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Dear readers

A warm welcome to the first issue in 2021 of JPR-Focus, our newsletter in a new format.

After the somewhat turbulent year 2020, some questions are buzzing in the minds like: What happens after COVID-19? What can we learn from it? What changes for me?

Such questions are not only relevant for the health system or the financial system. Certain assumptions must also be reviewed and questioned in the school system and food production. This is also particularly true for energy supply, because the zeitgeist is clearly moving in the direction of renewable energies.

This article attempts to outline the possibilities and potentials of the individual sources of renewable energy.

I hope you enjoy reading.

Best regards

Yours
Jean-Pierre Rickli

Possibilities and potentials of renewable energies

1. Introduction

The year 2020 was exciting and revealing. Many promises, predictions and assertions clearly turned out to be fairy tales.

Let us first take the tale of the global economy. The proponents of this type of economy were never tired of extolling this path as a warrant for the worldwide secure supply of goods of all kinds. Pure propaganda! As soon as China had to close its borders at the beginning of the year, the whole world was worried about the supply not only of finished products, but of practically all basic and primary products as well as materials. It turned out that nothing was produced worldwide, but practically everything came directly or indirectly from China. I have a different idea of a secure global supply of all resources.

However, we were spared the total collapse of this supply chain. Not because other supply routes were opened, but because the virus had reached us and our industry was drastically cut back when we had to stay at home. Then the truth burst out about a second tale: that of supply resilience, that means that the supply capacity can quickly recover after an event and be again operational.

As soon a few people with full trousers had bought the toilet paper shelves empty, these shelves remained empty for several weeks or sales had to be drastically rationed. This happened worldwide! An experience made in mechanical engineering, production and elsewhere was confirmed: highly efficient machines, plants and processes are very sensitive; so is the market. The word "resilience", still used moderately in 2019, made it onto the hit list in 2020. This also confirms a wise statement that says that you talk about what you do not have.

Another mantra of modern economists also proved to be a fairy tale. That is, that the market can provide a solution for everything. You just have to trust it. When we looked around for protective masks, there were none. Now that the worst is behind us and some protective masks have gradually been delivered after major government interventions, we don't really need them any more. The result? An obligation to wear them! We just have to get rid of the expensive goods. Meanwhile, these disposable products also contribute to the pollution of the environment and the oceans.

The tale of the free-market economy was also revealed. The fact that it is only valid to a limited extent was demonstrated by the example of medical protective equipment. They were in short supply everywhere in Europe and goods intended for Switzerland were promptly retained at customs or confiscated, in Germany and France. Export bans were also threatened for goods that had been ordered and paid for. This is how the free-market economy works in times of shortage. Every one is next to himself. It was not much different with the vaccine doses.

These observations are important for energy supply. Circumstances turned out well for the power supply: demand fell sharply and so the additional demand in the private sector was easily absorbed. Fortunately, there were no major breakdowns in the production facilities.

The situation for petroleum products and natural gas was also good. There were no shortages: demand fell sharply, the winter was very mild and the dispute between producer countries helped to create a huge surplus of offer over demand.

However, the wheel could turn and the energy supply is by no means safe from emergency situations. Cases such as those described above could also occur in the energy supply sector.

It is not only the observation that the market actually only works in situations of abundance that is important. Only then can the indispensable condition for a business transaction be fulfilled, namely simultaneity. This condition is all too often ignored in business circles. To discover that the borders can be closed not only in the event of war and that the barriers can be lowered and remain lowered was a completely new experience. Such a thing in peacetime! Note: handling circuit breakers is even easier than handling barriers!

The different understanding around the definition of goods, which are important for life and belong to daily needs, led to many discussions and frustrations. Suddenly, not only food products came to the fore. New products were suddenly in demand and even indispensable, at the latest when mothers and fathers were ordered to "home office" and the children to "home or remote schooling". Suddenly, printer paper and printer cartridges were called as products of daily use. Coffee, the most important fuel in the office, also gave rise to discussions. The coffee, beans or grinded, and the capsules were allowed to be sold. What happened when the machine broke down? Suddenly, household appliances were also important. The same happened in the new compulsory family discipline: cooking. Is cookware also an essential good?

There was also a certain surprise with the services. All of a sudden, mother, father and the children wanted to, had to sit in front of the computer and fought over who was allowed to use the only family computer first. This was mainly because Mrs. Boss, Mr. Boss, Mrs. Teacher or Mr. Teacher thought that each of their little sheep should be ready for roll call at 8 or 9 o'clock. If, exceptionally, enough devices were available, one quickly learned that a tablet is not as full-fledged as a laptop, despite the talk of the salesperson. And where everyone could or was allowed to sit in front of their own computer, there was the next hurdle: the broadband capacity of the internet connection.

For the power supply, as mentioned above, everything turned out fine. The old saying was nevertheless confirmed: the most important thing on a computer is the power socket. The often-voiced objection about the battery falls away as soon as the charge level gets close to zero. Then you also need the socket. This also applies to the coffee machine, the printer, the scanner and practically (almost) everything in the household. Electricity has also become an important good of everyday use!

It is the aim of this analysis to go through the nature and possibilities of renewable energies in order to get some clarity on their potential for our future energy supply.

2. Significance of electric power today

As we have seen above, basic needs have changed greatly over time. Electricity is no exception, on the contrary.

Fifty years ago, electricity was still a relatively simple matter. When there was a power shortage, the larger consumers such as washing machines were simply switched off at peak times. That way there was enough electricity for cooking. Dishwashers were only found in a few places. The power of the other household appliances was on average 2 to 3 times lower than todays, and handwork was still common.

If there was an outage, each household had a set of candles for lighting. To prepare hot water for a soup from a bag or a tea, the fondue rechaud filled with methylated spirit was sufficient. For the news, one had the transistor radio. Not everyone had a television set, black and white, nota bene. The telephone was still there for phoning, usually for emergencies such as death, accident or illness and independent of the electricity grid. For happy news such as births or marriages, there was the letter post; such news was not urgent.

Today, all this is unimaginable. Candles and spirit rechaud have been banned for fire safety reasons. Everything is plugged in: radio, telephone, television in every room, computer, router, alarm clock, printer, scanner. Handwork is also a thing of the past. Everything is mechanised and needs the socket. No wonder that the installed domestic power is much higher today; 67% more than 50 years ago, which barely suffices today.

This does not even include the electricity needed for the servers, cloud services and the like.

As we also discovered in the spring, there is hardly any potential for savings. Households have almost no appliances left with significant potential for efficiency improvement. Much of the electricity not consumed in offices, schools, canteens and restaurants was consumed in households by the high demand at home. The newly discovered discipline family cooking did not let electricity consumption subside at lunchtime either.

In the offices, server operation remained as a power guzzler.

In other words: in times of crisis like the one we are experiencing now, electricity is clearly no longer just a convenience (commodity), but is part of the basic necessities of life. The only unanswered question is: to what extent?

My first rough approach to answer this question would be for a family of 4:

- 70% of the household connection power should be available during the day (12 hours). In case of an acute power shortage, this 70% could be reduced to 55% and the 15% distributed to the evening hours.
- 40% of the connected load should be available in the three evening hours after dinner. If daytime power is distributed over the evening hours, then this share will also come to 55%.
- During the remaining hours of the night, about 20% of the connected load should still be available.

This means that about 55% of the connected load during the day to the evening hours and 20% for the night would have to be considered as daily basic demand. These percentages would have to be available in times of crisis, at least for an extended period of a few months. The electricity suppliers must ensure that this power would be available. This basic demand should also not be subject to what happens in the free market. It would be a kind of regulated market, which would ensure affordable electricity for all. Consumption above this basic requirement would then be purchased on the free market and considered a commodity.

This basic private need must also be ensured in times of crisis, even if our neighbour countries have turned off the switch for a certain period of time. Thus, in such times, not only the industrial demand is decisive for the degree of self-sufficiency.

However, this minimum supply must be ensured not only in times of crisis, but also throughout the year and even in more harsh weather conditions such as severe cold or heat.

3. What is energy needed for?

For decades, only statisticians and marketing people dealt with this question. As a consumer, one hardly had to deal with it. Energy was cheap, available practically everywhere and not dependent on the energy source, so to speak. The main question was really only the power required (W or kW) when switching on or the quantity (kWh) when paying. Those were the good old days of fossil vectors. Energy carriers or vectors are substances or forms of energy that do not occur naturally and can be "broken down" directly. They require conversion beforehand.

Today, when CO2 emissions are to be reduced and sustainable energy sources should or must be used, it is no longer so simple. The new energy carriers and their sources are no longer all-rounders and are not available everywhere and at all times. Since our energy needs are also different, combinations of different carriers or sources are becoming increasingly necessary.

In the course of discussions about the use or the waste of energy, two very related terms come up again and again: energetic effectiveness and energetic efficiency. Very often they are equated, which also leads to misunderstandings.

Efficiency is more technical and is quantifiable. For example, it expresses the quality of the conversion of a certain form of energy into another. We talk about the efficiency of a photocell, an electric motor, a diesel engine, which is often expressed as a percentage. This gives us a comparative measure for these aggregates or combinations of aggregates under certain conditions. However, one must not compare the efficiency of an electric motor with that of a diesel engine, because the input energy form, although printed in the same unit, is not the same. Unfortunately, this is done far too often, even by so-called experts.

Energy effectiveness, on the other hand, is a more qualitative term. It is used when different energies come into question or when a quantitative assessment is not useful, not possible or too complex. The latter comes when energy consumers are switched off or on, perhaps even several times.

Knowing one's own needs as precisely as possible is therefore a prerequisite for finding the optimal mix of energy sources for a specific application.

3.1 Building heating

This is one of the most primordial needs of mankind: to bring the indoor air to a pleasant lukewarm 20 to 23 °C during the cold period.
In the cave, the open fire took over this task. The desired room temperature was not reached. But at least one did not freeze and the fire scared off unwanted wild animals.

For a very long time, fire remained the measure of all things, whether as an open fire in a fireplace or enclosed in a heating stove that warmed up or simply tempered the ambient air. The technology regarding heating and living comfort became more and more efficient. The principle, however, remained the same: wood and, much later, coal were burned. This principle is still used in many places today.

The principle of central heating was invented about 200 hundred years ago: Heating water through a central heat source and distributing it as a heat transport medium. However, this principle remained reserved for industrial applications for a long time. It was not until the middle of the last century that it was widely used for heating buildings; first with firing coal, then with fuel oil and later on with natural gas.

As discussions about energy efficiency continue, it is becoming clear in wider and wider circles that heating water to a temperature of 40 to 80 °C with a flame of 2000 °C or above is actually a pure waste of energy. Although everything is measured in kilowatts (kW), there are more valuable and less valuable kW. This applies to the type of energy but also to its temperature level. If the temperature is high, the working potential of the source is also high. If this source is used for direct heating of a medium at a lower temperature, the working potential is not utilised (pure entropy increase). Such heat sources are typically found at the end of industrial work processes. Energy sources with a high temperature potential should be used exclusively for work processes and where high temperatures are required.

3.2 Lighting

This is also a particularly important need for people. Having light in dark places and enclosed spaces gives security and confidence. It also makes it possible to carry out activities before sunrise or after sunset.

In business premises, modern architecture and working at a computer screen almost inevitably end with an all-day lighting. In the evening, when the offices are empty, everything is dark.

Today, lighting also plays a major role on the roads: in cities and agglomerations; primarily because of safety considerations.

For decades, energy has been used for lighting only in the form of electricity. This should hardly change in the future. However, we need to use it a little bit more sparely.

3.3 Domestic appliances

I will now deal with this type of consumer separately, because it is very much subject to change. About 60 years ago, they played almost no role in terms of consumption. The big consumer was the cooker with integrated oven. This was the only household appliance that consumed either electricity or gas for its operation. Furthermore, there was a refrigerator in the kitchen, by no means everywhere, which for a 4-person household offered space for a litre of milk, 2 to 3 bottles of beer, cream, butter, a pack of eggs and the freshly bought meat. Perhaps, in very modern households, there was still a hand mixer with less than 100 W of power.

Otherwise, in the flat one found a vacuum cleaner, an iron, a radio and a television set mostly black and white. The latter, although an electricity guzzler by today's standards, was small enough to fit easily into the wall unit that was so coveted at the time. Today, it replaces the wall unit. The other sets were also much lower-powered than those of today. A washing machine was usually a community affair for all house flats. An own machine was only for the individual house owners. Depending on the supply situation, the washing machines were switched off centrally at midday.

Today, we still find the same appliances in households; they are highly efficient but much more powerful. They are now joined by microwave ovens, freezers, dishwashers, juicers, all-purpose mixers, bread mixers and second or third televisions. The washing machine has also become part of the modern flat installation, together with the dryer (tumbler) as a so-called washing tower.

The events of the last few months have shown that there is still a bigger power increase ahead. Today's common undemanding laptops and tablets for fast internet browsing have proven to be completely inadequate. In the future, one must expect the power consumption of one full-featured laptop per household member, one shared also full-fetched multi-functional printer / scanner / copier and the corresponding router with cable connections for data security as a standard, from morning until late evening.
Of course, the broadband connection should be able to serve all devices simultaneously.

In the offices, on the other hand, the development should be largely complete in terms of electricity consumption by appliances. Consumption in these places should tend to stabilise or even decrease slightly. In schools and other educational institutions, however, there could still be major changes.

3.4 Industrial plant control and drives

The stepwise de-industrialisation in Switzerland has led to a sharp decline in the energy consumption of industry in recent years. The remaining industries have improved their electricity efficiency to such an extent that they have already made their contribution to the consumption reduction.

Characteristically, all these consumers require a higher operating voltage than household appliances due to the higher installed power.

Another specificity of this type of consumers is their demand for high power quality. This means high expectations in terms of frequency and voltage stability. This also includes a practically uninterrupted supply and the absence of disturbing harmonic frequencies, which are often produced by inverters. The importance of meeting these requirements is increasing with digitalisation. This does not mean simple automation. It has already been completed for a long time. We are talking about the independent and "intelligent" control and regulation of systems as well as their integration into the entire production process and coordination with the other machines.

3.5 Process heat and process cooling

Many industries have a need for process heat or cooling. Due to the great variety of process designs, there is hardly a common denominator in terms of parameters such as temperature level, output or amount.

The disadvantage of this situation is that there are hardly any standard solutions, at the most similarities. The advantage is that engineers can exercise their creativity in finding special solutions.

Examples for what process heat is needed and in which industries:

- Boiling up an aqueous solution with the base material to dissolve and to purify it; for example, in the paper and sugar industries.
- Boiling of the prepared product before filling in the food industry (canning of fruits, vegetables, etc.).
- Heat for the finishing of products such as in the paper and printing industry.

- Boiling up a chemical mixture in a distillation unit in the alcohol distillery or in a chemical or petrochemical plant.
- Heating of products or mixtures to achieve an optimal reaction temperature in the chemical and petrochemical industry.
- Warming up viscous products for better transportability or processability in many industries.
- And... and... and...

Of course, not only heat is needed in many industries, but also a lot of cooling. The energy required for this, primarily electricity, is certainly not negligible.

3.6 Mobility

Under the term mobility we understand

- The private mobility for the way to work with personal means of transport or for leisure time including shopping.
- The public transport for the commute to work and leisure time, including shopping.
- The transport of goods.
- The professional mobility such as customer visits, doctor's appointments, field service assignments for repairs, maintenance, emergency assignments - fire brigade, ambulance, police, sick, etc. - and for services such as letter or parcel deliveries.

The energy consumption for mobility is one of the largest energy items in a country. However, the exact amount cannot be read directly from the statistics, because mobility as described above is statistically not defined. The transportation sector includes all transport companies and accounts for 37.5% of Swiss energy consumption. It does not include the need for mobility in the private and professional sectors with their own means of transport.

On the other hand, we have the consumption of fuels with 35.3% of the total consumption. This includes private and professional mobility, but does not include the railways, trolley buses and the mountain transport systems.

From these figures, we can say with a good certainty that the share of mobility in total energy consumption is about 50%. Tendentially, probably more!

It should also be noted that mobility requires higher quality forms of energy - mechanical power and electricity, which are only available through prior work. These are at the top of the energy hierarchy. This contrasts with the energy demand for space heating, which could, and even should, be met from waste heat, from an energy efficiency point of view.

4. Characteristics of the different energy sources

4.1 Generals

First of all, we have to clarify what renewable energies are. Some people will say: solar energy, because it never runs out. These people focus on photovoltaics. That is not entirely wrong. However, it is not quite right either. Why?

Let us have a closer look at it:

- It is correct because it is primarily solar radiation that allows photovoltaics to produce electricity.
- True but only one example. Almost all energy sources on earth actually come directly or indirectly from the sun. The currents in the atmosphere (wind) are caused by solar radiation. This solar radiation also causes the evaporation of the oceans, the transport of moisture in the air and the precipitation, thus also the glaciers and the rivers. Biomass is stored solar energy as well as all fossil energy such as coal, natural gas, oil, lignite and peat.
- Insufficient, because geothermal energy does not come from the sun, but from decay in the earth's interior. Tidal energy is also not driven by the sun, but by the moon.
- Absolutely not quite right, because the sun will also be used up one day. As a result, all energy sources created by solar energy will also come to an end. As will radioactively decay in the Earth's interior.

If everything has an end, what is renewable? Actually, everything is a question of the time horizon. As a first approach, renewable can be deemed to be the case if the following two conditions are met:

- The energy consumed is available again at the same level after two generations at the latest

and

- The energy source is practically fully available even after two generations, after taking into account all the applications from this source.

With the first condition, we ensure that our children and grandchildren encounter roughly the same conditions as we do. Another observation is that certain types of use need further differentiation. Trees are generally considered a renewable resource. However, only certain fast-growing species meet the first condition. For many other species, the growth rate is smaller. Therefore, the rate of use should be adapted or reduced.

The second condition, in turn, also brings limitations, for two different reasons.
On the one hand, even if the source is used directly, the energy is locally only available to a limited extent or only to a certain degree. This is the case, for example, with certain applications of geothermal energy. As a primary source, geoenergy fulfils the second condition, but is locally present to a varying extent. Either the utilisation rate would have to be adjusted accordingly or supplementary measures would have to be taken.

On the other hand, one must not repeat a mistake that has been made again and again. This mistake is to consider only the individual case. The consumption or emissions of the individual case may look small given the size of the source forest, wind or sun or compared to the entire atmosphere. However, when the individual cases are multiplied millions of times, then it can become a problem. For, the forest is finite, as is the atmosphere too.

The forest in its entirety is not simply available for individual cases of energy use. Many others are interested in it, such as people as a place of recreation, the paper industry, the timber industry, construction and the furniture industry. It is also a retreat for nature. This is also true for the wind, which supports the great water cycle - evaporation, transport, precipitation - as well as ocean currents. If there are too many wind turbines in the path, the wind will weaken, as will the ocean currents, or the precipitation will stop. The excessive use of biomass for energy purposes can also displace food production.

So, we need to reflect on our priorities as well as on the significance of sustainability!

Now that we know what is meant by renewable energies, we can take a closer look at an important common feature of all of them: their relatively low energy density, at least compared to non-renewable or fossil energy sources. Even among the renewable energies the energy density varies greatly.

This aspect is of great importance for the assessment of the potential of renewable energies. Unfortunately, it is lost in the usual simple consideration of kilowatts. This has led to unpleasant surprises on several occasions, as the expectations were not realistic.

Furthermore, some renewable energy sources are somewhat predictable, but not controllable. As a result, they are not necessarily available when they are needed. Thus, measures must be taken to improve their timely availability.

Each renewable source is actually unique, which makes it impossible to cover all these aspects in a general way. The following chapters will explain the most important things about it.

4.2 Solar Energy

Let's start with solar energy. By this we mean the energy that is obtained directly from solar radiation. The use of solar energy to meet our energy needs can be categorised as: Photovoltaic, Solar Thermal and Concentrated Solar Power (See Section 4.2.3).

The main feature of this energy is that it is available to all, but not equally. The fact that our earth is more or less spherical leads to different solar radiation depending on the proximity to the poles or to the equator. The rotation of the Earth around its own polar axis brings with it days and nights. The inclination of the Earth in its orbit brings further differences between the southern and northern halves. In addition, the elliptical orbit provides us with seasonal differences.

Last but not least, the solar radiation on the Earth is influenced by the meteorological situation. If clouds are present, then the irradiation is weakened, but not equally for all light frequencies. The shadows cast by high structures such as mountains, trees and skyscrapers should not be neglected either.

All this makes solar energy a highly local matter.

4.2.1 Photovoltaic

Photovoltaic technology converts the energy of solar radiation directly into electricity. With this technology, if things go well, about 15% of the solar energy incident on the solar modules can be converted into electricity today.

This value is a value from practice and has nothing to do with the published efficiency values. These are values measured in the laboratory under reference conditions. These are practically never met practice. Since the modules are usually fixed rigidly to the roof, the orientation to the sun will very rarely be optimal. The operating temperature is also many times higher than the reference temperature. Furthermore, today's solar cells operate in a relatively narrow frequency range - blue, violet, ultraviolet - and this proportion in sunlight varies with the time of day. This is also the frequency range that is strongly blocked by clouds. Therefore, the electricity production of this technology quickly drops to zero as soon as the sky is cloudy. Modern cells operate in a wider frequency range, which improves their overall efficiency.

The big handicap of solar energy is that it is somewhat predictable - weather report - but not directly controllable. In the case of cooling applications, electricity production is more or less in line with the electricity consumption. However, for other applications, the day's production must be stored for night consumption. It is ideal if the storage is also dimensioned to bridge a few days of bad weather.

Storage in this respect via the grid is becoming less and less of an option for consumers as the share of local renewable energies increases. This leads to an increase in the price of solar energy.

Today's practical experience shows that a photovoltaic system on the roof of a single-family house is sufficient for the household's electricity needs when:

- The house is energetically optimised,
- The residents show a frugal and conscious use of energy.

Under optimal conditions, a share of electric mobility can even be supplied.

In the case of larger residential and office buildings as well as factories, significant portions of consumption can be covered locally on site with photovoltaics. The rest, especially in winter and during bad weather, would have to be provided by power plants: from PV or other energy sources. It should be noted that in the vicinity of these consumers, land is often scarce or has already been claimed for other tasks.

4.2.2 Solar Thermal

Solar thermal energy is also used directly, but for the production of hot water. A wide frequency range is used for this. This use goes via so-called solar collectors.

Essentially, what is written under photovoltaics about the local availability of energy also applies to solar thermal. However, the utilisation behaviour is slightly different. With solar thermal, thanks to the wide frequency range exploited, interesting heat production is possible even when the sky is cloudy. In addition, heat production reacts much more slowly to changes than electricity production in photovoltaics.

Depending on the location, weather and season, the hot water can be used at temperatures for heating domestic and heating water or only as temperature-controlled flow water for heating. This also determines the size of the hot water storage tank.

Photovoltaics and solar thermal energy are only slightly in each other's way. A relatively small roof area is sufficient to cover the residents' heating needs. In return, the electricity demand for heating can decrease significantly, which more than compensates for the roof area given off.
With the partial use of hybrid solar modules, upstream warm water could also be produced.

4.2.3 Concentrated Solar Power (CSP)

We have seen above that solar energy has a relatively small energy density. The idea thus arose to concentrate it in order to improve the energetic yield. The principle is actually simple: the sun's rays are picked up on mirrors or lenses and concentrated on a focal point or a focal line. There, the heat of the concentrated rays is transferred to a transport or working medium. From there, the transport means takes the heat to a heat exchanger, where steam is then produced, which is fed to a working machine to produce electricity. If the radiant heat at the focal point is transferred directly to the water as the working fluid, then the steam produced goes directly to the working machine.

In a special technology, the bundled rays hit special, highly efficient photovoltaic cells, which produce electricity in a highly efficient way. Since these cells have to be cooled, steam is also produced in parallel, which is fed to a working machine to produce electricity.

These technologies are very complex and are only profitable, at least for now, for large plants as large-scale power plants in desert areas with strong solar radiation and as close to the equator as possible.

For countries in Europe, this technology is of little importance, unless the electricity produced can be transported to us with low losses.

4.3 Wind Energy

Wind energy too is unevenly distributed over the earth: locally, temporally as well as in strength. Since wind is nothing else than an exchange of cold and warm air or between regions of different air pressures, one can say: wind energy is solar energy that has been given work and thus has an increased energy density.

Converting this energy into a form we can use is tricky. The decisive factor is the wind speed. If it is low, then the wheels barely turn and don't produce much power. If it is too high, then there is a serious strength problem and the rotor blades are adjusted to offer as little resistance to the wind as possible and so are not allowed to produce any power. This way, they are not getting overloaded.

Not only the speed is important, but also the regularity of the flow. This is strongly influenced by the earth's surface. On the mainland, hills, high buildings or trees create turbulence. This makes the flow of wind turbines irregular, which also has a negative effect on the electricity production.

Thus, on land, extensive flat plains are more suitable than hilly landscapes. Likewise, the open sea is very advantageous, even more thanks to the steady relatively strong winds.

Consequently, wind energy in the Alpine region only makes sense in selected locations and, particularly for accessibility reasons, only for plants that relatively small installations. It is therefore more of a niche application there. All the more so when one considers the already heavily occupied land and air space. Many potential locations for wind power are already in conflict with other uses such as nature reserves, air traffic in approach and take-off corridors, etc.

As the development of the last few years has shown, wind is primarily considered for wind farms on the open sea. But even there, although the world's oceans seem endless, consideration for other users such as shipping is necessary. Wind energy is renewable, but whether it is sustainable remains to be seen. With the huge expansion of wind farms on the open seas, the long-term effects on the marine environment are yet to be seen. When so much energy is taken from the winds, ocean currents could also be affected. Windmills are not particularly quiet either. How far this noise affects life in the ocean depths has not (yet) been investigated.

At ground level, only very small plants may be considered.

4.4 Hydro Energy

There is not much left to say and write about hydropower in Switzerland and the Alpine region. Or is there?

In fact, there is still a lot to report in connection with the future energy supply. Hydro energy is an indirect form of solar energy. The incident solar energy evaporates the water from the large water surfaces, the air absorbs it and transports it further with the winds. As soon as the air cools down, the excess water is expelled and falls to earth as precipitation. Streams and rivers then carry this water back to the sea. At high altitudes, where the water falls as snow, the water is stored and is available again when it melts. Thus, hydropower is clearly renewable, at least for the next decades.

Essentially, we distinguish between

- Run-of-river power plants whose electricity production depends on the season and the weather.
- Reservoir power plants whose output can be controlled and varied very rapidly. In addition, they offer a certain amount of energy storage. Pumped-storage power plants are a special type of power plant. They make it possible to store the surplus electricity produced so that it can be made available again when there is a demand.

Whether this energy is then also sustainable is another matter. Let's take the example of Switzerland to explain this statement. It is generally accepted that about 96 to 98 % of the potential of hydro

energy has been exploited. We note that most of the work being done in this area is intended to reduce the negative impact on the environment - fish ladders, protective measures to keep fish out of the main channel, increasing the residual flow, etc. - and all tend to result in a reduction in electricity production. This means trying to re-establish a certain sustainability.

New projects, even very small ones, face almost insurmountable obstacles due to nature conservation, landscape protection and biodiversity.

In countries where the utilisation potential has not yet been realised, new projects are heavily criticised by environmental protection, especially large-scale projects. However, small-scale projects, especially in remote regions, may still have development potential, as the necessary interference with the natural environment is quite small.

4.5 Biomass

As mentioned in chapter 4.1, biomass is stored solar energy. The energetic value of biomass and also its energetic usability depend on many different factors:

- Green plants (grasses, vegetables, etc.) and green parts of plants or trees (leaves, etc.) have a relatively low energy value due to their high water content. Further processing into compost produces methane, an energetically valuable gas. This utilisation makes perfect sense. On the one hand, it produces valuable humus and fertiliser, and on the other, methane is collected and fed into an engine to produce electricity. The CO2 produced is actually that stored in the biomass. This process is therefore almost neutral as far as CO2 is concerned.

- Plants with a larger dry content like the grains. From the grains, liquid or gaseous fuels can be produced. The rest of the plant is then used as fuel for the production of process heat. This route has proven to be unsustainable because it leads to competition with food. Either the food is diverted for fuel production or the agricultural land is used for fuel production instead of food production. In both cases, food shortages or sharp increases in staple food prices can occur.
- Plants with oil-containing seeds. After appropriate treatment, the oil from the seeds becomes fuel. The problem with this solution is very similar to the previous one; fuel production displaces food production or encourages deforestation. Both are undesirable side effects.
- Woody plants - trees - are either used directly as fuel for energy production or as feedstock for the production of higher-value energetic materials - torrefaction, charring, gasification, etc. As long as consumption is in line with the regrowth of the corresponding type of wood, this solution is not only renewable but also sustainable. Such processes are also well suited for the recycling of wood waste from other uses.

4.6 Geothermal Energy

Geothermal energy is a multifaceted topic, the detailed treatment of which would go beyond the scope of this paper. This energy from the earth's interior is available to us for use in two forms:

- As a hydrothermal energy source either from medium-deep water reservoirs for heating purposes only or from deep locations - approx. 3000 metres - for which, thanks to the higher temperatures, use for electricity production can also be considered.
- In special regions of the earth, such as Iceland, geothermal heat flows out to the surface in the form of steam - saturated or superheated - which allows it to be used primarily for electricity production and then also for heating buildings.

Seen in this light, geothermal energy knows no daily or seasonal fluctuations and is always available when it is needed, provided it is not overused.

4.7 Mixed types

We often speak of near-surface geothermal energy. We do not classify this as an energy source here because, on the one hand, it first needs work to be usable and, on the other hand, it has a seasonal component, therefore it contains a solar component.

Something similar can be done via the heat utilisation of water reservoirs or also the utilisation of air heat. In each case, the heat pumps provide the necessary working power to make the energy usable.

We also bring to the mixed forms the heat output of hybrid solar modules or of concentrated photovoltaics. In these cases, the aim is to dissipate or use this thermal energy, because it is simply an uncontrolled consequence of the primary use, the electricity production.

5. Energy Vectors

We have learned about the characteristics of renewable energies in chapter 4. In doing so, we found that what our environment provides us with as energy is far from being able to directly meet all our needs in terms of the type of energy, its temporal and local availability or even its value, for example the temperature level.

For this balance between needs and availability, energy vectors or energy carriers are needed. Some of these are already known to us, but may need to be further developed. Others are also known to us in principle, as are the necessary technologies. However, there are still some development steps to be taken before they can be used on a daily basis. There are also many logistical problems.
Let us have a closer look at it.

5.1 The Electricity

The end of fossil fuels is looming. It may not happen as quickly as some believe, hope or wish. But it will come.

Electricity, already a major factor today, will increase its importance even further. The big difference: it will no longer be produced predominantly on the basis of fossil resources - coal, oil or gas - but primarily with solar and wind energy as well as hydro energy. This difference means that, since we cannot control these new forms of energy, or at least not very well, we must decouple electricity production from its consumption.

What does it mean practically?
If we don't need the electricity directly, we have to store it. Since electricity is a high-quality form of energy, it can also be used flexibly and can also be stored in a wide variety of ways. Admittedly, not always with the same efficiency and that is actually the big problem, because every transformation of the kind of energy is accompanied by losses. These can also be very high, at least for some processes that still have a great deal of development potential ahead of them. This is when we realise what nature has achieved for us over millions of years with the high-value fossil fuels.

Possible storage paths for electricity:

- The batteries: The charge-and-discharge cycle already has a relatively good efficiency today. However, they are relatively expensive, consume much valuable resources and the entire production process is associated with environmental pollution. Their applications are diverse and are also used for storage of larger capacities (up to 20-...50 MW).
- The well-known pumping/storage plants: They also have a relatively good efficiency. They are suitable for storing large amounts of power.
- The air storage systems: Because of their relatively low efficiency, such systems could not establish themselves. Perhaps, this was also due to the applications chosen so far?
- The electrolysis plants: The electricity is used to split water into hydrogen and oxygen. Both gases can then be used again in a fuel cell to generate electricity. They can also be led to a chemical plant where they are combined with CO_2 to form a gaseous or a liquid fuel. Such a solution would be quite interesting for seasonal storage. However, there is a lot of development work to be done before then.

5.2 The Biomass Vectors

Biomass is the energy source of life. It provides the food for all living things, directly or indirectly. Besides this main task, what is not needed for food can be composted and returned to nature. This produces methane, which can be used for electricity production and/or heat production.

In addition, biomass can be "refined" as an energy source in vectors. Examples of such refinements are:

- The pellets: The biomass is dried, finely grinded and compressed into cylindrical sticks. This produces a fairly homogeneous fuel with good burning properties. The pellets are relatively easy to transport. Storage must be dry, otherwise the sticks disintegrate into a shapeless difficult-to-handle mass.
- Roasted (torrefied), charred or gasified wood material: Partial or full pyrolysis enables an increase in energy content, a reduction in volume and, in part, an improvement in storability. Thus, time-delayed use becomes easier than with pellets.
- Biofuels: The transesterification of vegetable oils and fats can produce biodiesel. Other chemical processes enable the production of other fuels such as bioethanol or biokerosene.

Although there is a great deal of biomass on the planet, it must be remembered that a great deal of it is also already used or otherwise considered important for our lives and thus, worthy of protection. Therefore, the potential of these vectors is limited to the use of unused portions from other industries. The use of growing again fractions of biomass is conceivable, provided that there are no other priority uses - food, nature conservation, etc. - at stake. Their importance will thus increase strongly in the future, although it will remain far behind the electricity.

As a result, the use of biomass for energy is also under strong pressure to be more efficient.

5.3 Gaseous or liquid vectors

Currently, there are the already mentioned intermediate products hydrogen, biogas (methane from biomass), methane from a methanisation process and methanol as well as ethanol.

Although the discussion today still follows the old pattern - one winner, others are losers - niche solutions are more likely to emerge. This is because, as we have seen, the availability of renewable energy sources varies greatly locally. So, the choice of the locally optimal vector will also be.

These vectors arise in industrial processes where electric current plays a central role. They are therefore more expensive, because every process has losses. They also have advantages over electricity. They are easier to transport and, above all, they can be stored relatively cheaply. They are therefore very suitable for balancing production and demand, even over longer periods of time, and for fine distribution in remote regions.

The technologies for generating these vectors are available and are already being used industrially. However, there is still considerable potential for improvement.

In parallel, or perhaps slightly postponed, concepts for transport over longer distances, storage and also fine distribution must also be developed. From this, the respective infrastructure could be built. This will take some time.

6. Future sources of energy

So far, only known and reasonably proven renewable energy sources have been considered. This made it possible to estimate both their effective replacement potential and the time and effort that would be required.

It certainly does not take clairvoyant abilities to realise that the journey will be very difficult. Even meeting basic needs will be a big challenge. No production opportunities can be left out and tough measures will be needed on the consumption side as well. Thus, we have to look for other sources of energy.

Which ones do we have? Which new forms of energy can cover our needs without simultaneously producing high emissions and damaging the environment, as well as ensuring their availability over many generations?

There are only two forms, which today are viewed with great reserve or scepticism:

- Fusion energy
  There is the well-known mega-project ITER in southern France, which will perhaps show in the middle of the century what this path can really offer us. A much less known but much more controversial option is o-called cold fusion or low energy nuclear reaction (LENR). At first glance, it looks like charlatanry. However, because there are real results that cannot be fully explained, it would make sense to look at this option seriously and without prejudice.
- The free energy
  We are talking about the energy associated with Nikola Tesla, among others. In the meantime, other people have got results with it. It seems that we do not understand this form of energy, similar to cold fusion, but we are getting closer and closer to it. Here, too, it is important to approach the matter with an open mind and to investigate it seriously. However, it could be that not only the supply of energy, but also the machines, devices and appliances will become fundamentally different.

Both topics - cold fusion and free energy - have a similar problem: the lack of prospects. It is certainly interesting for a researcher to devote himself to fusion as at ITER. There, multi-billion-dollar budgets, fame and (almost) secure employment beckon. Research into uncertain waters is surely not as exciting.

It is also not attractive for investors to place money in something where they do not even know whether a business model can emerge from it, not to mention a return on the money invested.

We often boast about the achievements of our time. However, we should bear in mind that in many cases we have merely made use of the scientific findings of many earlier researchers. If these researchers had had a business model in mind at the time, many things would not have come into being. Perhaps it is time to get back to genuine science.

It will still take a while, however, until we are ready with these or at least one of these new energies. Until then, we are left with the following options:

- Continue to use energy sparingly
- Import energy
- Making even better use of waste energy. Many waste products that we simply burn today could, for example, be turned into valuable liquid or gaseous starting products for fuels and combustibles through pyrolysis.

It is no accident or oversight that nuclear energy based on fission technology has not been mentioned in this document. In some countries, such as Switzerland, it has been banned by law. Its reintroduction, as well as of improved variants, would only be conceivable decades later. By then, alternatives should have come onto the market.

7. Conclusions

The events of 2020 have shown us that, on the one hand, electricity is to a certain extent a basic need not only for industry and public life, but also for private households and, on the other hand, that some degree of self-sufficiency is essential in times of crisis.

The move away from fossil energy sources, and also in many countries from nuclear fission technology, is more than just a replacement of one source by another. It is the replacement of one all-purpose solution by a variety of specialised ones with their common and specific characteristics of which the most important ones are:

- Their energy density, i.e., their energy content per unit of mass or volume or per area required, is significantly lower than that of fossil sources.
- Practically all of them are subject to a diurnal cycle and a seasonal cycle, which, in addition, has different effects depending on the location on the latitude.
- The energy produced must first be converted on site into a transportable form of energy, usually electricity.
- The corresponding electricity production takes place regardless of whether the electricity is needed or not.
- They need large areas of land. Thus, in most countries, intensive use is very often in direct competition with other applications and concerns such as recreation, agriculture, timber industry, aviation, nature conservation, etc.

We need energy to cover many needs such as mobility, space heating or cooling, lighting, for the operation of appliances, machines or entire plants as well as for production processes that require heat or cold. The requirements are diverse and so are the requirements to the energy sources.

The diversity of properties and also the diversity of requirements mean that meeting our energy needs is becoming more complex. We will increasingly use several sources for this and locally, in very different measures. The large-scale solution, and also the ready-made solution, have had their day. Long live the tailor-made solution.

Especially where energy is needed most, the land is already heavily used. Its use for energy production is therefore severely restricted. Above all, multiple utilisations will be necessary. Power plant solutions will only be possible in a few cases. It will therefore be very difficult to cover today's energy consumption only with the currently known renewable energies; there is not even any question of an increase in consumption. On the one hand, we have to rethink our energy consumption and innovatively search for new energy sources that are genuinely in harmony with the environment.

Yours Jean-Pierre Rickli

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