Digitalization

In 2023, innovation activities in the field of cyber security benefited from the network of Innovation Hubs, as well as from their portfolio of startups and partnerships forged at the Group level.

These interconnections have enabled the sharing of best practices and operating models, as well as the construction and enhancement of info-sharing channels.

The main initiatives in this area are reported below:

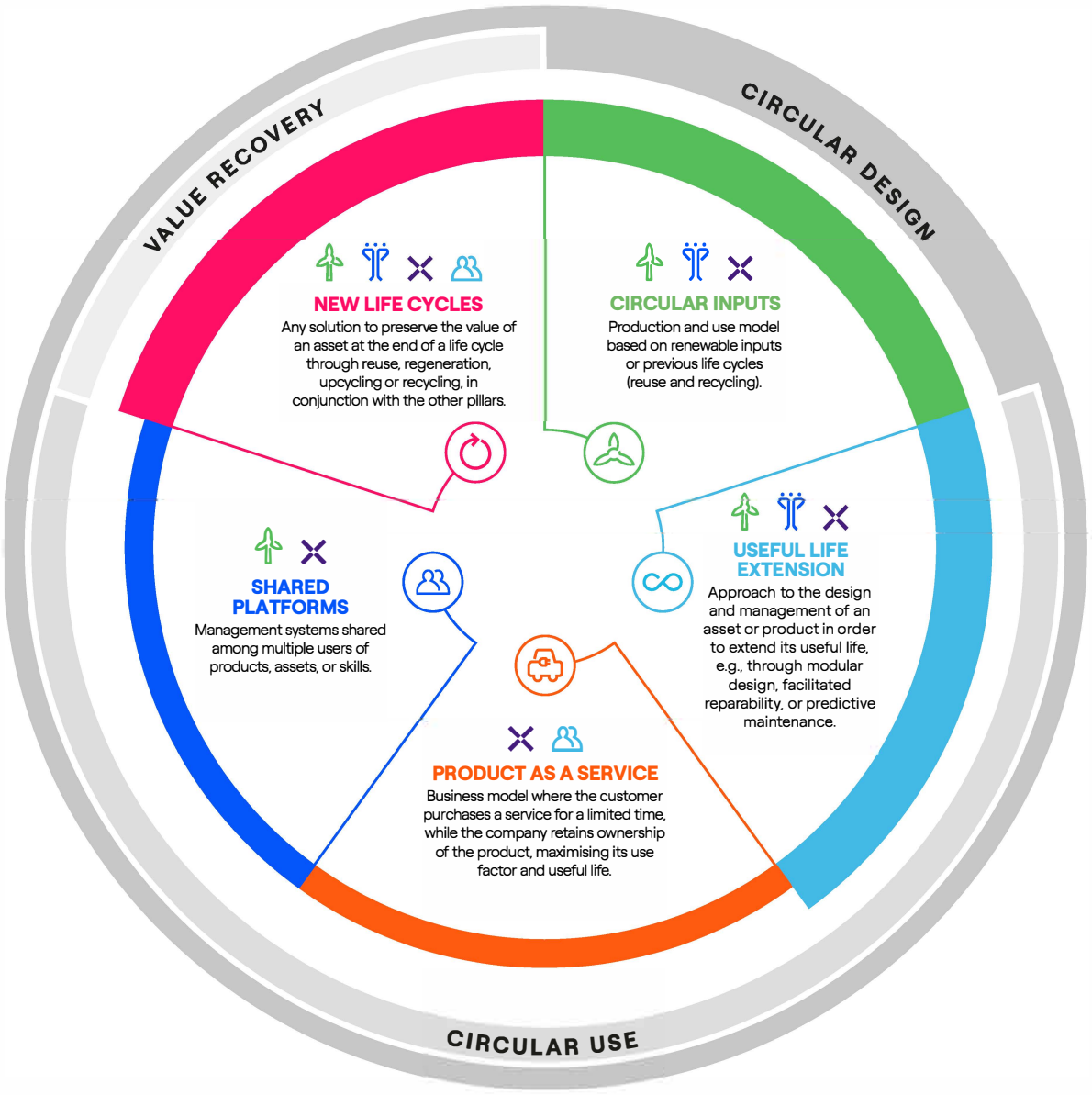
- analysis of solutions based on quantum key distribution[41] and quantum safe encryption algorithms[42] to improve understanding of how to go beyond current encryption models threatened by the future expansion of computational capacity offered by quantum computing;
- services and solutions to support software development to analyze open source code and third-party software libraries from the point of view of vulnerabilities and user licenses;
- analysis of browser isolation solutions (isolation of the browser from the network to prevent it from becoming an entry point for malicious actors) and browser security to understand the resilience of central protection techniques compared with distributed approaches;
- further development of solutions that exploit emerging technologies such as artificial intelligence and machine learning to enhance capabilities in detecting IT threats and automating the process of analysis, correlation and response to incidents;
- solutions for identifying vulnerabilities of assets and devices (IoT, web applications, etc.) with the help of innovative techniques;
- review of industrial environments through the implementation of a vulnerability identification process with scripts without impacting the operating environments;
- a study for the implementation of a multifactor authentication system for company systems, using a "passwordless" technique to replace the password with alternative secure solutions (for example, fingerprint authentication);
- analysis and scouting of solutions for the anonymization and masking of data in non-production environments and definition of the associated policy;
- analysis of solutions to prevent data loss to ensure compliance with protection requirements imposed by internal and external regulations;
- study and analysis of solutions for the management of cryptographic keys and business secrets;
- analysis of new anti-malware solutions to protect industrial environments;
- creation of the Cyber Harbor, an innovation center that brings together cyber security experts, companies, investors and the academic world to foster the creation of innovative and competitive projects in the IT security field for Italy;
- establishment of a communication channel with Italy's National Cybersecurity Authority (NCA) for the creation of the Hyper SOC, an infrastructure for the aggregation, correlation and analysis of events of interest to ensure the early identification of emerging threats and coordinate responses to deal with them effectively.

(41) Cryptographic technique for distributing symmetrical keys based on the principles of quantum physics.
(42) Encryption protocols based on algorithms and characteristics considered sufficiently secure against threats posed by the computational capacity of quantum computers.

The circular economy

For the Group, the circular economy is a strategic lever to support our decarbonization roadmap. It involves a steady expansion of energy production from renewable sources and the consequent abandonment of fossil fuels, offering a path towards a fair and inclusive transition. Achieving these objectives requires a profound transformation of the energy system and, at the same time, entails a different and growing need for raw materials and new approaches to managing assets, such as the distribution grid and generation plants.

The circular economy model adopted by the Group seeks to redesign the entire value chain of the goods used, not only to reduce consumption of raw materials but also to limit the associated environmental, social, economic and geopolitical impacts and risks: in other words, to make the business model more sustainable and competitive. The Group's vision encompasses all the different life phases of a product and is based on five pillars: circular inputs (inputs from renewables, recycling, reuse), extension of useful life (through modular design, facilitated repairability and maintenance predictive), product as a service (the Company provides the customer with a service and retains ownership of the product, maximizing its use factor and useful life), shared platforms (shared use of an asset among multiple users), new life cycles (recovery of the value of goods and materials, for example through reuse and recycling).



The Group's initiatives focus mainly on three of the five pillars, namely circular inputs, useful life extension and new life cycles.
With regard to circular inputs, during the tender phase suppliers of core components[43] are asked to specify the quantities of each material used in the production processes, indicating the share of recycled and recyclable material to support assessments in the selection phase. One example of the reduction in the use of input resources is the 3SUN Gigafactory project in Catania, which is intended to ensure greater independence for the photovoltaic supply chain, not only by bringing the production of cells and panels onto European soil, but also by using innovation to reduce the intensity of silicon use and building a diversified and sustainable supply chain. In 2023 3SUN worked on the development of the new production site and, from 2024, a new type of high-efficiency panel with HJT technology will optimize the quantity of silicon used, using layers of the material with a 15% smaller thickness.

With regard to extending useful life, in addition to using predictive repair and maintenance in the global management of power distribution and generation assets, the Group is also working on innovative solutions. For example, the Pioneer project in Italy involves Enel collaborating with ADR - Aeroporti di Roma on the development of a storage system that reuses end-of-life batteries from electric vehicles. During 2023, the detailed design of the plant was completed: with a storage capacity of 10 MWh, it involves the reuse of 786 second-life batteries.

With regard to the new life cycle pillar, initiatives are also under way in all the countries in which the Group operates to ensure the systematic reuse, both internally and through sale, of obsolete or unused generation equipment that still retains a useful residual life, or the recycling of materials recovered from maintenance activities on the distribution grid. Specifically, the Equipment New Life Program, which is active around the world for all generation technologies, seeks to give new life to components held in power plant inventories, to the equipment of decommissioned power plants and to plants undergoing repowering. In 2023, the project generated approximately €23 million in economic value, of which approximately €13.8 million in the form of costs avoided through the internal reuse of spare parts and equipment in all plants and €9.2 million from sales.

In order to identify areas requiring attention and related priorities concerning materials, and to consequently update the portfolio of projects and initiatives, an internal working group has been operating since 2020 with the participation of all the relevant areas of the Group. The working group's activities begin with a systematic analysis of raw material requirements for generation and distribution assets, solutions for customers and digital assets. Environmental, social, economic and geopolitical impacts and risks are then assessed, mainly with respect to the extraction and production phases of raw materials. Intervention priorities are then identified and a mitigation plan is developed, leveraging circular economy projects that reduce the consumption of raw materials, particularly critical materials.

(43) The core categories are those strategic for the business, including wind turbines, inverters, smart meters, photovoltaics, switches, panels, cables, transformers, charging stations, street lighting, smart home solutions and storage systems.