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Deepened, holistic viewpoints on current issues.
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Dear readers

A warm welcome to the first issue of JPR-Focus in 2022.

It is now clear that our future energy supply will be based on, if not fully renewable, at least low-carbon energy sources.

Many suppliers of the respective technologies have understood this. They are therefore campaigning intensively to position their technology as the one for the future. Big plans are being forged and equally big promises are being made. Is all this a lasting reality?

In this contribution, we will try to provide a realistic answer to these questions and, using Switzerland as an example, for what the supply could look like.

I wish you an entertaining read.

Yours kindly
Jean-Pierre Rickli

Possible energy supply model for Switzerland

1. Introduction

The path is clearly set for an energy supply based on renewable energies.

However, it is becoming increasingly clear that the conversion is much more complex than expected. It is not just a matter of filling the tank with a different fuel or fitting a new connection for the supply. It is often also more than simply connecting the house to two new power cables.

More and more corporate and company leaders, politicians of all colours and private individuals are realising that goodwill is necessary but far from sufficient. It takes a lot of time, a lot of money and patience to come to the conclusion that the optimal solution must be a combination of local sources. In other words, the optimal solution is primarily given by the possibilities available at the respective location and not by the needs. The external conditions are decisive and impose constraints.

This already makes the discussion about the energy source or the energy carrier of the future irrelevant. The answer is simple: all of them, just not to the same extent everywhere. However, priorities and rough approaches to solutions are possible. They are necessary for planning development work and infrastructures. We thus will need the answer to the following questions:

- Where is the journey going?
- How can we get there?

With this report we want to attempt to give, if not a definitive answer, at least some hints as to what the future might look like.

2. What changes compared to today?

2.1 The characteristics of the renewable sources

We analysed these characteristics into the details in JPR Focus 01/21. Here are the most important ones as a reminder:

- They are locally available everywhere. Everywhere there is solar radiation, air movement (winds) and in many places water flows and biomass grows. However, their availability is also very different locally. There are places with a lot of one type or another or places with a balanced availability but at a medium or low level. This availability changes with the time of day, with the weather and is often seasonally influenced.
- Locally generated energies (wind, sun, flowing water) cannot simply be transported for further use. They must first be converted into another form, into an energy carrier (electricity, gas or liquid). These can then also be used for energy storage.
- Storage is also necessary for these energies. This serves as a buffer between supply and demand. This also enables an optimal use of incoming energy.
- Renewable forms of energy have a relatively low energy density. This means that their use requires a large amount of land. Only their conversion into electricity, gas or liquid fuels brings them to a density comparable to today's energy vectors.
- This additional land requirement is usually not readily available where the energy is needed. These areas are already used for other purposes. Multiple use is therefore essential, which also severely restricts use for energy.

In summary, it can be said that the time of the all-rounders and the unique solutions is over. It is then a matter of finding the combination of the different types of energy available to cover the respective needs.

The best possible knowledge of energy needs is thus a prerequisite for the optimal use of local energy sources. If the needs are greater than the local supply, supply solutions will be considered regionally, inter-regionally, nationally or then internationally. This is where the energy vectors will play a role. The answer to these questions will be of great importance for companies, industry and other large consumers.

2.2 The characteristics of the energy vectors

2.2.1 The electrical power

Electricity will undoubtedly play a central role in the future energy supply. It can be transported relatively well, even over long distances. It is flexible and versatile. The most diverse needs such as lighting, driving machines of all sizes, heat and mobility can be covered with electricity.

In today's grid, the balance between supply and demand is ensured by the generating plants. Their output is regulated in such a way that the frequency or voltage is kept within narrow limits. To achieve this, for example, more or less stored energy is supplied to the plant from the storage facility. In this way, the supply is constantly adjusted to the demand.

Renewable sources cannot be modulated and many are not always available when you need the electricity. In addition, we will use them as fully as possible for reasons of efficiency. The consequence of this is that we will have to store the electricity produced if it cannot be consumed immediately.

In the future, electrical power will increasingly be produced as direct current first - photovoltaics - and also consumed as such as a result of digitalisation. The transmission of high power over long distances will also increasingly take place as direct current in order to reduce transmission losses. As a result, direct current grid solutions or grid islands could receive more attention in the future.

2.2.2 The hydrogen

The element hydrogen is often seen today as the saviour or the solution to all our problems. That is perhaps a little exaggerated. However, it will play an important role, because it is not only to be used for electricity generation, but also for heat production and, also very important, as a starting material in organic chemistry. That is where it finds its main use today.

Hydrogen in pure form can only be found in very small quantities on earth. This means that this substance must first be produced. Two sources are available for this: water and hydrocarbons. The latter are the main suppliers today. In a de-carbonised world, only water remains available as a source. The production then goes via electrolysis, which needs a lot of electricity. Perhaps new processes will be developed? However, this is still a long way off.

Consequently, the very large hydrogen production plants will have to be located where there is sufficient water and electricity, or where one is available and the other can be easily brought. Examples of such places would be where the electricity from the offshore wind farms comes ashore or coastal locations where the electricity from the Concentrated Solar Power (CSP) plants can be easily tapped.

From there, the hydrogen would have to be transported further or consumed directly. How? We will look at that later in this report. We will have to take into account the special properties of hydrogen as the smallest element and its high ignition capability.

2.2.3 The methane

Methane, CH_4, is found in nature as a gas. It is the main component of natural gas. This gas is primarily produced in fermentation processes of organic matter - composting, putrefaction, digestion - and is a very potent greenhouse agent.

The industrial composting of biomass enables the production of biogas. This can then be burned in a gas engine to produce electricity. However, if the biogas is purified of its CO_2 content (approx. 35 %), methane of similar quality to natural gas is produced.

Another process that is still being tested and demonstrated is the so-called methanisation. Hydrogen from an electrolysis plant is combined with CO_2 separated from the air. This produces methane, which can be treated like natural gas.

Both processes - composting and methanisation - are so-called CO_2-neutral processes. The use of methane contributes only marginally to the increase in CO_2, because it was obtained from CO_2 extracted from the air; either the one stored in the biomass or directly.

2.2.4 The methanol

Methanol or methyl alcohol can be produced in a similar way as methane from biomass or from the combination of hydrogen from electrolysis plants and CO_2 from the air. The production processes are different from those of methane: production from biomass is tried and tested and production from hydrogen and CO_2 is experimental.

Methanol, unlike methane, is liquid and can be transported in tankers or stored in large tanks. Its energy content is lower than that of petrol. Its combustion behaviour is also different. Current combustion engines therefore need to be adapted to run on this fuel. However, the technology for this is not only known, but also tested.

2.3 The Production of the Energy Vectors

With the fossil energy forms provided by nature, the world is relatively simple. Coal, oil and natural gas, although not everywhere, are sufficiently abundant in certain places. Their energy content is high, they are relatively easy to transport, either in bulk, as liquid in tanks and pipes, or as gas, liquefied in tanks or as gas in pipes.

In addition, they are almost all-rounders. They are suitable for both heat and electricity production. They are used extensively in mobility, especially in liquid form. They also play an essential role in many processes as components or as starting materials for new materials and products, for example in the steel industry, organic chemistry and the plastics industry.

Their drawbacks are:

- Their finiteness. There is still plenty of them, in terms of quantity. However, the efforts to extract them are constantly increasing.
- Their large-scale exploitation has released in a few decades as much CO_2 into the air as was stored over millions of years. This has led to a strong imbalance. We notice this in the climate.

If we follow the path of renewable energy sources and sustainability, we will have to do without these hydrocarbons and follow nature's example. The production of all these products, which are indispensable for us today, must therefore be generated from water and air with the help of electricity. The hydrogen and oxygen will be extracted from the water and the air will be used as a CO2 supplier. This way, as mentioned before, is not necessarily a decarbonisation of the processes; but it makes them somewhat neutral.

The development of new manufacturing processes is underway. But the road is demanding and long. The changeover will still take a lot of time and efforts.

It is therefore clear that the production of electricity will play a central role. On the one hand, it will be the main energy vector for lighting, for drives and for heating buildings. On the other hand, electricity will be needed for the production of hydrogen as a feedstock for industrial processes such as in the steel industry and in chemistry. Hydrogen is very important in mobility and in energy storage, especially in long-term storage, for example to compensate for seasonal differences.

It should therefore also be clear that there will be limits to both energy consumption and industrial production. Both would have to be drastically reduced in a sustainable society based on renewable energies. For, as it has already become clear, covering today's electricity consumption with renewable energy sources is a major challenge. But when electricity must also provide the feedstock for an expanding economy, critical questions and a cautious attitude are only natural. At least until "truly sustainable" sources are discovered.

2.4 The distribution of the energy vectors

As we have seen, the characteristics of fossil fuels

- High energetic value
- High flexibility in the application as an energy source
- Diversity as a source of feedstock for the industry
- (Still) high availability in certain regions of the world

have led to a cascading structure and distribution similar to the one of trees where nutrients are extracted from the soil through the roots and carried up the trunk to the branches to the finest ramifications.

The distribution of petroleum and petroleum products such as petrol, diesel oil, heating oil, etc. works according to this principle, whereby the means of transport are different. In the case of crude oil, tankers arrive at a port of unloading. From there it goes via pipelines to the refineries. From there, the individual products are finely distributed via tank vehicles on the road or by rail. Differences between supply and demand are buffered by the degree to which storage tanks are filled.

Natural gas on its side is distributed through a huge pipeline system. This network is divided into different pressure levels. The highest level is connected to the production plants and distributes the natural gas to the different connected countries. At each country connection, the national system is filled. The filling level is reached when the pressure reaches the corresponding value. The corresponding filling control valve then regulates the pressure according to the consumption in the country. From there, the national consumers are supplied. From the large ones on the higher pressure level to the small ones on the lowest level. Such a control valve is located upstream of each pressure stage, which regulates its filling.

The electrical grid is structured in levels very similarly to the gas grid. However, the filling or load level is not called pressure, but frequency in the upper levels and voltage at the bottom. The control stations are then called transformer stations.

The switch to renewable energy sources will greatly change this type of supply. On the one hand, supply will no longer be exclusively centralised, but highly decentralised in fine distribution and partly centralised for large consumers. On the other hand, as we have already seen, the combination of energy forms consumed will be very different locally. This will disrupt the quantitative structure.

The energy supply will thus have the following basic characteristics:

- The demand for liquid fuels will decrease drastically. In the future, such energy sources will only be needed for niche applications and primarily as seasonal energy storage and will be stored in large tanks. In addition, a non-negligible share will be produced locally. We can almost say that the large supply pipelines, the huge refineries and the corresponding infrastructure will no longer be needed in the future, at least not for the mobility sector. Another question is the supply of raw materials to the chemical industry. There could still be some demand there. The changeover to CO2-free or -neutral production will still take time, provided it is possible for all products.
- The natural gas grid will tend to be similar to the oil grid, for basically the same reasons. However, this grid will play an important role in the transition period. It could support the ramp-up of hydrogen and methane production and, perhaps, take over part of the distribution of methane. For the transport of hydrogen alone, it cannot be used without modifications.
- The electrical grid will also be subject to strong changes. The distribution grid, the lower voltage level, will then mainly fed decentralised. Since the direction of the power flows can change depending on the load situation, control and protection of this subsystem will become quite complex. This adjustment has already been initiated. The higher voltage levels will thus be relieved of supplying the distribution grid. They are needed for the supply of large consumers, for load balancing supra-regionally and nationally, for transportation over long distances and for the emergency supply.

3. How will we meet our energy needs?

We have seen in JPR-Focus 01/21 that we need the energy for the following basic purposes:

- Building heating
- Lighting
- Household appliances
- Control and drives in industrial plants
- Process heat and cold
- Mobility

We now want to see how we could meet these needs in the future.

3.1 Building Heating

Building heating is about bringing air to lukewarm temperatures of 21 to 23 °C and domestic hot water to a little over 50 °C. Thermodynamics tells us that the best sources for this should have a slightly higher temperature, i.e., a temperature of up to 100 °C. This keeps thermodynamic losses low.

Such temperatures are to be found:

- At the end of working processes, as lost heat so to say.
- At the end of heat exchange processes in the process industry, practically as remaining heat.
- In cooling systems of machinery and industrial plants.
- In hybrid solar panels.
- In sun collectors.
- In systems that make better use of ambient or geothermal heat - for example, heat pump processes.
- In medium-depth geothermal energy.

From my own experience, there is more than enough energy for building heating at this temperature level. The basic solutions are also relatively clear:

- The first thing to think about is to put solar collectors on the roof and, together with a hot water storage tank, cover the domestic water demand and, at least partially, the hot water demand by using it as inlet water for the heat pump. In this way, the output of the heat pump can be reduced. This solution was neglected for a long time because it was not subsidised; thus, uninteresting for subsidy optimisers.
- Solar panels should be provided as a supplement to cover the electrical energy for the heating system - heat pump, circulation pumps, valves, controls, etc. Hybrid solar panels could also perform this task. They can provide electricity and heat.
- In an urban environment, this solution will come up against its limits. The buildings are larger, higher and the available space is smaller. In addition, the buildings are closer together and problems with shadow cast are common. A solution with a small local or district heating network is more likely. The heating system could be run on biomass. Since it would then be of a certain size, a heat/power coupling could certainly be a meaningful option. Other power plants could also feed their waste heat into the grid.

The big problem with heat production coupled with electricity production at this low temperature level is that it happens all year round, even if you don't need to heat the houses. This inevitably raises the question of storage. This is probably the biggest challenge with this energy application.

With climate change, the cooling of rooms in summer is increasingly seen as a critical problem. In contrast to heating, which uses low-value energy (waste energy), cooling requires high-value energy, primarily electricity. This problem is not only due to rising temperatures. It also comes from the construction design, which is made to keep the heat in the rooms as efficiently as possible. Thus, in summer, it is hardly possible to get rid in the night of the heat accumulated during the day.

If this is to be achieved in a low-energy way, architectural measures are imperative, both structurally and in the planning of the surroundings.

3.2 Lighting

The lighting is probably the least problem.

The forced changeover to so-called energy-saving lamps, which also cleared the way for LED lamps, has greatly reduced the electricity demand for lighting. In rural areas and small buildings, this demand can be met relatively easily with solar cells. For medium-sized apartment buildings, an optimisation between production and consumption will be necessary. Of course, all with adequate electricity storage.

In urban areas, solutions with combined heat and power and small district heating networks for settlements or neighbourhoods will certainly come into play.

3.3 The household and office appliances

If electricity can no longer be obtained so easily, cheaply and sufficiently from the grid, people will have to think about this area and reflect on their priorities.

Perhaps, it is also then time to question the propaganda of the appliance sellers:

- Is the motor efficiency alone really the measure of all things for energy efficiency? Doesn't power also come into play?
- Is the flat-screen TV of the size of the living room wall really necessary? Can I enjoy my daily horror programme without age restriction, the daily news, on a smaller screen with less power?
- Is the 15-second warm-up time of the touted powerful iron so important to me that I cannot get by with the 30 seconds of the half-powerful one?
- Do I really have to have a fridge that has room for 10 bottles of beer? Can I get by with a smaller one with space for only 4 bottles?
- Is it necessary to keep the computer running at night? Are the few seconds necessary for booting up really unbearable?
- And...and...and...

The experience with zero-energy or even plus-energy houses shows that if you deal with your real needs, local supply becomes possible.

For companies, similar questions arise with regard to household appliances such as coffee machines, beverage dispensers, small kitchens and also for office equipment. Depending on the size of the company and its needs, solutions are to be considered locally, locally with a district heating grid with cogeneration or regionally.

3.4 The control and drives of industrial plants

This is where we are slowly getting to the heart of the issue of the switch to renewable energy. Perhaps that is why it is not addressed so much in the public discussion, if at all. Understandable! It is easier to talk about what is feasible - points 4.1 to 4.3 as we have seen, that is also the first 30% of our energy consumption - than to tackle controversial issues - how to tackle the 30% consumption share of industry. Savings and efficiency measures cannot simply make these shares disappear.

Except for very small industrial plants with correspondingly small needs, a regional, interregional or even a national supply solution will be necessary. A combination of different solutions could improve the security of supply.

There will hardly be any universal solutions; at best only local ones. The prerequisite for this will be the recording of needs today and their development over time. The amount of energy available and the chosen supply solution will then influence, perhaps even limit or determine the size of the company and its future development.

3.5 The process heat and the process cold

First of all, it is necessary to clarify the terms because cold is not simply the opposite of heat, at least not when it comes to producing it. Heat and cold in industrial processes are defined in relation to the respective temperature of the ambient air. Heating processes have a target temperature above that of the ambient air and cooling processes below. This means that in some cases, a plant is considered a cooling plant at high air temperatures and can function as a heating plant at lower air temperatures.

Today, process heat is primarily generated via combustion processes in order to be able to reach the required temperatures. The most common fuels are coal, gas, oil and, to a lesser extent, biomass; waste can also be used as fuel.

Process cooling predominantly requires electric current as a form of energy.

If only renewable energies are to serve to generate process heat in the future, there will be a major changeover. The entire share of coal, gas and oil would have to be replaced by other processes. Today, it is primarily the "combustion" of hydrogen that is under consideration. We should rather talk about exothermic oxidation. According to the technology available today, this hydrogen would have to be produced by electrolysis, i.e., with the help of electric current.

In view of the foreseeable enormous quantities of hydrogen required, setting priorities will be essential. Perhaps then even the concept of gigantic industrial production will have to be questioned?

Relatively little will change in process cooling. The main demand will remain for electricity. Possibly, in the future, solutions with thermal chillers could become increasingly interesting. A combination with heat storage would be conceivable.

3.6 Mobility

This is a very hot potato. On the one hand, because with about 50% of the total energy consumption, a huge package is in front of us. On the other hand, because according to federal statistics, almost 38% of total consumption is dependent on fossil energy sources. Lastly, because this sector has a profound impact on the lives of each and every one of us. Thus, any discussion about mobility gets emotional very quickly.

If we move away from fossil fuels, the entire transport system will be affected: individual transport and commuter traffic with individual vehicles, transport traffic as well as leisure traffic on land, over the seas and in the air.

That electrically powered vehicles - aircraft, ships, trucks or passenger cars - can be built and that they can be operated is not the real debate. The real questions are:

- How big is the payload; people or cargo?
- How far can the journey go?
- How long does the journey take then?
- How soon after the journey or after a hop can I drive further?

There are varying degrees of restriction on each of these questions, depending on the specific applications. In most cases, reference is made to the advances still to come in the respective technologies.

Two technologies are strongly in the running today:

- The electric means of transport with co-loaded electricity storage.
- The electric means of transport with co-loaded electricity generators, mostly fuel cells, which are powered (once more) by hydrogen.

Both solutions have their own limitations and advantages. For this reason, neither will win the race alone. Both will have their focus applications; where they can play out their strengths.

However, if everything were to be converted to electric propulsion, all that would really have been solved is the problem of emissions of carbon-containing compounds; assuming, of course, that the electricity came from renewable energy sources.

Various emerging issues are thus not addressed, although they could develop as big game spoilers, such as:

- Electric vehicles do not emit particulate matter from their exhaust pipe. On the other hand, they have tyres and brakes, just like vehicles powered by combustion engines. This means that they also produce particulate matter from abrasion. This is not so much found in the air, but on our plates. This problem is being recognised more and more. The energy transition does not bring any relief here.

- - Fuel cells have a high chance of playing the more important role in air travel. Their "waste product" is water, thus somewhat non-toxic, which is likely to be vented into the atmosphere during flight. If it were not done, the aircraft would be much heavier at landing than at take-off; water is in fact much heavier than hydrogen. So, there does not seem to be any problem with that. But what people forget is that water, in the atmosphere, is a very potent greenhouse gas. Think of the tropical nights when the sky is covered with clouds and there is hardly any cooling during the night. The climate would change even faster!

Scientists and engineers will still have something to do!

4. Vision of the future energy supply

Until we can really tap into "free energy" or "LENR", we will have to consider a vision of energy supply like the one below.

Where the building density is rather low - small buildings, medium distance between buildings - the buildings are primarily heated with photovoltaics, heat pumps, solar thermal as well as heat and electricity storage, that means locally.

Where the building density is higher or where there are local electricity or process heat consumers, a mini district heating network can make sense. Depending on the geographical location and configuration of these grids, either different grids could be cross-connected for reasons of supply security or additional heat suppliers could also be included in the grid. The higher local electricity consumption or the required process heat, for example for local bakeries or dairies, would then be produced by a combined heat and power plant.

The fuel could be either local or regional biomass, biogas or methane and methanol produced from green hydrogen, as well as the hydrogen itself. Since only relatively few plants would use biogas or hydrogen, they would probably be directly connected to a local production plant. Today's fine mesh gas distribution network would thus be largely obsolete.

The power supply for the lighting and the household and office appliances is ensured in a similar way via various mini-grids. As far as possible, the individual buildings have their own electricity production from photovoltaics and can cover at least part of their own needs. Their own electricity storage enables a certain degree of self-sufficiency. The surplus is fed into the mini-grid and made available for other consumers. There is also a storage facility in the grid to dampen fluctuations. The many mini-grids are interconnected to ensure load balancing.

Thus, today's distribution network will be still largely usable; however, with quite different functions. Here is a brief overview:

- It consists of many individual but interconnected mini-nets.
- It is no longer primarily used for supply, but for load balancing, for each producer/consumer, between the producers/consumers of the grid and between other neighbouring grids.
- The power can flow in both directions at any time and in any network strand.
- If surplus electricity is produced and cannot be taken over by neighbouring grids, the electricity flows to the next higher voltage level and is thus available regionally, supra-regionally or nationwide.
- This makes monitoring and protection complex and demanding.

Now we come to the larger electricity consumers for the control and drives in industrial plants. These will cover their electricity needs inter-regionally and nationally and will get their electricity from the transport levels. This will also be the case for the large consumers of process cooling. These grid levels are connected to power plants.

The large consumers of process heat will, as up to now, cover their needs for process heat with their own combined heat and power plant. They will use biogas, methanol or directly hydrogen as fuel. For the use of hydrogen, the proximity of a production plant will be decisive. Exceptionally, it could be biomass if it is directly available, such as in a sugar factory.

It should be noted that no huge solar or wind power plants can be installed in Switzerland. This means that no large-scale hydrogen production can take place. Thus, there will only be relatively small plants that can supply local or regional isolated solutions, of an industrial or mobility nature. Hydrogen transport will also be a specific solution in each case.

Now we come to mobility. This sector will experience the greatest changes. As already mentioned in 3.6, the era of the all-rounders, the derivatives from petroleum, is over. Special solutions will now have to be sought depending on the means of transport, transport route, transport distance, purpose and location.

Accordingly, we will encounter many different isolated solutions. Different energy sources do not necessarily mean different drive technologies. An invention was presented at the Geneva Inventors' Fair more than 10 years ago that makes it possible to change the energy source for a fuel cell by turning a switch.

Aviation will have to concentrate on those areas where it is strong and without competition. These are:

- Overseas connections
  There will be hardly any change from today in terms of competition. However, due to the switch to engine propulsion, i.e., propeller propulsion, flights are likely to take longer. Unless the industry finds a way to produce large quantities of aviation fuel from hydrogen. Biokerosene, based on biomass, is unlikely to play a major role because of the limited quantities. The new processes will probably be expensive and increase transport costs considerably. All reasons for a reduced transport volume compared to today.
- Speed
  This advantage for electric planes over high-speed trains will dwindle considerably. Considering the check-in times and the drive between the airport and the city, the remaining advantage would already be gone. This means that short-haul flights would be eliminated. For medium-haul flights, it would depend on the expansion of rail transport. If airspace occupancy permits and ground transport does not develop, air taxis could be a niche.

In water transport, the technologies will divide up the market relatively clearly. Depending on the supply situation, local solutions are quite conceivable. Essentially, however, it could look like this:

- Leisure traffic: Electric with batteries.
- Inland lake passenger transport and ferries: Electric with fuel cells. Possibly locally, methanol or similar produced from hydrogen.
- Overseas: Electric with fuel cells.

Land transport will be clearly divided in the future:

- Long-distance transport - passengers and goods - will mainly be handled by rail, internationally, nationally and regionally. In Switzerland, there will probably continue to be electric drives with power plant electricity as today. From case to case, electric drives with fuel cells will also be found.
- The fine distribution of goods will be ensured mainly locally, in some cases also regionally by road. The drives will be predominantly electric. With fuel cells for longer and less predictable journeys and with batteries for short and predictable routes.
- The motorised individual transport, private and professional, will decrease strongly. The main reasons for this are energy prices and restrictions on the choice of drive solution. None of the new technologies is an all-rounder. It will therefore be unavoidable to set priorities. In addition, there is the possibility of local stand-alone solutions. Thus, small cars will be used

in the first place, mostly electric with batteries in local transport. Car-sharing on demand or by agreement will be increasingly used. Likewise, appropriate vehicles will increasingly be rented on demand for transport tasks. With the further development of autonomous vehicles, such services will expand.

- For short distances, interest will continue to grow for bicycles as well as for cargo bicycles, whether with muscle power only or power-assisted.

Under these circumstances and differences in local and regional conditions, the development of extensive charging networks for electricity or hydrogen makes little sense.

5. How can we get there?

The following trends can be identified from the previous considerations:

- People's basic needs - comfortable room temperatures, lighting and household or office appliances - can be met locally with renewable energies.
- Since the local supply is very different, the optimal solutions will also be different locally. This will also result in local mini-grids as insular solutions. These will then be connected where possible.
- Thus, no single form of energy alone is the solution. The optimum will usually be a combination. Therefore, it is not about competition, but about cooperation, about complementarity.
- The more sustainable solution runs in the direction of using all locally available forms of energy. In this way, local small businesses and service providers can also be supplied.

In order to achieve this, the idea of an energy cadastre launched by JPR Concepts & Innovation in 2005 should be taken up again. The idea was not only to determine the existing roof area, as is the case with some apps available today, but to record the entire energy potential of the plot.

The real available energy data should be documented. The incident solar radiation taking into account the location of the plot, the shadow cast by neighbouring tall buildings, hills or trees; in the course of the day and seasonally should be determined. In addition, the wind conditions on the plot (micro wind turbines) or in the wider surroundings (large wind turbines), geothermal possibilities, local heat or/and electricity providers, local hydrogen providers, etc. should also be recorded.

This would allow existing installations to be improved and new projects to be better integrated. The planning of local and regional supply would also be improved. Possible gaps in supply to be covered by the addition of inter-regional or national energy sources could be undertaken in a more targeted manner.

The potential and nature of the local mobility concept would then be recorded and their regional or inter-regional needs clarified.

Now we can turn our attention to the larger electricity and heat consumers. We should keep in mind that the more sustainable solution is always the one that is the least far away. Transport always involves losses and thus lowers sustainability. The first questions are therefore: is there a major electricity producer or a hydroelectric power plant or a wind farm? Is biomass available for energy purposes? Locally or regionally or at most inter-regionally? Is there a local or regional hydrogen or methanol producer? Is there any local potential for this at all?

Remark:
Because of the high flame temperature, biomass should be reserved for applications for combined heat and power and for process heat generation. Today's technical concepts, however, are based on relatively large plants. JPR Concepts & Innovation, together with EPFL, has developed a concept for small steam turbines, which was presented in Milan in 2007. Such plants could lower significantly the power output limits of meaningful applications for heat-power cogeneration and process heat supply.

The answers to the above questions will also be decisive for determining the regional and inter-regional mobility concept.

The search for the more sustainable solution will thus also significantly determine the size of the respective industrial plants. Mega- or giga-factories will be a thing of the past in this context. The exception will be where the electricity and the feedstock (hydrogen) are produced. That is where the large industrial sites of the future will be.

As we have observed in this report, the storage of energy has a crucial role to play.

Heat from solar radiation and waste heat from processes must be stored so that it is available for heating buildings when the time comes. Hot water is used for this in most cases today. This solution is very efficient. However, it requires a relatively large amount of space, which is often not necessarily available in older buildings.

Storage with water also has the following disadvantage: the boiling point of water is 100 °C below normal atmospheric pressure. Higher temperatures in unpressurised containers are possible, but only using other media, which are not necessarily sustainable. More sustainable solutions are yet to be discovered. For example, some industrial processes could also be powered by solar heat. With electricity, the situation is much more complicated. It has to be stored for different purposes. So, there are also different solutions.

- Similar to heat for building heating, electricity generated during the day, if not consumed directly, must be stored for evening and night-time activities. This allows lighting, entertainment and other household appliances as well as technical operational equipment to remain in operation. On the basis of the storage capacity required, batteries tend to be the solution.
- Storage capacities must also be provided in the mini-grids. This is not primarily to compensate for the fluctuations between day and night, but for the differences between the various producers/consumers. Such storage capacities are much larger than those of the individual producers/consumers, but can also be ensured by batteries for relatively short-term fluctuations. Sustainable solutions are still being sought.
- In the case of larger-scale fluctuations, such as the seasonal differences between winter and summer, it is often a question of large amounts of energy that also need to be used flexibly. Conversion to substantial energy vectors such as hydrogen, methane, methanol, biomass or products from partial or full pyrolysis is recommended. There is still enormous potential for possible developments in the production, storage, transport and re-transformation into electricity and heat of such products.

- The short-term balancing of large amounts of energy in the transmission grid is very well fulfilled today by pumped-storage power plants. That is why such units will remain very important.
- Last but not least, there are the mobile applications. The storage needs for these applications are met by batteries. This sector will gain enormously in importance with the mobility. More sustainable solutions than today's still need to be developed.

As we can see, a lot still needs to be developed. Some solutions are already in operation as prototypes. But the road to industrial maturity is still very long. The stage of development of the different technologies is also very different. Therefore, we should not wait with the transformation until the last technology has also become green.

The conversion of blast furnace operations from coal to hydrogen is certainly not something that can be achieved overnight. Huge quantities of hydrogen are said to be necessary for this. So, it makes sense to initially drive this conversion with hydrogen that is not entirely green. The construction of smaller decentralised "green" electrolysis plants to cover other needs would then make it possible to gain experience with the operation and construction of such plants. This would also allow storage models to be tested on a small scale.

Something similar can be expected with methanisation to methane or to methanol with the plants for capturing CO2 from the air and also for process control.

6. Summary

The following main statements can be summarised from the above:

- In the future, today's electricity distribution network will be a balancing and redistribution network between the various local and regional producers/consumers. It will consist of many mini-grids. Any surplus production will be fed into the transmission grid.
- The electricity transmission grid is connected to the power plants. It provides for balancing between the regions, for supply in emergencies and for supplying the large consumers if they cannot cover their needs locally or regionally.
- The demand for building heating is ensured exclusively locally/regionally. Individual solutions as well as small district heating networks, possibly cross-connected for security of supply reasons, will take over this task. External energy sources may step in during emergencies.
- Consumers of process heat will operate their heat-power cogeneration plants with local/regional or, if necessary, inter-regional energy sources. This supply will determine the size of the industrial plant in the future.
- The characteristics of the various new energy sources will ensure a strong specialisation of the means of transport and less competition among them. Air transport will be concentrated on overseas routes and long hauls. It will become slower and thus less attractive. Rail transport will be decisive for the inter-regional, national and international ground transport of people and goods. Road transport will take over at the local and regional level.
- Since huge amounts of hydrogen are needed as a feedstock by various industries, the large industrial consumers will be located close to the large hydrogen production. Applications in

the energy sector will thus tend to be seen as niche solutions. A conversion of the current gas grid into a hydrogen grid is therefore very unlikely.

- There is still a great need for the development of electricity storage options. These are very diverse, as is the field of application for electricity.
- From a purely formal point of view, the use of "green" hydrogen would certainly be the better solution, at least for purists. The condition for this would be: the technologies for this are available, tested and also already in use at the expected production level. Since this is far from being the case, development should already be pursued today with the hydrogen that is usually produced now or with the electricity that is not quite green. This would allow valuable experience to be gained and the technologies to be brought further to maturity. This can help to achieve a quick and, above all, more efficient transition.

As we can see, we still have a long and difficult road ahead of us. It is a challenge for all of us. We have to live with nature again and not only from it. The laws of nature must also come to the fore again, because we are a part of it and not separate from it.

This is how we create the conditions for a sustainable future, i.e., a future where changes can be accommodated by nature and at its pace.

Yours
Jean-Pierre Rickli

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