VTE VOCATION, TECHNOLOGY & EDUCATION

CASE STUDY

Sustainability and energy transition in Swiss universities of applied sciences

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ABSTRACT

The University of Applied Science (UAS) in Switzerland were reformed around 25 years ago and have since achieved considerable success in education and applied research. At the core of the UAS mission are the challenges of realizing sustainability in the industrial context and determining how to tackle the energy transition. This paper presents two examples (residential buildings and consumer products) to demonstrate how the aforementioned challenges are confronted in the UAS. These examples bring the necessity to confront sustainability in a comprehensive and interdisciplinary way. Engineering skills should be complemented with knowledge of integration among the human and technological aspects of a project.

Key words: universities of applied sciences, sustainability, energy transition, new paradigm skills

INTRODUCTION

The University of Applied Science (UAS) in Switzerland were operated in 1995 when the First Federal Act on Universities of Applied Sciences was enacted. In 1998, around 50 professional colleges were merged to form seven regional UAS (Figure 1).

The Federal Council granted approval for the operation of Switzerland's first private UAS (Kalaidos) in 2005 and the operation of the second group of institutions (Les Roches-Gruyère) in 2008. These private UAS are required to meet the same requirements as those imposed on public UAS, but they do not receive public subsidies. In 2005, in addition to being entrusted with overseeing UAS degree programs in engineering, business, and design, the Confederation was given authority over UAS degree programs in the fields of health, social work, and art.

APPLIED RESEARCH IN SWISS UAS

Swiss companies are able to compete in world markets mainly on the merits of high-quality, specialized products and services. Switzerland therefore devotes more funding to research and development than most other countries. In this regard, Swiss UAS are competent research partners for both the private and public sectors. These universities specialize in applied research activities that can benefit Small and Medium Enterprises (SMEs) and that focus on finding rapidly deployable solutions to economic or social issues. The applied research carried out by UAS also plays an important role in the innovation process.

Applied research has elicited growing interest from industrial partners because related projects are generally short, and their results can be rapidly implemented. Research projects are funded directly by industries or by government agencies, such as InnoSuisse.[1]

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Figure 1. The seven public UAS and two private UAS in Switzerland. UAS, University of Applied Science.

APPLIED RESEARCH ON SUSTAINABILITY

Concern for sustainability in the economic, social, and environmental domains of Switzerland has steadily increased. Sustainability in industry is of particular importance because one-third of the total energy produced in the country, for example, is needed for industrial production. This issue is also tightly connected to how the country can transition to a greener mode of operation.

In addressing the abovementioned problems, considerable assistance is solicited from the UAS, which have explored all relevant aspects that encompass not only technological solutions but also managerial, social, economic, and ethical strategies. As schools, the UAS are required to offer equal opportunities as well as diversity and inclusion action plans. For example, SUPStain is a platform for University of Applied Sciences and Arts of Southern Switzerland (SUPSI) students that promotes dialogue on sustainability issues in favor of initiatives that motivate, inspire, and support sustainable project ideas. In this paper, we provide two examples of applied research on sustainability. These initiatives are distinct from each other, but they both demonstrate the adaptability of UAS in different fields.

First example: sustainable residential buildings

Household electricity consumption in Switzerland accounts for a substantial proportion of national demand, that is, 34.36% according to 2021 government data.[2] For this reason, the federal and local governments have encouraged the construction of nearly zero energy buildings (nZEB) buildings,[2] whose core principles are as follows: (1) Reducing the impact of households in terms of electricity consumption. (2) Striking a substantial balance between production and consumption. (3) This balance as achievable only if an annual average is considered

If one considers the local generation (production) of renewable electricity using photovoltaic (PV) cells, the problem lies in the intermittence of such sources, with generation varying at both daily and annual timescales.

On a daily basis, solar irradiation is highest during the day and lowest during the night, but even during the day, more solar energy than required is produced, which means that excess supply can be sold to the grid (green part in Figure 2). During the night, generation is insufficient, driving the need to buy energy from the grid (red part in Figure 2). The gray area in Figure 2 denotes self-consumed energy. If batteries are used in a building (left of Figure 2), then some of the excess energy produced during the day can be stored and reused during the night (yellow area in Figure 2).

Moreover, solar irradiation is abundant during the summer months, but the highest energy consumption occurs primarily in winter.

Figure 3 shows that PV cell-based energy production

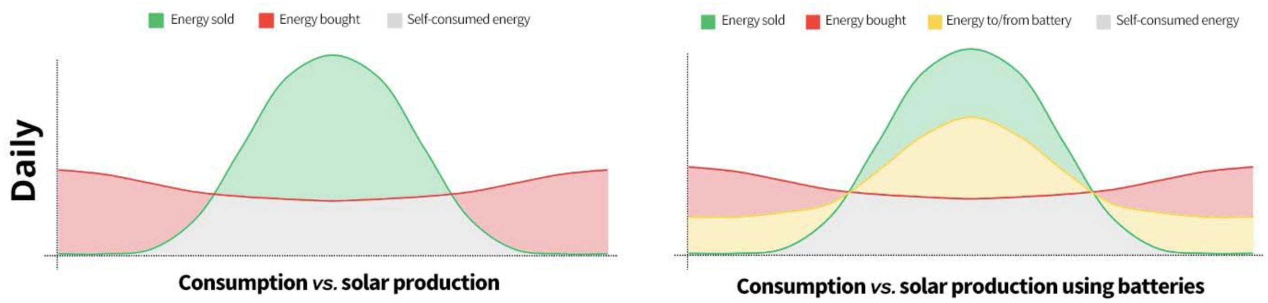

Figure 2. Daily solar energy production and energy consumption without batteries (left) and with battery storage (right).

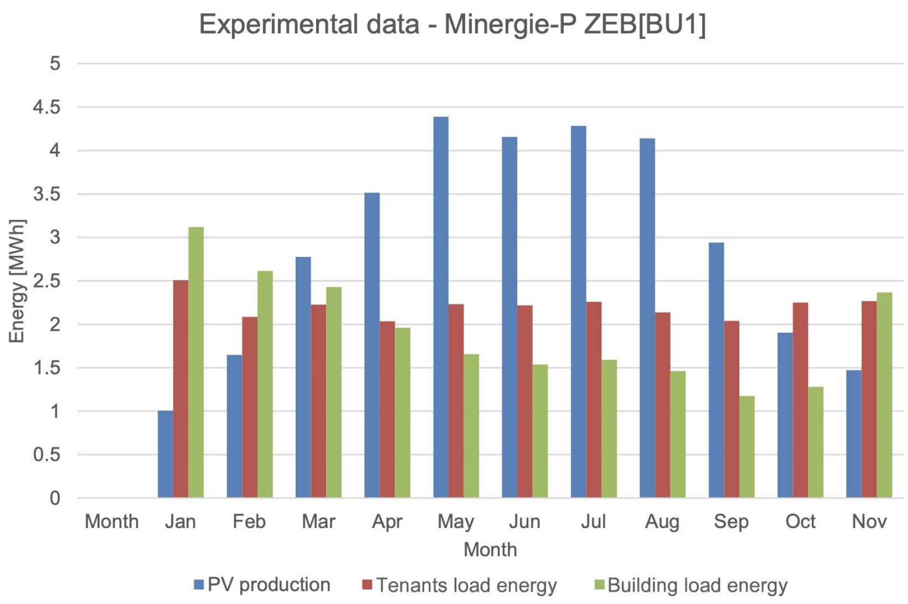

Figure 3. Cumulated energy in terms of production and consumption, monthly resolution for a full operating year. PV, Photovoltaics.

(blue part) is substantially higher during the summer months and much lower during the winter months. Production is insufficient to compensate for the energy load (consumed) in a building (green part) and from its tenants (red part). It is therefore useful to find ways to store the excess energy produced during the summer so that it can be used during the winter. Unfortunately, using batteries for prolonged storage to manage summer-winter cycle is excessively expensive.

Chemical storage solutions can preserve substantial amounts of energy, thereby enabling conversion into electricity when needed (seasonal lag). Figure 4 illustrates consumption versus solar production on a yearly basis. As can be seen, hydrogen is one option for use as a storage chemical and can be produced from water electrolysis. It also serves as an excellent long-term energy storage solution. Currently, the use of hydrogen in households is exclusively experimental.

In this project for the integration of energy storage using the hydrogen as a vector in residential buildings, the stakeholders involved are as follows: (1) System Evergreen is the industrial partner coordinating the engineering and construction of the pilot site.[3] (2) SUPSI Department of Technology Innovation is the academic partner developing the simulation model.[4] This serves as a good opportunity for two bachelor's degree students for their theses and one master's student for his master's thesis. (3) InnoSuisse is the federal agency for innovation that provides the funds for the feasibility study.[1]

This project has proved valuable for all the stakeholders involved. The industrial partner was able to secure a fast response time to organize a research team and elaborate on the modeling of the entire hydrogen system. The UAS involved three students in applied research, thus acquiring industrial and academic knowledge. InnoSuisse acted as a broker funding the involvement of the not-

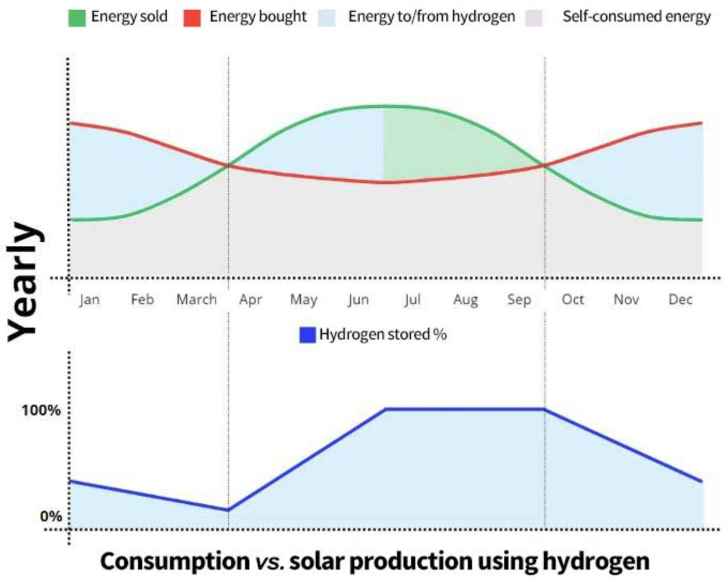

Figure 4. Energy cycle in a household during the year and hydrogen produced and consumed to keep the house independent from the grid.

for-profit UAS. InnoSuisse, as a public government agency, receives the opportunity to extend energy and CO_2 savings to other actors in civil, industrial and commercial sectors.

Second example: consumer production and how to avoid waste from footwear

This example of sustainability research is the result of applied research conducted on successive projects at the UAS SUPSI. It resulted in the publication of two books.[5,6] The results can be applied to any consumer product and the manufacturing, assembly, and delivery of the product. Here, we introduce a shoe or footwear as the product of interest and how its production can dramatically improve the prevention of wastage in materials, water, and energy.

Manufacturing has evolved from craft production to mass production and mass customization. In Figure 5, the X-axis represents product variety, while the Y-axis indicates product volume. The figure traces the evolution of well-known industrial revolutions, starting from craft production until the invention of steam power, which enabled a considerable increase in production volumes. Relevant technologies ranged from textile machines to cars, which advanced mass production according to the principles elaborated by Henry Ford. Mass production reduced the costs of manufacturing and assembly, but the variety of products significantly declined. The problems of mass production were subsequently overcome through the introduction of computers and electronics, which cleared the way for the more flexible production of diverse goods. For example, cars can be manufactured in different colors or with four or two doors all on the same production line. All products are designed, made, assembled, and delivered to shops and then, hopefully, sold. We say "hopefully" because not all products that are manufactured, delivered, and stocked in a shop will be sold. Many will remain unsold. For the footwear industry, a data analysis confirmed that 20% of footwear are unsold (the percentage for clothes and dresses is even higher at 40%),[5] because mass production is underlain only by approximate knowledge of the size of a market, the time to market, and actual customer specifications. These approximations are inevitable because the customer is at the end of the value chain only when products occupy shelves (Figure 6).

The 5th Industrial Revolution is based on a new paradigm: position the customer to the beginning of the value chain before products are even made.[7,8] If the customer can see or touch their prospective purchase—in this case, a pair of shoes—then they can choose certain components, colors, or materials and, most importantly, have their feet measured exactly so that the shoes are manufactured according to these measurements. Correspondingly, only the shoes that have already been bought will need to be made—this translates to the avoidance of a potential 20% of unsold shoes.

Two aspects came together to facilitate this paradigm change: (1) The digitalization of manufacturing and production after the 1950s. (2) The change in relationship between the producer and the customer, which gave rise to the concept of the "prosumer"—a synergy between a producer and a consumer who takes a

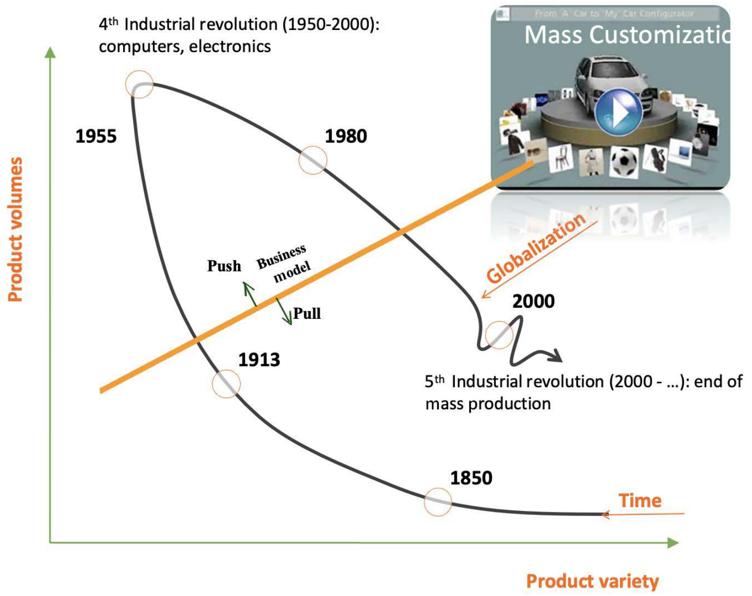

Figure 5. Evolution and involution of production paradigms on product variety versus product volume.

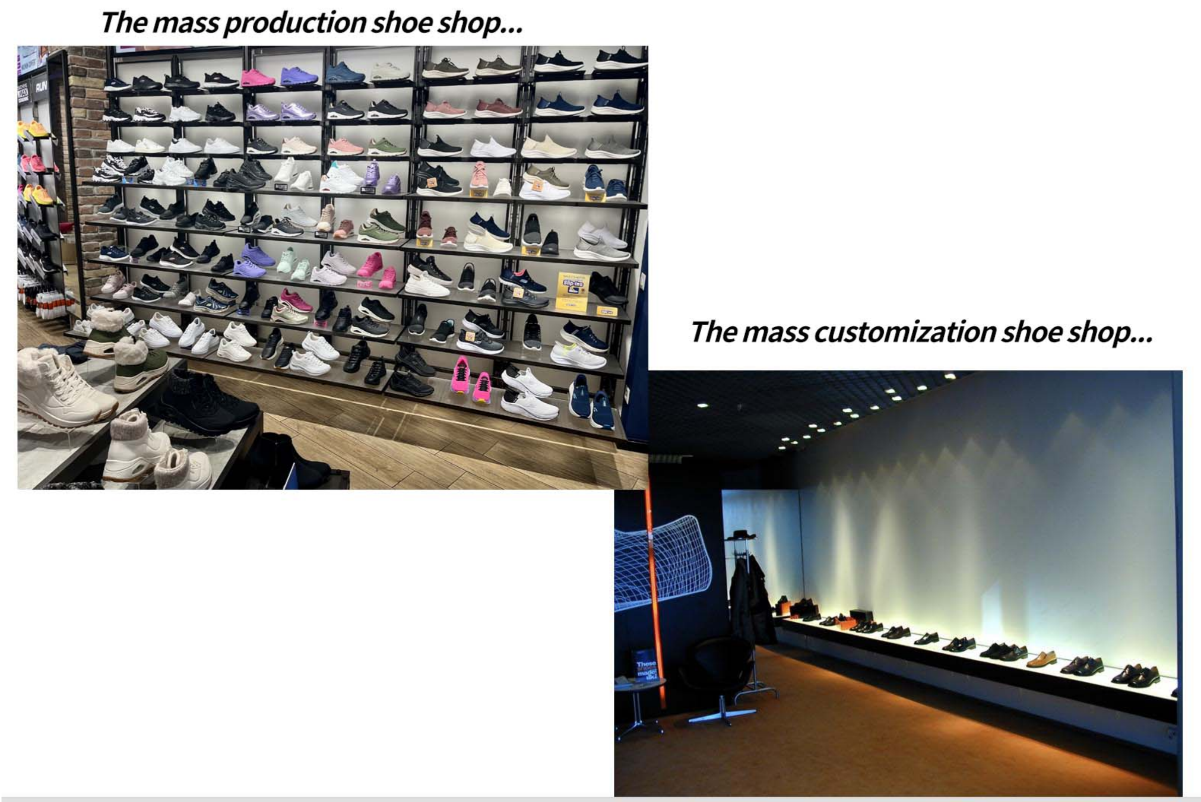

Figure 6. Different shoe shop configurations under the mass production and mass customization paradigms.

more active role in the product value chain.

Against this backdrop, a newly emerging business concept is mass customization, which still involves production in large quantities, as with mass production, but with a focus on the customer and not only on the market. In this paradigm shift from mass production to mass customization, but the goals are also to produce only: "what is necessary", "when it is necessary", and "to customer specifications".

Relevant skills are also changing, thereby increasing the importance of vocation, technology, and education.[8] One should now develop not only the basic skills of cutting leather, stitching and glueing, and polishing, among others, but also competencies that connect the consumer or prosumer to the producer. These skills are taught in UAS SUPSI. Additionally, the reduced wastage made possible by the paradigm shift from mass production to mass customization reinforces sustainability because it adds the production of only what is sustainable to the first three points above.

In courses on engineering as well as design and management, UAS students learn how to integrate practical and theoretical skills, along with the importance of understanding the needs of customers and relating them to the reality of production in a company and an entire supply chain.

CONCLUSION AND COMMENTS

Society is moving toward a more conscious attitude regarding sustainability. The education system must adapt and prepare young individuals to enter the labor market with the necessary knowledge and adequate skills to support paradigm changes. We have presented two examples of these transformations. One centers on the energy transition in the residential context, with the discussion encompassing renewable energy technologies that include hydrogen as a storage medium that enables grid independence for an entire year. The other revolves around consumer products and the entire supply chain from design and manufacturing to distribution and selling, with the description including the shift from mass production to mass customization. Both these examples show that the skills needed in the construction and manufacturing sectors must be adapted and that the Swiss UAS must mold students with excellent technology skills as well as a broader understanding of the social, economic, and environmental aspects of sustainability.

The skills adapted for sustainability issues have been developed from a bottom–up approach in collaboration with experts in the field and market movers. However, it is equally necessary to now move to a more systematic framework that considers a synergetic approach to developing the required skills.[9] Sustainable development is an expansive sector whose principles are applicable in many different yet complementary fields.[10] Therefore, sustainable development can be taught as part of specific training in another related branch. For the two examples described in this paper, the competencies required may differ: one focuses more on renewable energies and the integration of technologies, while the other requires basic skills of production and management integrated with, for example, life cycle assessment. Such a framework will be the focus of our research for implementation in the Swiss UAS.

DECLARATIONS

Author contributions

Boër C: Methodology: Writing original draft. The author has read and approved the final version.

Ethics approval

Not applicable.

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Conflict of interest

Claudio Boër is the Editorial Board Member of the journal. The article was subject to the journal's standard procedures, with peer review handled independently of the editor and the affiliated research groups.

Data availability statement

No additional data.

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