



# SWEET Call 1-2020: SWEET EDGE

## Deliverable report

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## Summary

Workpackage 5 (WP5) of the SWEET EDGE project focuses on identifying, testing, and demonstrating solutions for the energy transition within the Swiss midlands, using Wittenbach (SG) as a representative municipality. WP5 acts as a living lab to detect implementation challenges and integrate known solutions into the broader scope of the project. This report outlines the individual components of WP5 including their integration within the work package and their significance in the context of the EDGE project.

Significant potential for Agri-PV in Switzerland has been identified, especially within the midlands, thus increasing focus on this technology for the energy transition in Switzerland. Planning of an Agri-PV unit at the ZHAW Grüental campus is underway as is an evaluation of additional projects in the canton of Zurich, aiming to demonstrate the benefits of dual land use for agriculture and PV generation.

A campaign targeting the 10 % roofs with the highest potential yield from PV has contributed to a substantial increase in PV capacity. Planning for medium-scale municipal PV projects is ongoing and additional projects are identified and analysed in collaboration with ZHAW. A general analysis for factors that influence the speed of PV extension in Swiss municipalities is in the making.

The planned biogas plant in Wittenbach incorporates innovative energy-efficient measures. The combination with wood pyrolysis had to be reconsidered due to operational characteristics, focusing instead on optimizing biogas use, optimal heat sourcing, and exploring carbon capture and usage solutions.

A combination of theoretical analysis, practical considerations, and feedback from local stakeholders revealed limited benefits for implementing microgrids in Wittenbach. Our reports detail why a shift towards smart grid planning to enhance alignment between generation and consumption features a better cost-benefit ratio.

The transition to electric mobility is important for the decarbonisation of the sector and it also enables local sourcing of its energy needs. This transition is improved through workshops and data-driven planning for charging infrastructure in collaboration with ETHZ-P and EPFL-H. Further goals to increase efficiency and sufficiency in the mobility sector of Wittenbach were discussed with local politicians.

WP5 encompasses several sub-projects, which aim to analyse, pilot, and demonstrate paths to fast-track the energy transition in the Swiss midlands. Special focus is on quick growth of decentralized renewable generation and its integration in the Swiss energy system. A vital aspect of WP5, as a pilot and demonstration project, is its grounding in real-world applications, which inherently leads to additional challenges and causes for delays, and dependencies on decisions by local stakeholders and consortium partners. In addition, sub-projects had to be adapted to new political, economic, and research developments. These obstacles might lead to slower progress or forced project redefinitions of contents in certain cases, but they are an important aspect of WP5. Such real-world checks help to come up with solutions that are more practicable and broadly applicable, thus helping with the energy transformation in Switzerland.



## 1 Introduction

Work package 5 serves as a living lab on the one hand to identify problems in the implementation of the energy transition and on the other hand to test possible solutions in the Swiss midlands. Identified problems flow into the other work packages and already known solutions are implemented. For a variety of reasons, Wittenbach (SG) was chosen as the focus of the work package. The EDGE survey confirmed that Wittenbach is a typical municipality of the Swiss midlands.

This document is intended to summarize the current state and most important learnings of the work package and present a set of proposed content-related improvements.

## 2 Deliverable content

Our goal in WP5 is to create an energy system that will be standard for Swiss Midland-municipalities with the energy transition in more advanced stages. Sub-projects were setup to create and deploy solutions to get to this state and to tackle challenges that will arise in such a state.

The activities conducted in WP5 focus on those sectors and technologies that are deemed to be the most relevant for the energy transformation in the Swiss context of the midlands (see Figure 1 for an overview). For new additions of renewable generation capacity, PV has by far the biggest potential in terms of energy generation. Wind energy, energy from biomass technologies, and geothermal are three additional renewable technologies with high relevance for the Swiss midlands. Work in WP5 focuses mainly on PV and biomass applications. While wind turbines are a very valuable technology for the Swiss energy system, the resistance against projects from the local population is usually significant. Because Wittenbach does not have any cantonal eligibility areas for wind, no projects are planned. Power generation with geothermal energy is only in a research and demonstration stage for Switzerland as of now.

Key technologies for heating in Wittenbach are heat pumps and renewably run district heating networks. Wittenbach already has a district heating network and set the target that all buildings source their heating energy either from the district heating network or heat pumps (Energieagentur St. Gallen, 2020). With the development for heat provisioning going in a sensible direction, no further activities are planned regarding this topic. The electrification of the mobility sector is an ongoing development. We are trying to speed up the transition in Wittenbach by engaging in discussions with local politicians and the municipal administration and by providing better planning for the buildout of a charging infrastructure, which is an important factor for uptake of electric cars by residents. Power grids play a crucial role in the energy transition because they enable the electrification on a large scale. Wittenbach does not feature the necessary circumstances to establish a microgrid. After receiving feedback from local stakeholders, we are going to contribute to smarter power grid planning by creating plausible and robust scenarios for the uptake of PV and electric mobility, whose integration constitute a key challenge to distribution grids in the coming years. In general, increases in sufficiency and efficiency are important factors to facilitate the energy transformation. They are therefore taken into specific consideration in all sectors and for all activities.

In the following, the current state and planned activities of the project are summarized, thematically collected for easier reference.

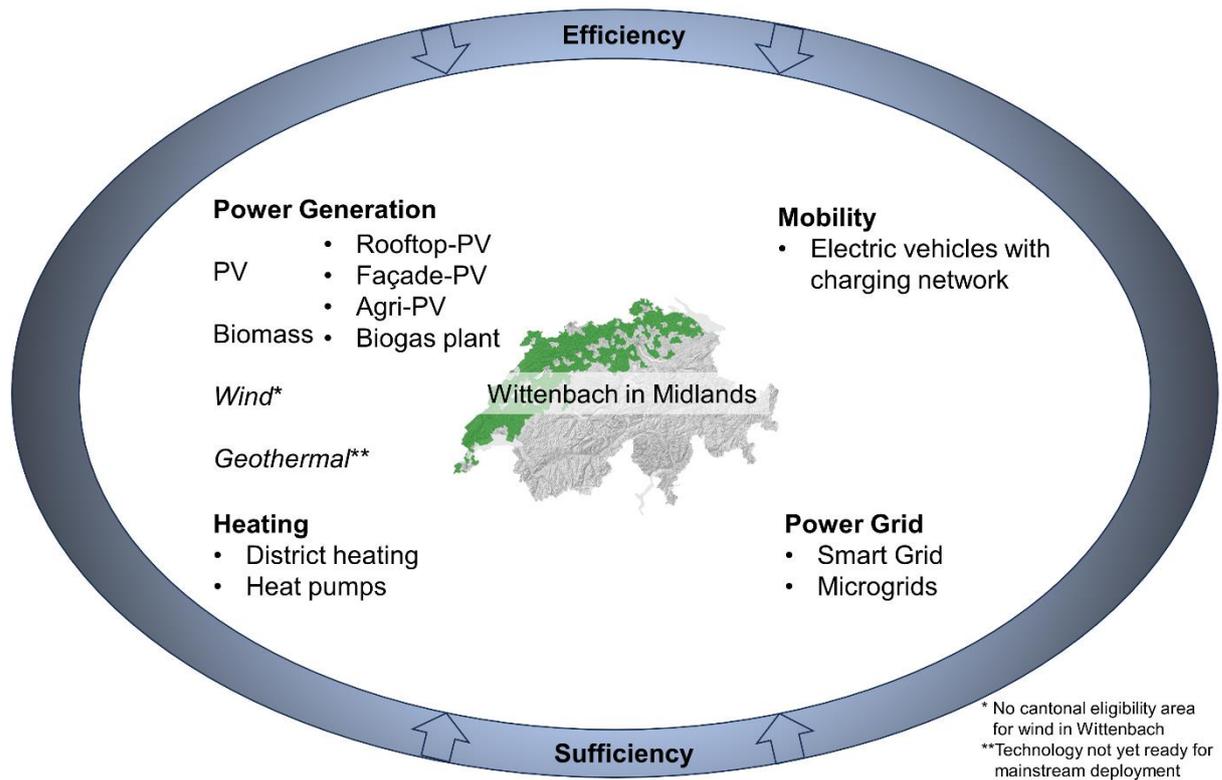


Figure 1. Important topics for energy future of Wittenbach as a municipality in the midlands. The power grid constitutes the important link between generation and consumption, enabling more functions by transforming from passive infrastructure to a modern active distribution grid. Generation technologies wind and geothermal, although generally suitable for the midlands region, are at the moment not in focus in Wittenbach. Efficiency and sufficiency are general developments, which are beneficial for all aspects of the energy transition in the Swiss midlands and elsewhere.

## 2.1 Agri-Photovoltaics

Agri-PV has a significant generation potential for Switzerland as published in our deliverable report D5.12, “Assessing the potential for agri-PV in Swiss agriculture”, using new and improved values for irradiation, which revealed a significantly higher potential than previously thought (Anderegg et al., 2024). The new figures and GIS data have already been incorporated in Nexus-E via the EDGE project. The midlands region with its large share of agricultural land consequentially hosts a large share of the Swiss Agri-PV potential. Land use conflicts are an important challenge for electricity generation infrastructure. Co-usage of land for PV and agriculture promises to be an elegant solution in this regard. Due to its higher winter electricity yield, it is seen as a sensible complement to roof-mounted PV.

In addition to evaluations of Agri-PV projects in Wittenbach, an agri-PV unit will be built on Campus Grüental of ZHAW and additional projects in the canton of Zurich are evaluated.

The planning for the construction of a 2'000 m<sup>2</sup>, 2-axis tracking Agri-PV plant on the Grüental campus in Wädenswil in 2024/25 is progressing well. The experiments with an agricultural focus will be led by the ZHAW research group “Regenerative Agricultural Systems” and financed separately. In addition to plant growth, the control of light input combined with time-optimised electricity production will also be investigated. Electric yield measurements and light control of the system will be part of the EDGE project.

The realisation of at least one Agri-PV pilot plant each in arable land and grassland in the canton of Zurich is newly planned. Assessments have been started with the Canton of Zurich and the Zurich Farmers' Association; however, the outcome is still uncertain. These projects, together with the installation on the Grüental campus, are intended to investigate and demonstrate the advantages of



agri-PV installations outside permanent crops, i.e. existing foil tunnels and greenhouses as shown in the "Feasibility Study Agri-Photovoltaics in Swiss Agriculture" (96% of the power potential for agri-PV is not in combination with permanent crops). If problems arise with the timely realisation of these Agri-PV systems, a report will identify the reasons for the hesitant addition of PV in the Agri-PV sector and recommendations for action will be formulated. Expected results are a field report from 3 to 4 different agri-PV applications (e.g. grassland, arable land with vertical and horizontal systems including irrigation management) as well as energy yield measurements on 3 to 4 realised agri-PV systems. In addition, various evaluations are planned, e.g. on the seasonality of electricity yields, qualitative discussion of the grid connection problem and comparison of tracking and permanently installed agri-PV systems.

In Wittenbach, an investigation of the possible agri-PV potential is planned, especially including thorough consideration of the grid connection problem. There are possible synergies with open questions in the context of our sub-project to fast-track the buildout of PV, specifically with the difficulties of grid connection in rural areas where the electricity grid is comparatively weak.

## **2.2 Rooftop- and Façade-PV**

The project team identified the top 10 % of roofs in terms of potential yearly energy yield in Wittenbach for solar PV. The owners of the associated buildings were subsequently personally contacted with offers of feasibility studies and general help during the planning and procurement phase. As of autumn 2023, this initiative was at least partly responsible for the decision to install new PV systems with an aggregated nominal capacity of 2.6 MWp (9 systems). As a further vector, large projects on municipal infrastructure are planned and discussed with municipal representatives. Examples are a PV roof over a large parking space near the public swimming pool, PV on the roof of the indoor swimming pool, PV on the roof of a retirement home, and the wastewater treatment plant. Other opportunities for PV installations are also actively being evaluated. Current planning includes a PV plant on the roof of the newly to be built biogas plant.

In a collaboration with the group of Prof. Stadelmann (UNIBE), a project was started to analyse the nationwide PV installation data provided by Pronovo. Work is ongoing to identify reasons for exceptionally high installation rates in certain municipalities. The goal of the project is to conduct a data-driven ex-post-analysis to assess the impact of policy decisions, cluster effects, one-off effects, and others to formulate high-impact measures for an acceleration of PV adoption. A summary of the findings and recommendations will be published as a report and/or scientific publication in 2024 (deliverable report D5.15, "Evaluations of Switzerland-wide community-specific PV potential utilization", due Nov. 2024).

## **2.3 Biomass**

### **2.3.1 Biogas Plant**

Biogas production in Switzerland is projected to increase significantly in the near future. The midlands will comprise of a large share of this increase because of the type and intensity of its agriculture. The increase should primarily lead to larger renewable methane production, i.e., feeding the gas into the gas grid. Biogas has an inherent value higher than its pure energy content because of its storability. It should therefore not be used in applications where other energy carriers can easily replace its use. Currently, a vast majority of Swiss biogas plants convert the produced biogas locally into electricity and heat using a CHP. For economic and regulatory reasons, parts of this heat are used in the digester. From an energy system perspective, it is in many cases not ideal to use the biogas directly after production at the same location. The solution presented in our study addresses the desired scenario of biogas plants that directly feed their biogas into the gas network to be used in a temporally and spatially flexible manner (see deliverable Report D5.11, Report on the energy concept of the biogas plant).

The initial plan was to build a biogas plant that is heated via a wood pyrolysis plant. The resulting biochar could have been impregnated with the fermentation slurry, which could possibly produce a high-quality fertiliser. The two processes of biogas fermentation and pyrolysis could have been operated



symbiotically, optimizing energy usage and closing resource cycles. To implement this solution, a market study was conducted on commercially available wood pyrolysis furnaces and CHP units that are able to produce EBC-certifiable biochar in an appropriate output range. In a second step, a study was conducted to find suitable combinations of heating technologies and devices that can cover the heat demand of the digesters all year round. While this is technically possible (albeit far from any optimal operating points), it was found that there are a number of obvious energy measures that should be implemented in a biogas plant with direct gas feed-in (as opposed to electricity-generating plants with a principal heat surplus due to the combined heat and power plant). These measures include heat recuperation of the digestate, waste heat recovery from the gas treatment and heating by means of a heat pump, whereby the digestate storage serves as a heat reservoir. This has the additional advantage of lower temperatures in the digestate storage, thus potentially lower ammonia and greenhouse gas emissions when spreading the digestate (Wild et al, 2024; deliverable report D5.11, "Report on the energy concept of the biogas plant"). By implementing these measures, the digester can be operated without further heating systems. For the case of plants with direct gas feed-in like in Wittenbach, the combination with wood pyrolysis therefore no longer makes sense from an energy perspective. Energetically, it is better if the biochar is produced at a location where the heat produced can also be used. Further, it makes more sense to feed the energetically very high-quality biogas into the grid than to convert it into electricity locally, provided that the infrastructure for gas is available, which is the case in Wittenbach (see Figure 2 for an overview of the biogas concept).

According to current planning, the presented energetic measures will be implemented during the construction of the biogas plant in Wittenbach. The combination of heat recuperation, waste heat utilisation and heat pump heating is innovative and holds a large potential for greatly reducing the self-consumption (gas consumption for fermenter heating) of biogas plants feeding gas into the grid. The project will continue to be closely supported by ZHAW as part of the EDGE project. During the construction of the biogas plant in Wittenbach, care should be taken to ensure that the necessary process variables are collected to validate the energetic model of the plant created as part of EDGE. It is unclear at this stage whether a separate P&D project is necessary for this. The energetic model, which is expected to be validated, should then be made available to the industry in a suitable form - as an easy-to-use tool (planned Report D5.18)

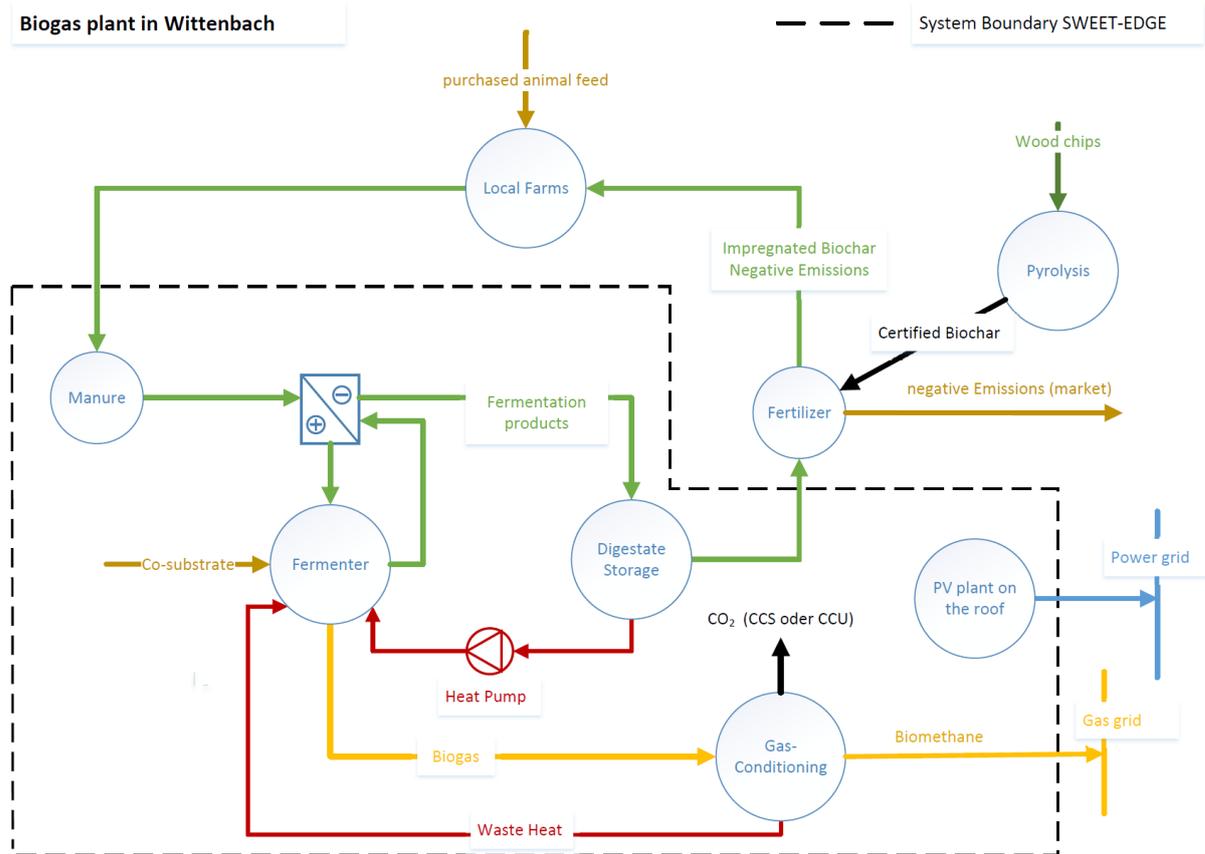


Figure 2. Energy and material flow diagram biogas plant Wittenbach. The biogas plant will consume and deliver electricity to the local grid, inject biogas into the gas grid, emit greenhouse gases that will be caught, and produce fermentation products that could be converted to fertilizer for local use.

### 2.3.2 CCUS with focus on biogas plant

For Switzerland to achieve net-zero or even net-negative emissions, carbon capture and storage is an integral part of the current federal plans. While sufficiency and substitution measures should be prioritized, hard-to-avoid greenhouse gas emissions (estimated by the Swiss Federal Council to amount to a total of 12 Mio. t CO<sub>2</sub>eq/year in 2050) need to be caught with CCS (5 Mio. t CO<sub>2</sub>eq/year) respectively compensated with negative emissions (7 Mio. t CO<sub>2</sub>eq/year). It is therefore of high significance to identify the best applications, locations, and synergies where and how such technologies should be applied. Biogas plants with gas grid feeding are predestined for CO<sub>2</sub> capture, as the CO<sub>2</sub> has to be removed either way, and further purification steps are of acceptable complexity and energy expenditure, depending on the intended utilization.

To gain an overview of the current state and developments in the field of CCUS a detailed literature study and several interviews with industry professionals were conducted. This involves a dissection of the current and projected future material streams, going from producers and production methods to consumers and their specific needs. A market study in the specific context of the planned biogas plant in Wittenbach reveals an economically viable path towards bioenergy with carbon capture and storage (BECCS) by storing the captured CO<sub>2</sub> in recycling concrete (for details, see deliverable report D5.13, "Report on CO<sub>2</sub> utilisation in biogas plants").



### 2.3.3 Related research project biochar with fermentation slurry

The in-depth analysis of the specific situation of Wittenbach resulted in the finding that a wood pyrolysis plant is not an ideal complement for the biogas plant (see above 2.3.1). However, the initial ideas to close resource cycles and make use of synergies between the biogas plant and biochar still make sense. Thus, clarifications are underway to discuss and test the use of biochar in combination with fermentation slurry, as envisaged in the EDGE project proposal. These are however not primarily energy-related issues. Several research groups at ZHAW are currently defining a separate project, including practical trials. The biochar would be purchased from commercial suppliers (e.g. Inega). The EDGE project team will be in close contact and contribute with energy-related expertise if needed.

## 2.4 **Smart Grid & Microgrids**

The formal definition for microgrids includes the ability to be operated independently of a wide-area grid. This formal definition is applied for all our considerations. The clarifications on the implementation of a microgrid in Wittenbach have shown that the central advantages of microgrids in Wittenbach and in Switzerland do generally not come to fruition to a large extent. Some of the main reasons are the reliability, capacity, and wide coverage of the already existing electricity grid, which offers little potential for optimisation in the areas of resilience and transmission losses, and already comprehensively cover Switzerland. A report detailing these findings was created as deliverable D5.14 (“Report on the suitability of microgrids for Switzerland”).

The local temporal alignment of generation and consumption on the other hand is a central issue because it addresses many of the challenges of the energy transition, such as fluctuating decentral generation, additional electricity consumption through mobility, and the provision of heating and cooling. The topic of smart grids is therefore very important for Switzerland, whereby the relevant advantages for the energy system can largely be achieved without the additional costs of a microgrid.

Based on previous experience and feedback from the field, it is planned to use the example of Wittenbach to develop a concept for smart medium- to long-term grid planning for grid connections of photovoltaics and e-mobility, including flexibility aspects. Many components of electricity grids are in operation for at least 40 years, which is why planning should already be done now for the fully decarbonized state. This holds great potential for a higher implementation speed of the energy transition as well as for considerable cost savings.

## 2.5 **Mobility**

Wittenbach considers sufficiency (less trips in vehicles in general) and efficiency (more public transportation) an important aspect of their mobility planning. They implemented measures to achieve these goals (Energieagentur St. Gallen, 2020).

We support the municipality in speeding-up the transition to electric mobility. To this end, a workshop with the relevant political and administrative stakeholders was conducted to make them aware of the scale and speed of the electric mobility transformation as well as to come up with more ambitious internal goals for adoption in Wittenbach. We planned and conducted the workshop in a collaboration with EPFL-H. Feasible measures to support a faster transformation by the municipal administration are better planning of charging stations and EV adoption within the administrative organisation itself. To give data-driven support for planning of charging stations, the general methodology for modelling of EV charging profiles in Switzerland was specifically applied to Wittenbach by ETHZ-P. This involves the convolution of several base profiles (e.g., “residents” or “visitors”), and spatial modelling of visited places of these groups. The model assigns probabilities of a “charging decision” taking place at any given parking based on a mixture of empirical data and heuristic decision making. The model further differentiates between battery sizes, charging speeds, and expected charging state in a probabilistic manner, amongst others. As a result of a week-long simulation, charging demands in Wittenbach are estimated. These results will be shared, explained, and used for further planning activities in collaboration with the administration of Wittenbach.



### 3 Conclusion

WP5 consists of several sub-projects that at times run relatively independently of each other. Their common denominator is the effect and importance on the energy infrastructure of Wittenbach, which is a representative municipality of the midlands' region. While the sub-projects can be temporarily independent during their formation phase, they then form an energy system that is more than just the sum of its parts. Various interdependencies exist once projects are up and running and connected to energy grids.

Results and active participation of other EDGE research groups are incorporated in these sub-projects on a case-by-case basis depending on the topical fit. Naturally, some activities of WP5, as a pilot and demonstration project, are strongly dependent on collaborations with local decision makers and EDGE partners. Apart from being strictly necessary, such collaborations are important to ensure that the project is rooted in what is practically feasible in ordinary Swiss municipalities. As a major disadvantage, progress in such a system is generally slower and unexpected obstacles can always arise and lead to delays. One advantage is that approaches are more sustainable for long-term applicability when there is acceptance from the municipality. A second advantage is that approaches should also work in other Swiss midlands municipalities because the pilot and demonstration project is carried out in a regular municipality without special conditions that would make the energy transition easier than elsewhere.

New political, economic, and research developments are taken into account as much as possible. Examples for such actions are the much stronger focus on Agri-PV as well as the more in-depth analysis of CCUS in the context of the biogas plant in Wittenbach.



## 4 References

Anderegg, D., Jäger, M., Strebel, S., & Rohrer, J. Potenzialabschätzungen für Agri-PV in der Schweizer Landwirtschaft. ZHAW Zürcher Hochschule für Angewandte Wissenschaften. <https://doi.org/10.21256/zhaw-2649>, 2024.

Wild, M., Siegwart, M., Stocker, N., & Rohrer, J. Nachhaltiges Energiekonzept für Biogasanlagen: Fallstudie Wittenbach. ZHAW Zürcher Hochschule für Angewandte Wissenschaften. <https://doi.org/10.21256/zhaw-2648>, 2024.

Energieagentur St. Gallen. (2020). Energiekonzept Wittenbach 2020. [https://www.wittenbach.ch/\\_docn/2802998/200903\\_EK\\_Wittenbache\\_2020\\_ffentlich.pdf](https://www.wittenbach.ch/_docn/2802998/200903_EK_Wittenbache_2020_ffentlich.pdf)