Accelerating the Energy Transition

Insights from the Swiss-US Energy Innovation Days 2022

A report by Swissnex in Boston and New York

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Introduction

The world is facing an energy crisis–the war in Ukraine has cut Europe's access to affordable fossil fuels, but it is only worsening an energy shortage that began during the COVID-19 pandemic, with global reductions in oil and gas production. At the same time, climate change-induced droughts and heat waves have forced drastic cuts to hydro- and nuclear power generation. Recent events have made it clear: we must fundamentally rethink our relationship to energy, and rapidly reduce our reliance on fossil fuels. This decarbonization must occur on both ends—in energy production, by slashing the use of oil and gas, as well as in its consumption, by cutting down on waste and increasing energy efficiency.

A group of energy innovators from Switzerland and the US met in Bern, Switzerland from August 16-18, 2022, to discuss solutions. Over the course of three days, they explored new technologies that can help with the transition—from electrical vehicles used as flexible energy storage units to supercritical geothermal generation. But above all, they agreed that more efforts should focus on rapidly integrating existing technologies, from photovoltaics to wind power, from household heat pumps to district heating networks. They also stressed the need to increase efficiency, for instance by improving insulation or implementing smart timing on production lines.

Lastly, they discussed the major role that digitalization will play in the energy transition, by helping decision makers choose the best set of strategies to reduce the carbon footprint of companies, neighborhoods, cities, or whole countries. Numerical modeling tools—as presented by several Swiss startups—can aid in decision making by integrating many factors, from the availability of renewable energy sources to expected consumption, as well as changes in regulation and financial planning.

This report summarizes the takeaways of the Swiss-US Energy Innovation Days 2022, and highlights some of the most promising developments in the field.

Bringing Our Strengths Together

A Conversation with Marianne Zünd

The energy transition can benefit from digital tools, says Marianne Zünd, creator of the annual Swiss-US Energy Innovation Days (SUEID). Sharing experience across the Atlantic can lead to new impulses, says the Head of the Media and Political Affairs Division of the Swiss Federal Office of Energy.

Every year, the SUEID conference brings together innovators from Switzerland and the US. The two countries have completely different energy markets, technologies, and policies. What can the participants learn?

The differences are not as large as one would think, as seen during all the past meetings. Both countries are facing the same issues in the energy domain and exploring similar innovations. Reflecting on each other's experiences and perspectives leads to new ideas and impulses.

Can you give us any concrete examples?

One Swiss participant told us that he solved a hardware problem during a coffee break discussion with a US participant. The Massachusetts-based company Via established contacts with the University of Lucerne during one of our previous conferences; it now has an office in Switzerland.

The climate and energy crises are in some ways reminiscent of the COVID-19 pandemic: rapid and courageous decisions are necessary. Is Switzerland's federal model of government holding back the development of a truly national response?

No, on the contrary. The Swiss cantons are all different—some have good conditions for hydropower, others for wind power, geothermal energy, or biomass. The Alpine regions above the low-lying winter clouds are very well positioned for solar electricity production. By bringing their strengths together, the cantons will contribute constructively to the national energy strategy.

Switzerland has one of the highest shares of fuel oil heating in Europe, a technology that is still permitted for new constructions in many cantons. Would a national ban bring clarity, accelerate the transition, and lower the price of renewable alternatives?

This question needs to be answered by policy. A national regulation on heating was taboo until now because the

> "The next generation is much more aware of energy issues."

cantons are responsible for regulating energy consumption in buildings, as specified in the federal constitution. The government of a direct democracy like Switzerland cannot simply write up national plans. It must first demonstrate their need and ensure political majorities. But there is clearly a political consensus now that we need to speed up considerably the transformation of the Swiss energy system.

Do we have enough qualified personnel to implement a rapid transition?

Finding new apprentices in some energy-related professions, particularly in the construction industry, has become difficult, and trained specialists are moving to other sectors. The Swiss government has recently launched several training offensives in collaboration with construction industry associations. Digitalization, in particular, is playing an increasing role in energy-related professions and the topic is being integrated into more and more professional training courses.

Where do you see the greatest potential for decarbonizing energy production in Switzerland?

Solar energy, which will become the energy of the future. Its potential in Switzerland is estimated at around 67 TWh per year, which exceeds the current national consumption. Wind power could contribute around 10 TWh. Hydropower still has the potential for development, deep geothermal energy too. Heat pumps and electric vehicles also contribute to decarbonization by converting energy much more efficiently.

Are there any low hanging fruits for increasing the efficiency of energy usage?

A lot of them have already been harvested in the industry, simply because there is a financial incentive to consume less energy. It can be simply using efficient lighting or, for energy-intensive companies, optimizing the production processes. Further energy harvests are waiting in the service sector—retailers, hotels, small businesses—and households. For the latter, using a heat pump or connecting to a district heating network is much more efficient than having individual fuel heating. And for transport, electric vehicles are more efficient than combustion engine ones. This is more and more known among the general public. The next generation is much more aware of energy issues, which are being incorporated into school and higher education curricula.

SFOE: Switzerland's Energy Agency

The Swiss Federal Office of Energy (SFOE) is the country's competence center for issues relating to energy supply and energy use at the Federal Department of the Environment, Transport, Energy and Communications (DETEC). The SFOE creates the prerequisites for a sufficient, crisis-proof, broad-based, economic, and sustainable energy supply. As part of this mission, the SFOE actively promotes efficient energy use, an increase in the share of renewable energy, and a reduction in CO_2 emissions, as well as promoting and coordinating national energy research and supporting the development of new markets for sustainable energy use and supply.

Digitalizing Decarbonization

More than new technologies, reducing our carbon footprint means expanding and accelerating the rollout of existing ones. But the complexity of our energy systems makes it difficult to choose the most efficient and effective methods. Digital models can help us make the best decisions, based on numerical simulations and lots of data. The upshot: many new business opportunities.

For a long time, the energy transition has been a rather abstract goal. But with the sharp reduction of fossil fuel imports from Russia, the difficult winter forecast ahead, and the increasingly visible impacts of climate change, the urgency is now obvious.

“The current international energy crisis is a real challenge for the country, but it also provides opportunities to make something out of it,” said Benoît Revaz, director of the Swiss Federal Office of Energy, during the Swiss-US Energy Innovation Days 2022. “We are taking in a few months measures that would normally have taken years. But the learning curve is steep, and this does not compensate for what has not been done during the last thirty years, in particular in terms of energy efficiency.”

Accelerating the Rollout

In recent decades, efforts to reduce CO_2 emissions have seemed focused on breakthrough technologies such as ultra-efficient solar panels, clean hydrogen production, tidal turbines, or compressed air energy. These, however, are yet to make a concrete difference. Increasingly, the key to the energy transition seems to lie in societal changes and in an accelerated rollout of existing solutions. “We need both high-tech and low-tech solutions,” said Revaz. “It is important to build platforms for sharing data, of course, but also for sharing experience and best practices. There are still a lot of low-hanging fruits to be picked.”

There are many steps we can take to decrease our carbon footprint, some of which are reasonably easy to implement. For instance, small and medium enterprises could save 30% of the energy consumed in industrial processes by systematically switching off their machines at night and reducing the warm-up phase in the morning, according to Revaz. Other steps require a new way of thinking. For instance, companies are increasingly looking at producing their own electricity, incentivized by the ever decreasing price of solar panels and the expected high energy prices in the near future.

Modeling Our Energy Future

One general challenge is to successfully integrate new technologies and approaches into existing energy systems, from the smallest scale of a single company to city districts and international networks.

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The complexity of energy systems makes it hard to compare scenarios and identify the best course of action. Should a city invest in photovoltaics or in district heating? Launch efficiency campaigns or create incentives for renewable energy? What could be the impact of electrical vehicles used as decentralized storage units in the electricity grid? One key approach to answering such questions is to simulate concrete energy systems at the individual, regional, national, or even international level, in order to help decision makers discuss and evaluate alternative scenarios. These models must account for numerous factors, including local supply and demand in increasingly distributed systems, storage of intermittent energy, but also economics, trade, policy, and social acceptance.

With a budget of CHF 21 million, the research consortium EDGE (Enabling Decentralized renewable GEneration), designs and analyzes energy systems for specific regions of Switzerland, taking into account the technical possibilities for generation, distribution, and storage offered by the local landscape. In addition, EDGE considers the differing cultural and economic conditions affecting energy systems in cities, midlands, and the Alps. “Our main goal is to fast-track the growth of decentralized renewable energy sources,” explained EDGE co-director Evelina Trutnevyte from the University of Geneva. “To find out how to move faster, you must also understand the legal, political, and societal aspects. This is why around a third of our team comes from the social sciences, with political science, economics, or management. Changing the way we produce, distribute, commercialize, consume, and govern energy is intrinsically interdisciplinary.”

EDGE is only one of several large projects developing simulations of energy systems recently selected for funding by the Swiss Federal Office of Energy’s program SWEET (SWiss Energy research for the Energy Transition). Other research consortia focus on heating and cooling (DeCarbCH), long term resilience (SURE), and planning tools for multi-energy systems (PATHFNDR).

Simulations are also visible in the startup scene.

Recently-created Swiss companies **(see page 14-15)** are commercializing modeling tools to evaluate the potential of building renovations, simulate photovoltaic farms in the Alps, design district heating networks, and create digital twins of cities to explore renewable energy strategies.

The Virtual Power Plant

Large operators such as the Swiss Federal Railways (SBB) are also reaping the benefits of smarter energy management. In order to reduce load on the grid, they are using software to track in real time the electricity needs of all running trains, and anticipate peaks in demand. These occur regularly, as the synchronized national timetable has many trains leave transport hubs every half hour, causing power consumption to jump up or down by more than a third. In case of a surge, the system sends a signal to all the trains to reduce heating in the wagons for a few minutes. Future developments in the system will include an automatic reduction of the trains’ acceleration and the use of onboard batteries for additional fine-tuning.

Such a “virtual power plant”, as described by SBB’s Markus Halder, avoids investing heavily in additional production capacity—namely new power plants—for the relatively rare moments of a surge. “This approach could also prove very useful to deal with the increasing impact of fluctuating production on the network, linked to having more intermittent renewable sources,” he explained. “Networks must become active and more resilient.” Such efficiencies could also help curb energy usage in the long run; left unchecked, the peak power consumption of the national rail network could grow by 40% by 2030.

Buildings are another major consumer of energy— around 45% of total consumption— and are responsible for a third of the total CO_2 emissions in Switzerland. In this domain too, modeling can help chart a path toward decarbonization. For instance, the real estate consulting firm Wüest Partner has developed a model for estimating the energy demand and carbon footprints of building portfolios. The model has been used for over a million properties across Switzerland and

Europe, according to Sergey Arzoyan, an energy consultant for the company. Using comprehensive building data along with on-site inspections to model energy demand, the model designs CO_2 reduction paths, provides financial planning, and analyzes risks such as new regulation or changes in the prices of energy and carbon taxes.

The Demand for Data

The growing importance of computer simulation, modeling, and monitoring makes the availability of high-quality data a crucial element in accelerating decarbonization. It also generates numerous business opportunities for services such as data creation, access, brokerage, analytics, and consulting. In the US, data providers such as Atlas Public Policy sell access to updated information such as current and expected fuel prices, national and regional changes in public policy, or funding programs for renovations.

Collecting data can be challenging, however. Some data, for example, the energy consumption of a single building, can be sensitive. To minimize the risk of privacy leaks and comply with data protection regulations such as the European GDPR, researchers are developing new methods that can aggregate the data of dozens of houses, explained Marco Miotti of Stanford University.

Still, homeowners might be hesitant to share their energy data, so some companies are counting on incentives. The US company Via Science is using blockchain technologies to represent such data in anonymous tokens that can be traded, generating financial rewards to homeowners. “Most utilities process only historical data for billing and maintenance purposes, without using real-time data for more advanced analyses,” explained Ray Neubauer of Via Science’s Swiss office in Zug. “Our system connects private consumers to companies which want to purchase data insights, without compromising data privacy.”

The growing importance of data and modeling makes the energy transition even more interdisciplinary. It also calls for making sure that professional training rapidly integrates the many aspects of digitalization, from data science to data privacy.

Overcoming Inertias

A Conversation with Marilyne Andersen

We have the technology to reduce the carbon footprint of our buildings, but it is still too rarely integrated into the fragmented construction sector, says Marilyne Andersen, a professor of sustainable construction at EPFL. "Adopting truly innovative ways of working and living is the only way to effectively reduce our environmental footprint," she says.

Are we on track to decarbonize the built environment?

Not at all. We might have ten years to reverse the trend. This pressure reveals the downsides of our usual decision-making processes, which involves multiple loops and consensus building. In my view, such processes cease to work in a crisis situation, especially when the overarching issue—climate change—has been neglected for decades.

The built environment is known to be a huge contributor to our total energy use and our carbon footprint—estimates are around 35-45%. It is even larger if you include what is indirectly associated with how and where we live, such as commuting, and the moving of goods or construction materials.

We now know pretty well how to reduce the operative energy needed, for instance, for heating, cooling, and lighting. This implies that the embodied energy necessary for the construction materials, the appliances, and their transportation to the site is of growing importance in the total footprint of a building. Optimizing a single aspect such as heat insulation can prove counterproductive when you consider the whole picture that includes gray energy.

What technological advances would be needed to improve the carbon footprint of housing?

We need a paradigm shift to get away from seeing buildings in isolation and consider them instead as part of the larger

"We need to design buildings that are more flexible for different uses, spread over a century or longer."

urban fabric, which is a shared resource. We need to anticipate repurposing existing buildings, whether through renovation or by reusing their components elsewhere. Any waste represents a loss of invested carbon, and even recycling of construction materials means downcycling them into material of less value. We need to design buildings that are more flexible for different uses, spread over a century or longer, and anticipate their end of life or disassembly.

Many new buildings do not use all the available innovations to lower their footprint. Are we underestimating soft factors such as politics, industry habits, or public acceptance?

The problem of inertia is definitely acute. The construction industry has not yet integrated all the available know-how into the building processes. The main reason may be the high fragmentation of the construction sector. Many disciplines and work sectors are involved, each of them with their own standards and procedures, and with a lot of liability strings towards the other providers. This discourages risk taking, which is necessary when you want to change the way you work.

In the end, innovation is often perceived as a problem more than as a solution, and providers are often one step behind what would be possible. A heating company may propose a thermostat with a digital display, but few will install a full smart heating solution that, for instance, includes weather forecasts. An issue is that many professionals—and building users—may not be fully aware of what is possible or may have too little incentive to choose the innovative route.

Of course, it is normal that research done at universities stays ahead of the industry; this is our mission. But one hopes that the market would take over innovations whose proof of concept has been done. It is often not the case in the construction industry.

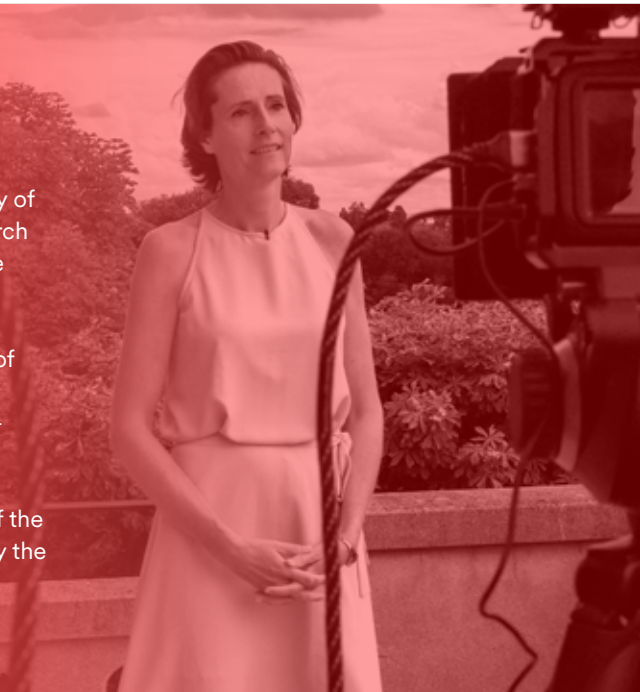
Your research involves "living labs" to test new ways of living and working. What are you hoping to learn?

One goal is to raise awareness about how we can reduce our footprint without sacrificing comfort or well-being. We would like to engage people more intensively in their energy consumption. Until recently, energy was so cheap that most of us would not really look carefully at the invoices from utilities.

It is still unclear what are the biggest acceptance challenges when it comes to changing our energy habits. Opening a window during a hot summer day makes sense if the goal is to feel a bit cooler from the draft, but not if it is to prevent the building from heating. We also want to study how to make a workplace that both has a smaller footprint and is still attractive. The adoption of truly innovative ways of working and living together is a challenge. It remains nevertheless the only way to effectively reduce our environmental footprint.

Between Data and Design

Marilyne Andersen's research lies at the interface between science, engineering, and architectural design. The director of the Laboratory of Integrated Performance in Design at EPFL currently leads the research consortium SWICE (Sustainable Wellbeing for the Individual and the Collectivity in the Energy transition). The eight-year, CHF 22-million program studies how to adapt buildings and urban environments to induce lasting behavioral changes and reduce the carbon footprint of living and working. The scientists will test new research hypotheses in realistic settings, in particular in so-called living labs based on co-creation approaches. Marilyne Andersen is professor of sustainable construction technologies at EPFL, acts as academic director of the Smart Living Lab in Fribourg, and leads the Academic Committee of the Holcim Foundation for Sustainable Construction, created in 2003 by the Swiss cement manufacturer.



Three Trends in Cleantech

1) Solar PV: From Agriculture to the Alps

The increasing demand for photovoltaic modules in 2022 has pushed up their price, but not enough to counteract its steady decline in recent years, which has made them an attractive choice for an increasingly wide range of applications.

Several Swiss startups are active in agro-voltaics—the integration of solar panels into farming infrastructure. Voltiris's system, installed in commercial greenhouses, reflects part of the sunlight to a solar module, letting other parts of the spectrum pass through to the plants below. The system can be customized to let through the wavelengths that are most beneficial to a particular crop, while automatically orienting itself towards the sun to maximize reflection to the photovoltaic module. This could help reduce the carbon footprint of vegetable production in greenhouses, whose heating remains very energy intensive. Another startup, Insolight, is replacing plastic tunnels for raspberries with solar roofs that can be made more or less transparent as required, in order to optimize the plants' growth. The company is testing pilot projects in collaboration with a Swiss electricity utility. Such new agronomic tools create an additional revenue source for farmers: electricity production.

Another trend in Swiss solar is the move towards the mountains. Solar panels installed at high altitude could play an important role in providing renewable electricity in winter, when they get more sunlight than at low altitude: they lie above the cloud layer, the thin atmosphere lets more light through, and snow reflects it. In addition, photovoltaic cells work better at lower temperature, and steep slopes require less surface area per panel. Altogether, an alpine solar farm can produce up to three times more electricity than one in a low altitude city. A new project proposes to create the largest solar farm in the Alps on a pasture 2300 meters (7500 feet) above sea level, above the village of Grengiols in Valais. It would be comparable to the largest hydroelectric power

plant in the country in Bieudron, producing roughly the same amount of electricity, 2000 GWh per year (enough to power nearly 450,000 Swiss households) and covering five km^2, a little more than the dam lake feeding the Bieudron plant. If constructed, the solar farm would increase Switzerland's national electricity production by three percent.

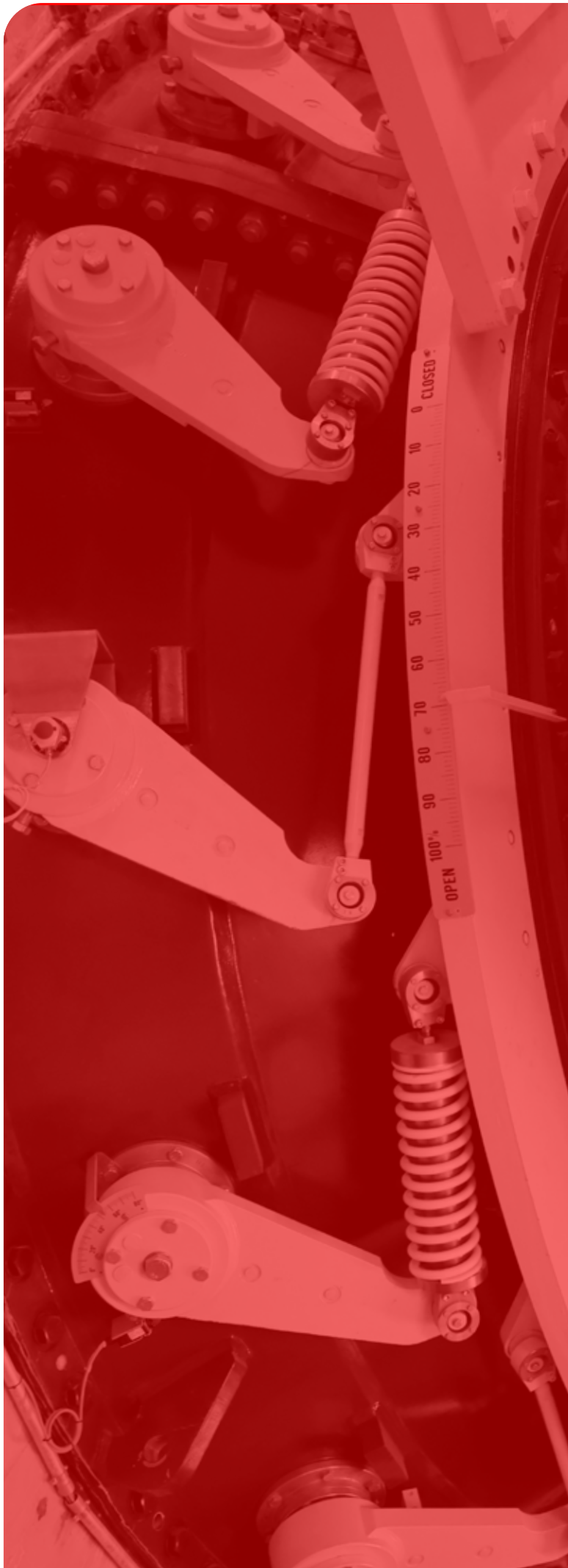
2) Supercritical Geothermal: Energy beneath our Feet

Warming and cooling a building using a heat pump is relatively straightforward. While it relies on the same principle, geothermal energy is much trickier. Generating electricity from geothermal energy means accessing sources of water at more than 150°C (300°F), found hundreds or thousands of meters below the earth's surface, which comes with significant challenges. Geothermal power has suffered setbacks in recent decades, following several small earthquakes triggered by pilot projects in Switzerland, the US, and South Korea.

A new technique called supercritical geothermal could mitigate such risks while allowing for much greater power generation, according to US company Altarocks. This requires reaching very deep hot water sources at temperatures above 370°C (700°F) and under a pressure of 220 atmospheres. Under these conditions, water enters a supercritical state that can hold much more energy than regular water or steam. A pilot project in Oregon is hoping to demonstrate proof of concept by 2025. Another company, Geothermic Solution, is exploring participatory financing for its large-scale geothermal projects by blockchain-based tokenization, using a smart contract on the blockchain to certify financial participation.

3) EVs Recharging the Grid

Only a small percentage of electrical vehicles currently on the market are capable of bidirectional charging, meaning that they can provide electrical current to the power grid (V2G for "vehicle-to-grid") or to a building (V2B). Expanding this technology would open up a massive storage capacity, helping to stabilize the grid in case of intermittent renewable electricity production or of an outage. This would also help autonomous houses have sufficient energy reserves—one fully charged small electrical car can provide 60 kWh, enough to power a Swiss household for four days. Providing storage capacity to the grid could earn vehicle owners revenues of several thousand dollars per quarter, according to Fermata Energy, a US company developing V2X ("vehicle-to-everything") solutions. This payout is related to the premium price currently offered by grid utilities for additional power available at moments of peak demand. In Switzerland, the consortium V2X Suisse is launching a pilot project with 50 bidirectional electrical vehicles in collaboration with the carsharing cooperative Mobility.



Spotlight on Swiss Startups

How New Companies Are Digitalizing the Energy Transition

Monitoring Smart Electric Grids

Zaphiro Technologies (Lausanne, 2017)

Electric grids have to integrate power sources that are increasingly decentralized and intermittent, and must prepare to include more distributed storage units. The networks must become more reactive in order to ensure grid stability and avoid blackouts. Precise monitoring of the state of the grid is necessary to anticipate demand surges, quickly locate disruptions, and optimize the planning of maintenance operations. EPFL spin-off Zaphiro has developed high-speed sensors to monitor medium voltage distribution networks. Installing sensors on 10-20% of the network provides full-grid visibility, according to the company. Launched in 2017, it has deployed its technology for twelve clients in seven countries, including China and the US.

Simulating Buildings

Scandens (Zurich, 2021)

Scandens develops tools to evaluate and reduce the climate impact of buildings. Their platform helps choose the best renovation strategy to reduce a structure's environmental impact, such as upgrading the heating system, improving thermal isolation, or installing PV panels. Using site-specific data, including local weather, energy prices, precise 3D models of buildings, and the availability of renewable energy, the model determines the most resource-effective path to optimize a building toward the 1.5°C climate target. Their model also provides risk analysis by integrating the expected effects of a change in regulation or the evolution of carbon certificate prices. The company, founded in Zurich in 2021, is preparing for market entry in early 2023. Its target clients are owners of real estate portfolios.

Creating Digital Twins of Cities

Enersis (Bern, 2011)

The company Enersis creates digital energy models of companies, cities, or regions. These models help monitor energy consumption and CO2 emissions, while identifying opportunities for renewable production and efficiency measures. The platform also simulates the electrical distribution grid to anticipate the impact of additional decentralized sources or storage units, such as electrical vehicles. The dashboard helps plan decarbonisation scenarios and provides useful data to help bring stakeholders onboard—an important step for acceptance and implementation. The company, founded in 2011, has grown to 50 employees and is active in Switzerland and Germany

Designing District Heating Networks

Planeto (Geneva, 2022)

Circulating warm water throughout cities is an efficient way to distribute centrally-produced heat from a waste incineration station or power plant. But building underground thermal networks in an urban environment is challenging and expensive. The upfront cost is significant, requiring careful planning and the forecasting of energy demands. A 2022 spin-off from the University of Geneva, Planeto, is developing a software platform to simulate urban heating networks, automate their design, and anticipate future energy consumption. The model includes building data, energy demand models, as well as financials.

Planning Alpine Solar Farms

Sunwell (Lausanne, 2020)

Solar farms in the Alps get more sunlight in winter than installations at lower altitude. They could contribute significantly to renewable electricity production in winter, when demand is highest. But the planning of such projects is difficult, due to mountain ranges' complex topography, the accumulation of snow, and exposure to wind. EPFL spin-off Sunwell has designed a software platform to help overcome these challenges. Their model integrates local weather conditions and optimizes the placement of the panels, their spacing, and their orientation in order to maximize production while reducing the impact of snowpack and wind. The company, founded in 2020, has provided expert advice on alpine solar projects in various settings, including on dam walls and on the surface of reservoirs.

Conclusions

It has become increasingly clear in recent years that the energy transition is long overdue. In the face of such an overwhelming challenge, it might be tempting to put our faith in a few big technologies to save us. In reality, however, the energy transition will be much more of a patchwork—and this isn't a bad thing. There is no one-size-fits-all solution to sustainability—even in a country the size of Switzerland, there are vast local and regional differences in possibilities for renewable generation and storage. Only by taking advantage of the opportunities offered by such differences will we be able to transform our energy systems for a more sustainable future.

In the realm of ideas, diversity is also a source of strength. Finding solutions to the challenges we are facing requires creativity. International, interdisciplinary collaboration can expose us to new ideas, help us take our own less for granted, and spur the sort of out-of-the-box thinking and innovation that we desperately need. Importantly, this innovation isn't limited to technical breakthroughs—we need to think just as much about how we relate to the energy we consume, and how we can best use the methods and resources we already have to live more sustainable lives.

The Swiss US-Energy Innovation Days 2022 offered insights into what our energy future might look like. Indeed, from smart grid management to optimizing energy infrastructure, we already have many of the tools we need—it is simply a matter of finding the best way to use them.

Swiss-US Energy Innovation Days

The Swiss-US Energy Innovation Days is an initiative of the Swiss Federal Office of Energy organized in partnership with Swissnex, with the support of Presence Switzerland. This report was produced by Swissnex in Boston and New York on the basis of the conference.

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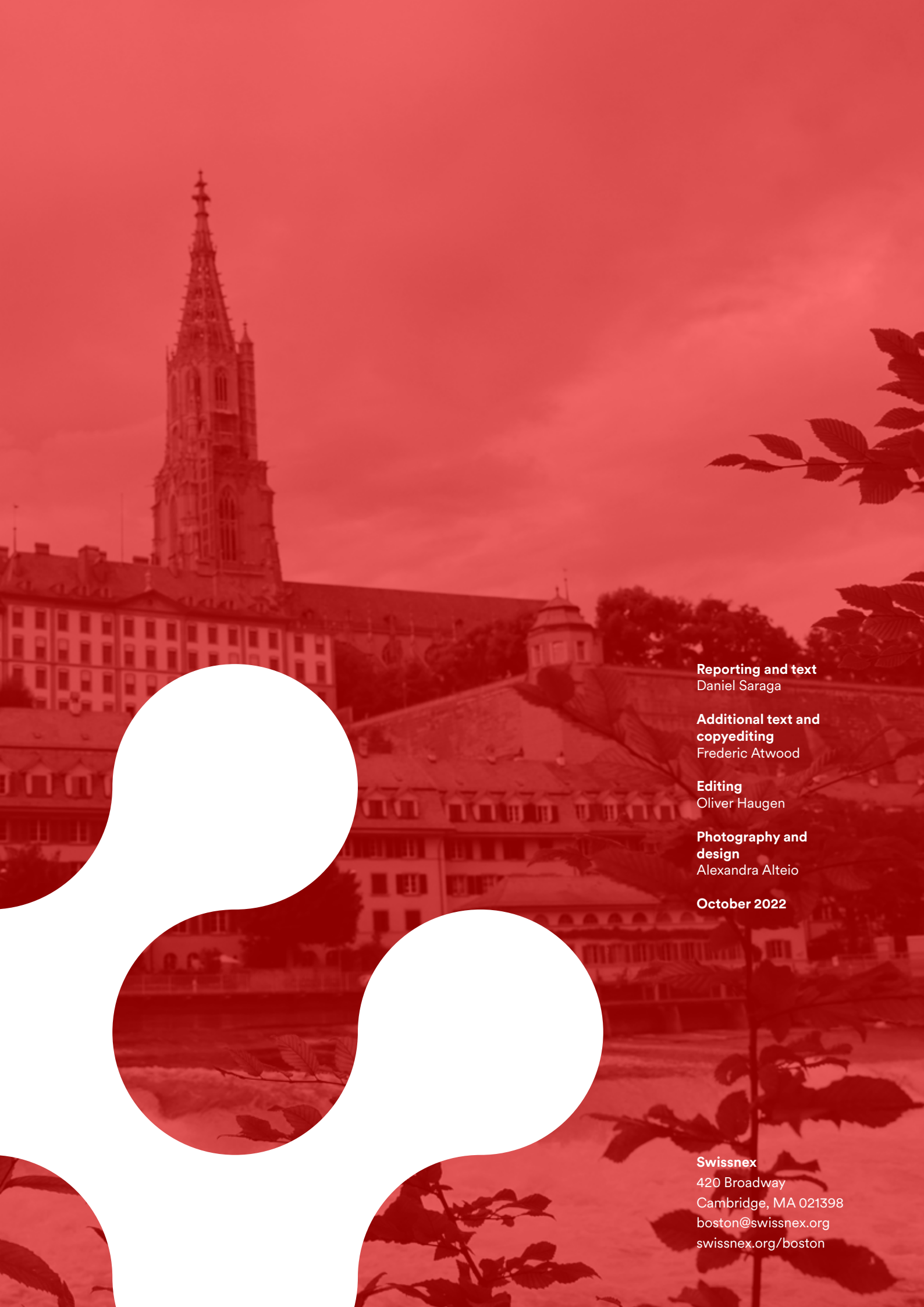

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