Best practice site visit Fuchstal/Apfeldorf

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Smart Grid in Electric Power Systems (renewable generation, sector coupling,lithium-ion battery storage system,)

- **Location**: Energiezukunft Fuchstal, in Fuchstal (GE)
- **Date:** 2024.03.06
- **Installed Technology**: renewable energy system, smart Grid system windmills, Solar PV Park , powerto heat generation and battery storage system (lithium-ion battery storage system)
- **Operator:** Fuchstal municipality
- **Participants:**

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- Jenő Szécsi

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- Dr. Tamás Miseta
- Dr. Béla Varga

PP3- BSC, Business support Centre L.t.d., Kranj
- Blanka Odlazek

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- Ambrož Bogataj

PP6- CEEO - Center for Energy, Energy Efficiency and Environment:
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- Jasmina Bešić

PP7- ICUK - Innovation Centre of the Usti Region:
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- Matouš Kostomlatský

PP8- ZMO - Oradea Metropolitan Area Intercommunity Development Association
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- Gerhard Schmid
- Thomas Reukauf
- Alexandra Mischke

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PP12- UNS-FTN - University of Novi Sad Faculty of Technical Sciences:

- Dr. Bane Popadić
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- Radivoje Drobnjak
- Milica Bozović

I Energiezukunft Fuchstal EZF 15.10.2024

Introduction

Energiezukunft Fuchstal, Fuchstal (GE): This event, hosted by the municipality of Fuchstal. (established from 2017 and directly owned by the local government of Fuchstal and the citizens), aims to point out the realization of the local energy transition and the partzipationn of citizens. The focus includes building and operating energy and smart infrastructures in Fuchstal supported by local service providors, as well as promoting, developing, and managing innovative projects such as data driven energy management/energy storage/heat supply.

During the visit to Energiezukunft Fuchstal , Mr. Erwin Karg, the Mayor of Fuchstal and Thomas Reukauf the project manager presented the operation of Energiezukunft Fuchstal at the Visitor Center. Energiezukunft Fuchstal is one of the biggest power to heat system operated by a local community in Bavaria.The virtual power plant managing the access the renawable energy system to the wholesale energy market for a local community is one of the first of its kind in Germany.

Visitor Center, Fuchstal (GE)

Smart Grid Components:

Wind turbines, bird monitoring:

- We visited 2 windparks with an installed capacity of 29 MWp, supported by 7 wind turbines (4 in 2016, hub height 149 m, and 3 more in 2024 hub height 166 m)). The total energy generation (4 wind turbines) in 2023 was 24 Mio. kWh , from 31.12.2024 (3 more wind turbines connected to the grid) the generation will increase to 54 Mio. kWh due to the installation of three more wind turbines with a capacity of6 The actual electrical energy demand of Fuchstal is 24 Mio kWh, meaning that the wind turbines generate 2 times the consumption of Fuchstal (4500 inhabitants). We also visited the first Bavarian camera-based detection system that slows down the wind turbines when birds approach, which is installed near the three new wind turbines in the Fuchstal community forest. These two observation towers with a technology platform, each 42 meters high, is equipped with several cameras and uses the latest technology from radar and video systems. The project has been supported by the Bavarian State Office for the Environment and the Weihenstephan-Triesdorf University of Applied Sciences.


FUCHSTAL
Bürgerwindkraft Fuchstal
Windenergieanlage 2
Wussten Sie schon?

wind turbines Fuchstal (GE)

Solar power plant:

- We visited one solar park of Fuchstal with a total output of 750 kWp and an anual generation of 1,3 Mio. kWh.

  This photovoltaic project is one of three photovoltaic projects in Fuchstal with a total installed capacity of 3 MWp. It has been initiated and implemented by the municipality. The municipal photovoltaic system is owned by the municipality of Fuchstal. This means that all income benefits the community of Fuchstal and all its citizens.The system is ecologically improving an area that was used intensively for agriculture before.

solar park Fuchstal (GE), bird monitoring system for new wind park 2024 ,Fuchstal (GE)

Energy Storage Unit:

The energy storage unit has a total output of 5,8 MW and a capacity of 3200 kWh, utilizing Samsung P3 78 Ah lithium-ion batteries with over 11.000 cells. (6,35 kWh/22 Cells). State of Charge (SoC) between 25% and 80% can be realized, it consists of 1 battery container with 45 ft and 2 inverters of 40 ft.

Lithium-ion Battery Energy Storage System (smart power GE))

Power to heat supply:

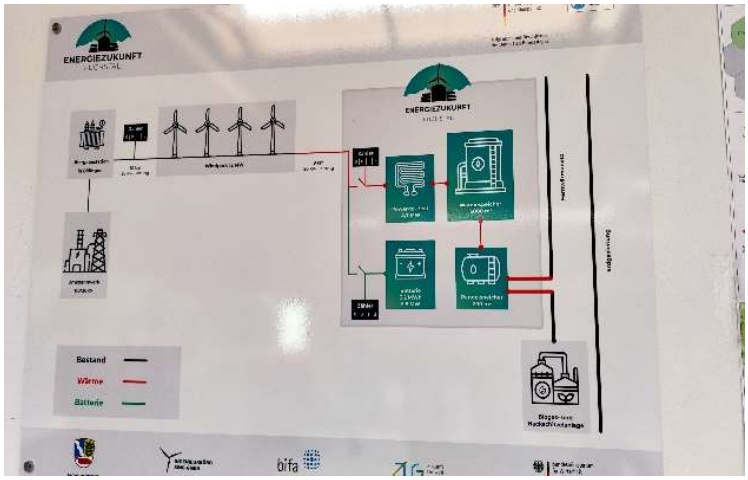
- The main component of the power to heat supply is a heat storage with a volume of 5000 m ³and a pendulum storage of 200 m³. The diameter of the heat storage is 21 m and it height is 16 m , fitting the capacity of 25.000 bathtubs. The heat storage has been built in order to avoid the cuirtailment of electricity generation from the wind and the solar park by generating heat for the local heat supply with its 210 connection points , 13 km of length and 6000 MWh consumption. Heat supply is

supported by a 800 kW bioggas plant and a 1000 kW wood chips plant. There are now also 2 gymnasiums, a 7-group daycare center, the Raiffeisenbank, the sports center and 200 properties in Asch and Leeder. The heating network is built and operated by the municipality of Fuchstal. Fuchstal community buildings receive the heat from the biogas plant through a heat supply contract. The biogas/mass power plants contribution to Fuchstal renewable generation portfolio is 8 Mio. kWh/a.

heat supply Fuchstal (GE)

System Overview:

The Energiezukuft Fuchstal includes a solar power plant with a peak capacity of 2 MW, 7 wind turbines with a total capacity of 29 MW , a 5,8 MW capacity battery storage system with 3.200 MWh, a biogas plant with 900 kW , a woodship plant with 1000 kW, a heat storage of 5000 m³ and a smart center to control these elements, and connecting electrical/heat /data transmission and data collection network components and equipment. It connects to the distributor's medium voltage network (20 kV) and a local heat supply with a length of 12 km. The renewable generation is sold to the wholesale market , Surplus energy is stored and marketed by a virtual power plant. The virtual power plant is optimizing the energy sales to the German wholesalemarket and the supply of Fuchstal.



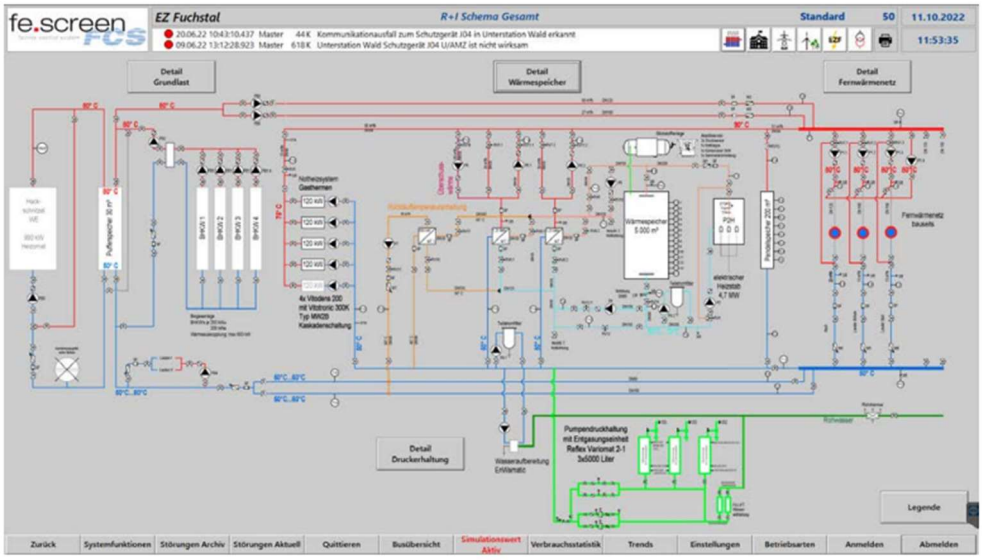
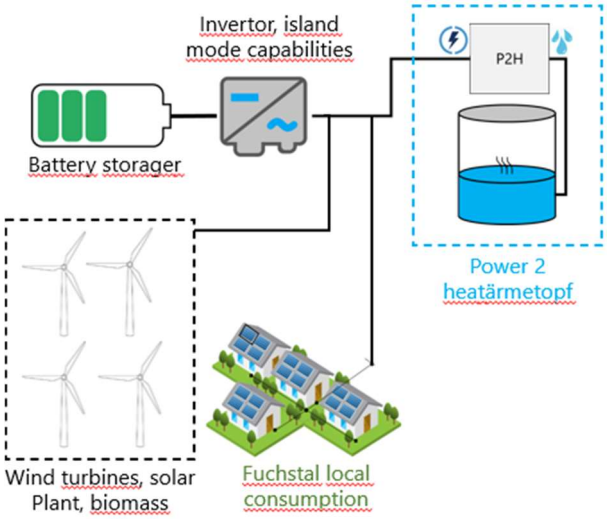


Abb. 4 Startbild, R+I Schema gesamt



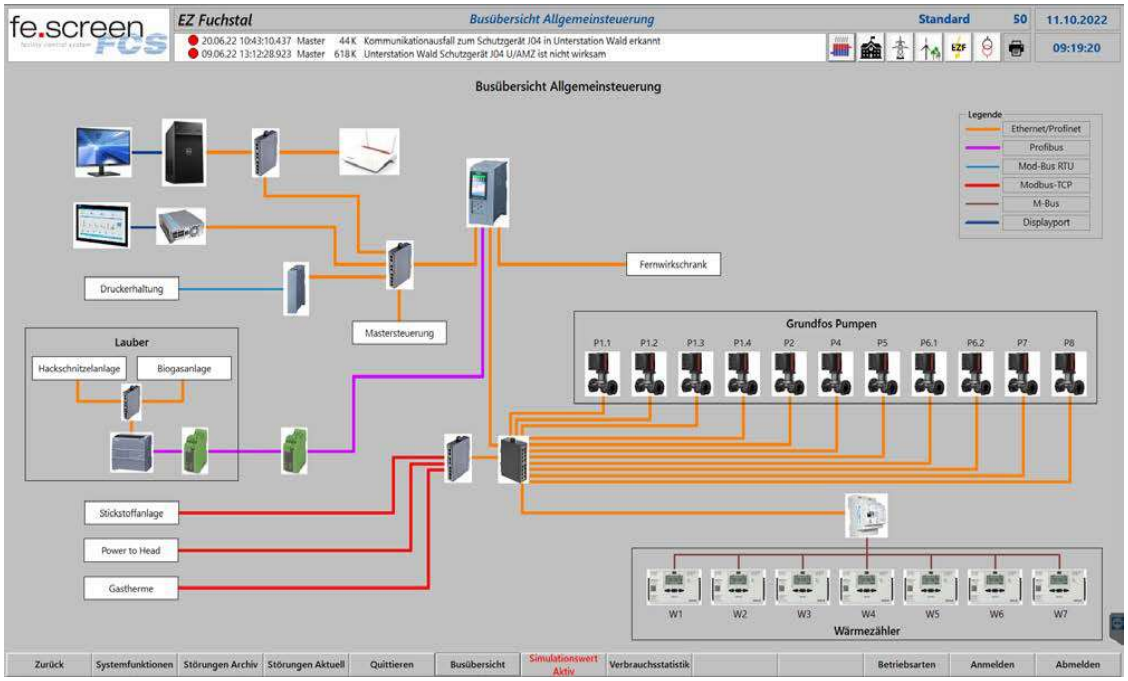
Energiezukunft Fuchstal EZF.y Fuchstal (GE)

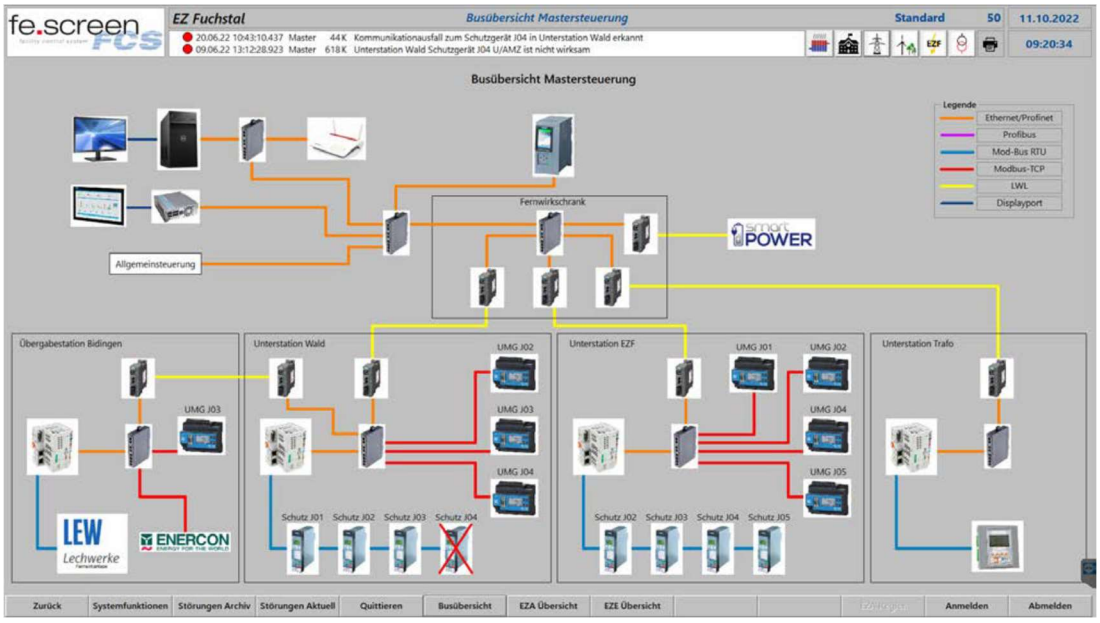
Operational Aspects Examined:

During the on-site visit, we thoroughly examined the system's operational aspects, including the Steering of the energy and heat supply systems suppported by a Virtual power plant.

A SIMATIC S7-1500 with digital and analog input and output modules is used to control the district heating distribution. A 19" touch panel with a box PC is installed in the on-site control cabinet and there is also a master computer in the energy center office. The system components can be operated, monitored and adjusted on the operating devices. Communication between the individual components takes place via various digital bus systems, with some being actively controlled (pumps and valves) and others only being monitored or read out (autonomous components such as pressure maintenance, heat meters, etc.).

A SIMATIC S7-1500 with digital and analog input and output modules is also used to control and monitor the power generation system, which is also located on site in the control cabinet. This master control is connected via fiber optic cable (LWL) to the substations in Bidingen, in the forest, in the EZF and the transformer station in which the WAGO PFC200 controls are used. It is also operated via the touch panel in the control cabinet or the master computer in the headquarters office. The master control is in the same network as the general control, which means that certain control commands can be exchanged between the two parts of the system.





EZF, screenshots from SCADA,Fuchstal (GE)

Operational Experiences power to heat , sector coupling:

- If the energy generation from the wind park and the solar park exceeds expectations or if the market prices are negative, excess energy
    - is stored in the battery unit up to a 90% charge, preventing surplus power from being fed into the grid and maintaining the schedule.
    - Is used in order to generate heat in a heat storage which feeds the local heat supply, supplying heat to 200 supply points.
- If the energy production from the solar panels and the wind turbines are lower than expected, the storage unit meets the shortfall, maintaining the schedule up to a minimum 10% charge.

Consumer Experiences:

Energiezukunft Fuchstal points out that small communities can play a significant role in the realization of the energy transition using storage to create aditional value for energy and heat supply.

Around €4.5 million in added value remains with the citizens of the community of Fuchstal from realizing the projects described. Furthermore, the added value of agriculture remains. Properties that supply the biogas plant as well as the delivery of wood chips from the community forest as added value on site. The value added from EEG systems and marketing of power remains with the local citizens and remains in the village.

II Energiewende Apfeldorf 16.10.2024

Energiewende Apfeldorf, Apfeldorf (GE): This event, hosted by the municipality of Apfeldorf. (established from 2020 and directly owned by the local government of Fuchstal and the citizens), aims to point out the realization of the local energy transition and the partzipationn of citizens. The focus includes building and operating a solar park and a smart local heat supply using a combination of enpower and heat storage.

During the visit to Energiewende Apfeldorf , Mr. Gerhard Schmid, the Mayor of Apfeldorf presented the operation of Energiewende Apfeldorf and the village developping project Village center with Future at the Visitor Center.

Visitor Center, Apfeldorf (GE)

Smart Grid Components:

Solar power plant:

- We visited the solar power plant with an installed capacity of 14 MWp, supported by 25.926 solar modules from Canadian Solar and a Huawei Sun2000-330 KTL -H1 invertor. The actual total energy generation is 15.500 kWh/a. The total investment of aprox. 15.5 Mio is 22% equity financed with funding from the community, the land owners and the local citizens which founded together the company Sonnenenergie Apfeldorf GmbH Co. KG. The actual power demand of Apfeldorf is

5 Mio kWh, meaning that the solar park genrates 3 times the consumption of Apfeldorf (1500 inhabitants).

Large volume Energy storage :

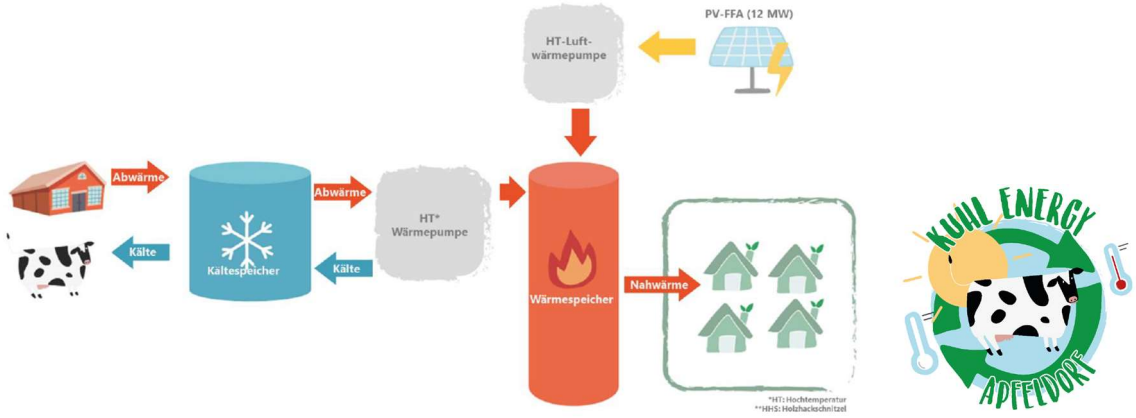
- The mayor of Apfeldorf reported its ongoing plans to invest into a storage capacity of 11 MWp and a capacity of 222 MWh connected to the grid of the regional utility. The target is to integrate the storage facility into the existing virtual power plant.

Apfeldorf solar powar plant-storage project, Apfeldorf (GE

Kuhl energy Apfeldorf:

- The mayor of Apfeldorf presented the ongoing project of the development of a village heat supply from a mix of renewable energy sources with innovative use of an existing milk cooling system. he previously conventionally operated milk cooling system is to be converted to heat pump operation. To provide this heat pump with the best possible emission-free supply, electricity from locally generated solar energy is used. The waste heat from milk cooling is to be used to supply the base load of a heating network.
  The planned heating network will be supplied via a newly built heating center

(HZ), which is to be located between the planned PV-FFA and the settlement. Project started in 2024 and it will receive a funding from German national climate protection initiative of 80%.



Outlook Store More

- a potential pilot project within store more has been proposed to the project coordinator. The main target is to pilot a new storage technology to be rolled out in rural areas of Danube region

In addition to building-up a renewable energy-based heat supply of the small village of Apfeldorf an innovative storage solution is envisioned to replace state of the art heat storage and battery. This innovative storage is comprised of a **Vanadium-Redox-Flow Battery (VFB) with a small auxiliary lithium-ion battery and a heat recovery system that enables higher efficiency and furthermore, due to an altered electrolyte, enables heat storage within the same battery** that already saves the electricity.

The following scheme shows the part of the energy system that would be connected to the hybrid heat and power storage.

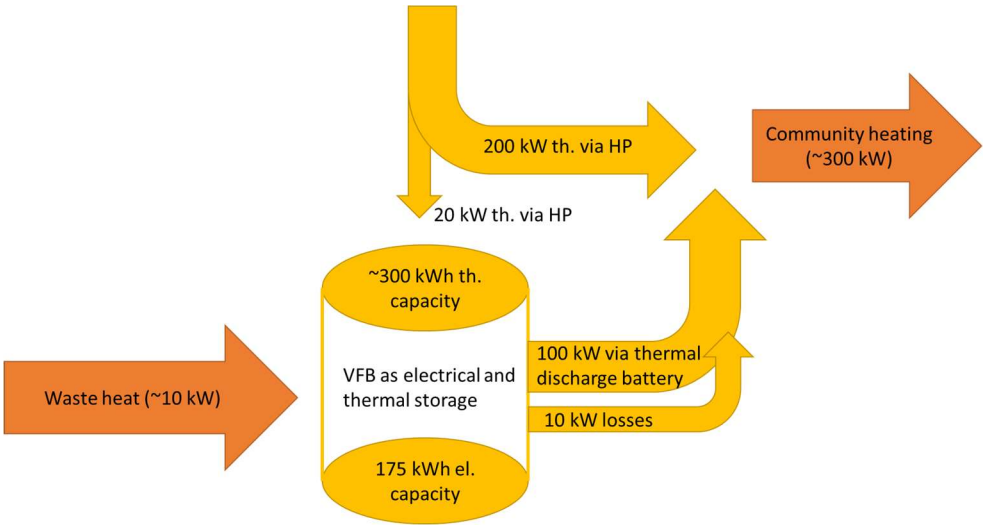


Figure 1 - Thermal power flows along the hybrid heat storage

As in real life the application would be highly dynamic between (partly) charging and discharging the battery thermally and (partly) directly powering the heat supply via the large heat pump, it is very hard to visualise within one simple scheme. Here the focus was laid on the probable thermal power capability. As to date no load thermal profile of the village and other requirements for a good sizing are unknown the following list of components represent a very rough estimation of the necessary size in order to compose a well fitted energy system. The necessary components of the hybrid storage system and their estimated size and costs are:

- 175 kWh / 30 kW (@ 600€/1 kWh[1]) 105.000 €
- 50 kWh / 30 kW (@ 300€/1 kWh[2]) 15.000 €
- Thermal Coupling Module + licence 30.000 €
- Sizing, Simulation, development EMS (4 PM @ 10.000€) 40.000 €

The estimated total costs for a hybrid energy storage system in the village of Apfeldorf amounts to 190.000 €. The idea is to spend part of Fuchstal/Apfeldorf project budget in order to realize the pilot installation together with a German research centre.

Conclusion

The best practice visit to Fuchstal and Apfeldorf showcased the impressive strides made by small communities in driving the energy transition through innovative renewable energy solutions. The Energiezukunft Fuchstal initiative, with its integration of wind turbines, solar PV systems, lithium-ion storage, and power-to-heat technology, demonstrates the potential of sector coupling to optimise local energy production and distribution. By effectively leveraging renewable resources, the community has achieved significant energy self-sufficiency while also generating economic value for its citizens. Similarly, the Energiewende Apfeldorf project exemplifies the power of citizen involvement and innovative financing in advancing sustainable energy systems, with its large-scale solar park generating three times the local energy demand.

Despite the successes of lithium-ion storage systems in enabling energy management and integration, the limitations of these technologies—such as restricted operational capacity, environmental impact, and finite resource dependency—highlight the urgent need for alternatives. In this context, the communities of Fuchstal and Apfeldorf are setting an example by exploring advanced energy storage solutions. These innovative approaches aim to replace state-of-the-art systems with technologies that offer improved sustainability, efficiency, and compatibility with future energy demands.

A particularly exciting development is the planned implementation of a hybrid storage system in Apfeldorf, combining a Vanadium-Redox-Flow Battery (VFB) with a small auxiliary lithium-ion battery and a heat recovery system. This approach seeks to overcome the dual challenges of storing both electricity and thermal energy within a single system. The ability to use the altered electrolyte for heat storage, in addition to electricity, represents a significant leap forward in storage technology. This innovation not only maximises efficiency but also addresses the environmental concerns associated with traditional lithium-ion systems.

By integrating hybrid thermal storage with local heat supply networks and renewable energy systems, Apfeldorf aims to create a highly dynamic, flexible, and sustainable energy solution. This pilot project, with an estimated cost of €190,000, will serve as a critical testbed for scaling similar systems across rural areas in the Danube region. The collaboration with a German research centre further strengthens the initiative's potential impact, positioning it as a pioneering model for future energy storage technologies.