section, thermal- , mechanical and electro-chemical energy storage will be presented with their potential.

Mechanical energy

Mechanical energy storage systems (MESS) have the largest share in the world's installed capacity and are among the most efficient and sustainable ESS, overcoming the intermittent aspect of renewable sources [70]. Mechanical energy storage harnesses motion or gravity to store electricity and could be divided into three main types of storage systems: pumped hydro, flywheel and compressed air, explained in table [71].

Pumped hydro storage	Flywheel	Compressed air
Pumped hydro storage (PHS) is the most developed commercial storage technology and has 94% of the world's energy storage capacity [60]. PHS is a type of hydroe-lectric energy storage, which can generate power as water moves down from one elevation to another trough a turbine [72]. The PHS is cost-effective, suited for long discharge durations, and enables water and waste control [73].	Flywheels consists of an electric motor that accelerates a rotor to high speeds and effectively converts the original electrical energy into a stored form of rotational energy. Flywheels is effective when energy is frequently supplied and removed and does not degrade proportionally with age or charge/discharge cycles, which makes them a viable short-term storage system [74].	Compressed air energy storage (CAES) captures, compress and store air in an airtight location, and then uses the gas to generate energy when it is needed. CAES has demonstrated its potential as a clean storage medium, it`s high lifetime scala-bility, low self-discharge, long discharge times, relatively low capital costs and high durability [75].

Choosing the suitable mechanical storage type depends on the requirements of application. If long duration is needed, it is preferred to use either pumped hydro or compressed air storage systems, knowing that the former has higher efficiency while the latter provides a faster start up. It is also recommended to use adiabatic or isothermal compressed air storage considering environmental concerns [70].

Thermal energy

Thermal storage system (TES) has the second highest installed capacity [60]. Heat creates a linkage between primary and secondary sources of energy, and the functional processes (conversion, transferring, and storage) possess 90 percent of the whole energy budget worldwide. Through storing the excess power generated from an intermittent energy source and make it available on-demand in the required amount, a TES could contribute to more appropriate thermal energy production-consumption [76] [77] [78] . Also, the use of TES in an energy system, reduces running costs and emissions, as low-carbon energy sources can be improved [79]. These benefits are especially evident when using solar technologies and Power-to-Heat concepts that will enable cheap and predictable energy [76] [42].

The global market for TES might triple in size by 2030, as investment to drive technological development and measures to enhance market pull, combined with a holistic decarbonizing energy policy, can unlock a rapid growth in TES deployment [80]. By exploiting the TES method for producing heat during the discharging time, the round-trip efficiency of the thermal systems could heighten from below 50 percent to around 70 percent to 100 percent depending on the amount of heat loss imposed [76]. As a result, investments in applications for cooling and power could reach between USD 13 billion and USD 28 billion by 2030 [80].

Electrochemical energy - Batteries

Electrochemical battery storage (EBS) systems have the third highest installed capacity among the energy storage technologies [60]. Still, EBS is the most effective method for energy storage, by converting chemical to electrical energy [69] [81]. Moreover, EBS enables a more balanced supply and demand, grid stability, storage of excess electricity and power, improved air quality, reduced emissions, and reduced costs [82] [62]. Among the ESB technologies, Li-ion has the highest market share with a capacity of 1.66 GW, due to its high efficiency, high energy density, high power density and longer life cycle [60] [83] . Moreover, Li-ion battery has a wide range of applications, such as electrical vehicles, mobile phones, laptops and power grids. Hence, the application of EBS with Li-ion batteries, has potential across several sectors and industries.

Rising energy costs and aggressive policy drivers make 2023 a record year for ESS installations. To meet the demand expansions, competition heats up to secure supply of EBS and companies are increasingly entering into long-term EBS-agreements. The potential also increases due to the decline in energy storage prices, as lithium becomes more available [84]. A 2022 analysis by McKinsey Battery Insights team, projects that the entire Li-ion battery chain, could grow by over 30 percent annually from 2022 to 2030, reaching a value of more than USD 400 billion and a market share of 4.7 TWh [85]. Hence, EBS systems are a key technology for enabling the transition to a low-carbon energy system [82].

Shortcomings for energy storage technologies

Despite the benefits, there are still some mentionable shortcomings regarding ESS's efficiency and lifecycle pollution. A major downside to hydrogen production is that it loses between 60-85 percent of the incoming electricity with current technology [86]. Also, although most batteries are recycled, most recycling processes around the world are highly polluting. Moreover, Li-ion batteries are generally not recycled as there are no available technologies to economically extract metals in a manner that enables reuse of materials [87]. Hence, for these products to be more sustainable, the technology efficiency and holistic life cycle must be developed.

Energy Storage

Solutions Company Highlight:

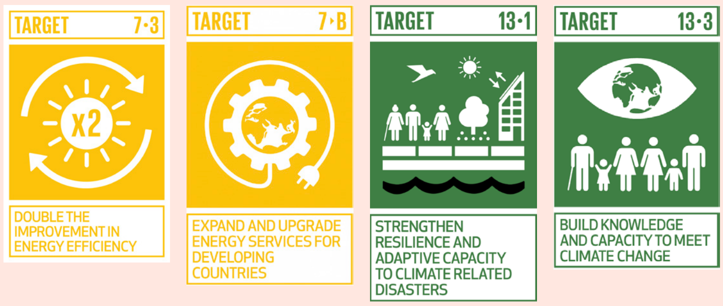
Samsung SDI

About

Samsung SDI is specialized in the field of energy and materials such as IT, Li-ion batteries and electronic materials. The company has developed a flexible battery, of unique structure design and material technology. The battery is so durable, that it still works after going through tens of thousands bending tests. Consequently, from June 2023, Samsung SDI became the 1st Lithium battery Business to Receive Carbon Footprint Label. The company has also developed core materials for cutting-edge IT products, such as semiconductors, displays and new energy solutions. As a result, they are on the next-generation core material market, through developing organic light-emitting diode (OLED) materials, highly advanced polarization films, and high-brightness contrast ratios [88].

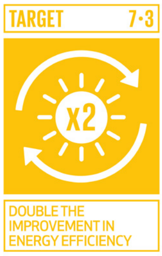
Impact on SDG Targets

Samsung SDI`s five strategies for creating sustainable value are composed of an integrated environmental management system for continuous improvement, building green partnership with suppliers, cleaner production and pollution mitigation, eco-design, and interactive communication [89]. Hence, Samsung SDI contributes to achieving SDG 7 for minimizing pollution, SDG 8 for achieving higher levels of economic productivity technological upgrading and innovation and SDG 12 by providing better technology efficiency.



3. Energy Distribution

Examples of key SDG Targets



Grids and Infrastructure

The power grid is a complex, interconnected system of generation, transmission and distribution and is a critical part of the infrastructure. Such infrastructure plays an important role, as it needs to cope with both short- and long-term variability in production and consumption to ensure that the electricity supply is maintained. The grid could further be divided into three different levels: macrogrid, minigrid and microgrid. While a macrogrid has a central structure that aims to serve a large population, the mini and microgrids are more local [90] [91].

The integration of distributed renewable sources into the power grid poses a challenge, as the grids were designed to accommodate large, centralized dispatchable power plants [12]. The centralized model is starting to break down because it`s lack of agility and reliability [92]. Hence, today's power grids need to be massively modernized to cope with the integration of renewables, while ensuring reliability and power system stability [93]. Hence, to facilitate the integration of renewables, cope with the increased capacity requirements and bidirectional flows, investments in management and control systems to accommodate distributed power generation is needed. To align with the Paris agreement scenario and improving system reliability in grids, an investment amount of USD 22.4 trillion towards 2050 in electricity networks is required [12]. Hence, the challenges associated with the integration of renewable sources to the power grid, poses great investment opportunities.

Distributed Energy Resources

Distributed energy resources (DER) are energy resources that are situated close to the end user and might be integrated to microgrids or mini grids. These resources often combine renewable energy installations such as rooftop solar modules, small wind turbines or small-hydro with a battery or a generator to form a microgrid or a mini grid [91]. The need for flexibility in distribution grids will increase as they evolve from unidirectional flow from large, centralized generators to bi-directional power flow between traditional generators and increasingly small-scale prosumers, which is the term considering producers that also consume electricity from the grid. Prosumers utilize DER, which allows them to take on a more proactive and dynamic role in electricity consumption and production process, as energy supply is decentralize to a local generation [12].

Such a distributed generation can benefit the environment through eliminating line losses, as electricity required from a centralized power plant decrease [94]. Moreover, the annual carbon emissions and net interaction of an optimized DES are reduced by 51.7 percent–73.2 percent and 33.5 percent–63.6 percent, respectively, compared to other systems [95]. Hence, micrgrids could complement the conventional power grid when electricity demand is high, maintain supply during a grid-outage, restore electricity supply faster and help remote communities gain access to a more reliable supply of sustainable electricity [91].

Digitalization of the power grid

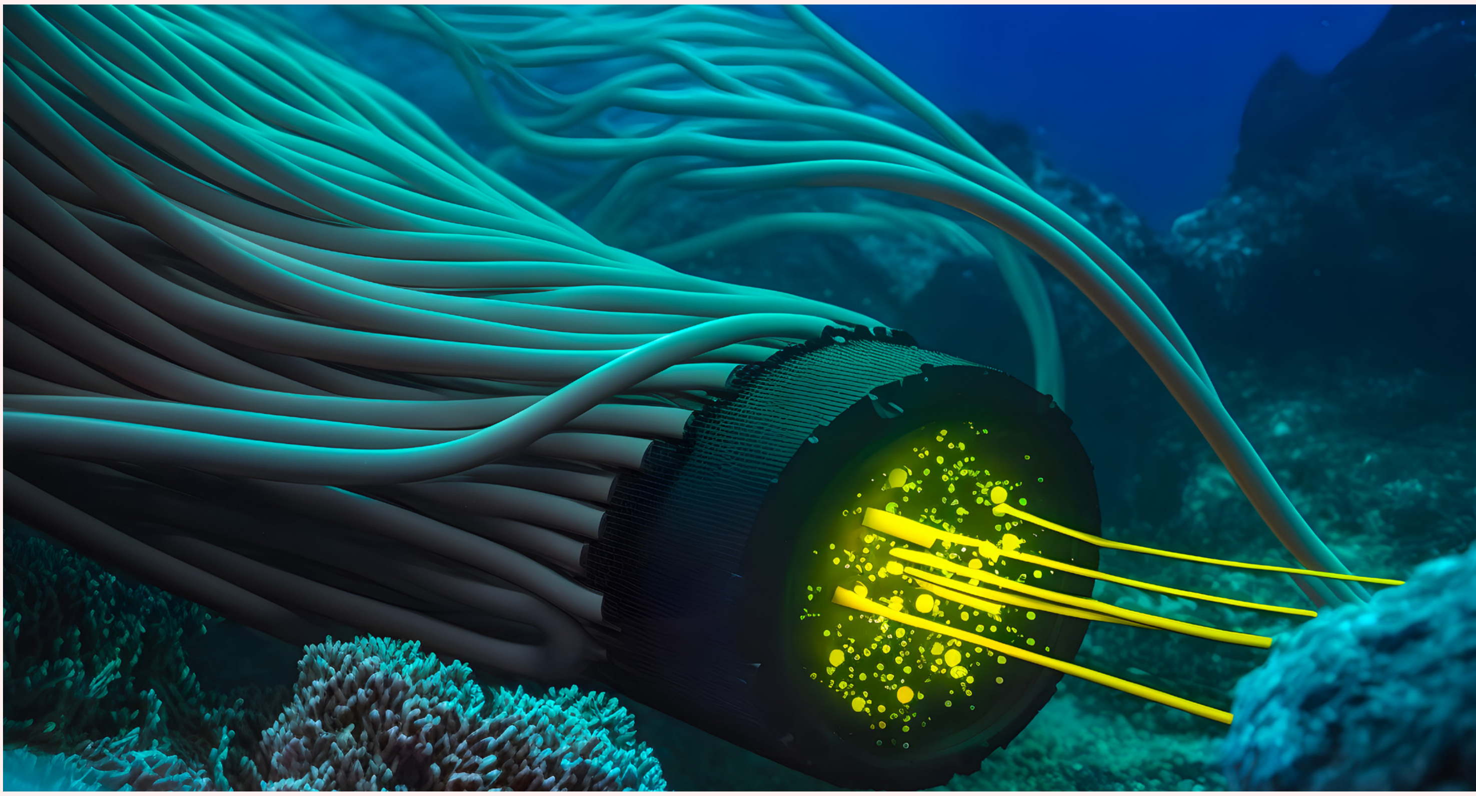
As our reliance on renewable energy increases, digitalization of power systems is required to ensure reliable operation [93]. The digitalization and smart energy management in buildings will change how buildings consume energy and allow them to provide grid services through enhanced demand flexibility [12]. Moreover, to ensure that renewable energy fulfils its full potential and manage the increasingly complex energy system, monitoring data from multiple sensors, increased connectivity, incorporation of artificial intelligence to predict behavior and enable fast decision-making will be essential. In this context, smart grids will facilitate the exchange of real-time information for forecasting, scheduling and trading between multiple stakeholders. Therefore, investment directed to smart networks, will also enable development and capital spent required for energy storage and renewables [93].

Shortcomings to energy distribution

Smart and distributed grids also contain mentionable shortcomings regarding their application. Firstly, policy and regulations must synchronize power grid expansion and other infrastructure developments with renewable power deployment to avoid bottlenecks [12]. However, sustainability may not be of great importance for governments and companies, making transition from outdated energy infrastructure based on traditional fossil sources less of a priority [96]. In addition, there might be challenging for grid operators to ensure that new distributed infrastructure facilitates all consumers in any specific geographical area, as the renewable energy generation is distributed to some locations and due to geographical space limitations [97]. Privacy is also becoming an issue, as measuring instruments are integrated in smart grids, which may support criminal targeting [98]. Hence, the rapid growth of new grid infrastructure and digitalization may give rise to other issues, like electricity resilience and privacy.

Energy Distribution

Solutions Company Highlight: Prysmian Group

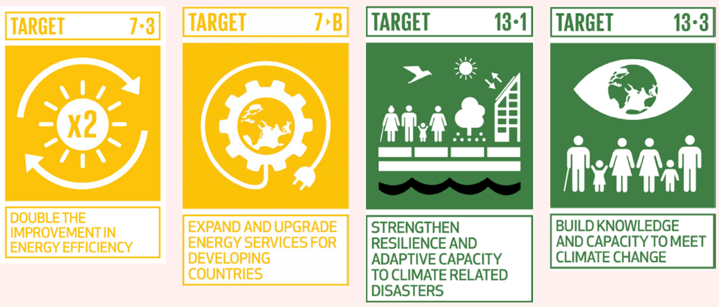


About

The Prysmian group is a part of the world's largest producer of functional and safe cables within the energy and telecommunication sector. The Prysmian group enables safe and effective infrastructure and stands for important connections that enables energy and information flow [99]. Their technology is used in submarine cables that can be laid at greater depth, optical fiber solutions that can pack the largest number of cables into the tightest space and underground cables to transport energy for longer distances [100]. Their ability to innovate and meet the customers' needs makes them a market leader. In addition, they have a track record of delivering products that are faster, smarter and more sustainable than ever before [101].

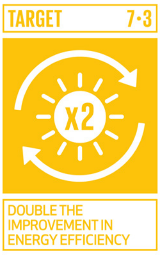
Impact on SDG Targets

Innovating energy transition, digitalization and sustainability is Prysmian group`s strategic priority and the company has about 5,600 patents covering their main innovation. Moreover, they have 26 R&D centers and 900 professionals for their purpose, and their role as a promoter for sustainable development accelerates the group's race to net-zero CO2 emissions [102] [101]. Therefore, the group supports SGD 8 and 9 through technological and sustainable upgrading and innovation of infrastructure. Additionally, as a pioneer in the lifecycle of cables and encouraging companies to utilize sustainable cable solutions, the company contributes to achieve SDG 12.



Energy Efficiency

Examples of key SDG Targets



A common application and key aspect for all renewable technologies, storage- and transmission systems is energy efficiency. Energy efficiency is any method ensuring the same amount of useful output from less energy consumed and refers to materials and processes that prevent energy loss [103]. In physics, the law of energy conservation states that energy can never be created or destroyed but converted from one form of energy to another. This law is the most evident argument for energy efficiency, where minimizing losses in energy storage and distribution is essential [59]. Energy is usually lost through heat energy, light energy or sound energy, all of which prevent processes from being 100 percent efficient [104]). Specifically, more than 60 percent of energy used for electricity generation is lost in conversion [105]. In this context, energy efficiency is one of the easiest and most cost-effective ways to combat climate change, reduce energy costs for consumers, and improve the competitiveness of businesses [106].

The largest energy efficiency opportunities of the future will be found in emerging and developing countries, which account for around 60 percent of global final energy demand [107]. Evidence suggests that environmental technology helps reducing overall energy consumption and improves overall energy efficiency [108] Moreover, sustainable economic development and energy efficiency are positively related, suggesting that sustainable development is associated with increased energy efficiency [109].

According to IEA, energy efficiency improvements will reduce energy-related greenhouse gas emissions by 40 percent over the next 20 years [110]. In 2021, global energy intensity, a measure of the economy's energy efficiency, is expected to improve by 1.9 percent after improving by only 0.5 percent in 2020. However, this percentage is still only half of the four percent a year that is needed to achieve a transition to net zero [110]. Hence, the IEA has brought together leading international figures to find ways to accelerate energy efficiency progress worldwide, as the current energy efficiency hampers the world`s ability to meet its climate goals [111].

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Team Solutions

The Solutions Investment Team is responsible for identifying solution companies, for use across Storebrand Asset Management, as well as for Solution funds: Storebrand Global Solutions, Storebrand Renewable Energy, Storebrand Smart Cities and Storebrand Equal Opportunities.

Philip Ripman, Portfolio Manager

Sunniva Bratt Slette, Portfolio Manager

Ellen Grieg Andersen, Portfolio Manager

Nader Hakimi Fard, Portfolio Manager

Christoffer Platou Bjørnsen, Intern

Marie Eskeland Børtveit, Intern

Last updated DECEMBER 2023
Storebrand Asset Management
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86169 12/2023