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TECHNOLOGIES OF CAPTURE AND STORAGE OF ENERGY FROM RENEWABLE SOURCES

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Abstract: *The article presents some considerations general related to renewable energies, and some technologies for capture, conversion and storage of renewable energies, practiced globally, emphasizing the need for technical solutions and innovative technologies for storage, in particular for the electric energy produced by photovoltaic panels and wind turbines, which have a regime unsteady / random to delivery of the energy.*
Finally, are presented some original concepts for capture, conversion and storage systems of electrical energy in the form of pneumatics energy or hydrostatic energy, technical solutions with great potential to be realized and transferred into production of energy from renewable sources

Keywords*: renewable energy, capture technologies, storage technologies, power hydraulics, wind industry, wind power, photovoltaic technology, hydrostatic transmission, fluid power transmission.*

1. Introduction

The main sources of energy harnessed and used worldwide are represented by fossil fuels in **78% of the total energy** produced, and this consumption adversely affects both the environment and the quality of human life. The solution, which is found in the current main research programs in the domain of energy, national or international, is to **increase energy efficiency for renewable sources.** [1]. The **main objective** of using clean and renewable energy is to **reduce emissions of greenhouse gases** [2]. EU adopted its own strategy to fight climate change by adopting a plan for **sustainable growth**, Europe 2020, which established a set of ambitious objectives, so-called 20-20-20 targets [3]. Renewable energy has provided 24% of the national consumption of **Romania** in 2014, thus fulfilling since 1 January 2014 the targets for 2020. Thereby Romania ranks sixth among EU Member States where the share of energy from renewable sources in gross final consumption [2].
A restriction encountered in producing electricity is because electricity must be consumed when it is generated and can be preserved only by storing them. This need has led, in addition to developing technologies and devices for capturing renewable energies, to appear and develop a range of **technologies, technical solutions and equipment to** store that energy **in order to use them subsequently**. [4].

2. Current technologies for the capture, conversion and storage of renewable energies

In the article are presented some examples of **technologies for capture / conversion of renewable energies into the energy used in everyday life**. Following the development of research in this field, there are already other **systems at laboratory level**, **pilot or demonstration plants** with real development opportunities in the next period [5].
The main **types of renewable energy** that have strong **potential for recovery** are: **solar** energy, **wind** energy, energy from **biomass**, kinetic and potential energy of water (**hydro**), **wave and tidal** energy, **osmotic** power and **geothermal** energy. Except the last two categories, all others are based on solar radiation reaching the Earth.

2.1. Technologies to exploit solar radiation

Harnessing solar radiation involves artificial means, called **solar collectors**, which are designed to capture the energy, sometimes by focusing direct sunlight. Energy, once captured, is used in **thermal** processes, **photoelectric** or **photovoltaic**. In thermal **processes**, solar energy is used to heat a gas or a liquid, which is then stored or distributed (figure 1). In **photovoltaic process**, solar energy is converted directly into electricity without the use of intermediate mechanical devices (figure 2). In **photoelectric processes**, are used mirrors or lenses that capture sunlight in a receiver, where heat is transferred to a fluid which puts into operation a system for conversion into electricity. [6]

Fig. 1. Thermal solar panels mounted on houses [6]

Fig. 2 Solar photovoltaic panels [6].

2.1.1. Technologies for the capturing, storing and converting solar radiation into thermal energy

Classic structure of a system for heating water using solar energy consists of the following components (Figure 3):

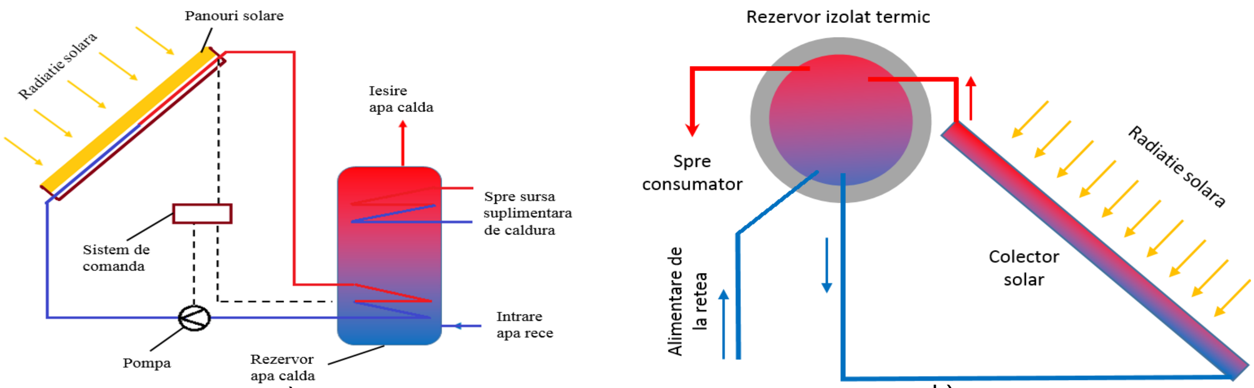
1. The solar collectors, which can be flat, with vacuum tube, or tubes with direct heating of the water;
2. Heat transfer system, circulation system and heat exchanger;
3. Hot water storage system;
4. The command and control system;

Solar systems which provide domestic hot water (DHW) can be classified into two categories: active and passive.

The active ones are divided into two subcategories: [5]

- Direct active solar systems, which pump cold water in the solar collector, in order to transform it into DHW.
- Indirect active solar systems, which have a closed circuit through which flows a heat transfer fluid (water, usually mixed with antifreeze), which circulates between the solar panel and heat exchanger.

For these systems, the **energy storage problem** is **solved**, **at least partially,** since, by definition, these systems **contain storage tanks**.



a) b)

Fig. 3. The structure of a solar water heating system: (a) indirect active system; (B) direct passive system [5]

Solar power plants with thermal energy storage systems [5]
To **accumulate the heat energy** in order to **produce electricity** at night or during cloudy days, two tanks are used, in which the storage **medium consisting of a eutectic mixture of salts of sodium nitrate and potassium nitrate**, the proportions being 60% and 40% respectively [5]. This mixture receives excess heat produced in sunny periods through a heat exchanger, and in the absence of solar radiation gets heat from storage tanks through the same heat exchanger. Figure 4 shows inlet and outlet temperatures of the steam generator needed to drive the electric generator.

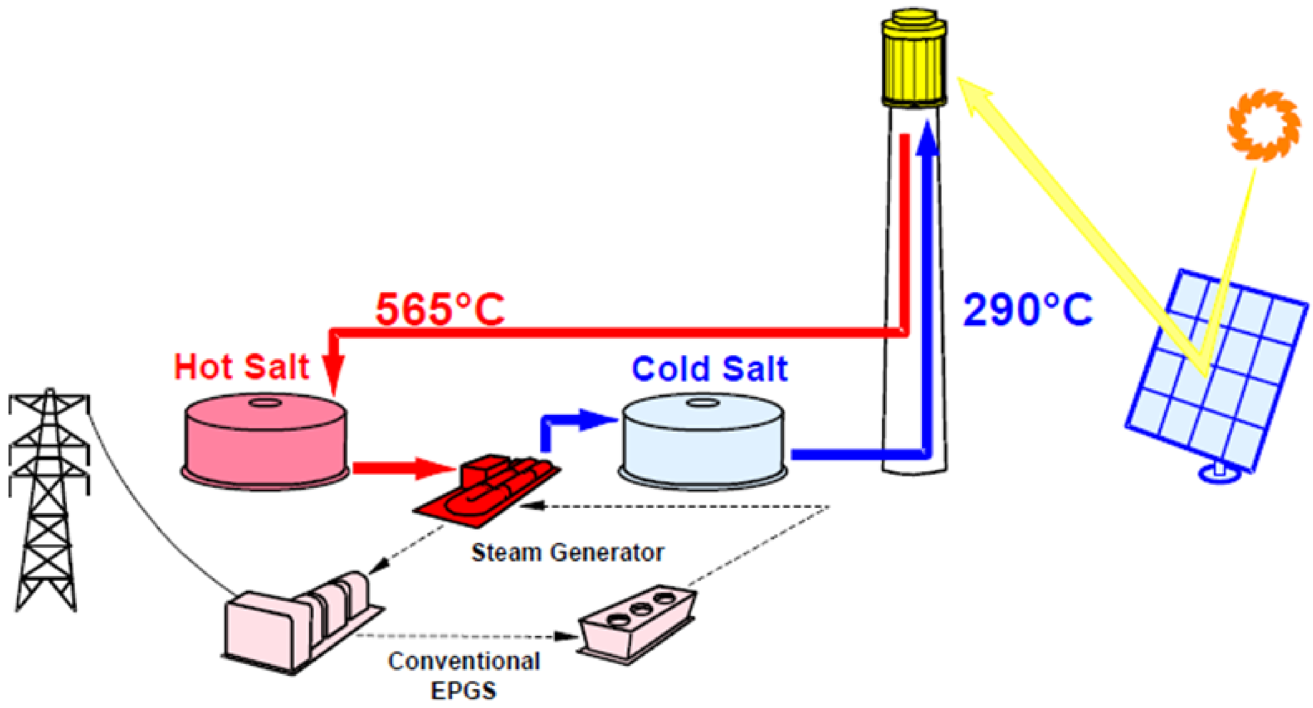


Fig. 4. Schematic of a molten salt power plant [7]

Some technical dates [7].
The thermal storage tanks, all pipes, valves, and vessels for **hot salt** were made from **stainless steel** because of its corrosion resistance to **molten salt at 565 °C**. Lower-cost **carbon steel** was used for cold salt containment because of the salts lower corrosively at **290 °C.**
The thermal storage medium consisted of approximately 1300 tonnes of nitrate salt nominally consisting of **60 % NaNO3** and **40 % KNO3**. This salt melts at 205 to 220°C and is thermally stable to approximately 600ºC. The thermal capacity is 110 MWh and the molten salt inventory is 1400 tonnes. The **dimensions** of cold tank are: 11.6 m diameter and 7.8 m high, hot tank has 11.6 m diameter and 8.4 m high.
A new storage method for solar thermal energy [8].
Engineers at Oregon State University (OSU) and the University of Florida have developed a new thermochemical device for storing and releasing energy from the sun.
In contrast to energy harvested with photovoltaic cells, solar thermal energy is generally developed as a large power plant, where acres of mirrors precisely reflect sunlight onto a solar receiver. This energy is then used to heat a liquid and drive a turbine that produces electricity. However, the same storage and intermittency problems associated with traditional solar remain.
The advance consists in a thermo-chemical storage system that acts like a battery where the transfer is based on heat rather than electricity. During ‘charging’, strontium carbonate decomposes into strontium oxide and carbon dioxide, consuming the thermal energy produced by the sun. When discharging, the recombination of strontium oxide and carbon dioxide releases the stored heat.

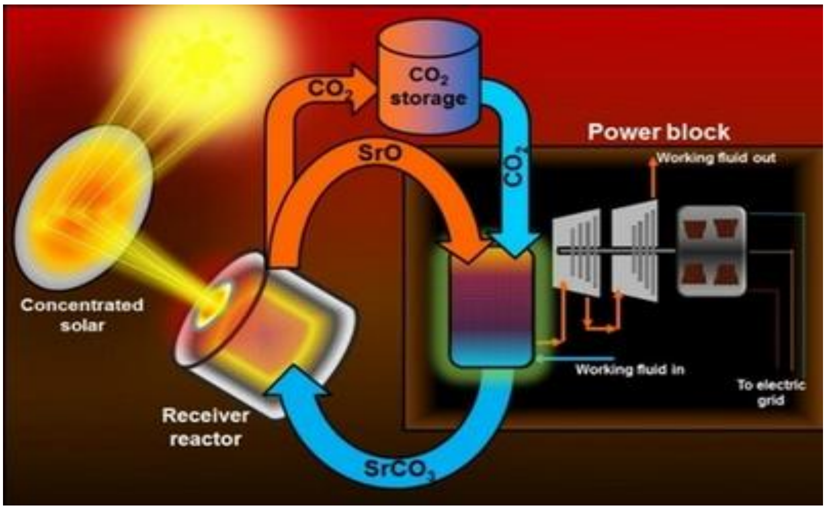


Fig. 5. Electric power plant with thermo-chemical storing system

An advance in the storage of concentrated solar thermal energy may reduce its cost and make it more practical for wider use.
In these types of systems, energy efficiency is closely related to use of the highest temperatures possible. The molten salts now being used to store solar thermal energy can only work at about 600 degrees centigrade, and also require large containers and corrosive materials. The compound we're studying can be used at up to 1200 degrees, and might be twice as efficient as existing systems.

2.1.2. Technologies for converting solar radiation into electricity

There are many technologies for the **conversion of solar radiation into electrical energy**. The easiest method is to use photovoltaic panels, which **convert directly** using semiconductors that exhibit the photoelectric effect. **Photovoltaic** solution can be used at any scale, from residential applications and ranging up to photovoltaic parks [5].
Indirect conversion is done using **solar concentrators** or lens systems. The light radiation is **concentrated on a heat exchanger** where the **energy is transferred to a fluid**, usually after applying a conventional cycle of energy production (ex. steam - turbine - power generator).
A third category with commercial potential, also **indirect** one, represents the combination of a **solar concentrator and a Stirling engine** that drives an electric generator.
Systems of these two categories using direct sunlight, require automatic orientation of the mirrors.
In photovoltaic systems, under the action of solar radiation, an electric current is generated due to the potential difference (Figure 6); the current intensity is directly proportional to the irradiance (Figure 7).

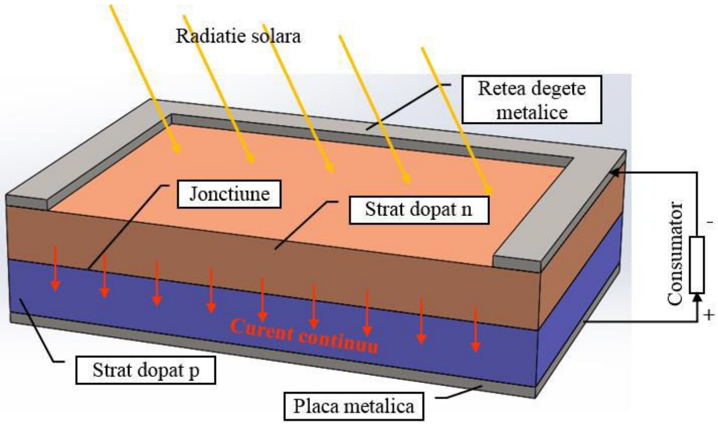


Fig. 6. Structure and functioning of photovoltaic cell [5]

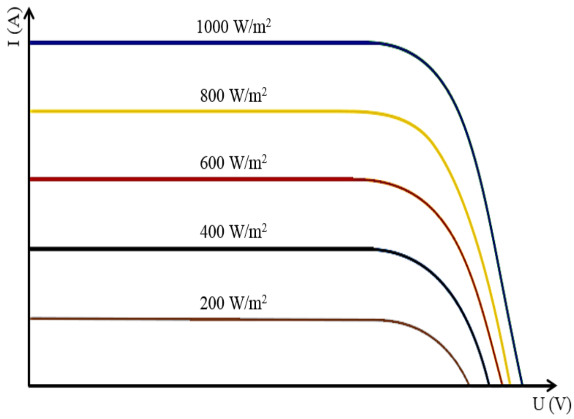


Fig. 7. Addiction between direct current and irradiance

A simplified diagram of a photovoltaic system is shown in Figure 8.
Permanent variations of voltage and current supplied by photovoltaic panels can damage the batteries. To prevent this risk, it is used a **charge controller** that adjusts permanently both parameters [5].

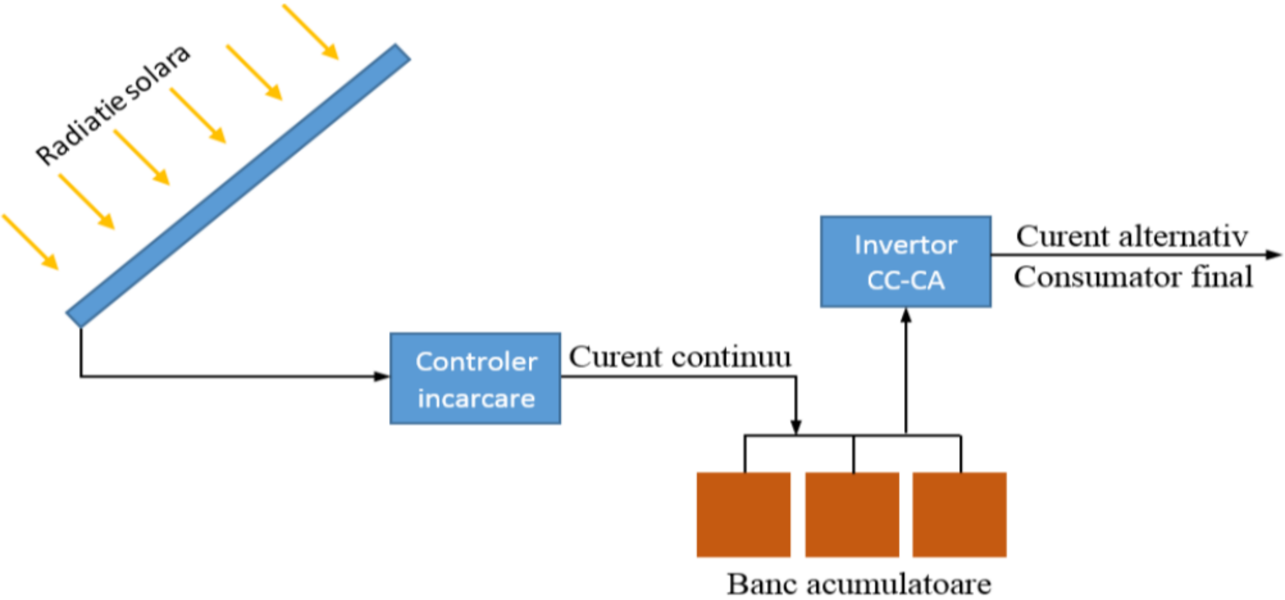


Fig. 8. Simplified diagram of a photovoltaic system [5].

To convert direct current into alternating current with suitable grid frequency and voltage, it is necessary to integrate a solar inverter into the solar system. For residential systems, **15% is considered a normal yield** for the whole system. According to latest reports, their effectiveness reaches 20% and even 25%. The main problem which arises is electricity **STORAGE**. This problem also occurs for systems which capture and convert wind energy.

2.2. Technologies for wind energy conversion into electricity

Wind energy is **used extensively** today; new wind turbines are built worldwide, and energy obtained from wind shows the **fastest growth** in recent years. Most turbines **generate energy 25% of the time**, this value increasing in winter, when winds are stronger. Depending on the position of the rotor axis, turbines can be with **vertical axis** (as shown in figure 9), or with **horizontal axis**, figure 10. Latest models are the most common.

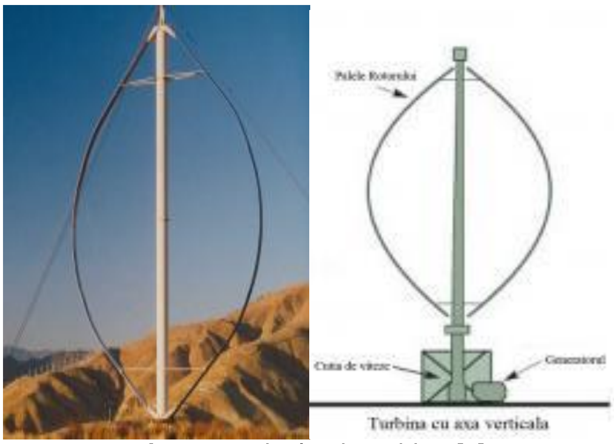


Fig. 9. Vertical axis turbine [5]

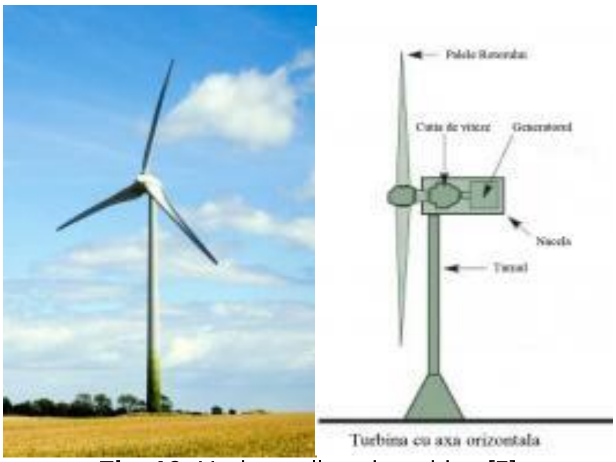


Fig. 10. Horizontally axis turbine [5]

Components of a vertical axis **wind turbines** are highlighted in Figure 11.
Specifically: the rotor hub, blades, nacelle, the pillar, the main shaft (low speed), speed multiplier, braking device, high speed shaft, electric generator, cooling system, pivot system, wind vane, anemometer and the control system (controller).

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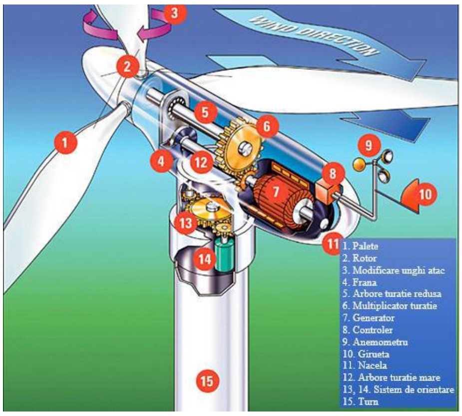

a)


b)

Fig. 11. The components of a wind energy conversion system (a) and turbine blade length of 62 m (b)

3. Storing electricity from renewable sources

Efficient energy storage is one of the most spectacular and sensitive areas of activity and initiative; development processes, equipment and technologies for the conversion and storage is an exclusive condition for competitive use of all renewable energy sources (solar, wind, tidal, etc.) [9]. The **necessity of designing and implementation** of new **systems for performance "energy storage"** is required by the discrepancy between energy production coordinates (place, time) and those of consumption. **Fluctuations in consumption** may be: diurnal, weekly and seasonal. In general, attracting in the competitive economic circuit of the alternative sources of energy is **based on the cost and reliability of storage technologies.**

Technology and equipment for energy storage [9], can be divided into:

- Technologies for storage of **short duration** and small capacities (less than 0.5 kWh);
- Technologies for storage of **medium duration (12 - 60 hours)**, with capacities up to hundreds of MWh;
- Technologies and equipment for **long-term storage (10-300 days)** and over 1,000 MWh.

If on technical advantages posed by energy storage, there is an unanimous opinion on the usefulness, in what concerns the economic aspect, from the data reported by entities who developed storage systems based on different principles, there is a great diversity in the **cost of MW installed** and **MWh stored** and distributed, due to the diversity of applications. It is obvious that the energy storage costs and raises the final value of the investment [4].

The cost of an energy storage system is influenced mainly by the price of storage element (battery, flywheel, accumulation basin, etc.) and power electronics. Table 1 below is presented a summary of these costs.

TABLE 1: The cost of storage [4]

Storage system	$/kW installed	$/MWh installed
Hydro pumping	5700 - 8100	160 - 230
Compressed air	4480 - 4950	120 - 220
Fly wheel	4300	350
Vanadium - REDOX	6000 - 9100	430 - 810
REDOX – FeCr	3100 - 9200	150 - 250
ZnBr	3500 - 5750	200 - 890
Zn Air	3200 - 3950	160 - 200
Pb Acidulous	3600 - 9000	220 - 600
Pb Acidulous	2500 – 6100	100 - 230
Pb Acidulous	4100 - 10800	300 - 1320
Li Ion	2000 - 11000	650 - 1150
Li Ion	5500 - 11000	750 - 2100
Li Ion	6500 - 24000	700 - 2800
NaS	5750 - 6580	260 – 294

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These energy storage systems (ESS) – in big number and appealing to knowledge from many different fields of technology – are based on conversion principles with **mechanical** character: Pumped hydro systems (Pumped Hydro - PHS), Compressed air storage (Compressed Air Energy Storage - CAES), Flywheels (Flywheel - FES), **Electrochemical Pb-acid** (Lead acid-LA), Nickel Cadmium - NiCd, Lithium Ion - Li Ion, Sodium Sulphur - NaS, ZEBRA - NaNiCl, Vanadium Redox-VRB, Zinc Bromine - ZnBr , **chemical**: Hydrogen - H, **electric, electromagnetic and heat**: Double Layer Capacitor (Double Layer Capacitor - DLC), Storage Superconducting Magnets (Superconducting Magnetic Coil - SMES), Molten Salt (Molten Salt - MS). They are now in various stages of maturity [4].

3.1. Storing electricity into the power grid

The network of electrical energy allows electricity producers to **send excess electricity at sites for temporary storage of electricity**, **which can become energy producers** when demand for electricity is higher. Also, **users of photovoltaic panels and wind turbines** can avoid the need for battery by connecting to the network, **which is actually a giant battery**. **PV users can store electricity for use at night,** and **those who used wind turbines have access to energy in periods of lack of wind.**

3.2. Energy storage panels / photovoltaic collectors

All independent photovoltaic systems, which are **not connected to the national electricity grid**, need special equipment to **store energy in excess produced from solar radiation,** energy which need to be used when the generator can not produce or produce under consumption needs. Batteries or accumulators are several types, depending on the material with which they are filled and there are **batteries with gel**, which have the electrolyte as a viscous mass, and **lead-acid batteries**, which contents sulphuric acid diluted with water, Figure 12, a, b, c, d,, [11].

a) Gel batteries b) GEL batteries OPzS c) OPzS solar batteries d) Lithium batteries (LiFePO4)

Fig. 12 Types of batteries and accumulators used for storing photovoltaic electricity [11].

3.3. Storing solar energy using hydrogen

A. One of the solutions of the future for **storing energy** from renewable sources, particularly **solar and wind**, is the **use of hydrogen obtained <u>by hydrolysis</u>**, especially for residential purposes. This solution is ecological and clean.

During the day, part of the **solar energy** produces hydrogen **by electrolysis,** which **is used at night** for power generation, Figure 13, [12].

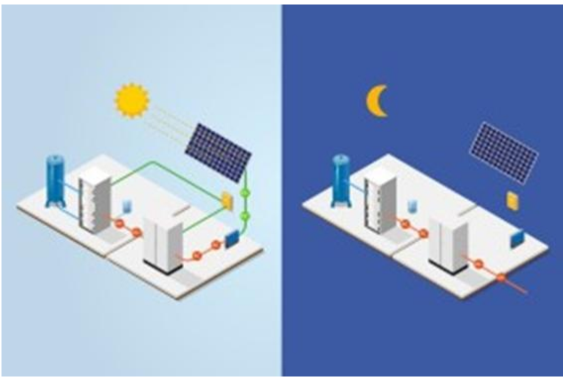

Fig. 13 Production of hydrogen daytime and night time use. [12]

On one hand, the **solution with alkaline liquid is cheap**, but there are an alternative, more **efficient**, that uses **solid electrolyte polymer (PEM - Polymer Electrolyte Membrane)**, but has the disadvantage of necessity use of requiring **very costly materials for** the **membrane** that **ensures** separation of H2 by O2: **gold, platinum and iridium**, some of the **most expensive materials.**

CNX Construction company found a solution via a **new electrolysis device AEM (Anion Exchange Membrane).** It uses an **alkaline solid polymer membrane**, which is cheaper than **PEM** solution, maintaining all advantages.

B. Some of the most promising **solutions for long-term storing energy, on an** industrial scale, appeared in the late 20th century, are those that use **hydrogen as energy carrier. The source of hydrogen – water -** practically exhaustless on planet, **involves developing techniques for electrolysis and "storage**". **Hydrogen can be** stored by liquefaction and may be kept in **cryogenic tanks,** technique already used in space [9].

The largest liquefied hydrogen tank is at the Cape Kennedy and has a capacity of 4000 m^3, equivalent to energy of **6,000 MWh, which can be used in fuel cells**. **Costs of storing hydrogen in cryogenic liquefaction** and maintaining its liquid state under critical conditions **are so big that make this path to be not widely** translated industrial and not become commercial in the foreseeable future.

C. A second way - the only one that has commercial potential so far - uses a **chemical process of "fixing" hydrogen on a chemical compound**, such as **aromatics products** (benzene, toluene, xylenes, etc.), and "**extraction**" it **through catalytic dehydrogenation**. In this way, the **support-molecules return to** the **initial aromatic structure** in **unaltered state,** and the product could be used in a new cycle of "storage" and hydrogen obtained is sent to the consumption. This **version of "storage"** through hydro-aromatic compounds is **much less expensive than the "storage" by liquefaction** and **has a good chance to be developed at an industrial scale**.

Example: In Quebec operates large industrial capacities in water electrolysis and catalytic hydrogenation of aromatic products. **The "hydrogenated"** product is loaded into high-capacity tankers and is transported to Europe, where it is unloaded to the French port of Le Havre. There operate large plants for catalytic dehydrogenation of the hydro-aromatic compounds, in which hydrogen is retained and the resulting product is reloaded in the same tankers that brought the hydrogenated product. An oil tanker of 100 000 tonnes "carries" energy equivalent to 82 000 MWh of electricity. In Germany, in the Rhine valley, even before 2000 operate a distribution network of hydrogen that supplied consumers in Germany, Switzerland and France

Obviously **reducing costs for long-lasting storage** of energy is determined by the achievement of **water electrolysis processes with high performance** as well as of **hydrogen-oxygen fuel cells with the highest** possible **yield** [9].

3.4 Storing electricity converted into compressed air in deep lakes [13].

One of the most **spectacular** solutions for **storing** electrical energy uses the **compression of the air,** which further is stored **via balloons** in **deep lake waters**.

HYDROSTOR Canadian Company invented a system of **underwater balloons**, under pressure, which could store renewable energy until needed [13].

The first experiment was conducted in **Lake Ontario** near Toronto in Canada, with a series of balloons set at 55 meters deep and connected to the main electrical network through a pipe.

The principle used underwater balloons, known technically as accumulators, filled with compressed air. This method is also used to raise sunken ships on the ocean floor. The **compressed air** is the main component of the system: the excess energy is converted / processed in the compressed air belonging to HYDROSTOR, while the heat generated by this process is also stored, Figure 14 a, b, c, d.

Where necessary, **natural pressure of the lake** is **used to pump air back** through the earth, starting a turbine and generating electricity. Balloons in Lake Ontario are able to store enough energy to power 330 homes, and system developers say that their capacity can be easily expanded.

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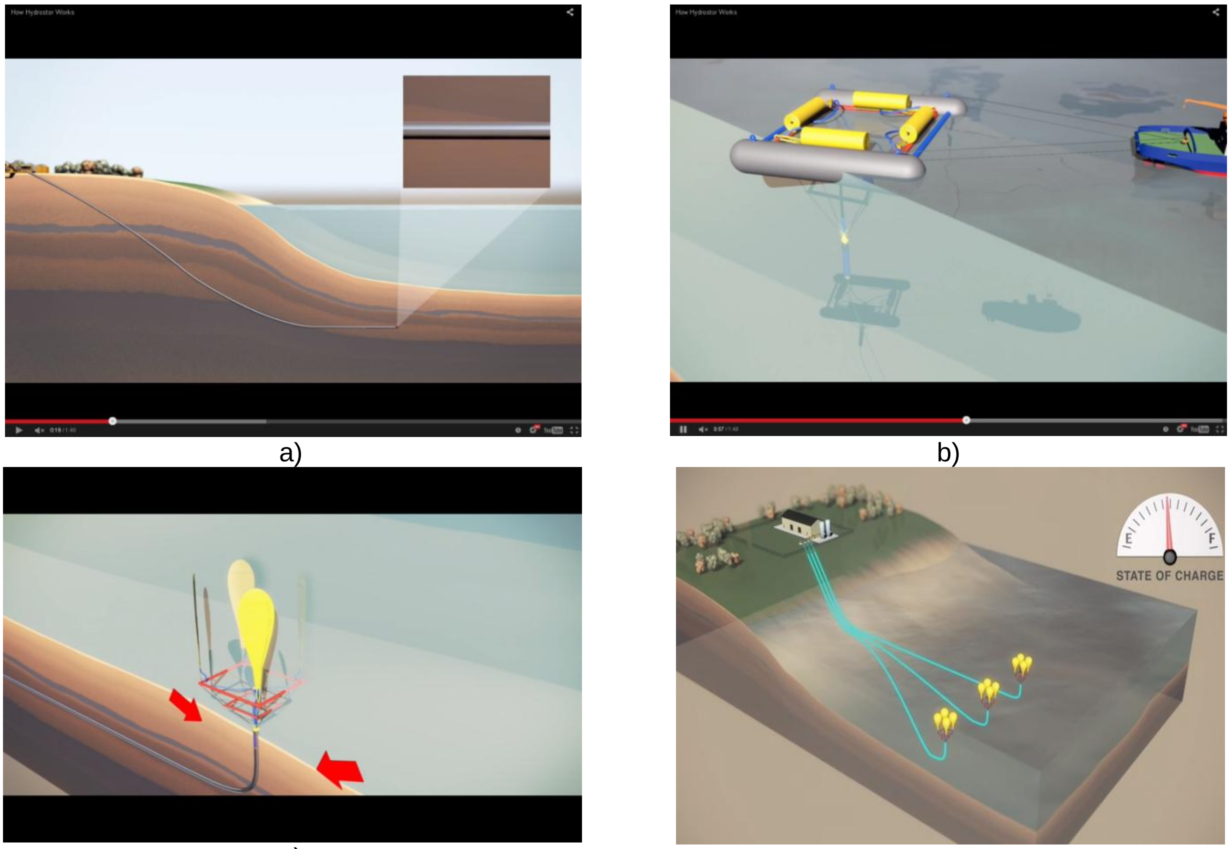


a) b) c) d)

Fig. 14. Pneumatic energy storage technology in deep lakes, [13].

3.5 Compressed air energy storage under the ground [14].

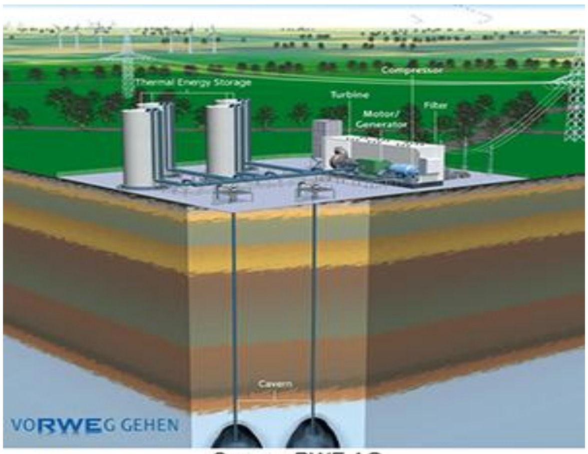
Last summer, a group of Midwestern utilities decided to pull the plug on an ambitious energy storage project that, with the help of the U.S. Energy Department, **was to have been built underground** in central Iowa, near Des Moines. The 270-megawatt project was cancelled after unfavourable geologic conditions -- layers of clay where no one expected them -- were discovered at the site. However, **the concept of storing a large amount of energy under the ground remains** intriguing.

The Iowa Stored Energy Park **would** have used compressed air to store off-peak wind energy 3,000 feet underground in a geologic formation akin to an enormous upside-down teacup. On windy nights, surplus electricity would have been used to run air compressors, forcing air to displace the water in the sandstone aquifer. Then, when the energy was needed during the day, the air would have been released and heated to run turbines.

Compressed air energy storage has not been used often. So far, there are only two such storage projects in the world. One is a **110-MW** facility in Alabama and the other is a **290-MW** facility in Germany. **This technology** would be very useful for storing intermittent power such as wind and photovoltaic energy.

3.6 Compressed Air Energy Storage in underground cavern (CAES) [15]

Compressed Air Energy Storage (CAES) plants are largely **equivalent to pumped-hydro power plants** in terms of their applications, output and storage capacity. But, instead of pumping water from a lower to an upper pond during periods of excess power, in a CAES plant, **ambient air is compressed and stored** under pressure **in an underground cavern**. When electricity is required, the pressurized air is **heated and expanded in an expansion turbine** driving a electric generator.



Source: RWE AG
Fig. 15. Compressed Air Energy Storage plants [15]

The special thing about compressed air storage is that the air heats up strongly when being compressed from atmospheric **pressure to a storage pressure** of approx. 1,015 psi (70 bar). Standard **multistage air compressors** use inter and after coolers to reduce discharge temperatures to 300/350°F (149/177°C) and cavern injection air temperature reduced to 110/120°F (43/49°C). **The heat** of compression therefore **is extracted during the compression process** or removed by an intermediate cooler.
The loss of this heat energy then has be compensated for during the expansion turbine power generation phase by heating the high pressure air in combustors using natural gas fuel.
The only two existing **CAES plants** in Huntorf, **Germany**, and in McIntosh, Alabama, **USA**, as well as all the new plants being planned in the foreseeable future are based on the diabatic method. Independent of the selected method, diabatic or adiabatic method, very large storages are required because of the low storage density. Preferable locations are in artificially constructed **salt caverns** in deep salt formations. Salt caverns are characterised by several positive properties: high flexibility, **no pressure losses** within the storage, **no reaction with the oxygen in the air** and the salt host rock. If no suitable salt formations are present, it is also possible to **use natural aquifers**

4. Innovative systems for capture, conversion and storage of energy

In the course of the study phase of the CORE Programme 2016, it was studying the possibility to manufacture of innovative systems for the capture, conversion and storage of electricity from the photovoltaic panels and small wind power stations
In this regard, given the specific activities of the Institute INOE 2000-IHP, were analysed two ways of converting electricity, namely: conversion in pneumatic energy, , respectively conversion in hydrostatic energy**.**

4.1. Systems for capture, conversion and storage in pneumatic energy

Technology of capture, conversion and storage of electricity, derived from wind turbines and solar panels, impose a unitary conception which contains all the elements necessary for converting electricity into pneumatic energy, preparation of compressed air, convert pneumatic energy into electricity energy, and the adaptation of the electric parameters to the requirements of the electric grid where is re-injected.
A block diagram of such a system is shown in Figure 16, below

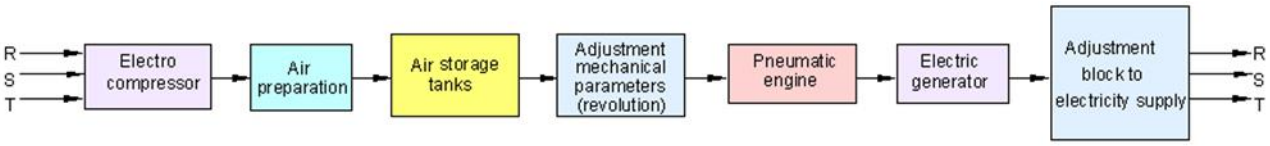


Fig. 16. Block diagram of a system for the capture, conversion and storage, in pneumatic energy

Given the block diagram in Figure 16, has been designed a scheme for achieving a complete capture, conversion into pneumatic energy and storing this energy, and, also, conversion of pneumatic energy into electrical energy, including adaptation of features obtained to the electricity grid, in which is re-injected, shown in Figure.17.

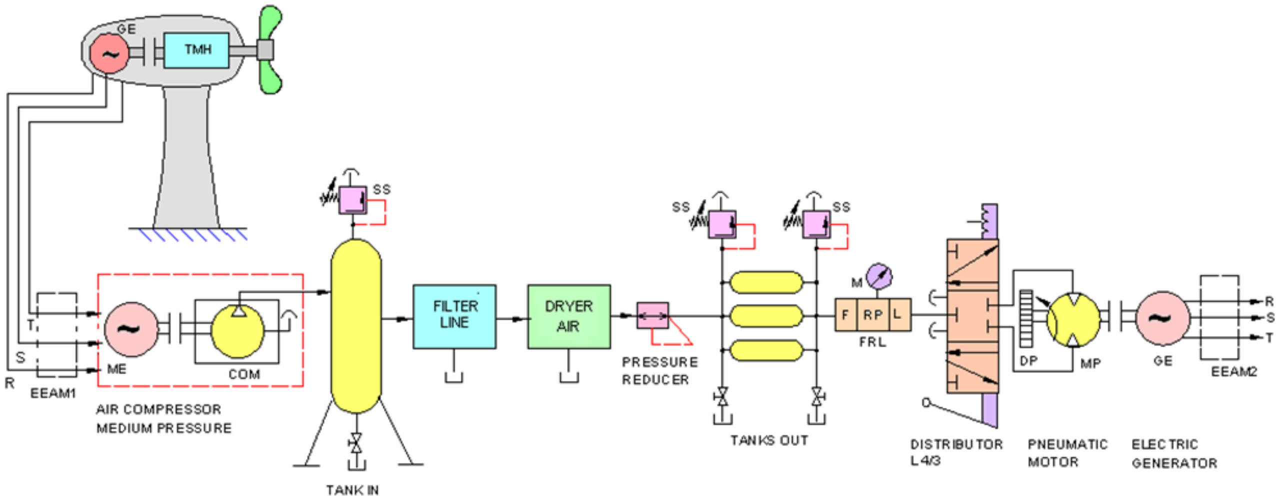


Fig. 17. Scheme of a system to capture, conversion and storage of the energy in pneumatic energy

The scheme is valid for the already existing wind farms, in which the problem is to energy storage
The scheme comprises an electro-compressor that convert electricity into pneumatic energy, an entering tank / container, which works at the discharge pressure of the compressor, a line filter and a cooler/drier of the air, a pressure reducer valve to the work value of the output air tank battery for storing, and, also, the elements for air preparation, type FRL (Filter-Regulator-Lubricator).
Also, a distributor which commands a pneumatic motor, which converts the pneumatic energy into mechanical energy, used to drive an electric generator, which converts mechanical energy into electrical energy and, finally, electric measuring equipment for specific parameters and its adaptation to the network where it is injected.
If it are done one or more of these new wind plants, they can be designed based on the sketch below, where mechanical energy of the wind is converted directly into pneumatic energy and then it is stored after the same pattern as above, as shown in Figure 18.

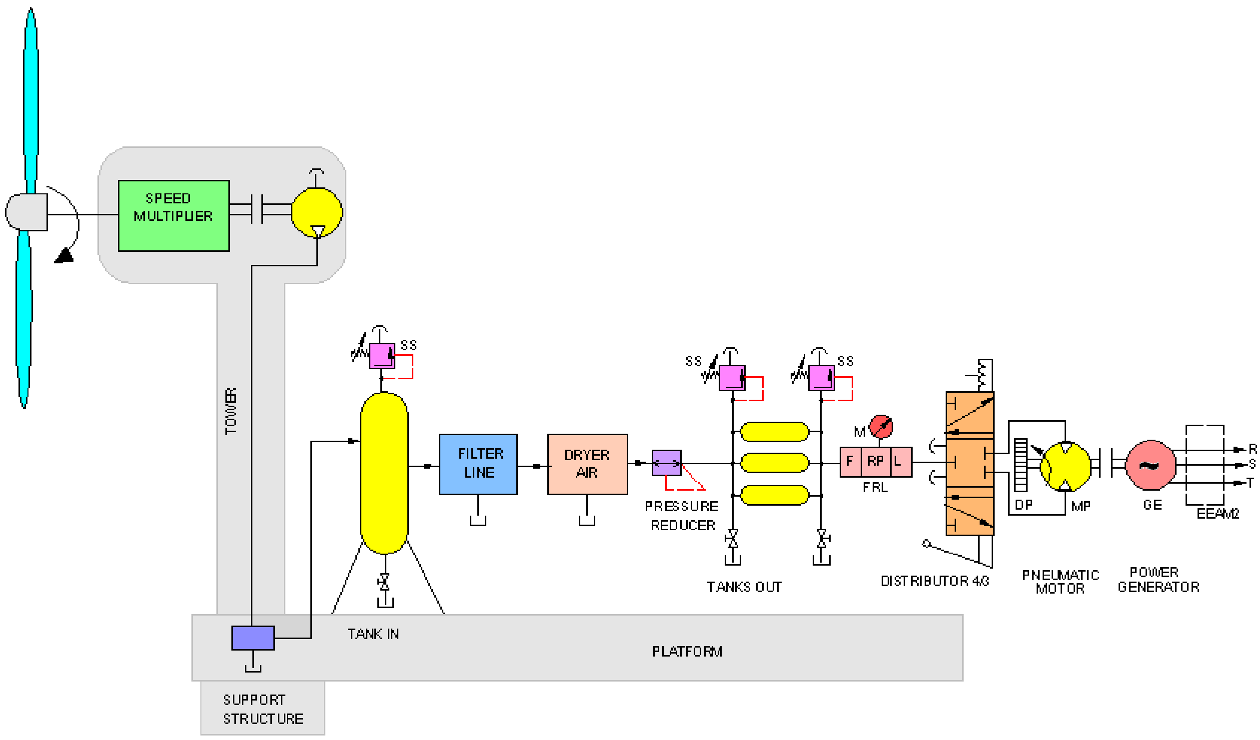


Fig. 18. Wind energy capture system, direct conversion and storage of the pneumatic energy

In this example the compressor that converts the mechanical energy of wind directly into pneumatic, is mounted in the nacelle of wind plant and through a piped system, reach the ground or the basement, directly in tanks / containers storage / storage of pressurized air.
It is a scheme that brings a number of advantages, inclusive high energy efficiency.
A similar example **of compressed air plant diagram**, found on the INTERNET, is shown in Figure 19 [16]

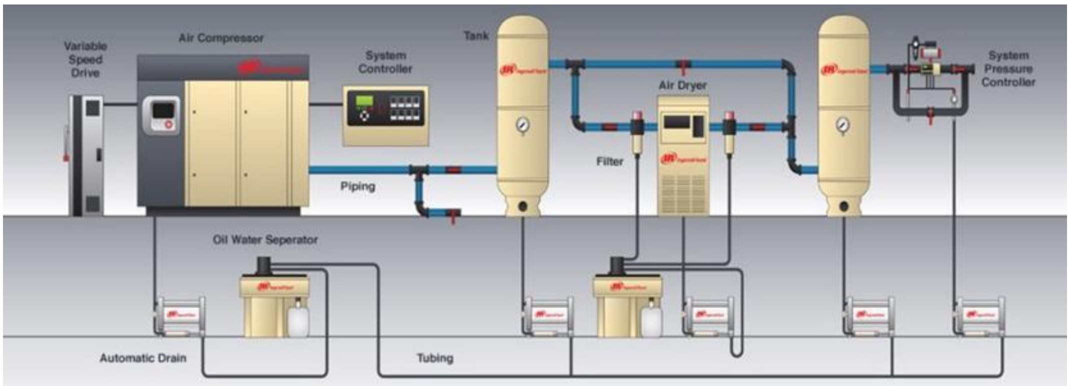
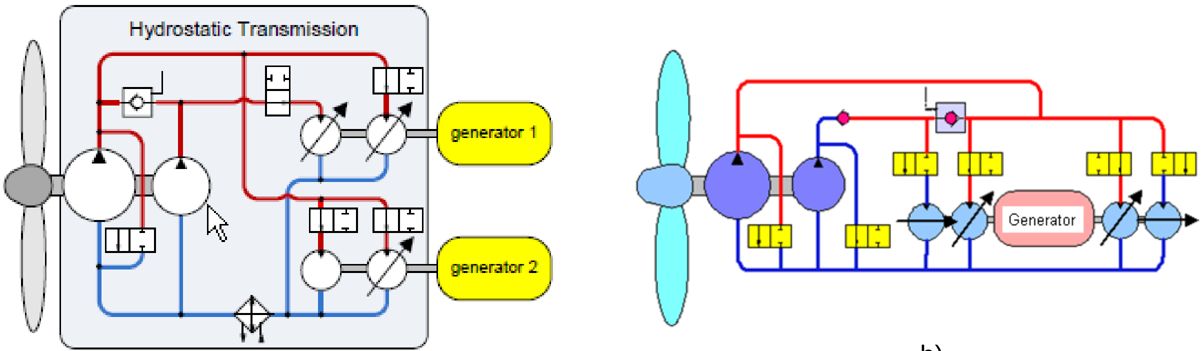


Fig. 19. Compressed air plant diagram (photo: creditkgpowersystems.com) [16],

4.2. Systems for capture, conversion and storage in hydrostatic energy

Starting from some hydrostatic schemes developed by the Institute RWTH Aachen University, Institute for Fluid Power Drives and Controls (IFAS) [17], shown in Figure 20, it have developed two simplified scheme to capture and conversion wind energy and hydrostatic storage of energy.



a) b)

Fig. 20. Hydraulic diagrams of the hydrostatic transmission [17]

In order to achieve the system for capture, conversion and storage the hydrostatic energy, it was developed a scheme embodying the hydro-mechanical conversion technology and the hydrostatic energy storage, shown in Figure 21,

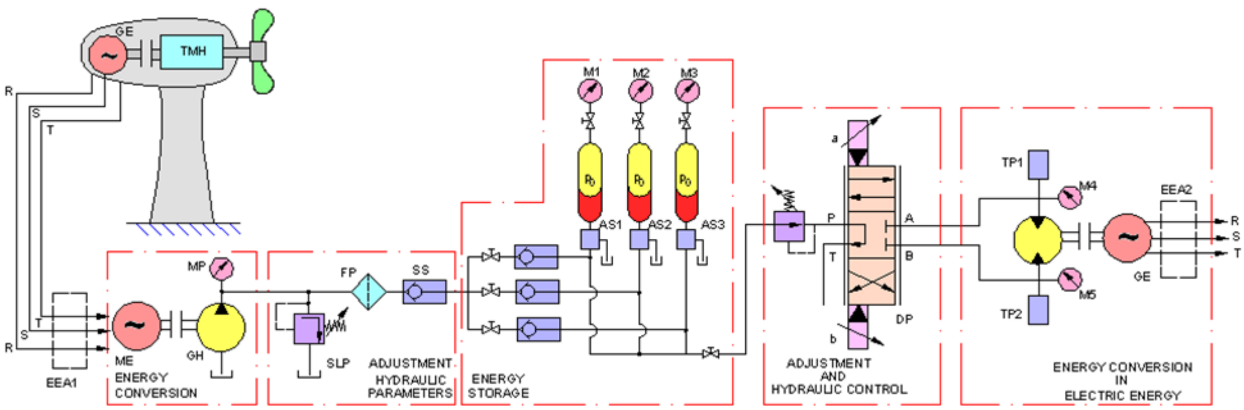


Fig. 21. Scheme of the system for capture, conversion and energy hydrostatic storage

The scheme comprises electro-pump, that converts electrical energy into hydrostatic energy, a group of protection and preparation (pressure valve and filter), rechargeable battery hydrostatic energy storage, and a proportional electro-hydraulic distributor, which controls an rotary hydrostatic motor, which converts the hydrostatic energy into mechanical energy, necessary for driving an electrical generator and, also , an electrical equipment for measuring and adjusting the specific parameters in according with the necessity of the grid where to be injected.
In case when are developed such new wind plants, they can be designed based on the sketch below, where mechanical energy of wind is converted directly into hydrostatic energy, and this is stored after the same pattern as above, as shown in Figure 22.

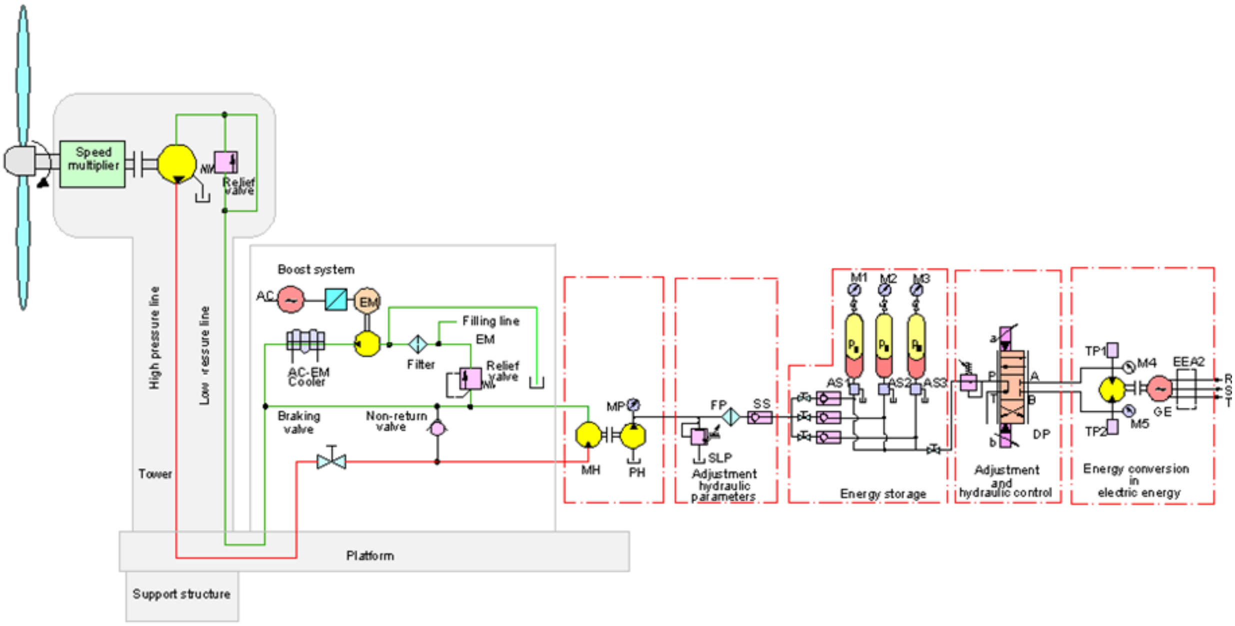


Fig. 22. System for Wind energy capture, direct conversion and energy hydrostatic storage

In this case, the hydraulic pump, which is actuated by the propeller through a multiplier of rotation, converts the mechanical energy of wind directly into the hydrostatic energy. The pump is mounted in the nacelle of the wind power plant, and, through some hydraulic pipes, fluid under pressure reaches the ground, or in the underground, where is stored in hydro-pneumatic accumulators installed. The diagram describes a situation where the convention hydraulic circuit is separate from the hydraulic circuit for storage and for hydraulic actuating of the electric generator.

5. Conclusions

1 - The article presents a series of renewable energy sources, capture technologies, as well as some methods and technologies for energy storage, applied worldwide;
2 - As a synthetic conclusion, it can say that use of renewable energy is in full expansion.
3 - The most important source of renewable energy represents, however, the rivers that led to the development of hydroelectric power stations worldwide, including in Romania;
4 - In recent years, solar power has grown greatly, both by making photovoltaic solar collectors and by developing solar thermal panels;
5 - Also a very important development, have the wind power plants, including in our country;
6 - Problem number one is storing electricity produced by solar panels and wind power plants, because of their working regime which is very inconstant;
7 - Therefore, the article presents a number of methods and technologies of energy storage, practiced worldwide, some still in an experimental phase;
8 - Finally, are presented some new concepts, original, to realise the systems for capturing and converting of wind energy and electric energy from the solar panels, schemes containing technical

solutions for storage energy in form of pneumatic energy or in form of hydrostatic energy, solutions with a great potentially for practical achievement.

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