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Analysis of Batteries in the European Community from an Economic, Financial, and Environmental Perspective

Superivisor

Prof. Carlo Carraro

Graduant

Vittoria Meneghin

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ABSTRACT:
In the last couple of decades, politicians, social media and scientists have been focusing on a problem that has become a international issue: the climate change.
We already know the potentiality of planet Earth in resources and energy for our evolution and growth; we have the possibility to understand how to combine the necessity of economical growth and the sustainability while doing this to because the main target is to maximise the positive effects on the environment, with the prospective to reduce our pollution and reduce the increasing of the temperature.

More often than before, in those years, there has been some natural extreme events in all over the world like, urricanes in the USA, Filippines or droughts in Iran or Brasil or particularly heavy rains in Europe (Gremany or Italy).

The climate is changing in a too much rapid way that is not possible to consider natural, so this kind of change are originated by the humans actions, from the heavy consume of fossil fuel, neglectic use of the soil, massive deforestation and extreme urbanization; actions that started with the beginning of the second industrial revolution (1870).

The damage that the climate change is causing, is not just on the environmental system, but also in the health one and in the economical one (national and international). So the question comes natural: how could we limit climate change and make it become a positive trend instead?

The possibilities are quite a few: integrate the environmental component on all the economical decision that the government takes, from the individual to the national level; on the investments sector, infrastructure policies and also in the sustainable models of sustainable growth that can stem the environmental problem that is going on right now.

First of all has to change the way of thinking and the necessities that are on focus with the collective target of saving the human race from our self and to give the possibility to give the next generation the condition to survive and grow.

Changes are necessaries and habits are going to become more responsible and sustainable, emissions have to decrease rapidly to stop the increasing of pollutants in the atmosphere that are causing and increasing the Green Gas effects (one of the most dramatic causes of climate change), not just as individual level, but also as community. Investments on the green technologies are one of the main goal that we have to persue in which there is to be the possibility to combine technology, investements, environment and economic growth, instead of invests on fossil fuels.

This work wants to focus on the current environmental and economical situation that are bonded together and trying to find the possible solutions to fight climate change using the best technologies available.
In this case the focus is putted on the Battieries used as storage system to reduce the usage of fossil fuel and try to abolish it.

The main case of study is going to be the FZSonick industry, placed in the Vicenza area with the goal to reduce the GHG emission with an implementation of technology with their Sodium Metal Chloride (SMC) or Salt batteries made with recyclable materials and do not contain rare-earth materials. They are the safest among existing high-density batteries in all conditions: transport, storage and operation.

Introduction

Climate change:

It's inevitable to say that the biggest threat the entire humanity is facing right now is the Climate Change: the Intergovernmental Panel on Climate Change (IPCC) cite "Human activities, principally through emissions of greenhouse gases, have unequivocally caused global warming, with global surface temperature reaching 1.1°C above 1850-1900 in 2011-2020. Global greenhouse gas emissions have continued to increase […] between and within countries, and among individuals (high confidence)."

The climate crisis is not affecting just humanity but also the entire sphere of biodiversity, highlighting the vulnerability of ecosystems worldwide. Perhaps the most striking issue is that are driven by an unsustainable production and consumption systems, including the volume and methods by which we extract and use energy.

The expression 'climate change' is used to indicate change in the climate system, the variations in the mean values based on different parameters (environmental and climatic) that happens in different occur across different spatial and historical scales: temperatures, precipitations, distribution

The terms 'global warming' and 'climate change' are often used interchangeably but they are not the same concept. To be more precise, in scientific literature, climate change and global warming are inextricably linked, even if they are distinct phenomena. The simplest explanation of this linkage is that global warming is the primary driver of the current changes in climate.

To mitigate the effects of the climate change action are taken in a different scale: international, national and even at the local level.
Mitigation refers directly to the possibility of lowering the concentration of the GHG levels emission into the atmosphere created every day.
Everybody in their own way create the releasing of GHG gases on a daily base, like for example, driving cooking and also with their choice in clothes (just think about the fast fashion and the production of materials).

The important thing is to understand that everybody has the chance and also the responsibility to reduce their emission to contrast the global warming and actively try to save the planet: people, institutions, industries and government have a part to play in this very important issue that now has become an inevitable threat.

The 2023 has been an extraordinary year, the rise of the mean temperatures reached 1,48°C compared to the pre-industrial era and the first quarter of the 2024 year has been also a period in which the average temperature has exceed the 1.5°C across all the world, including Central Africa, a generous part of the South America, the Mediterranean zone and also the Indian Ocean.

For sure, the imponent presence of El Niño, the continuous eruptions of volcanos in Iceland and the heightened solar activity during the 2023 have undeniably contributed to the temperature increase. However, even when considering these factors in isolation, there is no possibility to replicate the extreme temperatures observed without including the impact of anthropogenic action to the global warming effect.

Causes of climate change

The main cause of climate change are the green-house-gases (GHG), atmospheric gases that absorb and release infrared red rays, that are produced by the anthropogenic activities like industry, agriculture, deforestation and development of livestock farming.

The main GHG produced are: carbon dioxide (fig.1) with a concentration in the atmosphere of 419 ppm mainly caused by the combustion of fossil fuels and deforestation (75% of the total GHG emissions) , methane with 1.910 ppb mainly caused by agriculture extraction of natural gas (16% of the total GHG emissions), nitrous oxide with 337 ppb caused by the massive use of fertilizers (6% of the total GHG emissions) , and halocarbons caused by the refrigerants and industrial productions (3% of the total GHG emissions).

The human production of CO2 is the main factor of the global warming. In the 2020 the CO2 concentration was 48% higher than the pre-industrial level (NOAA Global Monitoring Laboratory).

Industrial operations represent a significant source of environmental pressure, contributing primarily to atmospheric emissions, aquatic ecosystem contamination, waste generation, and the depletion of natural resources.

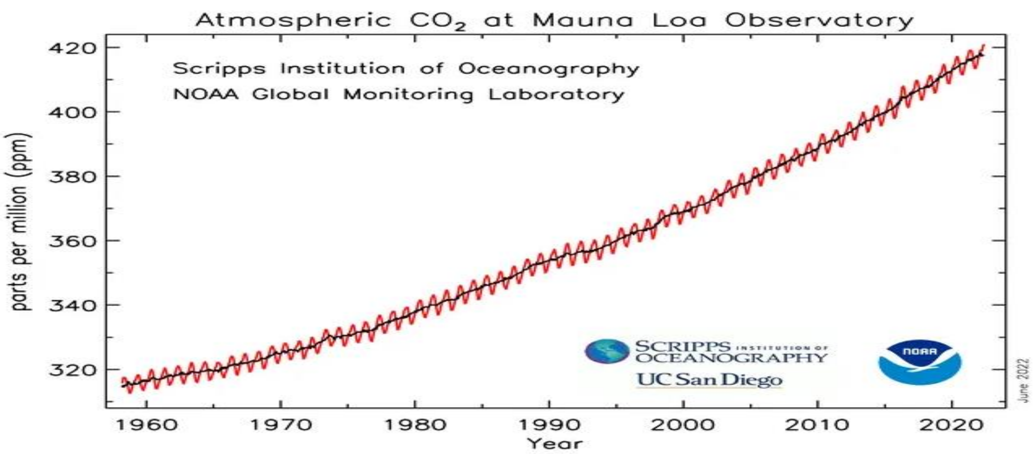

Figure 1 CO2 in the atmosphere

Environmental impacts

Throughout the 20th century, global biodiversity experienced a decline ranging from 2% to 11%, as evidenced by various indicators. This biodiversity loss is predominantly driven by land-use changes that progressively diminish ecosystem resilience and diversity.

Climatic change encompasses long-term alterations in environmental parameters within a region, typically assessed over approximately 30 years. These parameters include light intensity, temperature, humidity, wind patterns, concentrations of atmospheric gases, as well as the quality of air, water, and soil. These climatic shifts significantly influence agricultural productivity, animal populations, the hydrological cycle, wind patterns, rainfall distribution, and the growth and development of plant species, which are crucial for the integrity of terrestrial food chains.

Human activities have adversely affected roughly 75% of terrestrial ecosystems and 66% of marine environments. These activities threaten the extinction of 25% of the world's species. Social and economic development—manifested through urbanization, industrialization, and the expansion of agricultural practices—substantially alters land use and land cover. These alterations contribute to deforestation, habitat fragmentation, and soil degradation, thereby intensifying the decline in biodiversity. In the past decade almost 500 species of different animals went exctint around the glode. The situation, for the scientists is going to go much worse, the predictions says that from 200 to 10,000 species will be extinced by the end of the century if are not going to take some serious action about the climate change.

The climate change has it fast warming scale in the continent of Europe and will increase during all the century, but the magnitude and the velocity of the change is driven by how much the causes of climate change will be reduced on a global scale. On the worst hypothesis, without any kind of policy action the economical damage, driven by just the floods will exceed 1 trillion€ per year for the Europe continent at the end of the century.
Another problem is the sea level rising that is accelerating the pace. The rising of the sea levels is directly connected to the coastal erosion, storm surges and the more presence of salt water into the groundwater poses a significant risk to natural freshwater aquifers. This salinization can create substantial issues not only for dependent fauna and ecosystems but also for the entire water supply system utilized for agriculture and as a source of potable water for human populations.

Economic impacts

While the discussion often focuses on the environmental damage caused by human activities, it is equally important to examine the broader impact on society as a whole. These activities not only disrupt our lifestyle but also challenge the very foundation of our economy, affecting our daily lives in profound ways.

A recent report from the World Bank highlights the potential for countries in Europe to shift towards renewable energy and reduce reliance on fossil fuels. This transition offers numerous benefits, including enhanced energy security, sustainable economic growth, and greater affordability.

From 1980 to 2022, extreme weather and climate events resulted in economic losses estimated at EUR 650 billion across EU Member States(fig.2), with significant impacts of EUR 59.4 billion in 2021 and EUR 52.3 billion in 2022 alone. Tracking these economic losses is complex due to their significant year-to-year variability. However, statistical analyses indicate an upward trend in economic losses over time.

Climate hazards like temperature extremes, heavy rainfall, and droughts pose severe threats to human health and the environment, leading to considerable economic damage. The EU's 2021 Adaptation Strategy aims to build resilience, ensuring that the EU is well-prepared to manage and adapt to these risks. Among its goals is the reduction of overall financial losses resulting from weather and climate-related events.

If the climatic conditions projected for the 2080s were to occur today, the annual economic impact on the EU economy could range from an estimated EUR 20 billion loss in GDP under a 2.5 °C warming scenario to EUR 65 billion under a 5.4 °C scenario with significant sea level rise.

Climate change affects a broad range of natural assets that are valuable for producing market goods and other benefits like environmental services, biodiversity, and aesthetic values. When combined, this results in a mean value of approximately EUR 25 per tonne of CO_2, with the 95th percentile reaching EUR 96 per tonne. Recent studies suggest a trend towards lower values, with some indicating marginal benefits lower than the marginal abatement costs of post-Kyoto scenarios, around or below EUR 20 per tonne of CO2, and in some cases below EUR 12 per tonne.

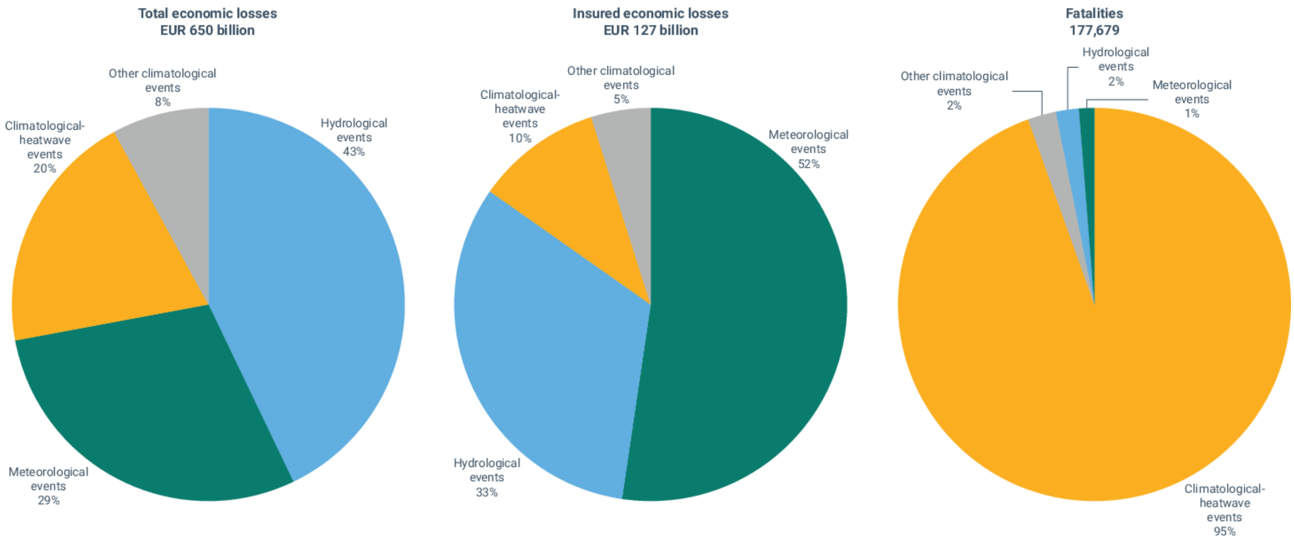

Figure 2 economic losses due to climate change

The necessity of the circular economy

Environmental problems are caused by the implementations of GHG gases and increasing of the temperatures that are directly related to economic problems like the unsustainable development. It's then necessary to pursuit different and new pathways and this could be possible also by linking the ecology and the economy sphere.

The linear economy has been the power of growth in our society for a very long time is based on extracting the resources directly from nature, transforming them into the final product and after its usage become general waste. This concept of economy has infinite limits that are going to destroy the planet, creating wastes and more climatic problems, so it's necessary to change the way of thinking and introduce a new way to think about the concept of economy that will take in consideration the impacts of its own action on the humans and the all ecosystem. The idea that is behind this new way of think is actually the first law of thermodynamic "nothing is created, nothing is destroyed but everything is in transformation" (Antoine Laurent Lavoisier).

The main goal is the importance to conservate the actual value of the resources: the product of the end of the production chain has not to be seen as pure waste but it is necessary to see beyond and think how to transform it and use it again and again in a circular way. In this way there is the chance, in the industry sector, for example, to use more times the same elements to reduce the cost of production and waste that will reduce the costs and increase the profit margin. Reuse repair and recycle of materials and already existing materials could give a second live to the resources that were considered waste.

The Green economy is an emerging factor at the heart of the economic and political agenda of the majority of developed countries. The concept of green economy is directly connected to climate change and energy efficiency that are environmental problems. There is the necessity of introducing this complex concept an international level and bond it with growth.

The economic system based on the reuse of its own materials could ba called circular economy and this generic term is used to define an economy that can relate only on itself. The materials flux could be divided in two sectors: the biological one, easily reintegrated into the natural system, and the technical ones, that will not be reintegrated directly into the biosphere but are going to be reused multiple times before that.

This is because the economic system is incorporated inside the ecological one, in which the economy could easily find materials and resources for its growth but at the same time it's important to respect the physical and biological limits of the entire system, otherwise it will collapse on itself.

The combination of economy growth and sustainable use of the resources could be seen a win win solution in which both accomplish to their goals without letting down the environmental problems. Another level of green economy concept is the increasing attention for the ecosystem, putting more effort on the environment sustainability on the long run.

Europe is more than aware that there is the necessity to rethink the existing development model based on decades of linear economy and structurally change patterns and consumption behaviours of the consumers as much as the behaviour of the hole system.

The two concept, very similar and interconnected like development and growth are not to be confused because 'development' il bonded to a qualitative improvement, for example in resource efficiency, while 'growth' is a quantitative increase in the energy and materials that are extrapolated from the earth and transformed through processes and putted inside the economy and returned to the earth in the form of waste.

Green economy is a challenging opportunity for the European countries to show to the rest of the world that is possible to change in the better without obscuring the growth and the development.

Sustainability, equity and growth have to be on the same level of importance; the action taken must be coherent and consistent to fight against climate change.

The main goal for the European Union is to reduce CO_2 emission by 617 tonnes with a positive impact on the work sector, with the realization of nearly 500 thousand new jobs positions and an economic growth of 7% for 2035. The strategy consist on convincing companies, through reduction of taxes, implementation of infrastructure and implementation of fund, on creating new products with new material, more eco-friendly and sustainable that are going to generate less waste and manage the residue wastes in a more responsible way through the reuse and recycle activities.

The international politics agreements

The importance of the environmental agreement through the politics has gain a very important meaning for the preservation and the stability of our climate system given its pivotal role in sustaining ecological balance, biodiversity, and overall planetary health. It is widely acknowledged that the world requires an ever-increasing production of goods (such as food, water, electricity, etc.), while the available resources are finite. The questions “how to produce, where and how much” has now become a crucial socio-political issues, both for the preference and for the future.

In those years and in the last years, started a global competition to claim the essentials goods, particularly in light of the impacts of climate change. More developed countries are trying to acquire vast agricultural land to less developed ones and this raise concerns about food security and complications about the climate change issue.

The entire socio-economical system has to begin a sustainable transition to become more reasonable with increasingly scarce resources to ensure a long term viability and resilience. Moreover, it’s crucial that the idea of reducing the pollution and the green-house-gases (GHG) has to be shared between all the other countries with a constant work and commitment to improve the environment. So, it become necessary to find a balance between the productivity enhancement and, at the same time, reduce reducing dependence on non-renewable resources, minimizing waste, and curbing the consumption of consumer goods that currently entail intensive resource exploitation and greenhouse gas emissions.

Right now only politics actions are strong and fundamental enough to face the climates problems created in those year; one important thing to consider is that the solutions have to cut out all the not renewable energy sources (fossil fuel and coal) that are constantly damaging the ecosystem but at the same time thei importance in the economy is fundamental.

It is essential to recognize that climate change impacts far more than just the environment. The consequences extend deeply into economic and political realms, affecting the stability and functionality of societies worldwide. This multifaceted issue requires a comprehensive understanding that addresses its extensive influence on global economies and governance structures that are directly or indirectly responsible for pollution.

The decisions and actions taken by governments today will have significant and long-lasting consequences. If these decisions are misguided, rectifying the damage in the future will be exceedingly difficult, if not impossible. This underscores the importance of making informed and conscientious choices, guided by the insights of scientists and experts in the field. By leveraging their expertise, we can implement strategies that will lead to substantial improvements in our climate. Such proactive and well-informed decision-making is crucial to mitigate adverse effects and foster a sustainable future for generations to come.

The implementation of environmental improvement policies, targeted towards the preservation of the planet, yields a discernible enhancement in the overall state of our environment. These proactive measures not only mitigate ecological degradation but also foster sustainable practices, thereby contributing to the long-term resilience and vitality of our natural ecosystems

The Intergovernmental panel of Climate Change

The IPCC (intergovernmental Panel of climate change) is a United Nations body established in 1988 by the World Meteorological Organization (WMO) and the United Nations Environment Programme (UNEP). Its primary function is to assess scientific information related to climate change and its first report came out in 1990; the function of the report are to summarise the climate conditions to better understand them an d what to do about climate change and how to stop it in a way that could be useful not only for the environment but also for the government around the world.

In the very first IPCC report cautiously suggested that human activities were likely contributing to climate change. It stated, "The unequivocal detection of the enhanced greenhouse effect from observations is not likely for a decade or more," (IPCC. (1990). Policymakers Summary) indicating that while there was evidence suggesting human influence, more data and analysis were needed for conclusive proof; in the latest report, specifically the Synthesis Report released in March 2023, it's said that "is extremely likely that human influence has been the dominant cause of the observed warming since the mid 20th century".

The governments own the report, the IPCC is made up of representatives from 195 countries who commission the report from academics and, since the report is used for negotiations around the world, all the different governments have to agree that they are on board with them by leaving comments on drafts of the main report.

The temperature target: stay under the 2°C

The climate changes we are facing and the extent to which they are altering the planet depend on the speed and quantity of emissions we are able to reduce. It is therefore necessary to find ways to limit the rise in temperatures and minimize the consequences, which also requires reducing greenhouse gas emissions. On a global scale, temperatures have increased by 0.8°C since 1880, but in Europe, they have risen by 1.4°C.

Scientific evidence increasingly suggests that irreversible and potentially catastrophic environmental changes could occur if the global average temperature were to exceed 2°C above pre-industrial levels (or 1.2°C above current levels). Thirteen of the fourteen warmest years on record have occurred in this century. Recent analyses indicate that current governmental interventions worldwide are insufficient to prevent a temperature rise of more than 3°C by the end of this century, with potential increases of 4°C or even 6°C not being excluded.

The European Union has long emphasized the need to keep global warming below 2°C, a necessity now recognized internationally. The EU bases its policies and actions on sound scientific evidence, aiming to lead global action against climate change by imposing binding targets on member states and promoting initiatives such as the emissions trading system. According to the European perspective, preventing global warming from exceeding the 2°C threshold is technically and economically feasible; the earlier measures are adopted, the more effective and potentially less costly they will be.

Despite the economic crisis and its impact on public finances, the EU continues to advance its climate protection policies. Structural policies in the climate and energy sectors have significantly contributed to the reduction of European emissions recorded in 2005. Less than half of the reduction observed between 2008 and 2012 can be attributed to the economic crisis. Early action to develop a low-carbon economy also fosters growth and employment, stimulating innovation in clean technologies such as renewable energy and energy efficiency. In addition to being one of the most promising sectors for job creation, the "green economy" enhances Europe's energy security and generates savings by reducing dependence on oil and gas imports.

The primary international agreement on climate action is the United Nations Framework Convention on Climate Change (UNFCCC), one of the three conventions adopted at the 1992 Earth Summit in Rio de Janeiro. To date, 195 countries have ratified the UNFCCC. Initially, the UNFCCC served as a framework for international cooperation to limit global temperature increases and manage climate change impacts.

The UNFCCC emerged from the United Nations Conference on Environment and Development (UNCED), commonly known as the Earth Summit, held in Rio de Janeiro in 1992. On June 12, 1992, 154 nations signed the UNFCCC, committing to a non-binding objective to reduce atmospheric concentrations of greenhouse gases to prevent dangerous anthropogenic interference with the Earth's climate system. These actions were primarily targeted at industrialized nations, aiming to stabilize greenhouse gas emissions at 1990 levels.

Key Provisions and Principles

The Convention recognized "common but differentiated responsibilities," assigning greater short-term emission reduction obligations to developed countries (Annex I countries), which include Australia, Austria, Belarus, Belgium, Bulgaria, Canada, Croatia, Denmark, Estonia, the Russian Federation, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Japan, Latvia, Liechtenstein, Lithuania, Luxembourg, Monaco, Norway, New Zealand, the Netherlands, Poland, Portugal, the United Kingdom, the Czech Republic, Romania, Slovakia, Slovenia, Spain, the United States of America, Sweden, Switzerland, Turkey, Ukraine, Hungary, and the European Union.

The primary goal of the treaty is to reduce greenhouse gas emissions to mitigate global warming. Initially, the agreement did not impose mandatory emission limits on individual nations but anticipated that future protocols or agreements would set binding emission reduction targets.

The cop 28

The 28th session of the United Nations Climate Change Conference (UNCCC) has just been done in Dubai. This was the biggest conference in a while, with the participation of near 85,000 people, which 150 were head of state, international organization, international corporate and exponents of indigenous population.

COP 28 was particularly significant as it marked a turning point in the 'global stocktake' process, whereby stakeholders and various countries assess the progress made, as well as the remaining challenges, towards the goals set by the Paris Climate Change Agreement.
For the first time in the COP history that has been expressed the will of abandon the massive use of the fossil fuels. This has been one of the absolute news that shoud lead all the countries to follow a more environmental green politic, more efficient and clear compared to the ones that has been done since now.

The advances regarding the environmental targets, such as the reduction of greenhouse gases (GHGs), enhancement of climate resilience, and increased financial and technological commitment to assist populations most vulnerable to climate change, have been found to be insufficient and slow compared to the milestones established at the Paris conference for the year 2030.

General actions

One important step was made in the two weeks of conference, the fist day has been stipulated an historic agreement on the operation ‘funding arrangements for addressing loss and damage’, including new funds under the UNFCCC: USD 661 million.

The fund has been created for responding to losses and damages (economical and non-economical) generated by the climate change caused to developing countries that vulnerable to the effects of climate change, like extremes heats, flood and other extreme weather events that could happen.

The creation of the fund, is a significant symbol of global solidarity reflecting both the urgency of the climate emergency and a step forward in international climate justice.

Another important keystone of the COP28 is that 118 countries signed to triplicate their renewable energy capacity and double the global rate energy efficiency by 2030 to cut off the dependency on fossil fuel.

This could be seen as a transition, passing from a completely fossil fuel basedenergy to a renewable one, that is going to take some time to find the balance and the energy security necessary to continue with the developing of the economy but with out damaging the environment, making the use of energy and so the production of climate damaging gases acceptable. This operation will be easier for some coutries, that has already taken a green path, but for the developing countries these action will clearly take some more time and also more investments.

Industries to make this transition are thinking about the green hydrogen as form of energy. It’s produced through a sustainable process that splits water using electricity that comes from green plants, like solar panels or wind energy.

The COP 28 created the ‘Innovations and Opportunity for collaboration with the private sector’to shrink the gap between developed and developing economies. The initiative offers to the private sector of developing banks the possibility to scale up the private capital they want to invest in to the emerging market starting from a range of sources including institutional investors. This will create the possibility to all kind of innovation, stakeholders and partners to achieve to better climate investments. Will also give the chance to discuss more knowledge learnt from already existing partnerships, opportunities and participation in climate finance.

To remain on the reduction of usage of fossil fuel 50 oil companies (national and international) that rapresent the 40% of the global production of it, deliberately signed a charted about the decarbonisation.

This initiative is based on three key foundations: achieve zera zero methane leakage from the production of their final product as gas and oil by the 2030, achieve the near zero emission in their direct operations and for last trying to achieve the zero the burning excess gas from thei chimney by 2030.

EUROPE ACTION ON COP 28

It’s important to say that the EU is the biggest provider of public climate finance in the world.

Charles Michel, the president of the European Council(Ursula von der Leyen is the European Commission President) highlighted how the EU is ready for a full commitment for a completely climate neutrality; he also wanted to underline how the Europe has already reduced the GHG emission of 30% in comparison of the 1990 levels and from now on wants to triplicate the usage of renewable energy and also double the energy efficiency, all of this with the strong emphasis on cutting the dependence on fossil fuels as soon as possible.

The European president of the Council Charles Michel at Dubai said that wanted to honour the commitment set by the Paris Agreement delivering USD 100 billion, and the EU state member announced their contribution of EUR 400 million to the fund 'Loss and Damage' to help the countries that right now are more vulnerable to the effects of climate change (double from what said initially). The return, for the economists, is going to be 10 times more than what initially invested. In 2024 EU already invested EUR 23 billions on the important topic discussed in the Dubai conference.

Innovation and technological solutions

After talking about the international politics that grand the possibility of a greener future with the promise of reducing the environmental causes of climate change, in this chapter there will be introduced some practical ideas of how to reduce GHG.
The urgency to reduce the GHG has never been more critical and just some innovatives ideas and a transformative approach that will go beyond the traditional methods is going to be break-through. Technological innovations are the first steps for a climate action and introducing new solutions across all the different sector is the only way possible to mitigate and revolve this climate situation for a more sustainable future.
By harnessing the power of these advanced technologies, we can address the root causes of climate change more effectively, enhancing the resilience of our ecosystems and economies.

Green Hydrogen:

A technology based on the production of hydrogen(fig. 3)— the most universal, light and highly reactive fuel ever known— through a chemical process that is the electrolysis**.** This method uses an electrical current to separate the hydrogen from the oxygen particle in a fluid, that is water. If the electricity created is obtained from renewable sources the production of energy will be without any carbon dioxide waste in the atmosphere.

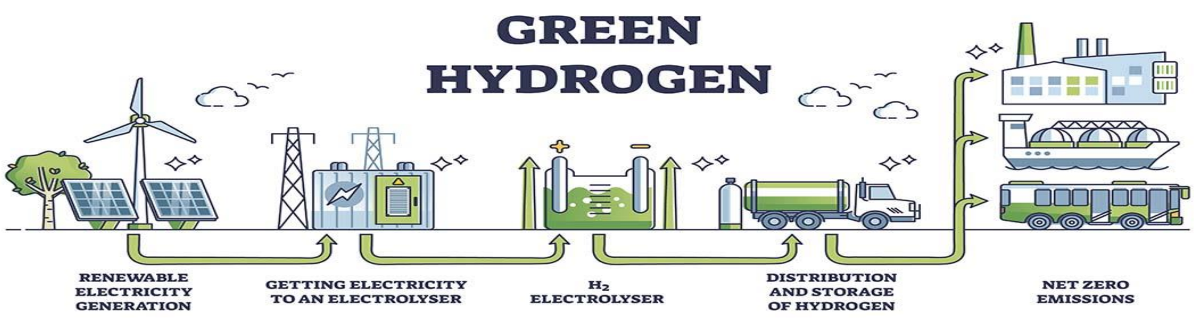

Figure 3 How Green hydrogen is produced

According to the International Energy Agency (IEA), producing green hydrogen instead of using fossil fuels could easily eliminate 830 million tonnes of CO_2 emissions annually around the world. Transitioning from grey hydrogen to green hydrogen globally would necessitate an additional 3,000 TWh of renewable energy per year, equivalent to Europe's current energy demand. However, the high production costs of green hydrogen raise concerns about its viability. These concerns are expected to diminish as the global push for decarbonization accelerates and the cost of generating renewable energy decreases. Europe leads globally in planned electrolyser projects and associated renewable energy capacities, primarily driven by offshore wind and solar PV. This progress aligns with the European Union's ambitious green hydrogen targets and substantial funding initiatives aimed at decarbonizing hard-to-abate sectors to achieve the Net Zero by 2050 goal. Following Europe, Australia has the second-largest pipeline of planned electrolyser projects, leveraging its rich wind and solar resources to develop green hydrogen and ammonia for export. Similarly, the Middle East and Eurasia are expanding their electrolyser capacities, driven by favourable business conditions. In contrast, while long-term projects in China and Latin America are currently limited, these regions have significant potential to reduce energy curtailment and cut CO_2 emissions in the industrial sector.

Smart Grids:

The adoption of green energy is crucial for fighting climate change, reducing reliance on finite fossil fuels, and enhancing energy security. As technological advancements progress and costs decline, green energy is becoming increasingly accessible and economically viable, establishing itself as a key element of sustainable development and a cleaner future.

To effectively integrate the growing array of distributed energy sources and generators, intelligent power networks, or smart grids, are urgently needed. These smart grids are essential for incorporating renewable energy resources into the energy system. Achieving this requires transforming current electricity grids into intelligent systems through the rapid deployment of new technologies that must undergo thorough testing and validation.

The restructuring of the electricity grid will enable market participants to fully capitalize on a variety of energy sources and technologies—such as energy efficiency, renewable energy, energy storage, carbon capture, electric vehicles, and other distributed technologies, in addition to large-scale nuclear and natural gas. These advancements will assist the electric utility industry in achieving global reliability, resilience, security, and economic goals (fig.4).

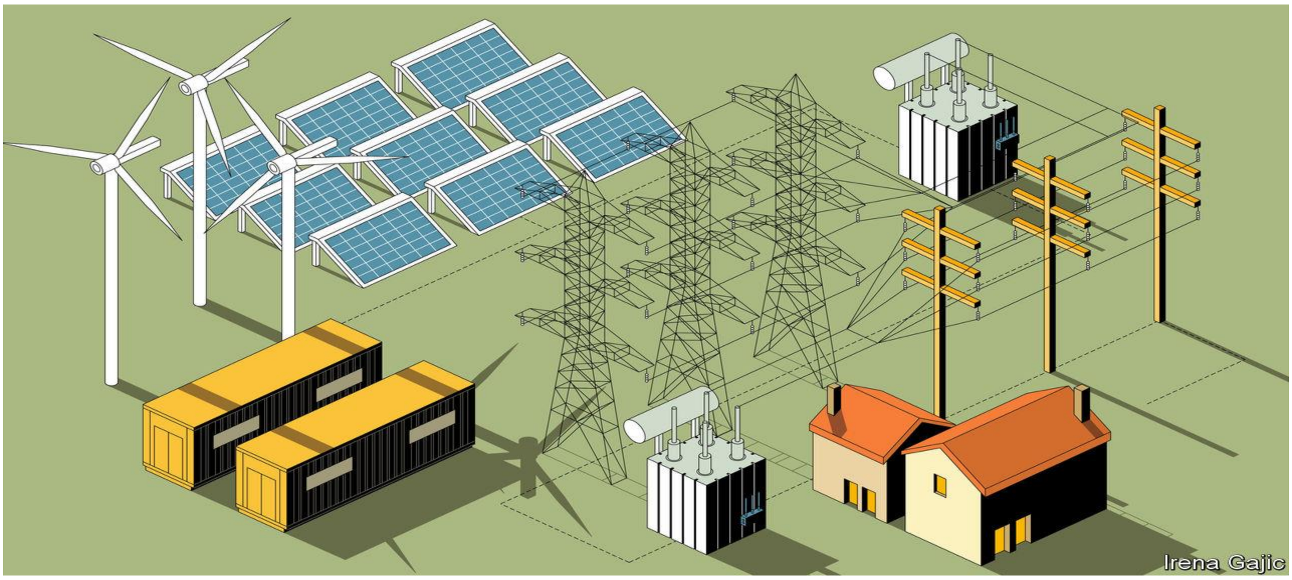

Figure 4 Power Grid system

The future application of information and communication technology, known as the Smart Grid, will revolutionize power generation, transmission, distribution, operation, and control in the wake of electricity restructuring. The Smart Grid will be designed to monitor, protect, and automatically optimize the operation of interconnected power systems and their components. This will range from central generation and distributed generation plants to transmission and distribution systems, commercial and industrial users, and consumer devices, thermostats, and appliances.

Direct Air Capture:

Carbon dioxide, or CO2, is one of the main GHG that is responsible of the climate change and the lifespan of this molecule could go from 300 years to 1,000 years.

Researchers found that the CO2, although its geological lifespan, is capturable from the air and can be stored in the underground or, more helpful and active, can be used for the production of fuels or in chemicals. Even if the CO2 is not highly concentrated in the atmosphere, the technology of fthe direct carbon capture (DAC) could remove significant volumes per year by putting in contact a chemical that is called sorbent, directly with the air. This is possible just through two processes (fig.5): the absorpsion and the adsorpsion. The first, the absorption has the capacity of dissolving the CO2 molecules into the absorbent material; the second, the adsorption consist in the resurface of the molecules of CO2 from the chemical material through its poures but stay captured in the grid of the material. After these two processes the CO2 could be stored in geological storage or used in the creation of carbon based fuels or the composition of other chemicals.

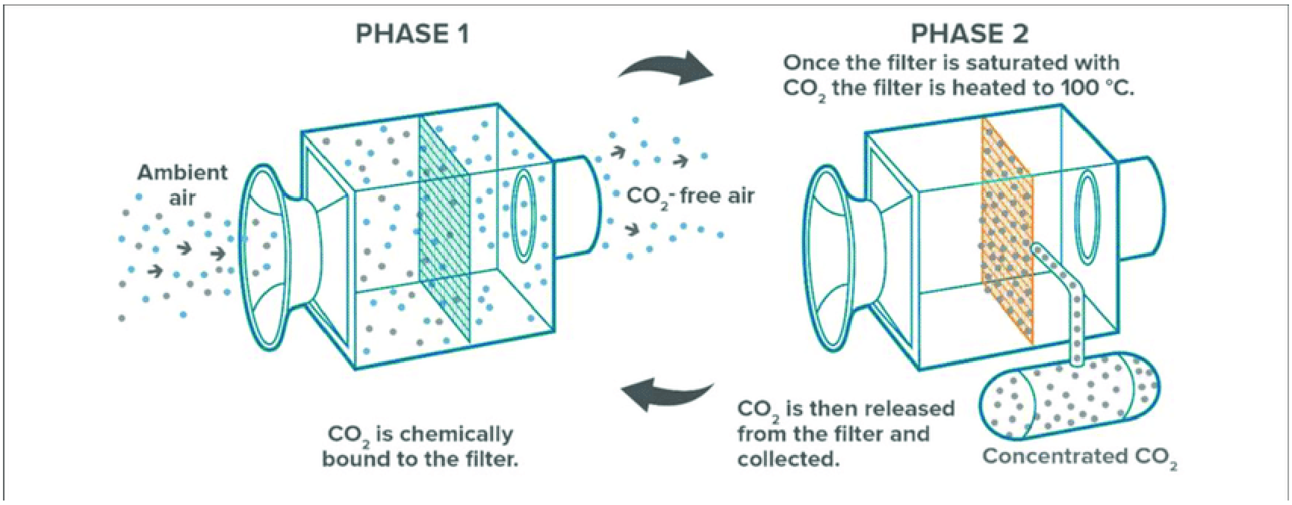

Figure 5 Chemistry behind the CO2 capture

One of the challenge with this kind of technology is the initial costs, the running energy cost (it works out of 80% of geothermical energy and 20% of electricity) and the structures where to actually put all the CO2 captured, but on the other hand DAC application are various and there are projects to implement their usage.

In the international credit mechanism there is the possibility for countries and companies to trade carbon credits with the equivalents tonnes of CO2 captured from the atmosphere and this could be an advantage for all the system.

Innovative technology

In this chapter the focus will be on the innovative technology of the battery energy storage system (BESS) and different aspects of them like battery function, types of batteries used, the advantages that could bring. At last will be examined the case of the FZSonick factory that produce a new kind of battery: the sodium chloride kind, an innovative product that is different from the rest and have big potential for taking over the other types of batteries. Could this new battery be better than the rest and be the revolution in this field?

In 2018, global energy consumption reached 13,864.9 Mtoe, marking an 18.45% increase from 2008. The growth rate for the previous year stood at 2.9%. According to recent data, oil continued to be the dominant energy source, accounting for 33.6% of consumption, followed by coal at 27.2%, natural gas at 23.9%, and nuclear energy at 4.4%. Renewable energy sources made up 10.8% of the total, with hydropower contributing 6.8%. Unfortunately, energy consumption per capita rose by 1.8%.

In 2015, the United Nations established the Sustainable Development Goals (SDGs), with SDG7 specifically focused on ensuring access to affordable, reliable, sustainable, and modern energy for all. This emphasis on SDG7 underscores the imperative of increasing the use of renewable energy sources to address global energy challenges.

With the urgency of going to the Net Zero, there has been an energy transformation toward a more sustainable future developing new way to create energy and storage it to stop depending on the fossil fuel that is a not renewable font of energy and generate GHG gases and make the use of fossil fuels less and less every year. Find a new and more efficient way of create and store energy is constantly growing and becoming a important issue.

In Europe the buildings are known as responsible for more than 40% of the consumption of the enery power and responsible also for the emission of 36% of CO2 emission, this makes them the only biggest consumer of energy in Europe.

For this reason, batteries, inserted in the contest of the energy system are covering an important role, in these years they are playing a fundamental role for the full transition into the clean energy system.

Different sector are covered by the batteries: the transport sector they are the most important component; millions of vehicles that are sold and are in the streets relay on their usage. The power sector use the batteries as storage system because they are becoming the dominant clean energy technology.
Batteries are very versatile and, as cited before, their usage is important in different projects and also in different scale.
Right now the only problem of the batteries is the cost that is slowly decreasing due to the improving that are happening, the more competitiveness od electric vehicles and storage applications.

Renewable energy system based on solar panels or wind energy have been the most targeted for energy project all around the world, but the problem with this kind of energy is that relay on the weather condition, so it can not be considered linear, but intermittent and this could create a problem. Right in this contest the Energy storage system (EES) become the possible solution to fill the voids left, with parameters of reliability, availability and quality in the power supply.
Battery technology is gaining more credibility and security due to its manufacturing that perfectly meet the performance requirements.
Energy storage is beginning to be a dominant composition inside the renewable energy plants.

Variations of power are controlled, the entire system is flexible, the energy generate could be created from different kinds of renewable energy sources and last but not least the energy generated can be stored and used in a time where is more needed.

For those reasons is more than possible that in the next years and decades there will be an increase of research and application of this technology with the profound transformation of the all energy storage system technology, more specifically for the batteries used.
This innovation could change all the manufacturing and commercialization of batteries and the supply chain will be driven by a new set of policies form the countries and continents that are going to use it that are going to be, at the same time, part of a new kind of energy transformation.

The sector of the battery storage used in the power sector is expanding with a extraordinary speed. In the year 2023 were added over more than 40 gigawatt (GW), value that is doubled in confront of the 2022.

The opportunities that the battery storage offers are variegate: it can be used as short term energy shifters, ancillary services can be delivered, the problem of the congestion in the grid can be alleviated and it can expand the actual access of electricity.

A lot of governments and private investors are supporting the develop of the technology behind of the battery storage with more targets, financial funds and reforms to improve the accessibility to the current market.

China right now is at the head of the battery supply chain will almost 85% of the global battery production capacity and also in the production of the fundamental materials like cathode and anode, active materials for the construction of the batteries.
Another fundamental problem of this technology is the extraction and process of the materials because the extraction sites are highly concentrated in few areas around the globes and China owns a generous percentage of those mineral sites.
The cost of the raw material are not stable, they are various and easily volatile: in 2021 and 2022 the prices rose pretty quickly but in the 2023 they decrease rapidly and continued to fall also into the first months of 2024. This is a evident signal for having more structured investment and international policies on this market that is expanding year after year.

Energy storage batteries are the fundamental part of the storage system and they are devices that has the possibility to transform the electrical potential into chemical potential and the opposite way around making possible to storage and use again and again the electrical energy.
This kind of energy is usually used in moments or situation in which the normal energy produced can not be use right away or, in a different scenario, when the request consumption of energy results to be not enough.

The type of battery used in the process, the structure of the converter and kind of different components are going to drastically change the efficiency of the charging and discharging process, durability of the storage and final cost the all system, non the less the costs of possible substitutions or repairing of the possible damage.
BES has lots of advantages, like giving the stability of power grids, the reduction of pollution and the reduction of heavy infrastructure involved.
This efficient technology is not much used, but with the rights investment and use could be for sure one of the new new renewable energy sources that will most contribute to the reduction of climate change and GHG gases.

There are different aspect that have to be considered to truly understand the importance and the challenges that are related to the use and the functioning of the energy storage batteries:

- The sources that generate energy for the system are the renewable kind, so it's important to know that they are variable type of energy (wind and solar power) and not always disposable when needed. For this reason batteries store the energy in excess when there is the availability and possibility.
- Efficiency of the grid is constantly improving because the stability and the efficiency of the power grids are constantly under improvements to give the best energy yield possible and able to perfrom undere different natural renewable energy sources.
- The ability to cope with a impervious situation is one of the aspect that characterize this technology, in case of extraordinary natural events or disaster (tornado, heat waves or floods) the system must provide an extra source of power to still give energy to the infrastructure that is associated to.
- Protection of the environment and the sustainability is one of the potentiality of the batteries; reduce pollution and concentration of GHG is one of the fundamental characteristic of the battery to fight the climate change and substitute to the fossil fuels.

A basic battery energy storage system consists (fig.6) of a battery management system (BMS) to monitore and maintain the operation of each battery pack safe and optimal, power condition system (PCS), and energy management system (EMS). The battery pack works outde of the equilibrium state during the crcling. This process of degradation is normal in the batteries, but can be accelerated by increased temperature, the charge of it (overcharging or undercharging) and increased temperature.

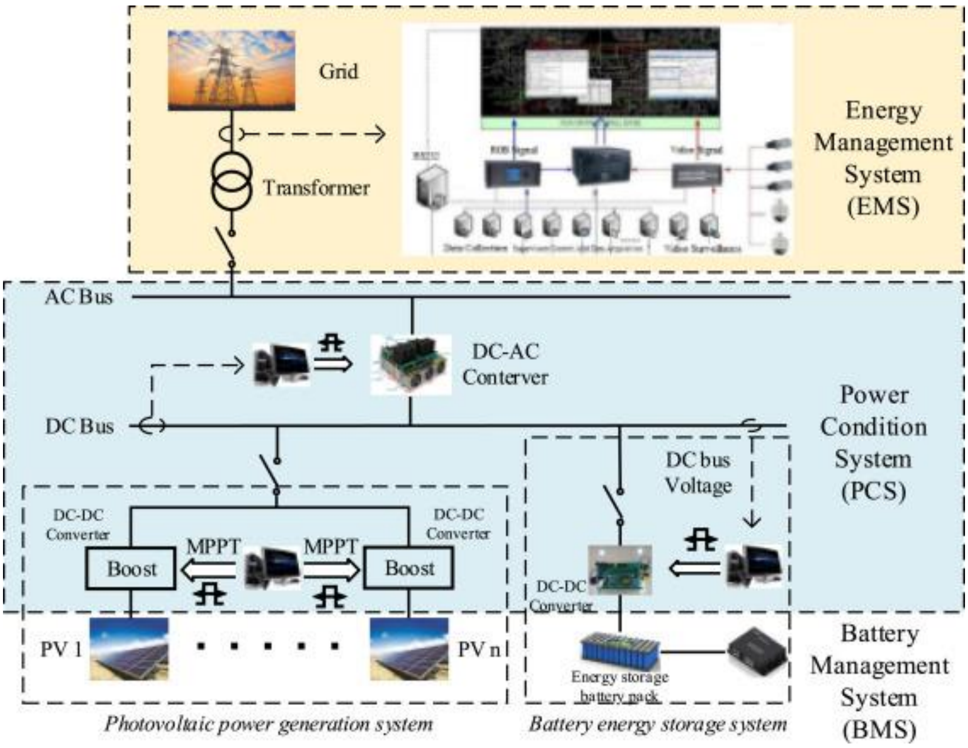

Figure 6 structure of battery storage system

A smart BMS installed can reduce by it self the degradation of the battery and improving the performance of it.

the storage technologies could play a vital role in improving the overall stability and reliability of power system (islolated/grid connected/systems with large share of renewable sources) and could defer the costs need to improve the transmission and distribution capacity to meet ever growing power demand.

power conditioning system (PCS):

The PCS form a vital part of the BESS. It interfaces the batteries to the loads (utility/end user) and regulates the battery charge/discharge, charging rate, etc. The PCS cost is significant and it can be greater than 25% of the overall energy storage system. However, this technology is maturing rapidly due to the recent developments in the power conditioning systems of the renewable and distributed energy sources.

Market Analysis

Europe, the US and Soth Korea are the countries leaders in this new technology. Important investments have been done mostly in the lithium-ion are now the most used batteries and for this reason the cost have been decreasing while, at the same time, the investments for new projects are continuously advancing and improving the design and the efficiency of the entire storage system.

The future goal of the renewable energy is perfectly matching the consumption of electricity with the generation of it. It is necessary to find the balance in all electricity grids to generate enough stable and relying supply. The solution in this situation is the flexibility of the market request that can be adjusted on the supply by the possibility of saving the excess energy produced in massive quantity in different time periods. For those reason it is important to create new renewable energy flexibility and regulations in the energy system.

Europe is trying to be more competitive on the global clean energy technology market by increasing their capacity to produce and also use clean energy, bringing benefits not just for the economy but also for the European citizens.

Individuals, private and public organizations are growing in the thought of shifting away from the use of fossil fuels: there are about 9.6 millions of customers that chose to buy energy from renewable plants (estimated 273 Terawatt hour) and green power markets just in the 2022, according to the National Renewable Energy laboratory. In the 2012 the quantity bought by customers was just 54 TWh.

Europe from this numbers could be easily make houses and infrastructure more efficient achieving at the same time to energy and climate goals set in the different climate conferences (Paris and Dubai). Integrating the renewable energy sources to the energy market could actually be the most effective way to ensure to the EU citizens sustainable and more affordable energy supplies.

Create a Deliberate for the energy market rules could easily make the energy cross the border of infrastructure, so the energy produced in one EU country is easily delivered and consumed in another. This will allow the consumers to choose energy suppliers based on their prices in all Europe and this will boost the competition and improve the long term markets already existing.

In 2019 Europe launched different programs and platforms like Battries Europe that is part of the European technology and innovation platform of the Battery Alliance that is managed by the stakeholders present in the battery industries and by the European commission.

EUR 925 million has been invested in a 7 year financial perspective in new EU research projects on batteries that are under the BATT4EU partnership.

At the same time some EU countries have joined a very important project focused on the battery research and innovation called IPCEI (Important Project of Common European Interest).

Forecast suggest that there is going to be an increase of investment and evolution of the usage of renewable energy sector; compared it a decade ago the capacity of creating new electricity in the global energy mix has been more than triplicated, almost quadruplicated.

Energy storage seems to be the only technology that has the potentiality and the capacity to speed up the renewable energy integration into the mix of energies eliminating the negative features of this particular energy source like intermittency and the uncertain use.

The market of the Battery Energy Storage system in 2024 was estimated in USD 34.22 billion and by the 2029 it will reach USD 51.97 billion with a rate of growing that is 8.72% estimated in the period 2024-2029.

Europe, in this contest have some countries that have fixed goals for the installation of energy storage systems.
For example, according to the Spanish Energy Storage Association, the country hasa the target of reaching 20GW of energy storage installations by the end of 2030 and increase it to 30GW by the 2050.

In the field of renewable energy sources, a substantial proportion of residential demand is met by solar energy, which consequently drives the demand for residential battery energy storage systems. For example, according to data from France Territoire Solaire, the total residential photovoltaic solar capacity in France reached 2,645 MW in 2023, reflecting a 36.4% increase compared to 2022.

ANALYSIS OF BATTERIES:

Right now there are different types of storage batteries that can be used, and each of them has its own attribute, energy capacity efficiency and life cycle that are to be taken into consideration for different kind of application. They come in different shapes and sizes and are made with a particular set of characteristics that makes them unique.

Batteries are divided in two main classes: Primary and secondary batteries.

Primary batteries are non-rechargeable type and designed for single-use. Once their energy is drained, these batteries cannot be recharged, thus functioning as single-cycle batteries. They contain chemicals that are consumed over time and through usage. When fully depleted, primary cells must be disposed of.

Secondary batteries, also known as rechargeable batteries or accumulators, can be recharged after discharge by reversing the current flow within the battery. Typically, secondary batteries are manufactured in a discharged state and require initial charging before their first use in a secondary process. Power sources are available in a variety of shapes and sizes, with each type of battery possessing unique characteristics that make them particularly advantageous for specific applications while being less suitable for others.

This section of the work will analyze the different types of secondary batteries used in energy storage systems that were used and ones that still are.
Below is an exploration of some of the most common types of batteries, highlighting their distinct features and applications.

Lead acid battery (LAB)

The lead-acid batteries are one of the first second batteries creates, invented in the 1859 from Gaston Pantè a French phisic.

Lead-acid batteries (LABs) has an important kind of energy storage equipment, this technology is used for its reliability, is pretty much always available, is low-cost, could be still used in aversive temperature conditions and ha a wide range of current.
Nevertheless, because of the high toxicity of the extraction of lead and its toxicity for the ecosystem and biodiversity, the environmental pollution, like the lead emission this is not a technology that is very much used and developed.

The Lead acid battery is composed (fig.7) by an electrochemical cell in which happen chemical reaction with:

- Lead byoxide in the cathode
- Lead (dust form) in the anode
- Electrolyte composed by sulphuric acid (H2SO4) solution dylude with water.

These kind of reactions are called redox in which the ions move from the reductant to the oxidant.

The water in the electrolyte solution is present to reduce the electrostatic forces that attracts the ions.

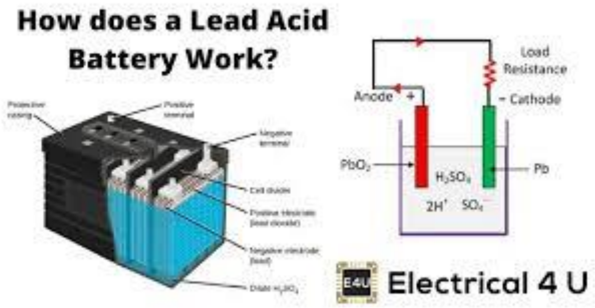

Figure 7 structure of a lead acid battery

The chemical reaction is:

$PbO_2 + Pb + 2H_2SO_4 \leftrightarrow 2PbSO_4 + 2H_2O$

Knowing its great potentials given by their mature technology and high reliability, lead-acid batteries continue to be widely adopted across various sectors, including conventional power vehicles, aircraft equipment, and energy storage systems. Their robustness and cost-effectiveness make them particularly suited for applications that require dependable performance over time. A prominent variant, the Valve-Regulated Lead-Acid (VRLA) battery, is extensively utilized as a backup DC power source in substations. In such installations, VRLA batteries are maintained at a full state of charge (SOC) through a technique known as float charging, which ensures they are always ready to deliver power instantaneously when needed.

However, as previously mentioned, they are the most widely used accumulators, and these reasons are based by :

- Efficiency of the battery that is more than 70%;
- Good performance even when used with high discharge levels;
- The gap of use can go between -40°C up to + 60°C;
- The singular cell tension is high enough;
- Different typology of measurement of the state of the charge;
- Easily produced in voluminous stocks;
- Different kind of batteries do not need important manutention;
- Could be recycled;

- Low price

On the other hand the possible disadvantages are:

- Cycle of life pretty shot (more or less 500 cycles)
- Low specific energy, usually is 30-40 Wh/kg
- They contain not just acid and lead, but also arsenic and antimony that are components very dangerous for the human health;
- Very difficult to have a production of batteries that has a small capacity;
- The risk of Sulfidation will completely damage the battery;

In this sector of application, the lead acid batteries require specific characteristics, in the storage use there are mainly three.
The systems in which are going to be used must have a tension higher than 2000V, density of the energy must be high like also the specific capacity, but more important is the availability of accumulators at low-prices.
Those condition could improve the peak service, the energetic ratio that could also be transferred in the economic system, between the quantity of energy bought and the one that has been distributed from a renewable source.

Lithium ion battery (Li-ion)

Lithium batteries are characterised by a very dense specific energy, high efficiency and a long life. These characteristics put them on the first place in the storage market with the production of billion od pieces every year all around the world. This batteries, used in the storage systems, are an electrochemical type of storage patterned also with renewable energy plants.
However the development of this technology still have problems in the field of security, costs and has a bigh time laps between the start temperature and the actual usage temperature and for last there is the problem of the availability of the materials.

The biggest problem in Lithium-ion battery is that are flammable: the elecrolytes used are the nonaqueous type and this leave always a big safety issue for their use.

This is the most used battery now a days and the electrochemist reaction are based on the presence of 3 pieces: cathode, anode and electrolyte.

This technology is based on the movement of Li ions from and electrode to another (fig.8);

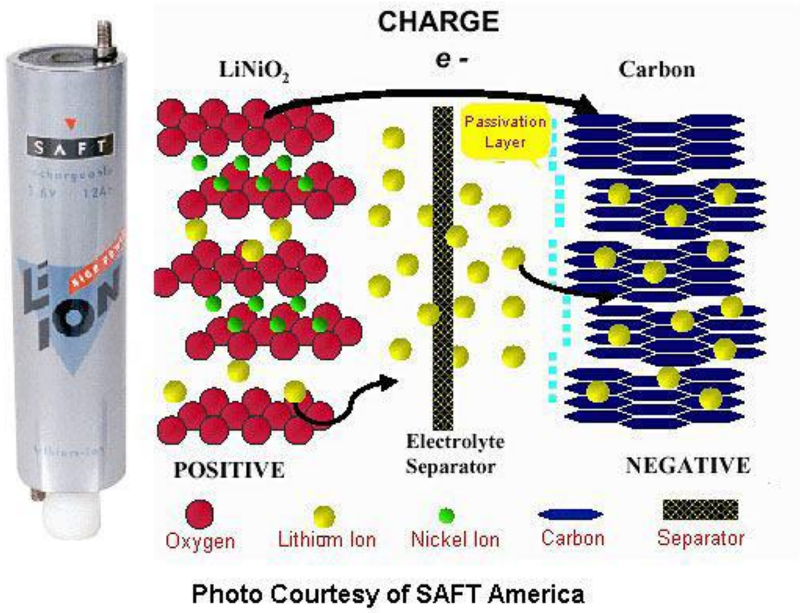

Figure 8 how does Li-ion battery work

During the charging process, the lit ions transfer from the negative electrode to the one positive (from cathode to anode), during the discharge phase it happens exactly the same opposite.

The chemical reaction is this one:

$Li_{1/2}$ CoO2 + $Li_{1/2}$C6 $\leftarrow\rightarrow$ C6 + LiCoO2

Advantages:

- Wide range of application: this kind of battery is not used just for the storage system, but also in the electrical vehicles, in smartphones and a lot of other electrical objects.
- Long life: for a professional lithium battery the cycles of life could be almost 3,000 charges
- Large amperage: a characteristic of this battery is that can easily work with high voltage that means that the also the intensity of the energy could reach very high peaks.
- No memory effect: the memory factor is a characteristic present in rechargeable NiCd batteries than shrink their span of life usage of 1-2% each month. The lithium ion battery does not present this effect, so its performance will remain stable during all life time.
- Low discharghe: if the battery is preserved in the right way thei value of discharge could be kept low even when the battery is not actively used.
- No deep discharge: An integrated control technology typically prevents deep discharge in lithium-ion batteries.
- Opportunity charging: Another advantage of lithium-ion batteries is that they can be recharged at any time, even if the battery is not fully discharged. Opportunity charging can occur either fully or partially without damaging the battery.

Disadvantages:

- Fire hazard**:** Lithium is a highly reactive element, which makes lithium batteries particularly prone to overheating if damaged. This reactivity can lead to thermal runaway, where the temperature of the battery rapidly increases, potentially causing it to catch fire or even explode. Thus, the physical integrity of lithium-ion batteries is critical to prevent fire hazards.

- Temperature sensitivity**:** Lithium batteries exhibit sensitivity to a range of temperatures. They perform poorly and may suffer damage at low temperatures below +5°C, where their efficiency drops, and at high temperatures above +35°C, which can accelerate degradation and increase the risk of thermal events. Proper temperature management is essential to maintain battery performance and longevity, as well as to prevent hazardous conditions.
- Low environmental compatibility in raw material extraction**:** The extraction of key raw materials used in lithium batteries, such as cobalt, aluminum, and lithium, is environmentally detrimental. The mining process involves extensive water consumption, contributes to soil and water contamination through the release of toxins, and causes significant disruption to ecosystems and landscapes. Furthermore, mining operations often occur under exploitative labor conditions, adding a social dimension to the environmental impact. These factors underscore the need for more sustainable and ethical practices in raw material sourcing.
- Disposal and recycling: The reactive nature of lithium batteries categorizes them as hazardous waste upon disposal. They require specific disposal methods to mitigate environmental and health risks. The current recycling infrastructure is inadequate, lacking a standardized, efficient process to recover the diverse and valuable materials within the batteries. This results in challenges for achieving low-emission, high-quality recycling that can reclaim essential materials while minimizing environmental impact.

SODIUM NICHEL CLHORIDE BATTERY - Ni – NaCl

In recent developments, sodium (Na) beta-alumina batteries have gained significant attention as one of the most promising solutions for stationary electric energy storage (fig.9). These batteries are crucial for several reasons: they play a pivotal role in accelerating the integration of renewable energy sources, such as wind and solar power, into the energy grid, and they contribute to the enhancement of the stability and reliability of electric power systems.

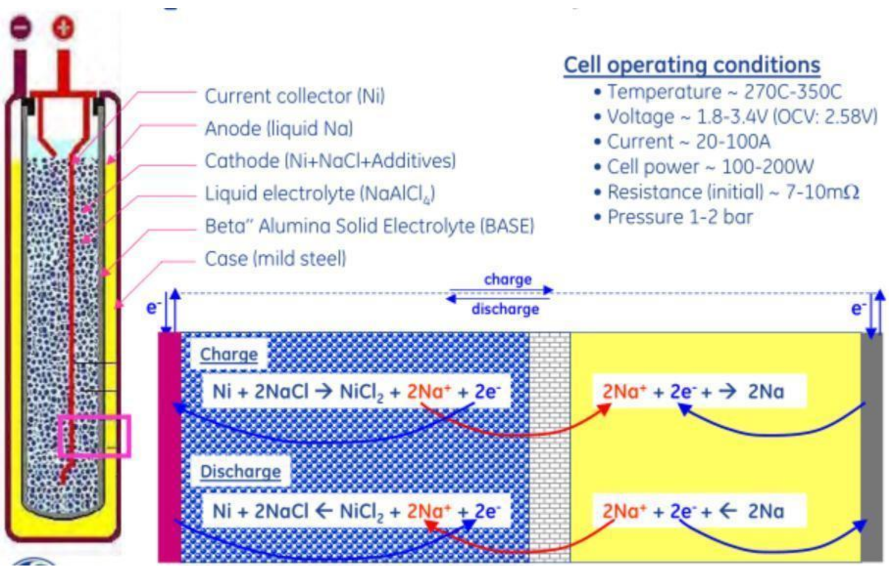

Figure 9 chemistry of Ni-NaCl battery

By providing efficient and durable energy storage, molten-sodium beta-alumina batteries facilitate better energy management, reduce the need for fossil fuel-based backup power, and support a more resilient and flexible electrical grid infrastructure.

The FZSONICK case study

Fzsonick story

The sodium nichel- cloride batteries, also known as ZEBRA (Zero *Emission Battery Research Activities*) were firstly produced by the MES-DEA factory that has its own production site in the Italian Swiss side in Stabio.
In 1999 MES-DEAstart its own production of this new kind of battery until the 2011, when the company and the innovative technology is bought by Elettra 1938, than in the future will be called FZSonik (before was know as FIAMM group) that has the working site in Montecchio Maggiore (VI).
Today, the company has become a leader in the design and production of innovative systems for storage, backup, sustainable mobility, and other applications. They are producers of safe and clean energy for people and the environment worldwide. While their operational headquarters are located in Switzerland, they have logistical headquarters in Italy and additional branches spread across the globe (America, Brazil, China, etc.) (fig.10).

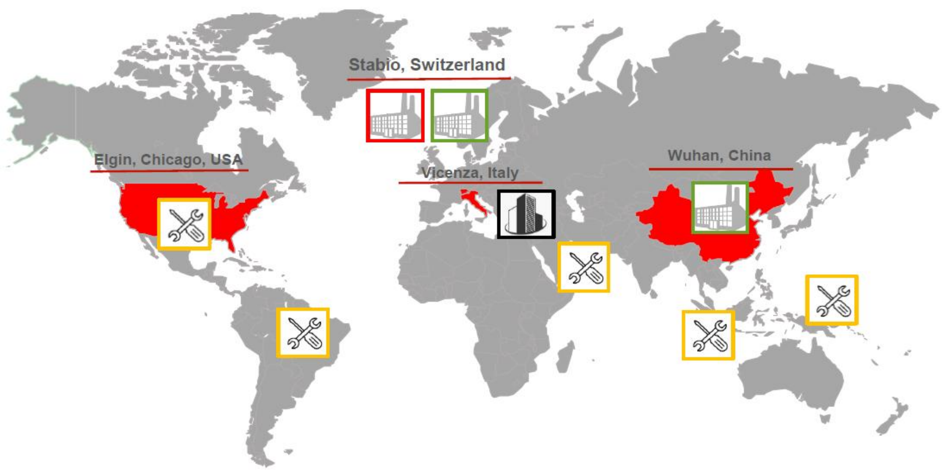

Figure 10 FZSonick in the world

The product

FZSonick's products (fig. 11) are technologically advanced because they produce next-generation batteries that are completely sustainable and safe, using naturally abundant raw materials that are not harmful to the environment, such as sodium, nickel, and chlorine. These batteries, thanks to their electrochemical storage system and integrated features, do not require maintenance services throughout their lifecycle. Moreover, the system can operate under any weather condition (with a working range from -40°C to +60°C), ensuring optimal performance worldwide.

Figure 2 Example of battery

Due to the easy availability of the natural materials that compose the battery, its high cycle life (> 4500 cycles at 80% Depth of Discharge), the high energy density it produces (100-120 Wh/Kg), and its full recyclability at the end of its life, FZSonick's technology holds a significant position in the realm of clean and sustainable energy. It has become a leader in its innovative sector (batteries), striving to provide value not only through its product but also to its consumers and stakeholders, continually improving and enhancing the performance of its products.

Categories of the batteries

Fzsonick manufacture batteries designed for a wide range of applications (fig. 12), including utilities, oil and gas, storage (both residential and industrial), mining, electric mobility and marine sectors (fig. 13).

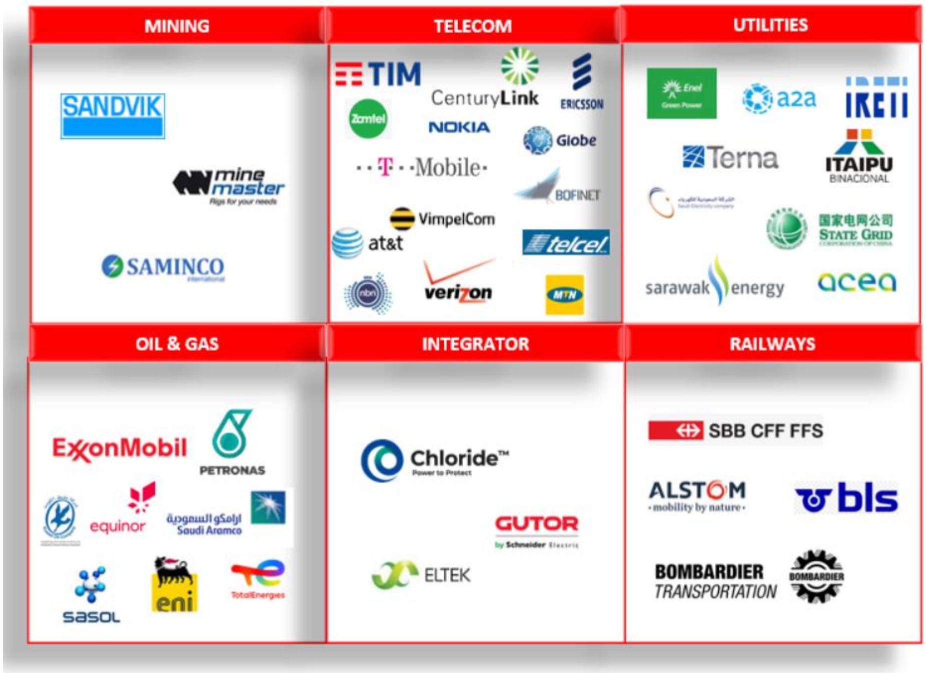

Figure 3 Applications of the FZSonick battery

In the oil and gas industry, FZSonick's salt batteries offer significant advantages over traditional lead-acid or lithium batteries. Unlike these alternatives, FZSonick's batteries do not require a cooling system, which saves valuable space in oil rigs where every square meter is critical.

This streamlined design enhances operational efficiency and reduces maintenance complexity, making it an ideal choice for remote and space-constrained environments typical of offshore facilities.

For the mining sector, salt batteries are particularly advantageous due to their inherent safety features and compact footprint. These batteries provide reliable power without the need for extensive cooling or ventilation systems, ensuring safer operations in challenging and confined mining environments.

In storage applications for residential and commercial use, FZSonick's technology has been thoroughly tested and proven effective.

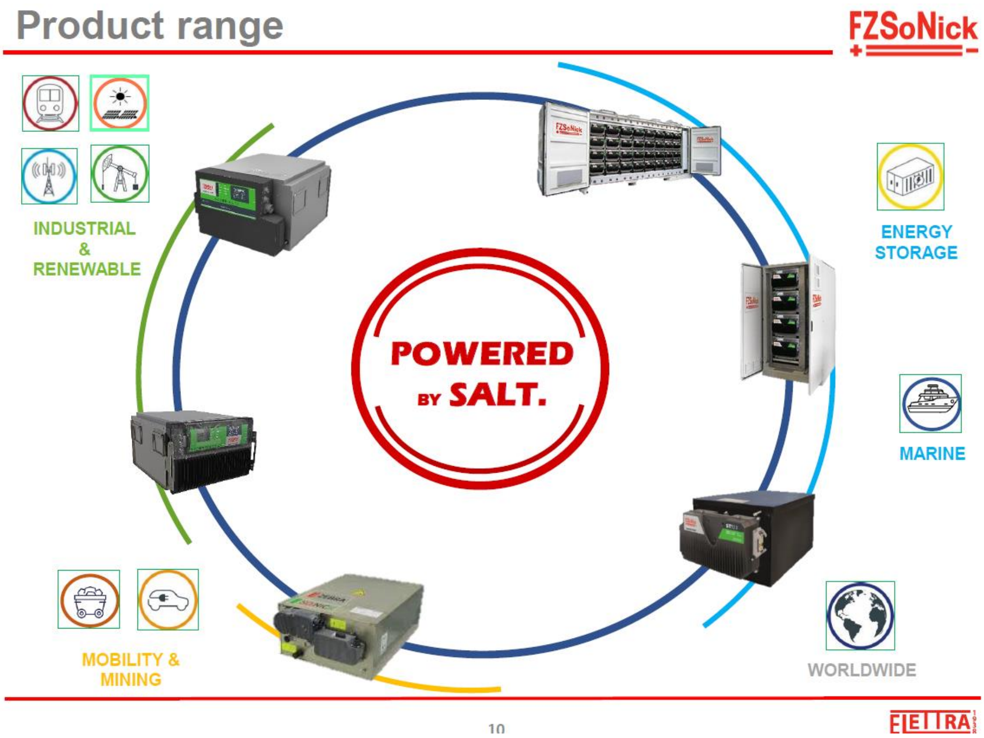

Figure 13 different types of batteries and their usage

These batteries are emission-free and do not release harmful substances, offering continuous and reliable operation. Their user-friendly design facilitates easy installation and management, making them a preferred choice for ensuring uninterrupted power supply and enhancing energy efficiency in homes and businesses

Technical characteristic of the battery

The size of the batteries are standard, they all the same for production and costs reasons.

The cell (fig. 14) is the core of the battery and is called ML3X (internal code). Previously, different types of cells were produced, but due to manufacturing and cost considerations, it was not worthwhile, so they transitioned to producing a standardized one. The drawback is that it cannot be modular anymore; previously, the entire battery could be more customized, whereas now it cannot. The cell dictates the energy capacity of the battery.

Figure 14 Cell

Each cell has a capacity of 40Ah, meaning the battery's capacity(fig. 15) increments in steps of 40Ah. Another drawback is the lack of commercial versatility: if a customer requires exactly 100Ah, the available options are either 80Ah, which would be undersized, or 120Ah, which would be oversized.

Figure 15 battery complete

This limitation prevents providing a battery precisely tailored to meet the customer's specific needs of 100Ah. Previously, with different cell types, it was possible to offer a more customized battery solution (tab. 1), but standardizing on the 40Ah cell has restricted this flexibility.

	48UP200	110UP80	125UP80	130UP80	220UP40	250UP40
Nominal Voltage	48 Vdc	110 Vdc	125 Vdc	130 Vdc	220 Vdc	250 Vdc
Charge Voltage Range	54 ÷ 59 Vdc	121 ÷ 160 Vdc	135,1 ÷ 160 Vdc	140,5÷ 160 Vdc	242 ÷ 300 Vdc	270,2 ÷ 300 Vdc
Vmin	40 Vdc	90 Vdc	100Vdc	104Vdc	180 Vdc	200 Vdc
Nominal Capacity (C4)	200Ah / 9600Wh	80Ah / 8600Wh	80Ah / 9600Wh	80Ah / 9900Wh	40Ah / 8600Wh	40Ah / 9600Wh
Warm-up time at commissioning	<13 h	<13 h	<13 h	<13 h	<13 h	<13 h
Recharge from 0% to 100% SOC	<13 h	<13 h	<13 h	<13 h	<13 h	<13 h
to 90% SOC	<8 h	<8 h	<8 h	<8 h	<8 h	<8 h
Recharge Current (internally regulated)	40 A	16 A	16 A	16 A	8 A	8 A
Max Discharge Current (1')	150 A	120 A	120 A	120 A	60 A	60 A
Thermal Dissipation at 25°C	110 W	110 W	110 W	115 W	110 W	110 W

Table 1 Differences between the different typology of batteries

So, the production is great but in the commercial part is still under evolution.

The technology used operates at high temperature (at least 250°C), a characteristic defined by international standards. High temperature is primarily utilized for three reasons:

- To melt specific internal components, such as sodium (Na), which has a melting point of approximately 95°C.
- For the cathodic mass (grains of metallic material) immersed in the electrolyte, facilitating electron movement between the anode and cathode. Inside, there is a liquid salt, tetrachloroaluminate sodium ($NaAlCl_4$), which is contained within the cell and melts at 150°C.
- Conductivity of the ceramic tube (solid electrolyte, namely beta-alumina). Both alpha and beta alumina are electrical conductors and do not insulate, but beta alumina is the only one that allows for ionic conduction. Sodium ions pass through it, but only at high temperatures, specifically above 250°C.

The conductivity of beta-alumina decreases significantly below 250°C, and at room temperature, it becomes an insulator for sodium ions, effectively blocking any reactions and rendering it inert. Therefore, the higher the operating temperature of the products and the battery itself, the lower the resistance between components, leading to increased electrical conductivity.

The materials, after passing various stages of verification, are integrated into the production line at different phases as needed. Specific materials are employed at particular stages and in various sections of the manufacturing process. FZSonick operates a substantial production area focused on ceramics, which is categorized into α (alpha) alumina and β (beta) alumina sections. Each of these sections uses distinct materials and processes to produce different components, which must function in unison within the final product.

The α alumina and β alumina follow separate manufacturing protocols that cater to their unique properties and applications, yet they must synergize to ensure the overall effectiveness and reliability of the battery. Thus, evaluating the product's environmental safety requires a comprehensive approach that includes the entire lifecycle—from material sourcing to production processes and end-use—highlighting the significance of both the creation and usage phases. The integration of such detailed assessments ensures that both the ecological impact and the operational efficiency of the battery technology are optimized.

The integration of α (alpha) and β (beta) alumina phases, referred to as "glassing," employs glass powders to facilitate the bonding process. During cell production, the cathodic material—consisting of aluminum powder, iron, and salts—is incorporated along with the liquid electrolyte, culminating in the formation of the final cell.

There are two principal types of batteries produced: vacuum-sealed and non-vacuum-sealed. In vacuum-sealed batteries, air is evacuated from the space between the inner and outer enclosures using specialized pumps to create a vacuum (negative Δp). This vacuum environment is critical for certain operational and efficiency parameters.

The battery assembly area is a designated section of the manufacturing plant where battery components are subjected to specific thermal treatments in furnaces. In this area, the assembly process brings together various parts, including α and β alumina, components involved in thermocompression bonding (TCB), and the glassing phase(fig. 16). Each component undergoes precise integration to ensure the functionality and integrity of the assembled battery. This meticulous assembly process is crucial for achieving the desired performance characteristics and reliability of the final battery product.

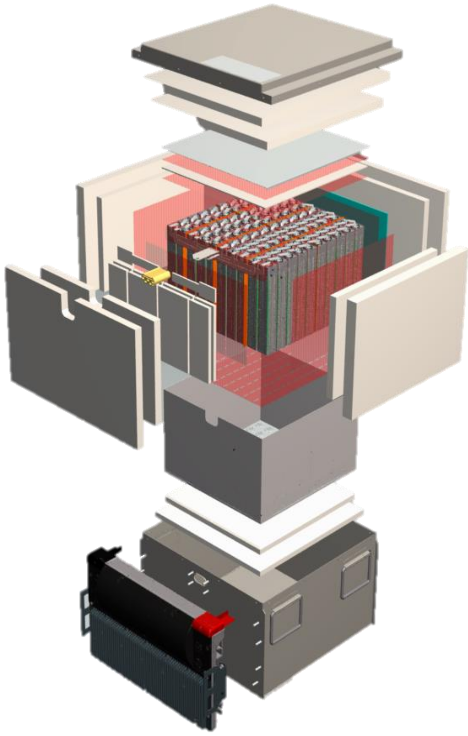

Figure 4

The furnaces employed in the production process are significant contributors to energy consumption, thermal dissipation, material wear, and emissions. To address these issues, it is crucial to perform a thorough cost-saving analysis. This analysis should consider not only the direct economic factors but also the energy sources utilized. For alignment with social corporate responsibility (SCR) objectives, the energy's provenance—whether from renewable sources or otherwise—must be evaluated to ensure sustainable practices.

In scenarios where the battery experiences a malfunction due to manufacturing defects or external damage, specialized containment areas have been developed. These containment zones are engineered to confine any potential emissions and provide a safe environment for operators. While the battery is designed not to ignite or explode, there remains a possibility of gas leakage. These gases, while non-toxic, can cause irritation to the eyes and skin. This characteristic underscores the importance of safety measures but also highlights that the environmental impact of such leaks is relatively minor and non-critical. The overall environmental impact is further reduced by the high recyclability of the materials used in the batteries, which contributes to a sustainable lifecycle and reduces the footprint of manufacturing processes.

These practices reflect the company's commitment to minimizing environmental impact while maintaining operational safety and efficiency.

Molybdenum serves a critical role in the battery assembly process as a metallic material, applied in the form of an ink. This ink is deposited onto the alpha collar of the ceramic component. The subsequent bonding process involves heating the assembly within a furnace. This thermal treatment enables a bond between the nickel metal and the ceramic material. Due to the inherent differences between these two materials, traditional welding techniques are ineffective.

Instead, the molybdenum ink acts as an intermediary. When applied to both the ceramic and metal surfaces, it allows for a connection through a thermal bonding process. This technique facilitates the adhesion of the two disparate materials, resulting in a secure bond. However, the process is intricate and specific to particular production lines, making it challenging to replicate broadly across different manufacturing settings.

The molybdenum bonding process exemplifies advanced material science applications, where precise thermal and chemical interactions are harnessed to achieve reliable connections between otherwise incompatible materials. This specialized method underscores the complexity and innovation involved in modern battery manufacturing, contributing to the overall robustness and functionality of the final product.

There is also the "ilumin" (nickel-plated steel), which is the metal container where the ceramic core is deposited and surrounded by 4 pieces of ilumin. Their function is to create capillarity.

As the cell is charged, electrons react, and sodium ions migrate from inside to outside, forming liquid sodium (Na) at 265°C. The more it is charged, the more the liquid increases; the more it is discharged, the more sodium liquid (active material) empties out. The sodium settled at the bottom of the cell is drawn up through capillarity throughout its height, ensuring the cell remains uniformly wetted and conductivity increases (thanks to the springs).

The cell is hermetically sealed (the positive pole is only the button on top, while the negative pole is the entire body), and the collar of alpha-alumina (electrical insulator) separates the two poles. This piece is located between the connection of the metal parts (positive and negative poles) and acts as a bridge between the negative pole, the collar, and the positive pole.

There is also a particular process called ‘Thermo-compression bonding’ (TCB). It is the production process where the operating temperature is raised to 1000°C. This allows the ceramic to heat up, and when it reaches its melting point, a metal foil is placed on its surface. Inside special hydrogen-utilizing furnaces, welding and pressing processes take place. Altogether, these steps require several hours to complete.

The form of the cell is specific, it’s a tetra-loaded shape because it will increase the surface area for the exchange of ions and, at the same time, will decrease the resistance.

After the creation of the cell, the hole created will be the place for the positive pole and before the sealing part inside will be putted a granulate of nickel, a granulate of refined iron and salt.

The collar is made of nickel because it is the only metal capable of withstanding the highly aggressive internal environment (rich in NaCl). However, nickel presents a challenge—it is four times less conductive than metals like iron or copper. This necessitates using four times more nickel to achieve the same conductivity level. Despite copper being more cost-effective, it cannot be used due to the corrosive nature of the environment (fig. 17).

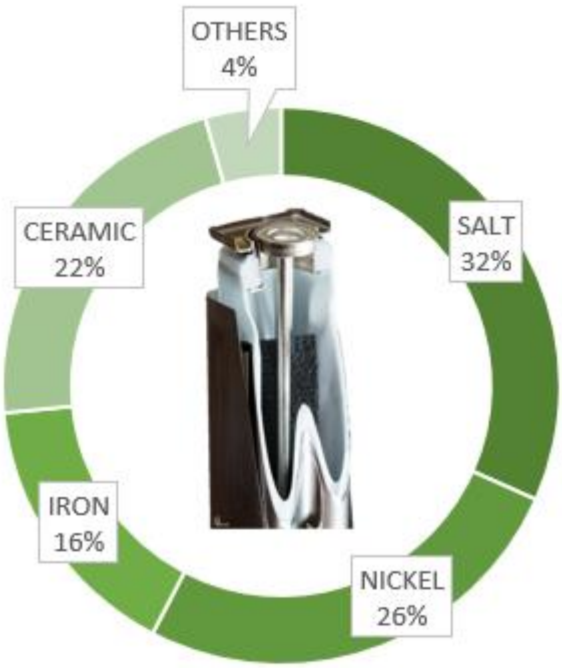

Figure 17 percentage of different components

In addition to solid nickel components, nickel powder is also used, which is blended with iron powder and NaCl during granulation (a process conducted in Stabio). Given that nickel powder is carcinogenic, it is handled within a sealed environment. The focus lies not on nickel itself but rather on its powdered form. This iterative process continues until granules of the desired size and density are attained. These granules are then inserted into the beta-alumina tube.

Subsequently, the tube undergoes drying in an oven to eliminate any residual moisture. A negative-pressure environment is created to ensure complete and uniform infusion of the liquefied powder into the tube, achieving the desired standard quantity.

Following this process, the cell is sealed with the positive pole. At this stage, the cell is considered complete and is referred to as a virgin cell.

Among the various cells, a sheet of mica is placed (a mineral composed of a network of alkali aluminum silicate silicates). Its property is that it is an excellent electrical insulator while also being a good thermal conductor, which is crucial since the cells need to be uniformly heated. Between each sheet of mica, there is a heater, a heating circuit (similar to the resistance in a toaster). These materials have thermal inertia, meaning they require time to be heated and cannot be heated quickly. If the temperature is not uniform, the ceramic inside could break (structural failure due to temperature differences), so there are specific heating times (e.g., 11 to 12 hours, approximately 5°C per hour).

Sodium is a reactive material, and chemically, in the event of a technical fault, only 60% of the battery's energy is dissipated. In contrast, lithium, if exposed to air or in the event of a technical issue, can release 100% of its energy in the form of heat.

During the preparation of the cells with mica, the core of the battery is placed inside a stainless steel container used solely to hold it together. It is then thermally insulated (not in an adiabatic environment, with a thickness of 4-5 cm for specific insulation purposes). The more insulation used, the less energy required to maintain its temperature (trade-off: more insulation improves efficiency but takes up more space). However, excessive insulation can hinder cooling after heating (Joule effect).

The insulation consists of compressed microporous silica powder and silicon dioxide, which is inert and fireproof, providing higher safety compared to other batteries. For example, in the event of severe damage, the internal temperature could reach 1000°C, but the surrounding insulation reduces the external temperature perceived to be lower.

In the case of deep mechanical damage causing cell rupture, it triggers a thermal runaway event. This occurs when one cell breaks and in severe cases, others follow suit uncontrollably, causing internal temperatures to rise rapidly. Fortunately, with insulation, external temperatures remain manageable around 150-200°C, making them safer for human handling.

On the contrary, if the battery is exposed to a fire (such as in a petrol test), it does not explode or overheat excessively, thanks to the presence of this insulation. This feature adds cost, increases surface area, and consequently weight, but it significantly enhances safety.

Sodium is a reactive material, and chemically, in the event of a technical fault, only 60% of the battery's energy is dissipated. In contrast, lithium, if exposed to air or in the event of a technical issue, can release 100% of its energy in the form of heat.

For instance, if the liquid inside the cell leaks and comes into contact with other liquids within the cell, it may short-circuit. However, the battery itself can still be used normally even if it is damaged. Therefore, when a decrease in performance is noticed (which requires the failure of multiple cells, particularly in larger batteries; a single cell failure can significantly impact performance if the battery is small), the battery is dismantled and the damaged cells are replaced with new ones. Conversely, with lithium batteries, if a cell fails, the entire battery must be discarded without the possibility of repair.

The electronic part of the battery requires programming by skilled technicians to make it operational. It is programmed according to the specific requirements of the buyer, who provides the company with the necessary specifications to optimize its performance and achieve set goals. The components are premium, which is another reason why they cost significantly more compared to lithium.

Safety checks ensure that the battery operates within specified parameters and safety controls.

The battery ends up weighing approximately 100 kg. It is then placed inside a steel container with a lid.

Next comes the electronic component (the battery is not sold without electronics) — the Battery Management System (BMS) manages critical functions(fig. 18)(fig. 19), including thermal management for both heating and cooling, as well as charge management. When charging begins, the BMS limits and adjusts the charge based on the condition of the cells. This function is internally managed by FZSonick and does not rely on external components.

Figure 18 BMS system

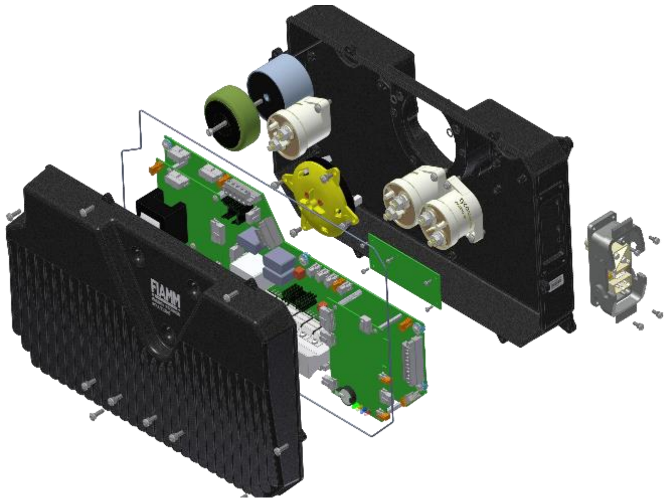

Figure 19 BMS technology

When the battery is completed and it's cold, it takes 12 hours to warm it up (fig. 20) and another 12 hours to have a complete charge(fig. 21). To test and ensure that the battery is fully functional without potential issues, it undergoes a 7-day process from start to finish. This process includes heating, charging, testing, and waiting for cooldown (fig. 22).

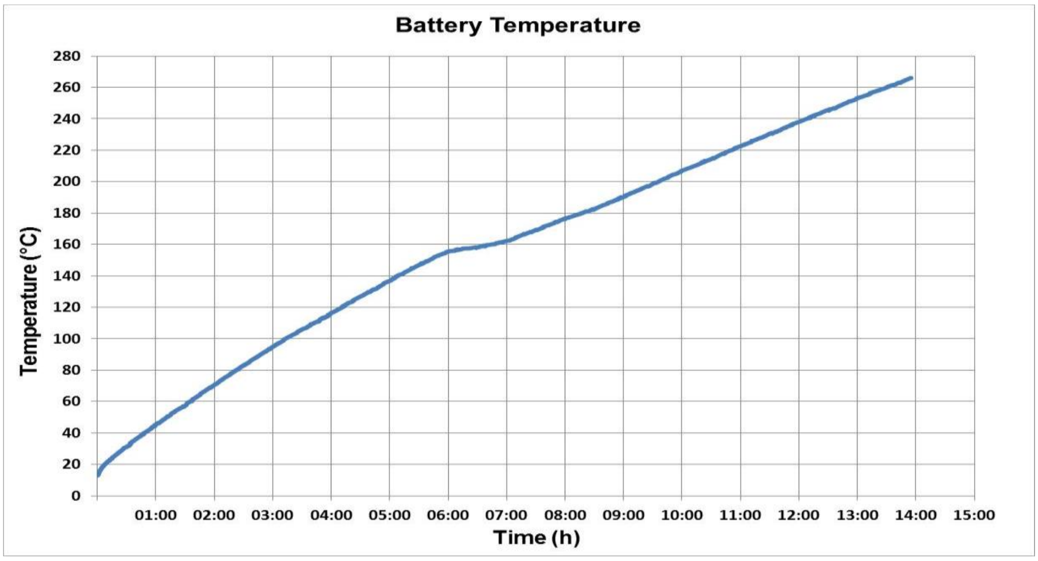

Figure 20 Increasing of temperature of the battery

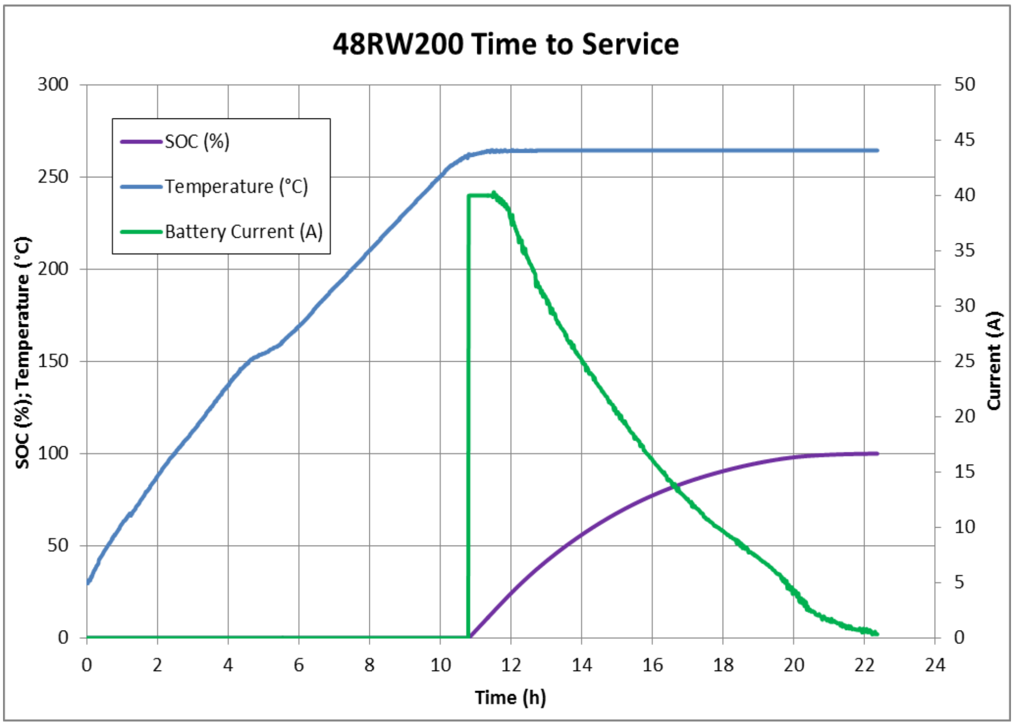

Figure 21 Relation between temperature and current

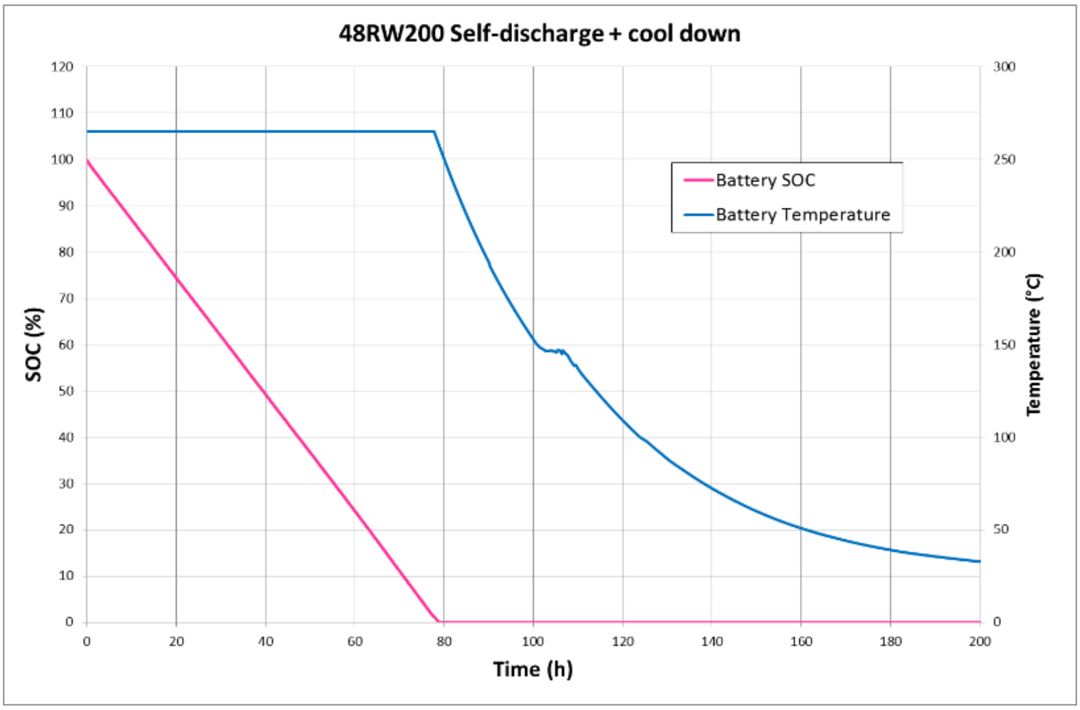

Figure 22 Battery discharge

The voltage of the battery is determined by the number of cells arranged in series (fig. 23), forming a string(fig.24). Each cell contributes 2.5 V, allowing for module configurations ranging from 24 to 600 V (equivalent to 10 to 240 cells).

Figure 23 Union of cells

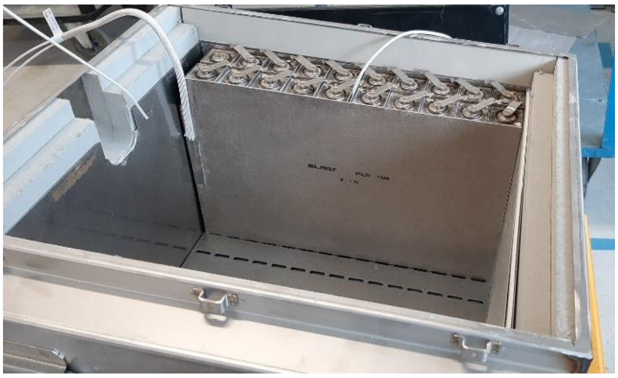

Figure 24 Series of cells

Unlike lead batteries, which can be sold in sub-modules for customer assembly and thus offer modularity, these batteries can be connected in series due to their specific construction. Therefore, they are pre-assembled and available in standardized configurations listed in the catalogue.

Due to its ability to operate at very high internal temperatures, our battery can function effectively in 'extreme' environments. For instance, it performs reliably in desert conditions where temperatures can soar to 60°C, as well as in environments where temperatures plummet to -20°C. This versatility stems from its robust thermal management capabilities.

In contrast, batteries like lithium-ion or cadmium batteries have narrower temperature ranges within which they can safely operate. These batteries are more sensitive and may experience performance issues or even failure if exposed to such 'extreme' conditions.

The inherent thermal resilience of our battery not only ensures consistent performance but also enhances its reliability and longevity in diverse environmental settings. This capability makes it particularly suitable for applications where temperature variations are significant, ensuring operational safety and efficiency under challenging conditions.

FZSonick actively collaborates not only with its own research and development laboratories but also with public research institutes and universities, such as Supsie. These collaborations provide opportunities for students and other stakeholders interested in activating research and development projects on new battery technologies. This includes efforts to explore new and more efficient materials to replace nickel or other components used in batteries.

Test and security

The performance of this high-temperature battery is exceptional, largely owing to the unique cell design which activates at 200°C. The battery system is engineered to function in a battery back configuration, operating within a temperature range from a minimum of 250°C to a maximum of 350°C, depending on the specific application requirements. This broad operating range highlights the battery’s ability to maintain functionality across varying conditions.

The battery's insensitivity to external temperature fluctuations is a significant benefit. This stability is achieved through the combination of insulating layers and the battery's activation temperature. These design elements ensure that the battery remains operational regardless of external thermal variations, providing reliable performance in different environmental settings.

Nevertheless, a potential constraint exists in the form of the Battery Management System (BMS). This electronic device is integral to the battery's operation, managing charging, thermal regulation, and safety functions. Despite the robust design of the battery, the BMS components are sensitive to high temperatures, with an operational limit of up to 150°C.

The (BMS) provides significant advantages, especially in high-temperature scenarios. When the battery exceeds a specified temperature threshold, it autonomously triggers a safety lock, placing the entire battery system in a secure state. This automatic response occurs without the need for physical intervention by an operator, ensuring a rapid and effective safety mechanism.

This distinction between the battery's high-temperature tolerance and the BMS's more restrictive temperature capacity underscores the importance of integrated system design. While the battery can endure significant thermal stress, the electronics governing its operation may necessitate additional protective measures to ensure overall system reliability and safety in all conditions.

Before the battery is put in the market it has to pass different tests based on the different extreme situation in which can be in danger: the immersion test(fig. 25)(fig. 26), the fire exposure(fig.27)(fig.28) and the mechanical abuse (rod penetration(fig.29) and drop test(fig. 30)).

Figure 6 immersion test 1

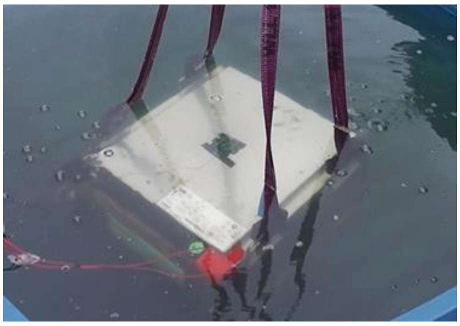

Figure 56 immersion test 2

Figure 27 Fire Test

Figure 28 prepare for fire test

Figure 29 Rod test

Figure 30 drop test

Positive Aspects and Comparison with Lithium Batteries

Performance and Cooling Requirements

When comparing sodium batteries to lithium batteries, several advantages of sodium batteries become evident. Sodium batteries exhibit significantly better performance in terms of thermal management. Unlike lithium batteries, which require sophisticated cooling systems to prevent overheating and maintain optimal functionality, sodium batteries operate efficiently without the need for such cooling mechanisms. This is due to their inherent design, which allows them to function effectively across a wider range of temperatures without the risk of thermal runaway—a common concern with lithium-based systems.

Lifecycle Durability

The lifecycle of sodium batteries is another notable advantage. Typically, sodium batteries can endure approximately 4,500 charge-discharge cycles, though this lifespan is contingent on the specific usage patterns. Frequent and rapid cycling can reduce the battery's longevity. In contrast, when utilized in applications such as telecommunications backup, where the battery is only employed intermittently, the effective lifecycle of sodium batteries is extended. This makes them particularly suited for environments where reliable and infrequent power is critical.

Lithium batteries, on the other hand, suffer from significant performance degradation when left inactive for extended periods. Their efficiency diminishes over time if they are not regularly used or maintained, leading to a reduced lifespan. In contrast, sodium batteries do not experience such issues. Their components remain stable and effective even after prolonged periods of inactivity, ensuring that they retain their performance capabilities over many years without use.

Efficiency in Extreme Conditions

Sodium batteries also demonstrate superior resilience in extreme environmental conditions. They maintain functionality without the need for temperature-sensitive management systems, making them ideal for deployment in harsh climates where temperatures can fluctuate widely. The lack of need for active cooling not only simplifies the system design but also reduces the overall operational costs and maintenance requirements associated with the battery system.

Comparison with other batteries

Fzsonick could also be compared with other batteries (fig. 31) to show its characteristics and why this technology is becoming one of the best(fig. 32) (tab. 2).

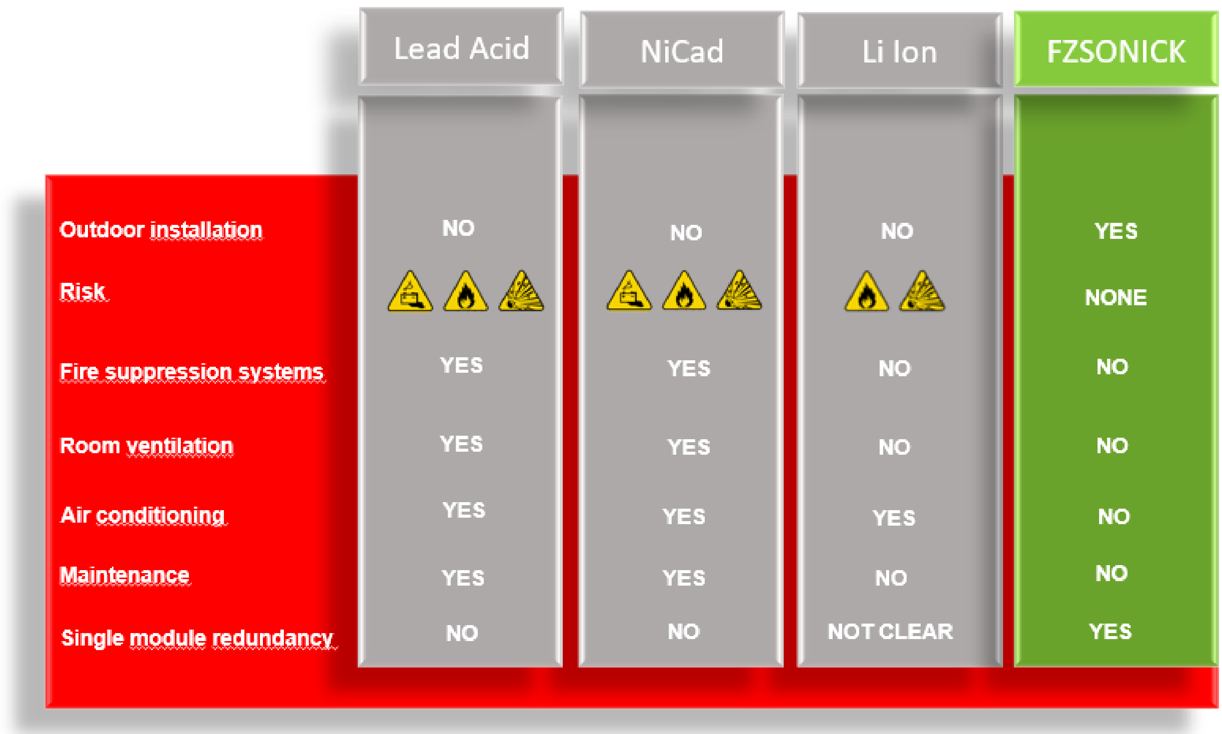

Figure 31 characteristic between batteries

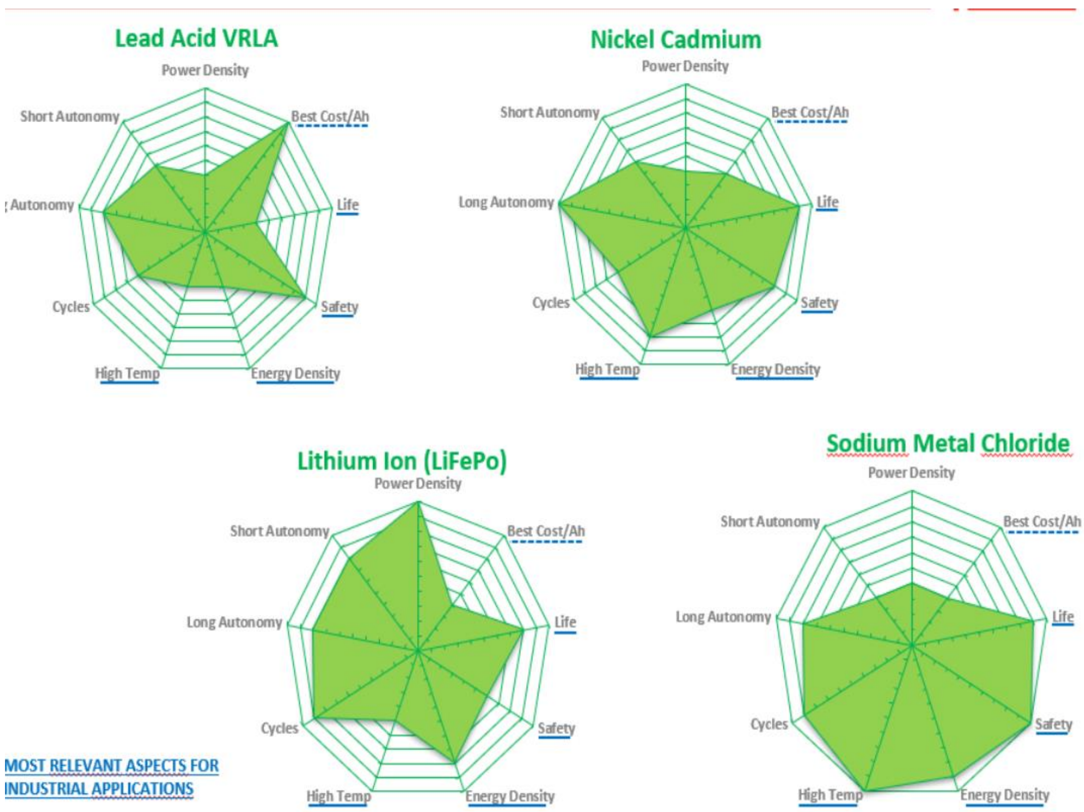

Figure 32 Relevant aspects of different batteries

	Performance Decay vs. Temperature	**Reduction of lifetime for 10°C temperature increase**
SMC	None	None
VRLA	High	50%
NiCd	Medium	20%
LiPo	High*	>20%

Table 2 performances of batteries

Certifications and Environmental Commitment

FZSonick is highly committed to environmental sustainability and the safety of its products. As part of this commitment, their batteries undergo rigorous testing and hold a variety of certifications(Fig. 33), ensuring adherence to international standards for quality, safety, and environmental impact.

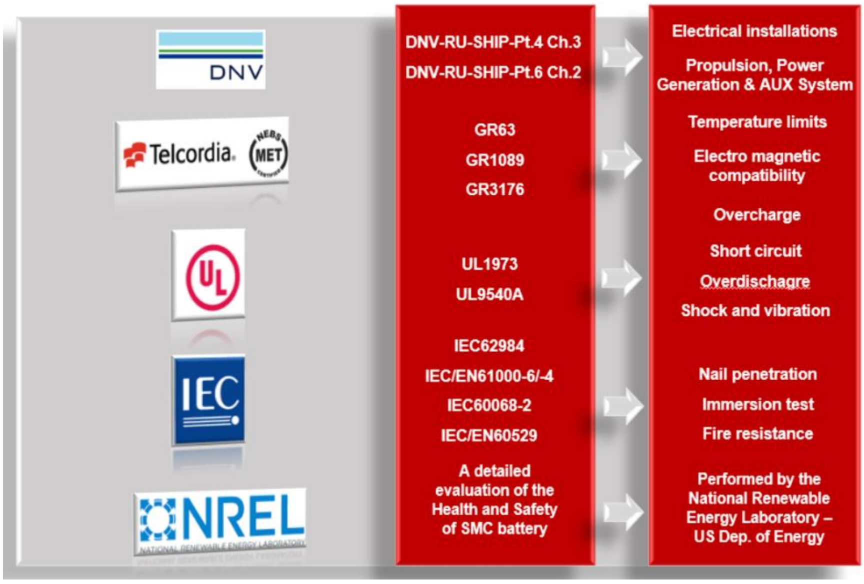

Figure 7 certification of FZSonick

International Certifications

- IEC 62984: This standard specifies performance and safety requirements for high-temperature batteries used in stationary applications, such as sodium-nickel chloride batteries.
- IEC 60068-2: This series of standards covers environmental testing, including procedures for determining the resistance of electrical components to environmental stress, such as temperature and humidity.
- IEC/EN 60529: Provides the degree of protection provided by enclosures (IP Code) against intrusion, dust, accidental contact, and water.
- IEC/EN 61000-6/-4: These standards relate to electromagnetic compatibility (EMC), specifying immunity requirements for industrial environments and emission standards for residential, commercial, and light-industrial environments.

Underwriters Laboratories (UL) Certifications

- UL1973: Covers batteries for use in stationary applications, such as emergency power systems, and includes requirements for performance and safety.
- UL9540A: Evaluates the fire propagation characteristics of energy storage systems (ESS) to ensure they do not contribute significantly to fire hazards.

Telecommunications Certifications

- GR-63-CORE: This is a telecommunications standard for the physical protection of telecommunications equipment in network facilities.

- GR-1089-CORE: Covers electromagnetic compatibility (EMC) and electrical safety requirements for telecommunications equipment.
- GR-3176: Specifies requirements for the safety, durability, and performance of telecommunications equipment, ensuring reliable operation under various conditions.

Marine and Offshore Certifications

- Type Approval RINA**:** This certification from RINA (Registro Italiano Navale) validates the compliance of products with marine standards for safety and performance.
- DNV AIP (Approval in Principle)**:** A certification from DNV (Det Norske Veritas) that signifies the product's compliance with marine and offshore standards, ensuring safe and effective use in harsh marine environments.

FZSonick is exploring additional green certifications to enhance the sustainability profile of their battery products, such as the 48 TL, ST 523, Cabinet Zebra, and TL range. These certifications include Energy Star**,** EPEAT**,** and Blue Angel**,** which are recognized for promoting environmentally friendly and energy-efficient products.

Potential Green Certifications

- Energy Star**:** This certification signifies that a product meets energy efficiency guidelines set by the U.S. Environmental Protection Agency (EPA) and the Department of Energy. It is well-regarded for reducing greenhouse gas emissions and other pollutants caused by inefficient energy use.
- EPEAT (Electronic Product Environmental Assessment Tool)**:** EPEAT evaluates the environmental impact of electronic products throughout their lifecycle. It covers criteria such as material selection, design for recycling, energy conservation, and end-of-life management.
- Blue Angel**:** A German certification, Blue Angel is awarded to products and services that are particularly environmentally friendly. It emphasizes low emissions, energy efficiency, and the use of sustainable materials.

A key certification sought by many customers is EcoVadis, which is widely used to assess corporate social responsibility (CSR) across four main categories: environmental impact, labor and human rights standards, ethics, and sustainable procurement practices.

Recognition Issue and Transport Certification

FZSonick’s sodium batteries face challenges in obtaining ABR (Agreement on Dangerous Goods by Road) and UN (United Nations) transport certifications. Despite their different chemical properties compared to lithium batteries, sodium batteries are often misclassified as similarly hazardous. This misclassification leads to stringent transport regulations, complicating the certification process. Unlike lithium batteries, which are classified as dangerous goods due to their potential safety risks, sodium batteries are safer but are nonetheless subject to similar transport restrictions, creating logistical hurdles for distribution.

Environmental Considerations in the Manufacturing Process

While FZSonick's batteries are designed to be environmentally friendly, attention must be given to the environmental impact of the manufacturing process itself. For instance, certain cleaning agents and materials used in production may not meet green standards. Therefore, a holistic environmental assessment should consider both the end product and the manufacturing process, ensuring that all stages align with sustainability goals.

Lead-free soldering has been adopted primarily for environmental and safety reasons. Traditional lead-based soldering is known for its toxicity and environmental impact, making it less favorable for most applications. Exceptions are sometimes made in military applications where performance requirements may justify the use of lead-based solder due to its superior reliability in specific scenarios. In general production, however, lead-free alternatives are preferred to minimize health risks and environmental pollution.

Waste Management and Environmental Footprint

An integral part of the environmental impact assessment is evaluating the waste produced during the manufacturing process. The environmental footprint of the production process includes not only the materials and methods used but also the quantity of waste generated**.** Defective units and production by-products need to be minimized to reduce the overall footprint. Efficient waste management practices are essential to ensure that the manufacturing process is as green as the product itself.

Key Points on Environmental Footprint (Fig. 34):

- Defective Units**:** The number of defective pieces identified during production can contribute significantly to the waste footprint. Reducing defects and improving quality control are essential to minimizing waste.
- Waste Disposal: The method and location of waste disposal are crucial. Proper disposal practices must be followed to ensure that waste materials do not harm the environment.
- Recycling**:** Wherever possible, recycling materials from the production process should be prioritized to reduce waste and improve sustainability.

	Life cycle stage	Short description of the processes included
	Raw material acquisition and pre-processing	Includes mining and other relevant sourcing, pre-processing and transport of active materials, up to the manufacturing of battery cells and batteries components (active materials, separator, electrolyte, casings, active and passive battery components), and electric/electronics components.
	Main product production	Assembly of battery cells and assembly of batteries with the battery cells and the electric/electronic components
	Distribution	Transport to the point of sale
	End of life and recycling	Collection, dismantling and recycling

Figure 34 carbon footprint of the battery

Minimizing Waste and Environmental Impact in Battery Production

In battery manufacturing, considerations revolve around parts per million (ppm) for batteries and percentage points for cells, reflecting efforts to reduce waste and minimize environmental impact.

Process Waste: Process waste, or "sfrido" (leftover metal from stamping), is a significant concern. For instance, in machining ceramic tube B, waste from the base rectification process must be considered. Minimizing such waste is crucial to reducing environmental impact and optimizing production efficiency.

Efficient transportation is essential for both economic and environmental reasons. Optimizing logistics ensures that resources are utilized effectively, reducing costs and minimizing the carbon footprint associated with transportation.

Improving cost efficiency goes hand in hand with environmental considerations. Utilizing less material, optimizing workflows (such as centralized lighting and batch production), and increasing production batches are effective strategies. For instance, instead of producing 200 batches, producing 300 batches directly reduces production costs and ultimately lowers the final product price.

Efficiency in batch production involves streamlining processes to maximize output while minimizing resource consumption and waste. This approach not only enhances economic viability but also aligns with environmental sustainability goals by reducing energy consumption, material usage, and overall production footprint.

Integrated Management Systems and Environmental Responsibility

In its manufacturing processes, FZSonick adheres to stringent material specifications and maintains a robust supplier chain management framework. Key Performance Indicators (KPIs) are utilized to monitor performance across various domains, including environmental sustainability, making it an integral part of their management system.

FZSonick maintains environmental management standards akin to ISO 14001 certification, covering both battery production and the Fiamm division. These standards ensure systematic environmental management and compliance, promoting sustainable practices throughout their operations.

The company manages Material Safety Data Sheets (MSDS), detailing product characteristics, safety considerations, and environmental impacts. This includes protocols for handling incidents such as eye contact with materials or potential toxic gas emissions. Hazardous materials are stored in dedicated areas before undergoing internal processes to mitigate risks.

FZSonick integrates its practices through a comprehensive manual that incorporates ISO 9001 certification standards for quality management. Notably, ISO 45001 certification is not pursued due to compliance regulations in Switzerland, where the Montecchio headquarters oversees business units including automotive components such as horns and antennas.

Material Qualification and Compliance Standards at FZSonick

At FZSonick, the process of material procurement and qualification is crucial to ensuring that all supplies meet stringent standards and specifications set forth by the company. Here's an overview of how FZSonick manages material qualification and compliance:

FZSonick only engages with suppliers who are qualified and certified. Supplier qualification involves verifying that suppliers meet the specific requirements and standards established by FZSonick. This ensures that suppliers adhere to regulatory requirements and company-specific standards.

Suppliers must comply with mandatory regulations, which are legal standards required by the regulatory system. These regulations ensure that materials meet minimum safety, environmental, and quality standards mandated by law.

In addition to mandatory regulations, suppliers must also meet technical standards, which include industry-specific requirements and standards. These standards ensure that materials used in production meet technical specifications and performance criteria suitable for FZSonick's products. The industry may also set personalized specifications for materials, requiring suppliers to meet additional stringent criteria or customized requirements. These specifications align with the company quality and performance expectations, ensuring that materials contribute to the overall quality and reliability of their products.

Once materials are procured, FZSonick continues to monitor compliance through ongoing assessments and audits. This process ensures that materials consistently meet regulatory, technical, and company-specific standards throughout the supply chain.

Economic Aspects and Advantages of FZSonick Batteries

FZSonick batteries offer numerous economic and practical advantages compared to other solutions available on the market, primarily in the field of energy storage and backup systems. Here is a detailed analysis:

It stands out for offering a complete product that includes all necessary components for installation and operation. This Business-to-Business (B2B) approach allows customers to save compared to other batteries that require the purchase of additional components such as inverters and separate integration systems.

another of the distinctive features of this battery is their long lifespan and reliability over time. With a lifespan of 10 years in storage and up to 20 years in telephone backup systems, the batteries require minimal or no maintenance costs during their lifecycle. This represents significant economic savings for plant owners.

Battery Applications and Usage

batteries find application in various sectors:

- Residential: Used in 50% of residential applications, providing energy storage solutions for households and communities.
- Oil and Gas: Employed in 24% for operations in the oil and gas industry, where reliability and safety are critical.
- Commercial and Industrial Storage: Coverage of 7% for industrial and commercial applications, providing secure and continuous energy.
- Telephone Backup: Significant role in 7% to ensure operational continuity in telecommunications.
- Other Sectors: Residual use of 12% in various other applications, demonstrating the versatility of solutions.

The long lifespan of FZSonick batteries is supported by the concept of "calendal life", where durability is primarily determined by the natural degradation of the ceramics used, rather than intensive use. This ensures consistent reliability over time without compromising performance.

Current and Future Considerations

The goal of the company is to build a "virtuous" battery, with more advantages than drawbacks, easy to use across various sectors, and to reduce battery costs to make it more accessible and safer (particularly for nickel).

The fundamental issue with lithium lies in its extraction and disposal, despite efforts such as "second life" initiatives (pollution and working conditions remain concerns). In contrast, sodium is abundant and chlorine readily available. Recycling exists but needs improvement, highlighting the importance of the research and development section.

In every battery created by FZSonick, sodium chloride, a waste material at the end of the production process, is sent to approved companies for disposal and used in road surface applications. Currently, the limitation of this battery compared to lithium is its lower performance, yet it finds diverse applications and is highly adaptable.

The greatest challenge is reducing nickel components, hence the focus on research and development. The company aims to contribute to green progress, transitioning the economy away from extensive use of petroleum and coal to more cost-effective, green, and sustainable solutions.

CONCLUSIONS

This work addresses a topic that has garnered significant interest across various contexts: the challenge of climate change and global warming. Through a comprehensive 360-degree analysis of the associated risks and the political strategies adopted over time, both current and necessary future measures were explored to provide an overview of the global situation. It is crucial not to overlook the economic aspect, which is equally important and must be considered to achieve greater sustainability.

The urgency for faster and more effective international policies is clear, and national actions are also vital in halting climate change and encouraging greater citizen participation and engagement in this critical issue. The measures taken so far, although significant, remain insufficient to fully combat the phenomenon of global warming. Continued efforts are required to contain environmental damage and to preserve our planet for ourselves, future generations, and the current diverse animal and plant species.

Our commitment must extend beyond the individual level to collective action, emphasizing the need for collaboration, as the future rests in our collective hands. As highlighted in the concluding chapters, investing in technological innovations is essential to reducing greenhouse gas emissions, mitigating rising temperatures, and enhancing the ecosystems in which we live.

Research and development play a pivotal role, enabling the creation of cutting-edge technologies that actively reduce pollution through the use of novel materials and innovative processes. These advancements not only contribute to environmental preservation but also drive progress towards a more sustainable and resilient world.

Furthermore, fostering public awareness and education on the importance of climate action can empower individuals to make more informed and responsible choices. Promoting community-based initiatives and supporting green policies at all levels of governance can accelerate the transition towards sustainable practices. Embracing renewable energy sources, enhancing energy efficiency, and developing sustainable infrastructure are crucial steps in this journey.

In summary, combating climate change requires a an approach that integrates environmental, economic, and social considerations. By working together and harnessing technological advancements, we can create a positive impact on our planet and ensure a healthy, thriving environment for future generations. The challenge is immense, but with collective effort and commitment, a sustainable future is within reach.

Bibliography

Adam, A.D. and Apaydin, G. (2016) ‘Grid connected solar photovoltaic system as a tool for green house gas emission reduction in Turkey’, *Renewable and Sustainable Energy Reviews*. Elsevier Ltd, pp. 1086–1091. Available at: https://doi.org/10.1016/j.rser.2015.09.023.

Araya, M. (2016) *The Relevance of the Environmental Goods Agreement in Advancing the Paris Agreement Goals and SDGs A Focus on Clean Energy and Costa Rica’s Experience*.

Bhattacharya, A. (2022) *Finance for climate action Scaling up investment for climate and development Report of the Independent High-Level Expert Group on Climate Finance*.

Bointner, R., Pezzutto, S. and Sparber, W. (2016) ‘Scenarios of public energy research and development expenditures: financing energy innovation in Europe’, *Wiley Interdisciplinary Reviews: Energy and Environment*. John Wiley and Sons Ltd, pp. 470–488. Available at: https://doi.org/10.1002/wene.200.

Borowski, P.F. (2022) ‘Water and Hydropower—Challenges for the Economy and Enterprises in Times of Climate Change in Africa and Europe’, *Water (Switzerland)*, 14(22). Available at: https://doi.org/10.3390/w14223631.

van den Broek, J., Afyon, S. and Rupp, J.L.M. (2016) ‘Interface-Engineered All-Solid-State Li-Ion Batteries Based on Garnet-Type Fast Li+ Conductors’, *Advanced Energy Materials*, 6(19). Available at: https://doi.org/10.1002/aenm.201600736.

Cahill, A.E. *et al.* (2013) ‘How does climate change cause extinction?’, *Proceedings of the Royal Society B: Biological Sciences*. Royal Society. Available at: https://doi.org/10.1098/rspb.2012.1890.

Candidato, R., Rondi, L. and Tieri, A. (no date) ‘POLITECNICO DI TORINO La separazione tra crescita economica e consumo del pianeta: l’Economia Circolare’.

Chen, C.C. and Pao, H.T. (2024) ‘Circular economy and ecological footprint: A disaggregated analysis for the EU’, *Ecological Indicators*, 160. Available at: https://doi.org/10.1016/j.ecolind.2024.111809.

Conti, C. *et al.* (2018) ‘Transition towards a green economy in Europe: Innovation and knowledge integration in the renewable energy sector’, *Research Policy*, 47(10), pp. 1996–2009. Available at: https://doi.org/10.1016/j.respol.2018.07.007.

‘CriticalMineraltopicpageheaderimage’ (no date).

‘DAL GREEN DEAL AL’ (no date).

Domaracká, L., Seňová, A. and Kowal, D. (2023) ‘Evaluation of Eco-Innovation and Green Economy in EU Countries’, *Energies*, 16(2). Available at: https://doi.org/10.3390/en16020962.

Energy Storage Applications Summary (no date).

Feldman, L. and Hart, P.S. (2021) ‘Upping the ante? The effects of “emergency” and “crisis” framing in climate change news’, *Climatic Change*, 169(1–2). Available at: https://doi.org/10.1007/s10584-021-03219-5.

Fuglestvedt, J. *et al.* (2018) ‘Implications of possible interpretations of’greenhouse gas balance’ in the Paris Agreement’, *Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences*, 376(2119). Available at: https://doi.org/10.1098/rsta.2016.0445.

Harris, S.A. (2023) ‘Comparison of Recently Proposed Causes of Climate Change’, *Atmosphere*, 14(8). Available at: https://doi.org/10.3390/atmos14081244.

How to invest in sustainability by investing in technology-the ‘Genius of the And’ (no date).

Institute of Electrical and Electronics Engineers, Institute of Electrical and Electronics Engineers. Peru Section and IEEE Power & Energy Society (no date) *Proceedings of the 2018 IEEE PES Transmission & Distribution Conference and Exhibition - Latin America (T & D-LA) : Lima, Peru, 18-21 September, 2018*.

‘italy and green economy’ (no date).

Komorowska, A. and Olczak, P. (2024) ‘Economic viability of Li-ion batteries based on the price arbitrage in the European day-ahead markets’, *Energy*, 290. Available at: https://doi.org/10.1016/j.energy.2023.130009.

Lamperti, F. *et al.* (2021) ‘Three green financial policies to address climate risks’, *Journal of Financial Stability*, 54, p. 100875. Available at: https://doi.org/10.1016/j.jfs.2021.100875.

Lorek, S. and Spangenberg, J.H. (2014) ‘Sustainable consumption within a sustainable economy - Beyond green growth and green economies’, *Journal of Cleaner Production*, 63, pp. 33–44. Available at: https://doi.org/10.1016/j.jclepro.2013.08.045.

Mikryukov, A., Chilimova, T. and Serebrennikova, A. (2021) ‘Investments in green economy as a driving force for sustainable economic development’, in *E3S Web of Conferences*. EDP Sciences. Available at: https://doi.org/10.1051/e3sconf/202129606037.

Miller, S. *et al.* (2021) ‘Heat waves, climate change, and economic output’, *Journal of the European Economic Association*. Oxford University Press, pp. 2658–2694. Available at: https://doi.org/10.1093/jeea/jvab009.

Ozkan, M. *et al.* (2022) ‘iScience Current status and pillars of direct air capture technologies’, *ISCIENCE*, 25, p. 103990. Available at: https://doi.org/10.1016/j.isci.

Petrović, P. (2023) ‘Climate change and economic growth: Plug-in model averaging approach’, *Journal of Cleaner Production*, 433. Available at: https://doi.org/10.1016/j.jclepro.2023.139766.

Rahmatinejad, J. *et al.* (2024) ‘1T-2H Mixed-Phase MoS2 Stabilized with a Hyperbranched Polyethylene Ionomer for Mg2+/Li+ Co-Intercalation Toward High-Capacity Dual-Salt Batteries’, *Small*, 20(2). Available at: https://doi.org/10.1002/smll.202304878.

Renewable Energy Agency, I. (2020) *Renewable capacity highlights (31 March 2020)*. Available at: www.irena.org/publications.

Robson, P., Bonomi, D. and Research, D. (no date) *Growing The Battery Storage Market 2020*. Available at: http://www.energystorageforum.com/.

Ryelandt, O. (no date) *‘Sustainability assessment and perspectives for battery storage in a solar home system in Cameroon’*. Available at: http://hdl.handle.net/2078.1/thesis:37880.

SYMBIOTIC DOME: UNA RISPOSTA ADATTIVA AL C AMBIAMENTO CLIMATICO (no date).

Tehmina, S. (no date) *Role of greenhouse gas inventories in climate change mitigation at institutions of higher education*. Available at: https://dsc.duq.edu/etd/1271.

Transport Policy and the Environment Six case studies (no date).

Urekeshova, A. *et al.* (2023) 'The Impact of Digital Finance on Clean Energy and Green Bonds through the Dynamics of Spillover', *International Journal of Energy Economics and Policy*, 13(2), pp. 441–452. Available at: https://doi.org/10.32479/ijeep.13987.

Wang, X.C. *et al.* (2022) 'Integration and optimisation for sustainable industrial processing within the circular economy', *Renewable and Sustainable Energy Reviews*. Elsevier Ltd. Available at: https://doi.org/10.1016/j.rser.2022.112105.

Weyzig, F. *et al.* (2014) *The Price of Doing Too Little Too Late Green New Deal Series volume 11*. Available at: www.gef.eu.

Wrålsen, B. and Faessler, B. (2022) 'Multiple Scenario Analysis of Battery Energy Storage System Investment: Measuring Economic and Circular Viability', *Batteries*, 8(2). Available at: https://doi.org/10.3390/batteries8020007.

All the information about the FZSonick study case were taken directly from interviews made to the employee in both work sites: in Montecchio Maggiore(VI) and Stabio, Swizzerland.

Web sources

https://www.ipcc.ch/report/ar6/syr/downloads/report/IPCC_AR6_SYR_SPM.pdf

http://www.dirittoambientale.eu/2023/01/23/qual-e-la-differenza-tra-cambiamento-climatico-e-riscaldamento-globale/

https://climate.ec.europa.eu/climate-change/causes-climate-change_it#:~:text=e%20il%202010.-,Cause%20dell'aumento%20delle%20emissioni,assorbendo%20CO2%20dall'atmosfera.

https://www.eea.europa.eu/en/analysis/indicators/economic-losses-from-climate-related#:~:text=Economic%20losses%20from%20weather%2D%20and%20climate%2Drelated%20extremes%20in%20Europe,-Published%2006%20Oct&text=Between%201980%20and%202022%2C%20weather,EUR%2052.3%20billion%20in%202022.

https://defenders.org/blog/2022/07/animals-brink-of-extinction

https://www.renewablematter.eu/2024-estate-temperature-record-intervista-carlo-buontempo-copernicus

https://www.carbonbrief.org/state-of-the-climate-2024-off-to-a-record-warm-start/

https://www.ifc.org/en/events/2023/private-capital-mobilization-by-mdbs

https://www.consilium.europa.eu/en/meetings/international-summit/2023/12/01-02/

https://energy.ec.europa.eu/topics/energy-strategy/clean-energy-all-europeans-package_en https://energy.ec.europa.eu/topics/research-and-technology/energy-storage_en

https://www.cnbc.com/2024/05/21/heres-how-to-buy-renewable-energy-from-your-electric-utility.html?&qsearchterm=green%20energy%20market

https://energy.ec.europa.eu/topics/research-and-technology/energy-storage_en#eu-initiatives-on-batteries

https://energystorageforum.com/news/energy-storage/when-global-green-economy-met-energy-storage

https://www.mordorintelligence.com/industry-reports/battery-energy-storage-system-market

https://www.fzsonick.com/