Switzerland: the rise of utility-scale energy storage technologies

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Context

As is the case with several other countries, Switzerland's climate policy towards a climate neutral energy policy (Energy Strategy 2050) makes the transition from the existing use of several types of energy (fossil, nuclear, renewable, etc) challenging. Given the intermittent production of certain renewable energies (wind, hydropower) or the geographical obstacles imposed (geothermal), a consistent energy transition is not possible without a performant energy storage.

That being said, to make energy storage technologies safe, secure, effective and efficient, innovation must be encouraged, market barriers reduced, and existing and future legal frameworks created to favour not discriminate against the development and use of innovative storage technologies. In accordance with a targeted CO2 neutral environment, all this will ultimately permit a reliable grid based on clean energies.

This article specifically covers indirect storage technologies (ie, storage by way of transformation in other forms of energy) given their demonstrated performance, but the technologies discussed below are by no means considered exhaustive.

Legal obstacles in general

Based on current scientific knowledge, leading Swiss researchers consider that where large amounts of energy need to be stored for the medium to long-term, technologies such as compressed air and pumped hydro storage as well as power-to-X systems are favoured in terms of performance.[1]

Although the Confederation and private sector funds encourage innovation in different types of technologies, a direct promotion for their use is currently lacking. Encouraging incentives and policies (eg, through loans or tax credits) would be more than welcome.

The capacity, performance, geographical limitations, costs etc, of current or future energy storage technologies depends on the physical process underlying the conversion and/or the storage, and its implementation. A technology-neutral approach may make sense so as not to create discriminations in terms of regulation and market access.

For instance, industry associations and concerned companies grouped under the umbrella organisation AEE Suisse established a roadmap in 2022, [2] in which it appealed in particular: (1) to put an end to existing discrimination among energy storage (in particular in the field of power energy storage technologies, pumped storage (see below) is considered as favoured); and (2) to establish similar conditions and an equal treatment among technologies, for example, the exemptions from network fees or the payment of net consumption fees (minus losses) should apply equally to all technologies.

In addition, to secure the economic viability of energy storage companies, AEE Suisse further argued in favour of a clear delimitation between the grid exploitation (where a monopoly is not excluded) and the market participation in view of energy trading.[3]

Finally, given that certain provisions restrict in Switzerland the grid extension (ie, if safe, functioning and efficient grid cannot be otherwise obtained by optimisation or reinforcement of the existing grid),[4] the implementation of future regulatory measures shall not be jeopardised by this kind of provision, be it in practice or by law.

Legal challenges with respect to certain energy storage technologies

Chemical storage technology

The chemical storage of energy is achieved by converting it into another energy source and releasing it by means of a chemical reaction (electrolysis), such as power-to-X systems or battery energy storage.

In our opinion, power-to-X systems (such as power-to-heat, power-to-gas or power-to-liquid) are particularly interesting. This is because the energy transformed through electrolysis (heat, gas or liquid) can either be re-transformed back into the initial energy or introduced as such as a new energy carrier (eg, in the context of power-to-gas – into the gas grid or mixed with natural gas). In terms of future regulation, the possibility of introducing a newly created energy should not be prevented or otherwise restricted compared to the re-conversion into the initial energy. In our view, this equality of treatment would favour all possible uses.

In the context of power-to-gas, the Swiss Federal Office of Energy – greatly inspired by Austria that made the discovery some ten years ago – has adapted and continues to develop the project Underground Sun Conversion.[5] However, instead of using natural gas deposits, which Switzerland does not happen to have, the idea is to use porous rocks naturally filled with salt water (so-called saline aquifers), evacuating the salt water by pressure (during the process, the risk of earthquakes must be carefully avoided), introducing hydrogen and CO2 into the subsoil and let the naturally present micro-organisms (arcahea) transform the hydrogen into methane (main component of natural gas). The CO2 produced is then reused for the production of renewable gas, as initially discovered in Austria. Although Switzerland's contemplated geo-methanisation is an adaptation to the Swiss soil specificities, concerns raised that Swiss water protection regulations tend to restrict the development of aquifer storage,[6] which we recommend reviewing in order to promote such specific technologies which use underground energy conversion.

Finally, regarding batteries, although sodium-ion, molten-salt and other types of batteries could have made good alternatives to lithium-ion batteries as they can be connected to electrical grids at lower costs and with less impact on the climate, studies still need to prove their potential to increase efficiency. As current leads, lithium-ion batteries for energy storage are being increasingly used in large-scale projects, such as Tesla's 'Megapack' or the alliance between Samsung and ABB in view of a joint development and sale of energy storage solutions using the Samsung's lithium-ion batteries and ABB's electronic components, therefore driving innovation forward from the mere vehicle-to-grid. In this context, existing and future policies relating to recycling and electrical batteries will inevitably affect large-scale energy storage.

Mechanical storage technology

In the context of mechanical storage, energy (in particular electricity) is converted into kinetic or potential energy by means of a mechanical accumulator. This is tried and tested technology used for large-scale and long-term storage.

The best-known example in Switzerland (and probably the most widely used worldwide) is pumped storage. Whereas an upstream reservoir pumps water due to extra energy it receives, the downstream reservoir receives water (via pipelines connecting the system together) and produces energy using the water's kinetic energy. This technology has been carried out for decades and will continue to be the cornerstone of Switzerland's electricity production strategy, as shown by the recent commissioning of the Nant de Drance hydropower plant in 2022 (900 MW).

Another example is the compressed-air energy system where pressurised air (or heat generated by the compressed air) is stored in underground cavities or surface reservoirs and then returned back to the environment by a turbine which again produces energy.

By definition, both these techniques require large volumes or spaces, in surface or underground. Therefore, there are obvious market barriers in terms of resources and building permits. This may explain why this technology currently benefits from a more favourable legal framework in Switzerland, compared to other storage technologies.

A successful, and no less performant mechanical storage has been developed in Switzerland since 2017, by the start-up Energy Vault.[7] It uses electricity to lift (recycled) composite blocks (of over 30 tonnes, piled like Lego bricks) with a 120-metre high crane which would lower them and therefore release kinetic energy when required. The need is triggered by elements such as weather conditions and consumer demand, all calculated by the AI-based algorithm developed by the startup. The obvious advantages in terms of construction and maintenance costs, independence from geographical limitations and lifespan (as compared to batteries energy storage) are probably what made major countries such as the US, China, and Australia interested in this technology.

Thermic storage technology

Thermic storage has the advantage of not converting energy, since the mere use of existing thermal accumulators (such as water, soil, rocks, etc) is needed to store and release back the energy. For instance, after having tested concrete as thermal accumulator without success, Switzerland's current studies have turned to geothermal storage techniques using bedrock or groundwater at depths of 20-100 metres as storage, the heated material (eg, water or rock) is then transported underground via geothermal wells or probes, finally the heat is extracted back from water or rock and lifted up to the surface.

Given that this technology is dependent on the presence of natural thermal accumulators, it cannot be developed anywhere and is rather suitable to near-surface infrastructures. Its promotion and further development should take these considerations into account.

Conclusion

Not all energy storage technologies are suitable for large-scale and/or long-term storage. The most used existing techniques are pumped storage and power-to-X solutions. Although funding for R&D is dedicated to other technologies, the existing Swiss legal framework may, in our view, be enhanced.

No discrimination should exist between energy storage technologies so as to promote future innovation and the use of simple, secure, efficient energy storage technologies, taking into account Switzerland's geographical specifications.

Finally, as mentioned above, policies or regulations in some other areas (such as the regime for building, drilling, etc, permits; policies in the area of electrical batteries and recycling; energy trading regulations; etc) should be taken into consideration and interact where appropriate, for the purpose of a consistent and harmonious legal framework of renewable energy storage.

Notes

[1] Urs Steiger and Bernd Müller (eds), 'Handbook Energy Storage: SCCER Heat and Electricity Storage, 2nd edn, 2021, p18 https://doi.org/10.3929/ethz-b-000445597, accessed 14 February 2024.

[2] AEE Suisse, Forum Stockage d'énergie Suisse, Feuille de route pour le stockage de l'énergie 2.0, June 2022, https://speicher.aeesuisse.ch/fr/news/feuille-de-route-pour-le-stockage-de-lenergie/aeesuisse (in French), pp2-4.

[3] Ibid, p5.

[4] see eg, for electricity, Art 9b para 2 of the Swiss Act on Electricity Supply.

[5] Swiss Federal Office of Energy, Du gaz renouvelable issu du sous-sol suisse, November 2022, https://www.aramis.admin.ch/Default?DocumentID=69630&Load=true (in French).

[6] Swiss Federal Office of Energy, Fiche d'information sur le stockage de chaleur, May 2022, www.bfe.admin.ch/bfe/fr/home/versorgung/energieeffizienz/waermespeicherung.exturl.html/aHR0cHM6Ly9wdWJkYi5iZmUuYWRtaW4uY2gvZnIvcHVibGljYX/Rpb24vZG93bmxvYWQvMTEwOTk=.html, p 1 (in French).

[7] Energy Vault www.energyvault.com.