

Deliverable DT1.3.2

PILOT REPORT

Activity A.T1.3: Implementing Pilot Projects

St Julien and Val de Quint (FR)

Drôme (FR)

Savona (IT)

Thannhausen (AT)

W.E.I.Z. Campus (AT)

Selnica (SL)

Graing (DE)

Municipality of Udine (IT)

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DOCUMENT CONTROL SHEET

Project reference	
Full title of the project	Increasing RES uptake through Microgrids in the Alps
Acronym	ALPGRIDS
Contract agreement n.	N° 843
Duration	01.10.2019 – 30.06.2022
Project website	www.alpine-space.eu/alpgrids
Project coordinator	AURA-EE

Short Description
This document presents the pilot projects established within the ALPGRIDS project and lessons learnt concerning the local and legislative framework, technical aspects and the set-up of local energy communities.

Document Details	
Title of document	Pilot project plan
Action	A.T1.3 Implementing pilot project activities
Deliverable	DT1.3.2
Delivery date	October 2021
File name	Deliverable DT1.3.2 V2.1.docx
Reviewers	Consortium
Dissemination	Public

Version	Date	Author	Organization	Description
2.1	7.12.21	Michael Stöhr Guillaume Bontron Noémie Poize Barbara Bonvini Andrea Dornhofer Thomas Nacht Tomaz Robic Florian Rothmoser Pasquale Motta	B.A.U.M. CNR AURA-EE Università di Genova W.E.I.Z. 4ward Energy ENERGAP Rothmoser DEMERA	Final for submission

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Abbreviations

EWH	electric water heater
PMO	Personne Morale Organisatrice (organisational legal entity)
PV	photovoltaic
RES	renewable energy source(s)
RES production	production from RES

Pilot 1: St Julien and Val de Quint (FR)

1.1 Context and general objectives

1.1.1 Local context

The Val de Quint Valley is located in the south-eastern part of France, in the Drôme French department, in the Vercors Mountain southern foothills. Six villages can be found in the Val de Quint Valley: Saint-Julien-en-Quint, Saint-Andéol, Vachères-en-Quint, Sainte-Croix, Ponet-et-Saint-Auban and Marignac-en-Diois (see Figure 1).

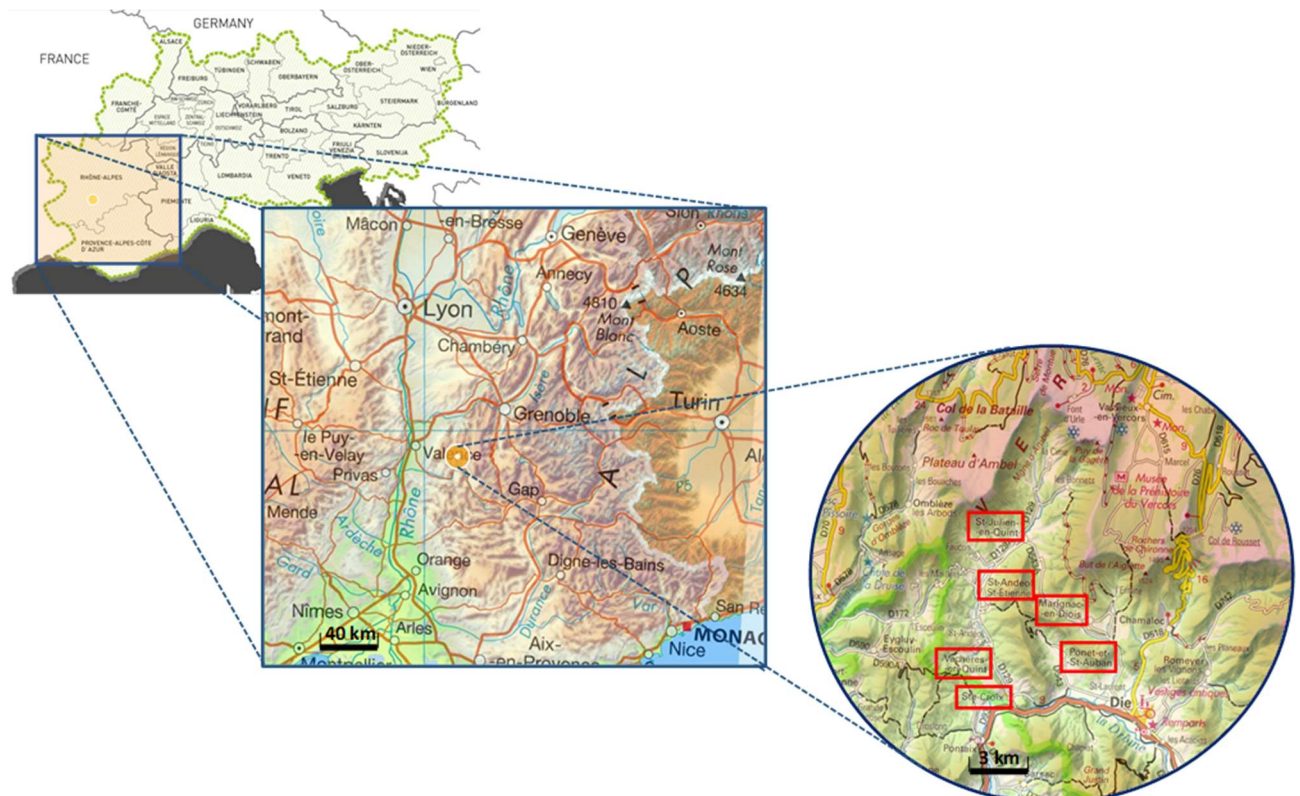


Figure 1 – Location of the Val de Quint Valley (sources: www.espacealpin.fr and www.geoportail.fr)

The Val de Quint is a rural area of approximately 760 people. Mostly a residential area, it is also concerned by agriculture activities and tourism as well as few very small enterprises.

The microgrid activities have begun in the Saint-Julien-en-Quint village, where a share self-consumption project has been developed prior to the ALPGRIDS project. This project gathers around 33 consumption points and one PV production facility. This already existing project constitutes one of the studied pilot sites: the Saint-Julien-en-Quint Pilot Site.

Furthermore, as the local stakeholders aim at extending the microgrid activities to the entire Val de Quint area, this will form an extended pilot site: the Val-de-Quint Pilot Site.

For both pilot sites, the common motivation of the stakeholders is to develop shared self-consumption, in order to

- develop a more resilient energy system, the area being at one end of the distribution network
- purchase renewable energy produced locally at an acceptable price
- provide support to local rural spatial development

1.1.2 Objectives

These pilot sites pursue two classical general objectives, which are (i) the evaluation of the impact of the regulatory framework in the economic value of a microgrid and (ii) the optimization of the configuration and dimensioning of the local shared self-consumption projects, in order to help the local stakeholders. Besides these general objectives, a more specific objective is defined: the evaluation of the additional economic value of the microgrid's local flexibilities related to the global grid actors' needs, by the mean of the use of **dynamic prices of complementary energy**.

The maximization of the self-consumption ratio is indeed a key point to maximize the economic value of a microgrid. The production of the renewable energy sources being intermittent and non-dispatchable, the only way to maximize the self-consumption is to use the microgrid flexibilities (load control, energy storage ...), in order to match energy consumption and production. Hence, microgrids usually include flexibilities and an Energy Management System (EMS) to operate these flexibilities.

These flexibilities are used considering only the economic value inside the microgrid. Yet, the global grid also needs flexibilities to be balanced and maximizing self-consumption in one area might not allow reaching an overall optimum. The local microgrid flexibilities might help global grid actors to be balanced, and thus it might gain additional economic value considering the needs of both the microgrid and the global grid. This way, microgrids will become factors that ease the integration of larger amount of renewable energy sources in the global grid thanks to its shared flexibility.

Dynamic prices of complementary energy may form the link between the microgrid's flexibilities and the global grid needs. Being a global grid actor, the energy supplier is indeed a balance responsible entity: it pays penalties in case of imbalance between its energy sales and production. The prices of the complementary energy it offers might then consider these penalties: prices will be cheaper if the supplier experiences an excess of production. Given these variable prices, the EMS microgrid can optimize the use of the microgrid flexibilities to minimize the energy cost for the microgrid consumers.

The specific objective of the pilot is then to assess the reality of this additional value of microgrid flexibilities. This study will be carried out considering two questions:

- How to set up the dynamical prices of complementary energy?
- What kind of flexibility is the most valuable?

This study will be supported by the analyses of different governance model allowing to provide such variable prices.

1.2 Technical description

1.2.1 Saint Julien en Quint

The Saint-Julien-en-Quint pilot site comprises 1 PV production facility (30 kWp capacity) and 33 consumption points, spread over two Low-Voltage substations (see scheme on Figure 2).

Some figures about the energy consumption and production estimations are displayed in the Table 1. The part of the consumption related to the hot water tanks (around 34 MWh/yr) is considered as flexible consumption, which can be controlled and time-shifted in order to optimize the microgrid operations.

The installation of smart meters (devices called 'Linky') by Enedis, the local DSO, was in progress during the first half of 2020 in Saint-Julien-en-Quint. These devices will allow real-time metering of energy consumption and load control of flexible consumption among other things.

Table 1 – Main figures concerning Saint Julien en Quint & Val de Quint

	Saint Julien en Quint	Val de Quint
number of delivery points	33	561
RES production capacity	30 kWp	1,600 kWp
annual RES production	41 MWh/yr	2,130 MWh/yr
annual energy consumption	180 MWh/yr	2,479 MWh/yr

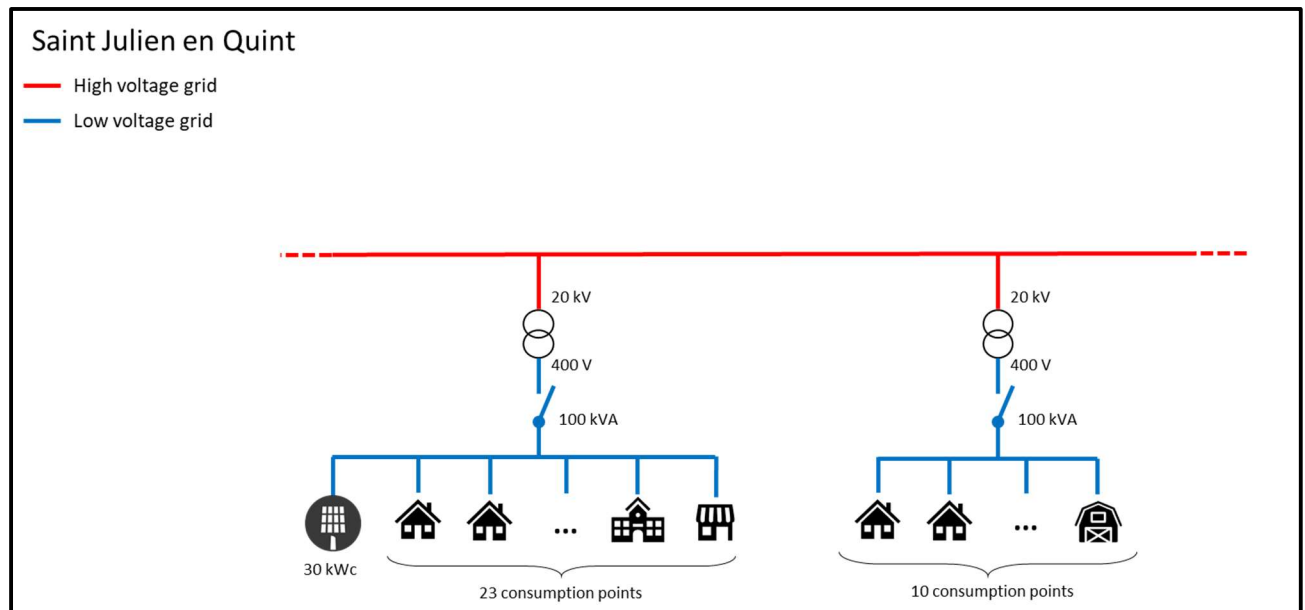


Figure 2 – Scheme of the Saint Julien-en-Quint microgrid configuration

1.2.2 Val de Quint

While the Saint-Julien-en-Quint pilot site already exists, the Val de Quint pilot site responds to the ambition of the local stakeholders to extend the microgrid activities to the entire Val de Quint area. It is a much larger project (see Table 1) which is still under study. It might include:

- **RES production:** The main energy production is fulfilled by PV facilities, but the addition of small amounts of micro-hydraulic and wind power might be considered.
- **Consumption:**
 - o 561 consumption points with 2 bigger consumers:
 - “Old Sainte Croix Monastery” meeting & event center
 - Saint-Julien-en-Quint Town Hall
 - o micro-electrolyser aimed at producing hydrogen for mobility
- **Load control:**
 - o hot water tanks
 - o heat production linked with small heating network
- **Energy storage:**
 - o electrochemical batteries
 - o hydraulic batteries (micro pumping-storage facilities)
 - o hydrogen storage (electrolyser + storage + fuel cell) with heat cogeneration (fuel cell)

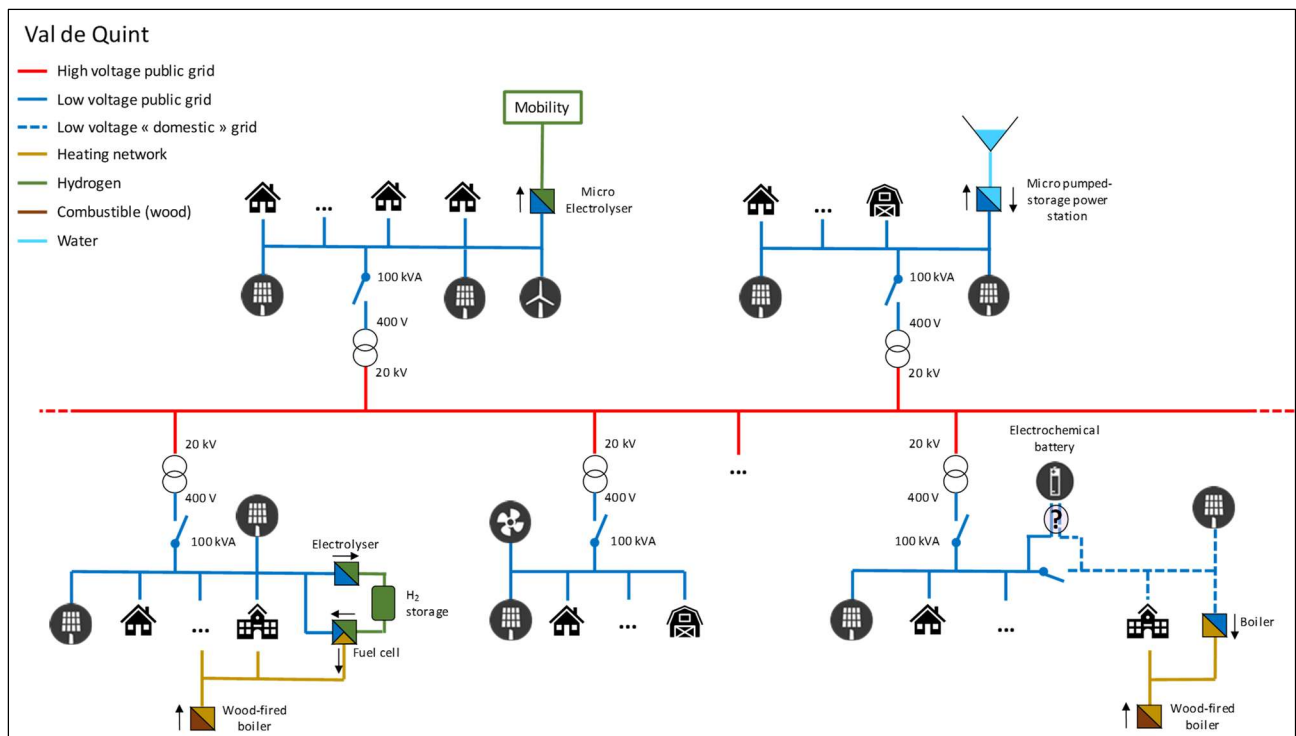


Figure 3 – Scheme of the Val-de-Quint microgrid configuration

The exact configuration of this pilot site and dimensioning of its elements is still to be defined. The scheme in Figure 3 represents the elements that might be considered to date. The simulations made in the framework of the Alpgrids project consider different setup configurations.

As in Saint-Julien-en-Quint, the installation of Linky smart meters was in progress during the first half of 2020 in the whole Val de Quint area.

1.3 Legislative framework

1.3.1 Extended collective self-consumption

For both pilot sites, the microgrid projects consist mainly of collective self-consumption operations, relying on the public grid for ensuring the energy exchanges. In France, such a kind of operation is defined by the article L315-2 of the Energy Code (Code de l'énergie) as "*extended collective self-consumption*" ("*autoconsommation collective étendue*"), the details of which are specified by Decree of 21 November 2019. This kind of collective self-consumption gathers one or several energy producers and one or several energy consumers bound together inside an organisational legal entity (the "*Personne Morale Organisatrice*", PMO) and it must respect two criteria:

- Producers and consumers must be linked to the low voltage grid of a unique DSO, with a maximal distance between the two furthest participants of 2 kilometers.
- The cumulative power of the energy production sites must be lower than 3 MW (or 0.5 MW in the non-interconnected areas).

These criteria are respected by the Saint Julien en Quint pilot site, but not by the Val de Quint one: considering a self-consumption project spread over 6 villages, the distance between the participants exceeds largely the 2 km criterion.

On the 18th of October 2020, a new Decree modified these criteria. It allows, upon reasoned request, the possibility to override the geographical criteria by increasing the maximal distance between the two furthest participants up to 20 kilometers, provided the operation concerns rural areas. With these new rules, the Val-

de-Quint project now meet the criteria to be considered as an extended collective self-consumption operation by the French laws.

1.3.2 Standing charge for use of the public electric network (TURPE)

In France, the standing charge for use of the public electric network is called TURPE (“Tarif d’Utilisation du Réseau Public d’Electricité”). The latest version of the TURPE, at the beginning of the Alprids project, was the version 5bis. On the 1st of August 2021, a new version of the TURPE, namely the version 6, became effective. The pricing structure remains the same between version 5bis and version 6: the differences mainly relate to the price levels of the different component of this common pricing structure.

Since the CRE’s Advisements of the 7th June 2018 and of the 18th June 2018, the TURPE (5bis and 6) offers the possibility to apply specific tariffs when all consumption and production points of a same collective self-consumption operation are situated below the same Low-voltage sub-station:

- The variable component associated to the part of the energy consumption covered by the local energy production has been lowered, as the energy fluxes in that case do not pass through the high voltage grid.
- Conversely, the variable component associated to the part of the energy consumption that need complementary energy to be covered has been increased.

Should the self-production ratio be high, this optional tariff may be more attractive than the classical one. Yet, as the consumption and production points must be situated below the same low-voltage sub-station, this optional tariff will not be applicable to the Saint Julien en Quint and Val de Quint collective self-consumption operations as these encompass several low-voltage substations.

In the pilot sites cases, we will then study how the spatial limitation of the applicability of the optional collective self-consumption TURPE tariff may affect the profitability of the microgrids, considering various optional TURPE hypothesis:

- no optional TURPE applicable (current situation)
- optional TURPE allowed between production and consumption sites located behind the same low-voltage sub-station and classical TURPE for energy exchanges between sites located behind different low-voltage sub-stations
- optional TURPE allowed for all sites included in the collective self-consumption operation, regardless to the low-voltage sub-stations involved

Furthermore, it is of interest to emphasize that the TURPE version 5bis and version 6 define both:

- seasonally adjusted tariffs, with higher grid access fee during winter and daytime (i.e. during high grid load periods) and lower ones during summer and nighttime (i.e. during low grid load periods)
- and non-seasonally adjusted tariffs, which remain constant regardless of the period of the year or of the day

In the TURPE version 6, these two kinds of tariff are perpetuated but the non-seasonally adjusted tariffs will disappear in 2024 (for consumers connected to the low-voltage grid with a connecting power lower than 36 kVA). In the pilot site cases, both seasonally adjusted and non-seasonally adjusted tariffs are considered.

1.3.3 Economic support to collective self-consumption

In France, unlike individual self-consumption, which benefits from tax exemption and feed-in tariff for the excess energy, the collective self-consumption did not benefit from any economic support until the year 2021. The only support available for collective self-consumption was potential investment grants, mainly granted by regional or local authorities. In 2021, some changes in the French legislation made possible for collective self-consumption to benefit from economic support. The modalities and type of economic support depends on the installed production capacity of the project:

- For projects superior to 500 kWp, calls for tenders are opened on a regular basis. If the self-consumption rate is greater than 50 %, a project can candidate to claim a premium on the self-consumed energy. The winning project will be those claiming the lowest premiums. They will then benefit from:
 - The premium claimed on the self-consumed energy (capped to 40 €/MWh)
 - The compensation of the TURPE fee and of the TCFE tax¹
 - Feed-in tariff for the excess energy (fixed at 50 €/MWh)
- For projects inferior to the 500 kWp threshold, a feed-in tariff for the excess energy has been introduced, provided that the project does not benefit from any public investment aid (“S21” tariffs).

These new economic supports to self-consumption are a major change in France, though some terms are not yet well defined.

1.4 The energy community

1.4.1 Players involved, their roles and contractual relationships

The Val-de-Quint microgrid projects was initiated by a group of local people, both individuals and local municipalities. They gathered together in the **ACOPREV SAS**, in order to be able to make the investments for the development of the RES facility. The ACOPREV SAS roles are:

- The “Personne Morale Organisatrice” (PMO), as defined in the French laws governing the shared self-consumption: it defines the allocation key of the locally produced energy between the consumers. This allocation key is transmitted to the DSO.
- Seller of the local RES production to the consumers.
- Seller of the not consumed RES production (energy in excess) to a Balance Responsible Entity which includes these excesses in their balance group.

The **consumers** involved in the microgrid activities must be shareholder of the ACOPREV SAS, as the ACOPREV SAS is the “PMO”. They receive two energy consumption bills:

- one corresponding to the part of their consumption provided by the ACOPREV local RES facility (the self-produced part), issued by ACOPREV SAS
- one corresponding to the remaining part of their consumption (the complementary energy part), issued by their individual energy provider

The **DSO** (Enedis) gathers all the energy data. It measures the detailed energy consumption of each consumer, thanks to the “Linky” smart meters, as well as the detailed energy production of the ACOPREV production facilities. With these data, Enedis

- calculates the self-produced part and the complementary part of the consumption of each consumer, given the allocation key established by ACOPREV, and transmits these data to ACOPREV and the complementary energy providers
- calculates the part of the local production that is not self-consumed (the energy in excess) and that must be included in the balance group of the Balance Responsible Entity

The part of the consumption of the microgrid that is not covered by the ACOPREV facilities production (the complementary part) is supplied by **energy suppliers**. Every consumer has a contract with the energy supplier of their choice. These contracts do not involve ACOPREV.

¹ The TCFE tax (Taxe sur la Consommation Finale d’Electricité) includes a municipal tax, a department level tax and a national level tax, both based on the consumed energy (both self- and allo- consumed energy).

The **Balance Responsible Entity** (BRE) chosen by ACOPREV to manage the energy in excess for its Saint-Julien-en-Quint production facility is CNR. There is no link between the BRE and the consumers.

Figure 4 provides a schematic representation of the contractual relationship between the stakeholders involved in the Val de Quint microgrid project.

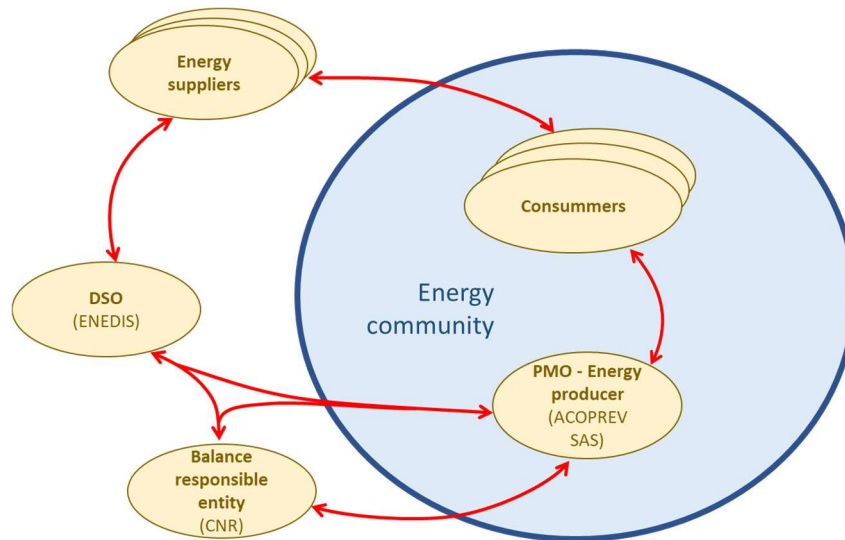


Figure 4 – Scheme of the relationship between the stakeholders involved in the Val-de-Quint microgrid project (a red arrows linking A and B means “A and B are linked by a contractual relationship”)

1.4.2 Classification of energy community

ACOPREV, the so-called “Energy community” involved in this pilot site, can be classified as a Class 3 energy community: “Collective residential & industrial self-consumption”.

1.5 Results

1.5.1 Scenario chosen for implementation / pilot design implemented

(a) Modelling

All simulations consider:

- a one-year period: from 01/08/2017 to 31/07/2018
- a 1 hourly time-step (thus, simulations do not consider transients)
- energy aggregated at low-voltage substations

One of the goals of the Val-de-Quint pilot site is to assess the economic interest of energy flexibility and storage capacity in the framework of collective self-consumption. With more than 500 consumers spread over an area with a radius of 10 km, the operation of this capacity cannot rely on real-time measurements: forecasts are to be considered. To do so, the simulation tool includes two modules that interact with each other:

- an **optimisation module**, that defines the scheduled operation of the flexibility / storage capacities, based upon forecasted inputs and the actual state of the energetic system.
- and a **simulation module** that represents how the energetic system evolves given the scheduled control of the flexible/storage capacities (defined previously by the optimisation module) and the real production and consumption data.

The optimisation module is launched on a regular basis (every 6 or 12 hours, depending on the simulations) and when differences between the real and the forecasted state of the energetic system exceed thresholds.

The simulation module is launched every hour and considers the output of the last optimisation run. This process is represented in Figure 5.

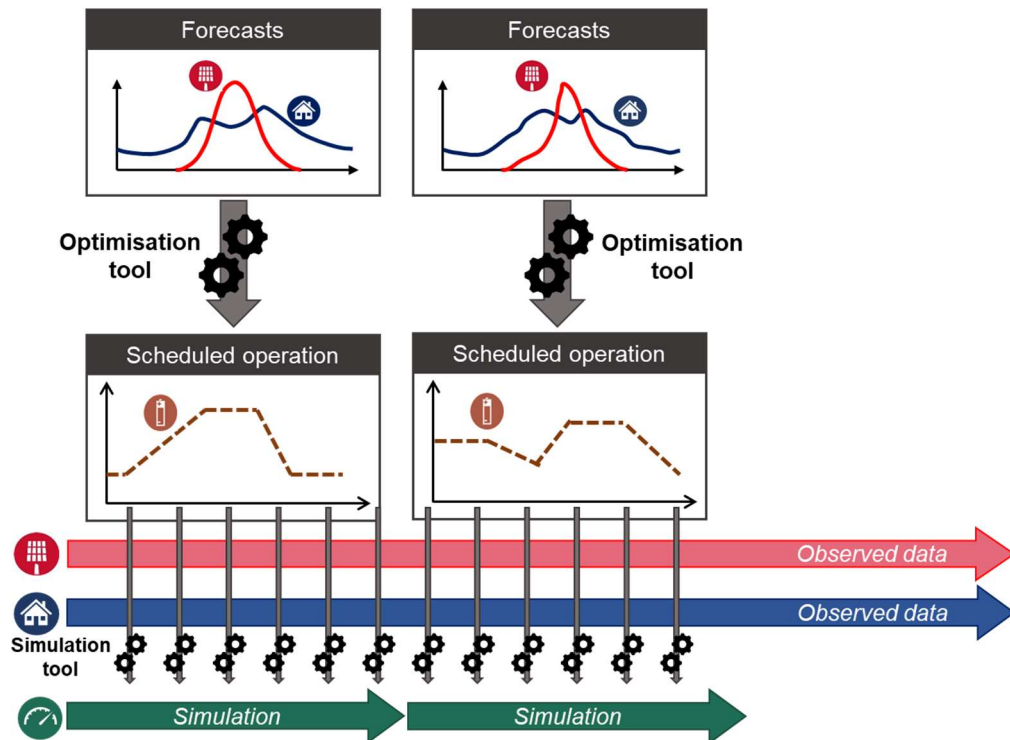


Figure 5 – Scheme of the simulation tool process.

(b) Consumption data

PEGASUS, a former Interreg funded project (Mediterranean) focusing on sustainable energy local community, has considered Saint Julien en Quint as a pilot site to analyse collective self-consumption. Thus, from August 2017 to July 2018, a measurement campaign of electricity consumption at a 10-minute time step was carried out among 31 consumers of the Saint-Julien-en-Quint village, covering various kind of consumers. For 4 of the residential consumers, the part of the consumption associated to the electric water heater (EWH) use was also measured.

As the Val de Quint perimeter covers a large number of consumers (more than 500) and that the pandemic situation made it difficult to use 2020 and 2021 consumption data (see 1.5.2), the 1-hourly load curve estimations are based on the PEGASUS measurements. They are estimated for each of the 41 low-voltage substations of the Val de Quint perimeter, considering the total number of consumers connected and the typology of each consumer: public building, public lighting, permanent housing, second home, farm, tertiary activity etc. This typology was estimated thanks to field investigation and use of satellite images. For each consumption point, a load curve is randomly chosen among the PEGASUS load curves belonging to the same typology of consumption. The load curves are aggregated at the low-voltage substation and validated considering:

- The total consumption at the village level (measured data given by the DSO)
- The maximal power estimated at the low-voltage substation (simulations done by SDED – Service public Des Energies de la Drôme)

Eventually, the choice of the load curves and their scaling were adapted to meet these criteria. The location and annual consumption of each low-voltage substation of the Val-de-Quint area are displayed through Figure 6 (blue dots).

Through a field investigation, EWH ownership rates were estimated for the 6 villages of the Val-de-Quint area. Considering the PEGASUS load curves specific to EWH, specific EWH consumption load curves are also estimated for each low-voltage substation. The annual consumption of the EWH is thus estimated at 400 MWh/year, representing 16 % of the total consumption.

Considering the forecasted data, we choose to consider, for each low-voltage substation, the monthly average of hourly load curves. The relative mean absolute error of the forecasted consumption is 12.3 %.

(c) Production data

ACOPREV has identified 36 potential PV production projects in the Val-de-Quint area, including both free-standing (fixed or with tracking technology) and roof-top installations, which are considered in the Val de Quint simulations. These PV installations still being only on project stage and not existing ones, we do not have any measured production data for the simulation period (2017/08 – 2018-07).

The production data are thus estimated considering satellite measurements taking also into account the orographic mask effects. The incoming solar radiation is transformed into energy thanks to the standard one-diode-model considering the panel tilt and azimuth of each project. Lastly, a standard energy-losses is applied. The location and annual production of each potential PV plant are displayed by Figure 6 (red dots).

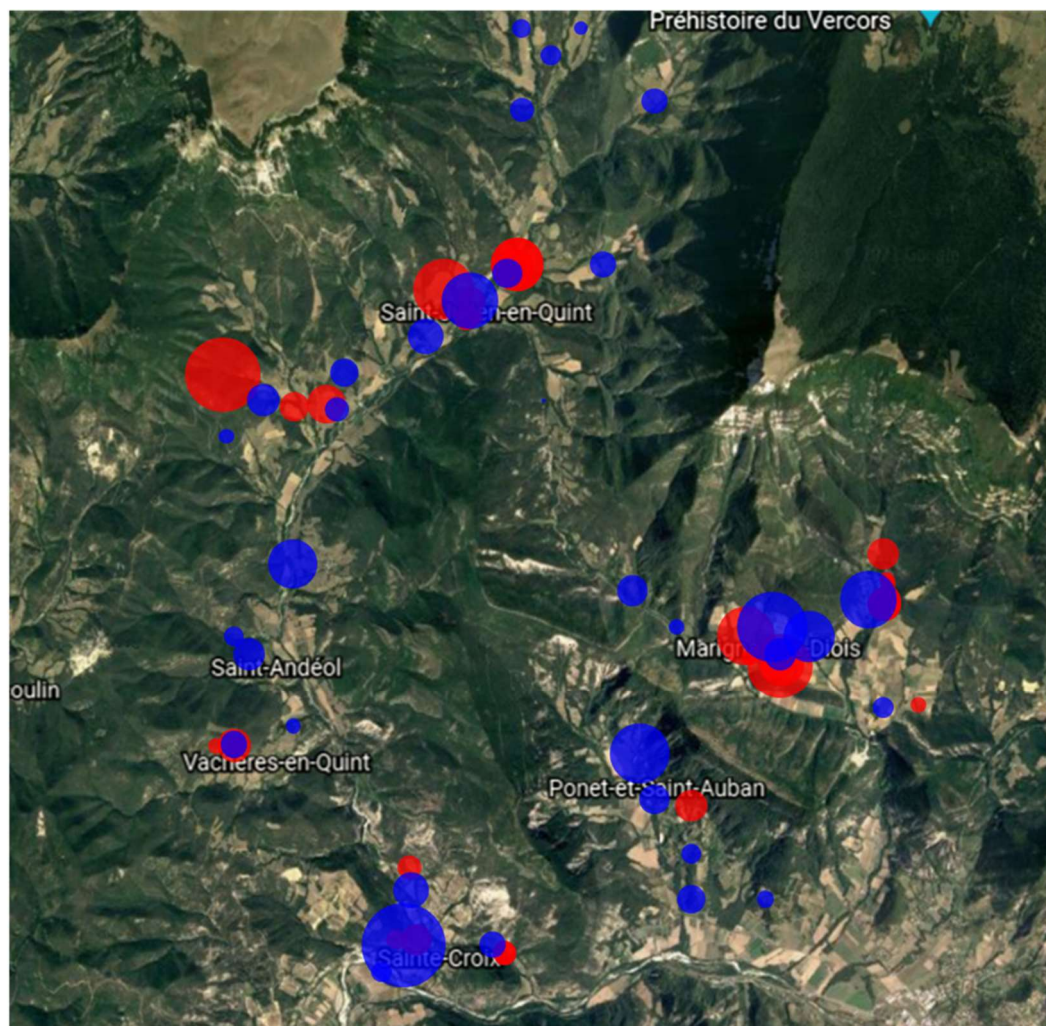


Figure 6 – Location of the 41 low-voltage substation of the Val-de-Quint area (blue dots) and of the 36 intended PV production assets project (red dots). The dots area is proportional to the total annual consumed (blue dots) and produced (red dots) energy.

Considering the forecasting, the incoming solar radiation is forecasted via neural-network modelling fed with Numerical Weather Prediction (NWP) models outputs. Two NWP model outputs are considered jointly: ARPEGE (Météo-France) and IFS (ECMWF²). ARPEGE is updated four times per day at 0, 6, 12 and 18 h UTC, while IFS is updated twice a day, at 0 and 12 h UTC. The forecasted incoming solar radiation is then transformed in forecasted energy production using the same one-diode-model and energy-looses-model used for the production estimation. The overall relative mean absolute error of the production forecast at +12h lead-time is 17.6 %. This figure is calculated summing up all the production sites: it encompasses thus a smoothing effect due to the compensation of random error between the different sites.

1.5.2 Obstacles encountered

(a) Consumption data

Due to the health crisis produced by the Covid-19 pandemic, we experienced in France several lock-down periods. The way how people live and work, and thus consume electricity, was deeply impacted. Thus, we estimate that the consumption data that might have been measured during the year 2020 are non-representative. Unfortunately, using former measurements is not possible, as the smart-meters were not installed before 2020 in the whole Val-de-Quint area.

We have then chosen to rely on the PEGASUS data. These data concern the same area but imply extrapolation steps to be used for the whole Val de Quint area.

(b) Modelling tool

The optimisation tool we used is a Mixed-Integer Linear Programming (MILP) solver. This implies that the modelling must be linear in pieces. It was an issue for the EWH modelling as the stored energy must be reset every day at 6am.

1.5.3 Proposals for modifications of legislative framework

(a) The need of a stable and simple pricing environment

Even if the collective self-consumption appeared in the French law in 2017, the pricing environment is still evolving. In 2021, we saw the publication of both a call for tender for collective self-consumption project exceeding 500 kWp and feed-in tariffs ("S21" tariffs) for project smaller projects (see 1.3.3). Depending on various criteria (individual or collective self-consumption, total installed power, wind or PV energy production, roof-top or free-standing PV production etc.) the operation may benefit of some tax exemption and/or feed-in tariff for the excess energy and/or specific standing charge for the use of the public grid and/or investment aids and/or premium on the self-consumed energy.

The pricing environment being very complex, each project becomes a particular case. Small changes in a project can imply great changes in its economic viability. This prevents replication and thus mass-deployment. To allow for the definition of a replicable collective self-consumption scheme, a stable, simple and seamless pricing environment is needed.

(b) The investment through project companies

The transposition to French law of the European Union directives on Renewable Energy and on Citizen Energy Communities introduces a constraint for the owner of the production facilities involved in a collective self-consumption project: *"the collective self-consumption activity cannot constitute, for the self-consumer, the consumer or the producer who is not a household, his main professional or commercial activity"* (Energy Code article L 315-2 of the 1st July 2021). This constraint will prevent the development of self-consumption projects, as the investments are made through specific project company, like ACOPREV SAS for example. They are owned by citizens and territorial authorities, but its main activity is the production of energy for the collective self-consumption.

² European Center for Medium-range Weather Forecasts.

A modification of the law is therefore needed. It could be done by allowing project companies with a minimum threshold of shareholders constitute of citizens and territorial authorities to be involved in collective self-consumption activities even if it constitutes their main commercial activity.

(a) Operation with several energy producers

Collective self-consumption operations may gather several “producers” sharing their energy with the self-consumers. Yet, the legislation requires that each producer sets up a contract with each consumer. As a result:

- Each self-consumer receives as many electricity bills as producers involved in the self-consumption, plus one bill from its complementary energy supplier. This might be hard to understand for the consumers and will probably prevents them from joining a collective self-consumption operation.
- Each producer may produce as many electricity bills as consumers involved in the self-consumption. This administrative work as a cost, in time and in investment and will surely prevents small energy production project led by individuals to join a collective self-consumption operation.

A simplification is needed. The idea might be to define a centralising actor who sets up contracts with all the energy producers and sells all the energy to the self-consumers. This way:

- Each self-consumer receives only two electricity bills: one from this centralising actor plus one bill from its complementary energy supplier.
- Each producer produces only one electricity bill, aimed at this centralising actor.

As a proposal, the PMO, legal entity institute by the French law to define the energy allocation key (see 1.4.1) might assume the role of this centralising actor.

1.5.4 Elements proposed to be included in an Alpine Microgrid Model

The Val-de-Quint pilot site clearly illustrates that the capability to optimally use the flexibility of the consumer loads is a key point to ease the economic balance of the collective self-consumption operations in France. It improves self-consumption and self-production rates without investing in storage assets. The key role of the flexibilities should be highlighted in the Alpine Microgrid Model.

In rural areas, sparsely populated, collective self-consumption operations are often spread over several low-voltage substation. Even the small Saint Julien-en-Quint operation involves two substations. This kind of operation relies therefore on the distribution and transportation networks. Yet, in rural alpine areas, due to climatic and topographic constraints, these networks are more or less fragile. This is why the collective self-consumptions should share their flexibility with the local network needs as it will strengthen the local network and ease the economical balance of the operation thanks to additional revenues. These mutual benefits should be part of the Alpine Microgrid Model.

Pilot 2: Drôme (FR)

AURA-EE has chosen to work on various pilot sites at all of which a collective self-consumption scheme will be set up. Actually, previous studies have shown that business models of collective self-consumption were difficult to implement, because their profitability is highly dependent on the load profile of the consumers involved. By working on a wide range of situations, AURA-EE hopes to identify the best conditions under which such projects can be implemented, so as to help municipalities and energy communities to develop more easily their future projects.

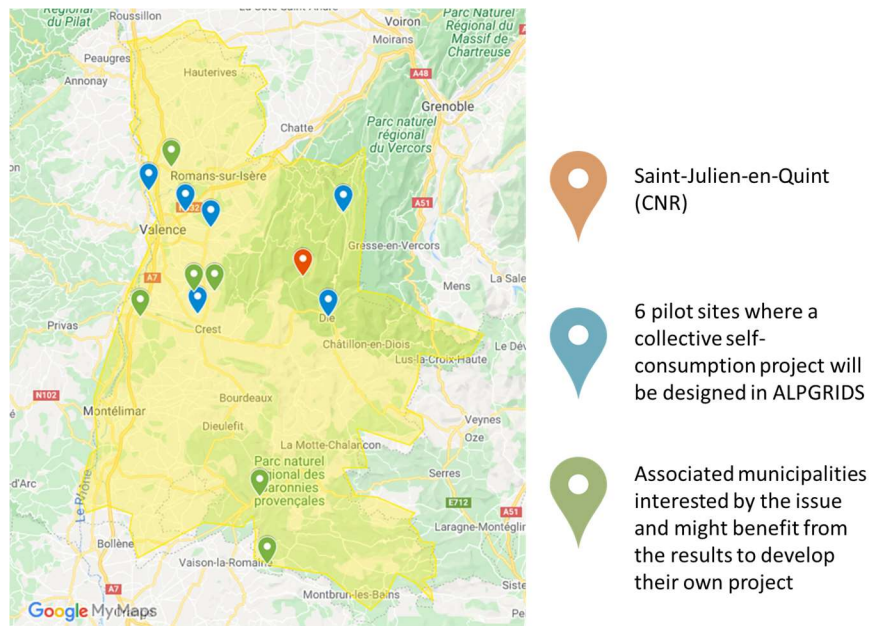


Figure 7 - Pilot sites in Drôme

Pilot 2.a: La Chapelle-en-Vercors (FR)

2.1 Context and general objectives

La Chapelle-en-Vercors is a rural village located in the Regional Nature Park Vercors in the Alps. An energy community exists already on this territory and operates several PV plants for 4 years. The aim of the pilot project within ALPGRIDS is to design a local collective self-consumption scheme where the local energy community directly sells electricity produced by its PV plants to the municipality for use in public buildings. Island operation of the local grid will not be studied since no specific need has been identified on this issue. Thus, the objective is to set up an efficient business and legal model where local consumers, in particular local public building operators, can have a better control of their bill thanks to the local provision of RES electricity.

2.2 Technical description

At this stage, a list of 11 public buildings has been identified as well as possible locations for new PV plants. See Table 2 and Figure 8. Smart meters have been installed in December 2019 and in collaboration with the municipality, AURA-EE has requested the automatic registration of the load curves (30 min timestep). This registration is operating since May 20th 2020, for all the Linky smart meters (≤ 36 kVA). For the swimming-pool, whose power consumption is higher, the detailed values are already being registered at a timestep of 10 min since May 2019. Among the 10 public buildings, only those which will prove to have „interesting“ load curves will be kept in the final project (i.e. buildings with consumptions occurring during peak PV production,

in summer and during day time). Two private buildings could be possibly added (retirement homes) in the study if we succeed in gathering their consumption data as well.

Table 2 - Buildings for possible new PV plants in Chapelle en Vercors (Drôme)

Building	Power subscribed	Annual consumption (kWh)	Load curve registration starting date
SWIMMING POOL	132 kVA	31,500	28/05/2019
PUBLIC BUILDING	6 kVA	1,700	28/05/2020
MUSEUM	9 kVA	800	28/05/2020
MAYOR HOUSE	12 kVA	9,400	28/05/2020
MULTIPURPOSE ROOM	24 kVA	6,784	28/05/2020
SOCIAL CENTER	24 kVA	24,300	28/05/2020
MARKET PLUG	36 kVA	600	28/05/2020
CHURCH	36 kVA	10,700	28/05/2020
CAMPING SITE	36 kVA	15,300	23/04/2021
SCHOOL	36 kVA	16,400	28/05/2020
SCHOOL ANNEX	6 kVA	2,660	28/05/2021

Regarding PV production, all the electricity generated by the existing plants is presently fed into the public grid and sold to the grid operator at a feed-in tariff fixed by national legislation. It is not possible to break the feed-in tariff contract unless high indemnities are paid. Thus, the only possibility for a collective self-consumption project is to design new PV plants. Two locations have already been identified (capacity < 36 kVA, see map). The exact size will be calculated so as to reach an optimal balance with the local consumers.

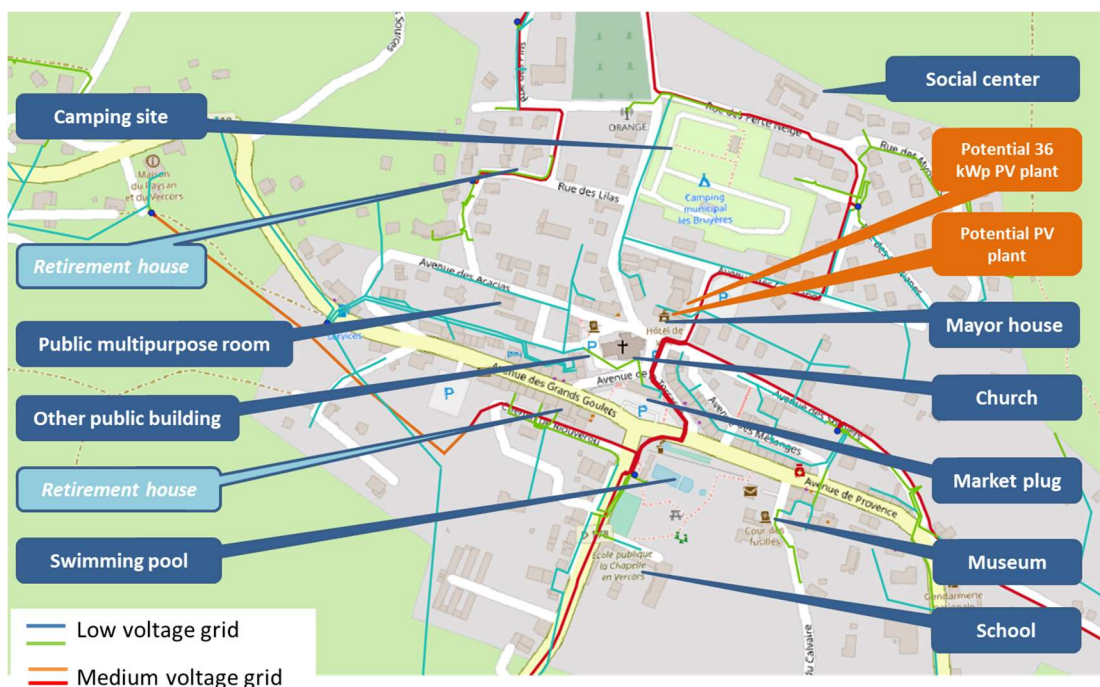


Figure 8 - Possible location of new PV plants for collective self-consumption in Chapelle-en-Vercors (Drôme)

2.3 Legislative framework

The project will be developed under the French framework for collective self-consumption, which was introduced by a new law in 2017 ([law 2017-227](#))³, subsequently complemented by several decrees. This law has been converted into the Energy Code (article L315-2) and then completed by another law (2019-1147) which enlarges a bit the definition. This legal framework enables every electricity consumer to purchase electricity directly from a local RES producer, provided some conditions are respected:

- The distance between each other is less than 2 km.
- They are linked through a legal entity.
- They are connected to the LV network.
- The total nominal power of the RES production units is less than 3 MW.

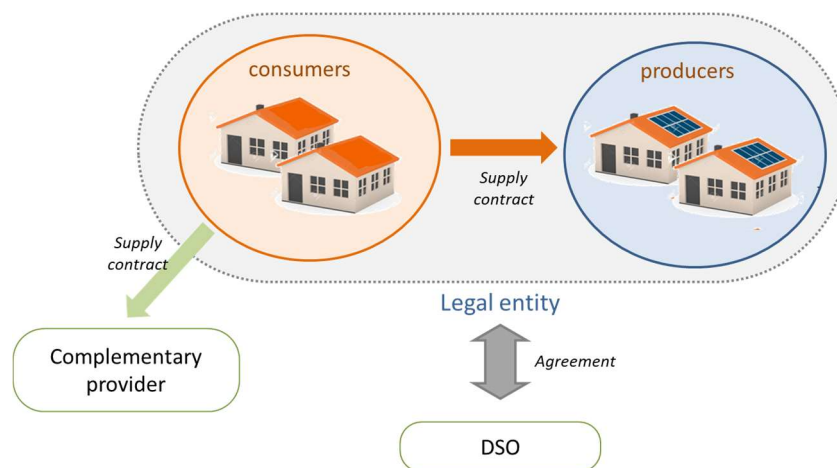


Figure 9 - Legal entities involved in collective self-consumption schemes in France

Consumers and producer need to establish a legal entity (Personne Morale Organisatrice, PMO, see 1.3). An agreement between the legal entity and the distribution grid operator (DSO) needs to be signed. It defines precisely how the RES production is shifted between the users (different repartition keys can be set up). Each consumer concludes two supply contracts, one with the PMO, and one with a complementary supplier for the residual electricity. The latter might be the previous supplier of the respective consumer and the new contract replaces the previous supply contract.

2.4 The energy community

2.4.1 Players involved, their roles and contractual relationships

The energy community chosen for the pilot project is VercorSoleil, a citizen-owned cooperative company which has been created in 2015 and presently operates 25 PV plants in 6 municipalities, including La Chapelle-en-Vercors. The aim of this energy community is to develop RES plants and to support the energy transition on the territory. Citizens, municipalities and local companies are shareholders of the company, which has a cooperative governance (1 shareholder = 1 voting right). They bring funds which serve to invest in RES plants and to operate them for several years. Till now, the energy community has only developed PV plants (through feed-in tariff contracts), but they are also involved in the development of e-mobility projects and try to develop projects with other renewable sources.

Within ALPGRIDS, they are in charge of the design of, and investment in, PV plants, and they will sell the generated electricity to the local consumers, among which are public buildings (a legal solution will have to

³ <https://www.legifrance.gouv.fr/loda/id/JORFTEXT000034080223/2017-03-30/>

be found to make it possible, as regards public procurement rules). They will also bear the role of the legal entity "PMO".

2.4.2 Classification of energy community

This pilot is the closest to Class 6, "municipal utilities".

2.5 Results

2.5.1 Scenario chosen for implementation / pilot design implemented

The sizing of the PV production leads to a 26 kWp PV plant settled on 2 different buildings.

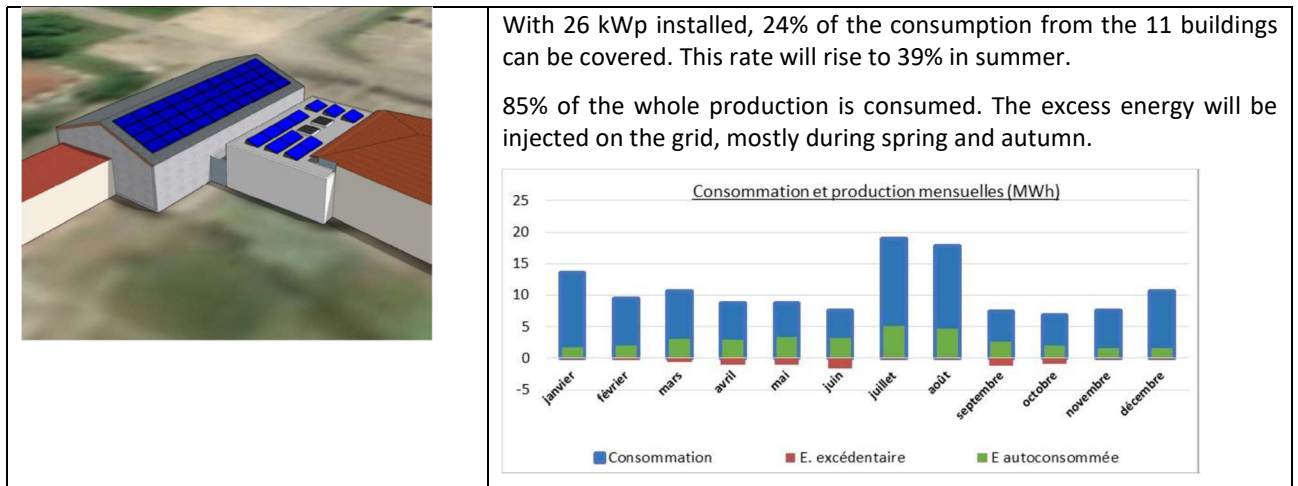


Figure 10 - Design and projected energy flows in Chapelle en Vercors (Drôme)

Two scenarios have been analysed as regards the selling of energy

- Scenario 1 : increase of the initial price for the municipality but slow annual increase (1,2% per year)
- Scenario 2 : steady initial price for the municipality and increase of 3% per year afterwards.

The first scenario leads to a 16 years payback time for the energy community and the second one to a 24 years payback time. No subsidy are taken into consideration in the calculation.

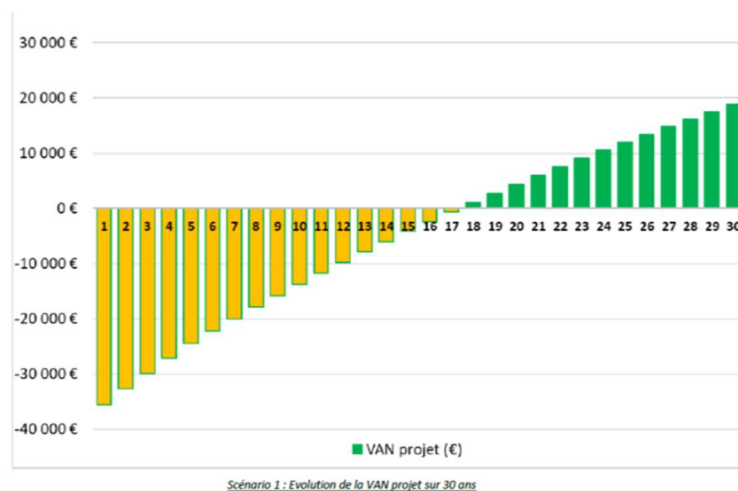


Figure 11 - Cash flow according to scenario 1 in Chapelle en Vercors (Drôme)

2.5.2 Obstacles encountered

The main difficulty was to obtain the load profiles of the buildings from the DSO.

2.5.3 Proposals for modifications of legislative framework

The legislative framework has improved a lot during the 2 last years and very recently (October 2021) a new decree stated that collective self-consumption would now benefit from a feed-in tariff for the excess energy, which is a very positive change. Thus, the expectations could more concern tax exoneration (it already exists for individual self-consumption) or administrative simplification regarding the legal contracts to be set up between producers and consumers.

2.5.4 Elements proposed to be included in an Alpine Microgrid Model

We could observe that solar energy can represent a significant share of municipal buildings through the collective self-consumption scheme. This can probably be true for other EU countries since municipal buildings more or less have similar uses across Europe. The business models can be improved when these buildings have daily or summer uses (like swimming pools, campgrounds, retirement houses.)

Pilot 2.b: Saint-Marcel-les-Valence (FR)

2.1 Context and general objectives

Saint-Marcel-les-Valence is a semi-urban village, located close to Valence, the main city of the Drôme department. The municipality owns many public buildings, produces electricity with existing PV plants and plans to develop a new PV plant on a sports hall. The aim of the pilot project is to design a local energy loop, namely a collective self-consumption scheme, allowing the municipality to reduce its electricity bill. Island operation of the local grid will not be studied since no specific need has been identified on this issue. Thus, the objective is to set up an efficient business and legal model allowing the municipality to lower its electricity bill.

2.2 Technical description

At this stage, a list of 17 public buildings has been identified. Additional buildings might be added later. Smart meters are already installed and in collaboration with the municipality, AURA-EE has requested the automatic registration of the load curves (30 min timestep). This registration is operating since July 2020 for subscription contracts above 36 kVA and February 2020 for most of the others. Among these 17 buildings, only those which will prove to have „interesting“ load curves will be kept in the final pilot project (i.e. buildings with consumptions occurring during peak PV production, in summer and during day time). One private building could be possibly added (retirement home) in the study if we succeed in gathering their consumption data as well.

Table 3 - Buildings for possible new PV plants in Saint Marcel-les-Valence (Drôme)

Building	Power subscribed	Annual consumption (kWh)	Load curve registration starting date
SPORTS HALL	60 kVA	105,000	13/07/2020
TECHNICAL PUBLIC BUILDINGS	42 kVA	50,100	13/07/2020
SCHOOL A	42 kVA	21,100	13/07/2020
SCHOOL A RESTAURANT	72 kVA	35,400	13/07/2020
STADIUM A	66 kVA	31,800	13/07/2020
CULTURAL CENTER	60 kVA	31,000	13/07/2020
MAYOR HOUSE AND SCHOOL B	42 kVA	69,300	13/07/2020
THEATER	36 kVA	9,200	20/02/2020
MULTIPURPOSE ROOM	36 kVA	12,700	20/02/2020
REST AREA	18 kVA	t.b.d.	20/02/2020
STADIUM B	36 kVA	11,400	20/02/2020
WASTE WATER PUMPS	6 kVA	1230	20/02/2020
MAYOR HOUSE	9 kVA	t.b.d.	20/02/2020
CHURCH	12 kVA	t.b.d.	20/02/2020
TENNIS CLUB	36 kVA	19,600	20/02/2020
WATERING SYSTEM	12 kVA	5,400	16/07/2020
YOUTH CENTER	24 kVA	12,000	20/02/2020

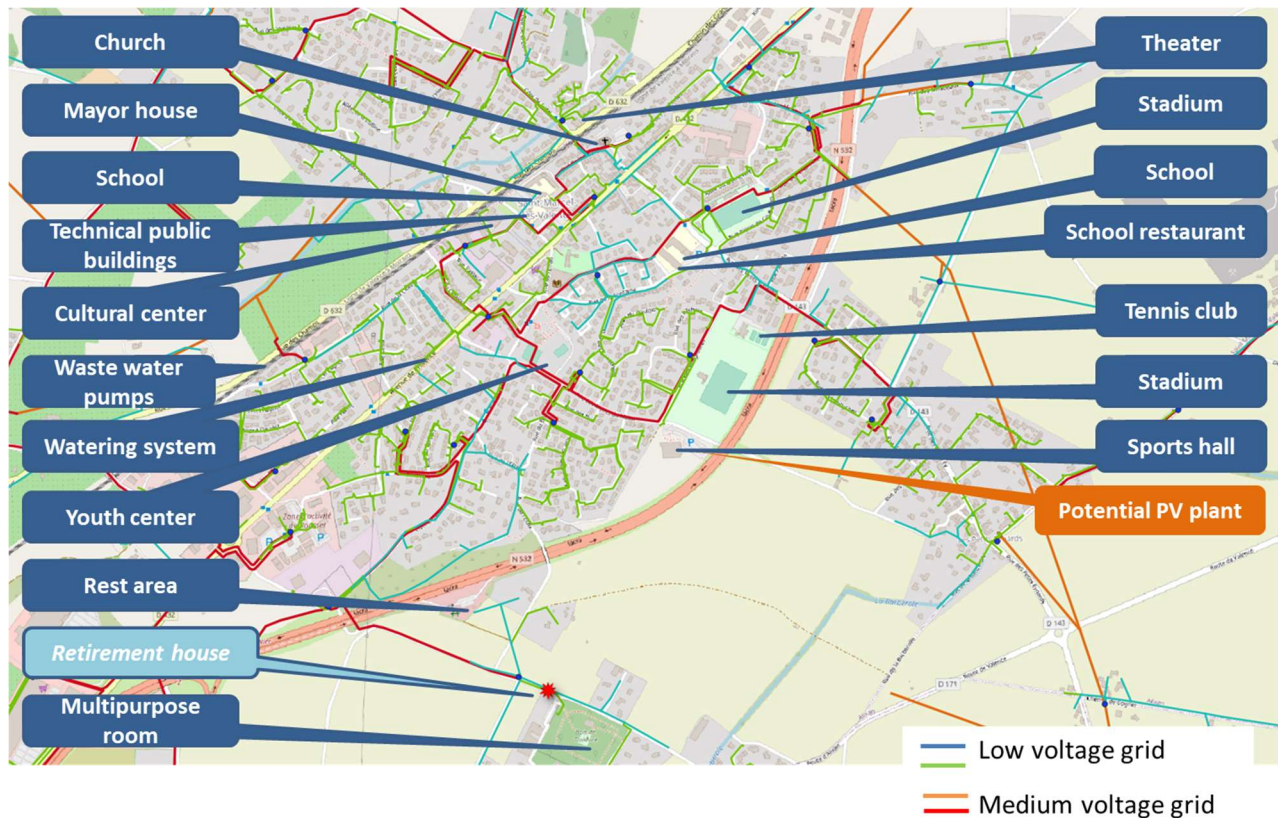


Figure 12 - Possible location of new PV plants for collective self-consumption in Saint Marcel-les-Valence (Drôme)

As location for a PV plant, the municipality considers the roof of an extension of the sports hall. This plant will be designed to provide electricity to the other buildings through the collective self-consumption scheme.

2.3 Legislative framework

See Pilot 2a.

2.4 The energy community

2.4.1 Players involved, their roles and contractual relationships

In this case, the energy community is identical with the municipality which is its only member. If additional private buildings are added in the consumption perimeter, a legal entity will have to be created which will gather the municipality together with all the private consumers.

2.4.2 Classification of energy community

This pilot is the closest to Class 6, “municipal utilities”.

2.5 Results

2.5.1 Scenario chosen for implementation / pilot design implemented

The sizing of the PV production leads to a 105 kWp PV plant settled on the sports hall.

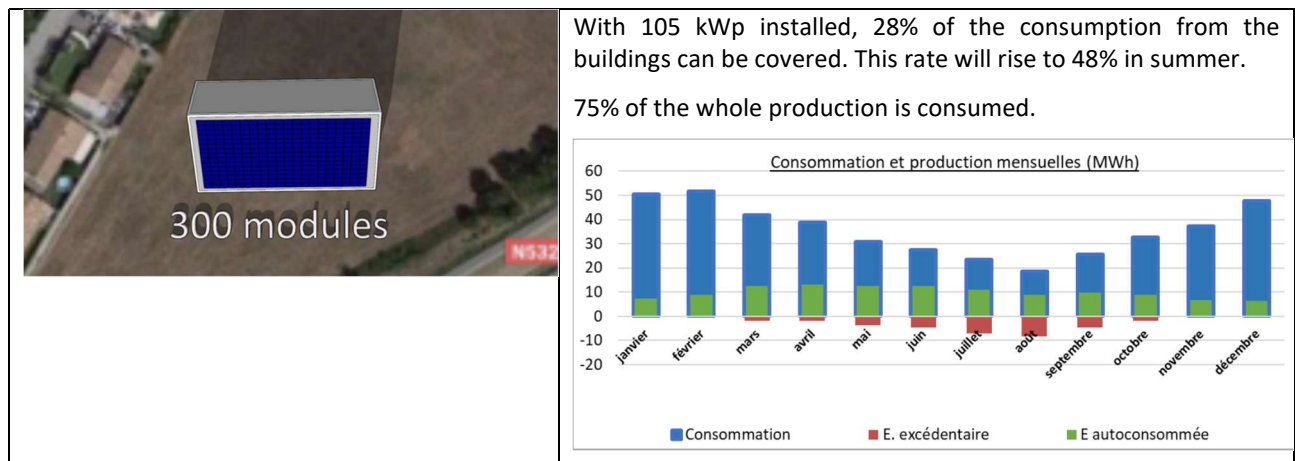


Figure 13 - Design and projected energy flows in Saint-Marcel-les-Valence (Drôme)

If we consider a 30 years observation period, the municipality can have a payback time of 26 years (including discount rate). The savings for the municipality correspond to 11,239 €.

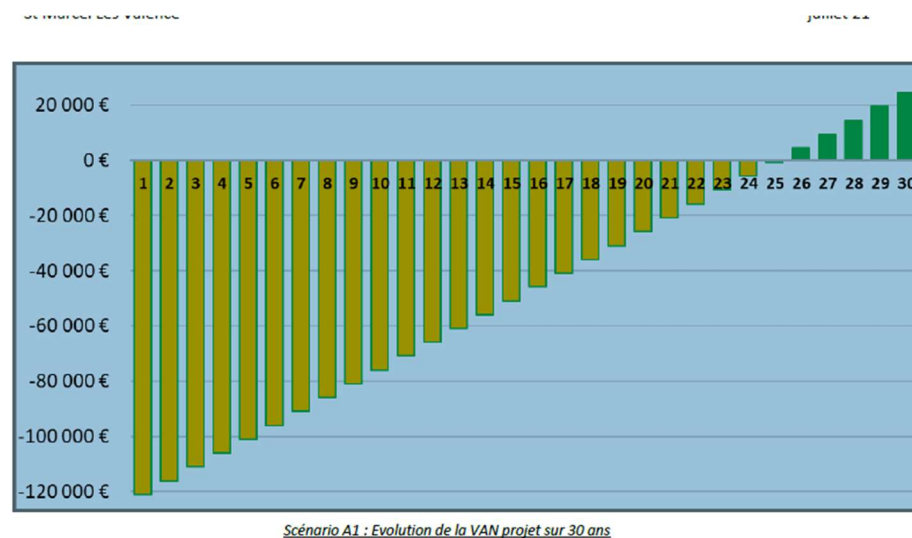


Figure 14 - Cash flow according to scenario 1 in Saint-Marcel-les-Valence (Drôme)

This payback time can be improved in the excess energy (25% of the production) benefits from a feed-in tariff. A feed-in tariff of 9.5 c€/kWh would lead to a 19 years payback time.

2.5.2 Obstacles encountered

No specific obstacle encountered.

2.5.3 Proposals for modifications of legislative framework

See Pilot 2a.

2.5.4 Elements proposed to be included in a Alpine Microgrid Model

See Pilot 2a.

Pilot 2.c: Montélier (FR)

2.1 Context and general objectives

Montélier is a semi-rural village, located close to Valence, the main city of the Drôme department. The municipality owns many public buildings, produces electricity from existing PV plants and plans to develop a new PV plant on a sports hall. Aim of the project is to design a local energy loop where the municipality could directly deduce the electricity production of this new plant from its public buildings' consumption, through the scheme of collective self-consumption. Island operation of the local grid will not be studied since no specific need has been identified on this issue. Thus, the objective is to set up an efficient business and legal model allowing the municipality to lower its electricity bill.

This study case is very close to pilot 2.b, but the consumer load profiles are different.

2.2 Technical description

At this stage, a list of 10 public buildings has been identified as well as possible locations for new PV plants. Smart meters have been installed in December 2019 and in collaboration with the municipality, AURA-EE has requested the automatic registration of the load curves (30 min timestep). This registration is operating since May 20th 2020, for all the Linky smart meters (≤ 36 kVA). For the swimming-pool, whose power is higher, the detailed consumptions are already being registered at a timestep of 10 min since May 2019. Among these 10 buildings, only those which will prove to have „interesting“ load curves will be kept in the final project (i.e. buildings with consumptions occurring during peak PV production, in summer and during day time). Two private buildings could be possibly added (retirement homes) in the study if we succeed in gathering their consumption data as well.

Table 4 - Buildings for possible new PV plants in Montélier (Drôme)

Building	Power subscribed (kVA)	Annual consumption (kWh)	Load curve registration starting date
SPORTS HALL	36	t.b.d.	March 2020
MAYOR HOUSE	36	38,300	June 2019
GARDEN FOUNTAIN	18	8,200	June 2019
MULTIPURPOSE ROOM	12	12,300	June 2019
SCHOOL RESTAURANT	36	24,000	June 2019
CHURCH	12	t.b.d.	
TENNIS CLUB	24	t.b.d.	March 2020
TECHNICAL PUBLIC BUILDING	12	3,600	June 2019
SPORTS HALL	30	18,500	June 2019
SOCIAL CENTER	42	t.b.d.	April 2020
OFFICES	84	t.b.d.	April 2020

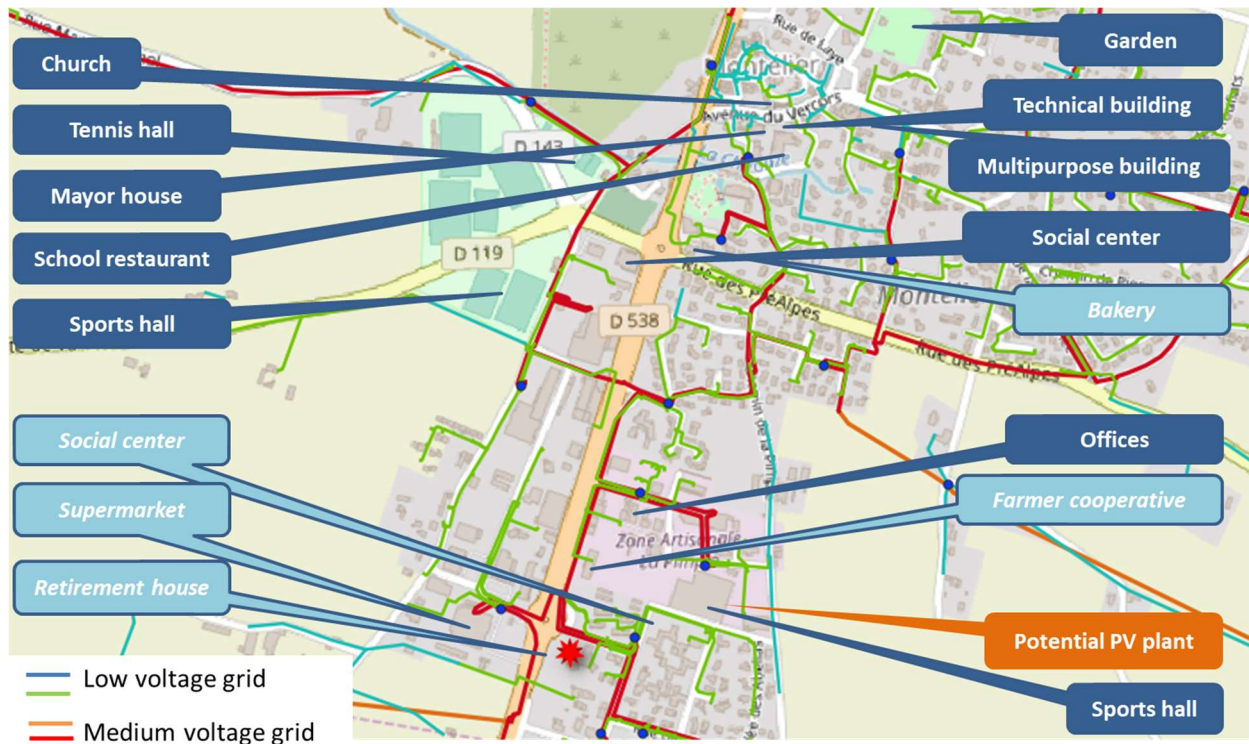


Figure 15 - Possible location of new PV plants for collective self-consumption in Montélier (Drôme)

2.3 Legislative framework

See Pilot 2a.

2.4 The energy community

2.4.1 Players involved, their roles and contractual relationships

In this case, the energy community is identical with the municipality which is its only member. If additional private buildings are added in the consumption or production perimeter, a legal entity will have to be created and will gather the municipality together with other the consumers and producers.

2.4.2 Classification of energy community

This pilot is the closest to Class 6, “municipal utilities”.

2.5 Results

2.5.1 Scenario chosen for implementation / pilot design implemented

The sizing of the PV production leads to a 38 kWp (1st scenario) or 92 kWp (2nd scenario) PV plant settled on a shadowhouse close to the sports hall.

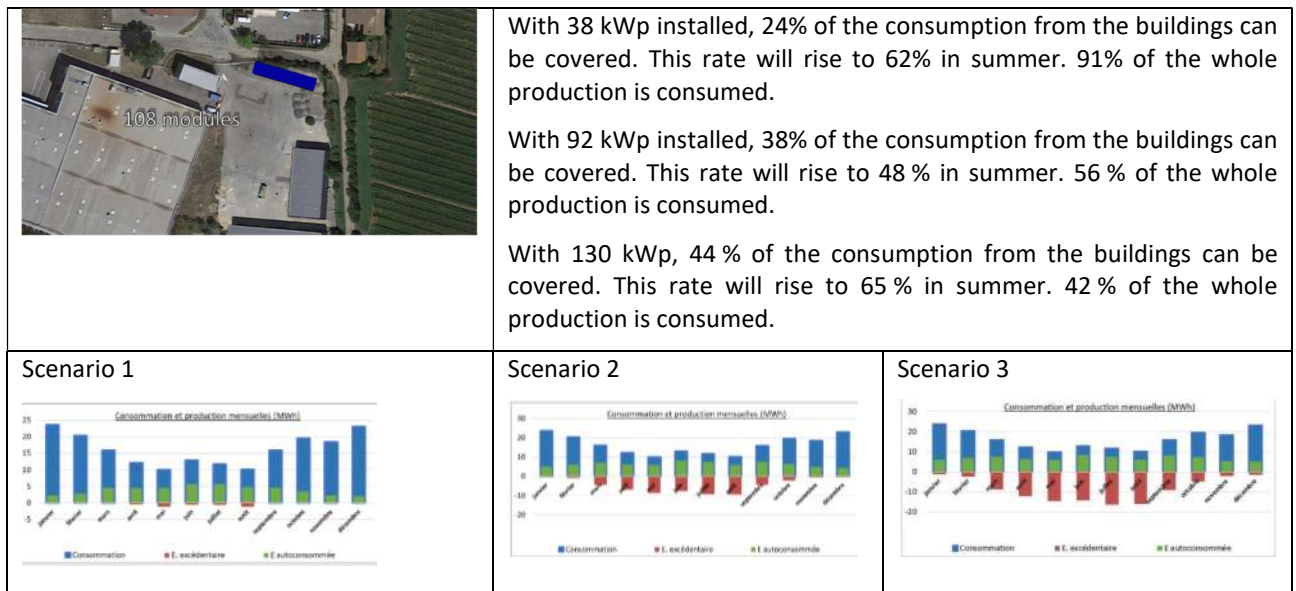


Figure 16 - Design and projected energy flows in Montélier (Drôme)

If we consider a 30 years observation period for the 1st scenario, the payback time is really too long and no economic balance is met. If we consider a 30 years observation period for the 2nd scenario, the payback time (including discount rate) keeps being very long.

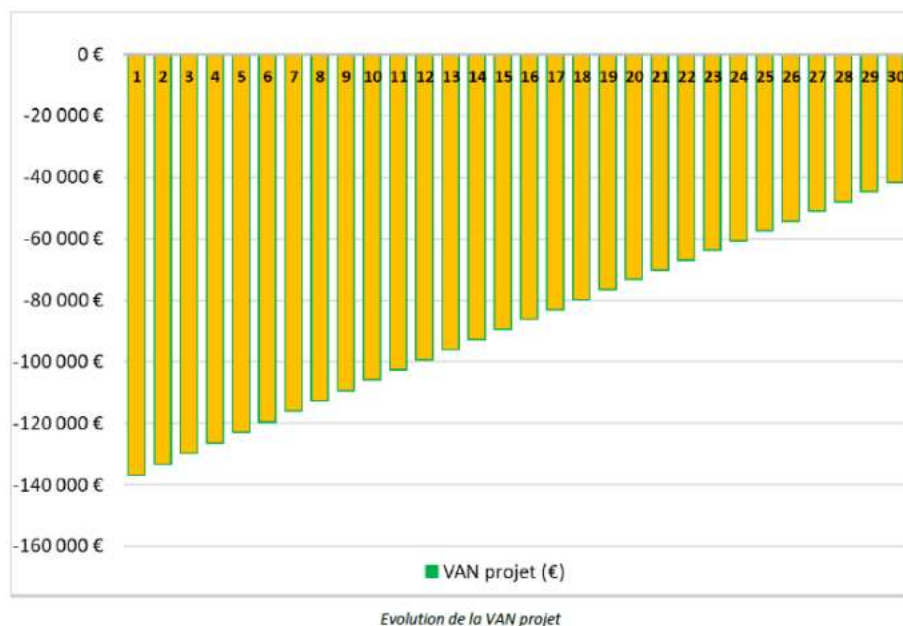


Figure 17 - Cash flow according to scenario 1 in Montélier (Drôme)

2.5.2 Obstacles encountered

There is no economic model due to the fact that the investment is made on PV shadowhouses, which cost much more than a bare PV plant.

2.5.3 Proposals for modifications of legislative framework

See Pilot 2a.

2.5.4 Elements proposed to be included in an Alpine Microgrid Model

See Pilot 2a.

Pilot 2.d: Die (FR)

2.1 Context and general objectives

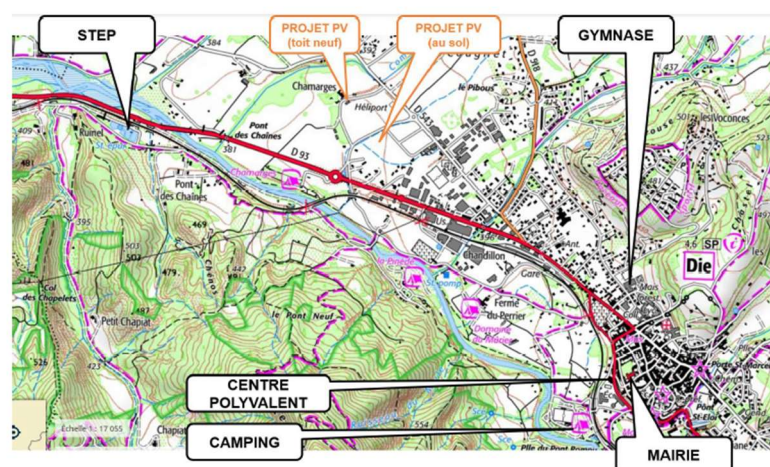
Die is a small village, located in the east of Drôme department, in the river Drôme valley. It is quite touristic and welcomes many people in summer. The municipality owns many public buildings, among which a waste water treatment plant. Aim of the project is to design a local energy loop where the water treatment plant could directly buy electricity to a local energy community. Island operation of the local grid will not be studied since no specific need has been identified on this issue. Thus, the objective is to set up an efficient business and legal model allowing the municipality to lower its electricity bill for the water treatment plant.

2.2 Technical description

At this stage, only the waste water treatment plant has been selected since the idea is to make a focus on this type of use and to see if collective self-consumption could be applied to many other treatment plants. But many other neighbouring industrial buildings could be added to the project afterwards. The plant has a 150 kVA power subscription and its consumptions are being registered at a 10 min timestep since several months.

Table 5 - Building for possible new PV plants in Die (Drôme)

Building	Power subscribed	Annual consumption (kWh)	Load curve registration starting date
WATER TREATMENT PLANT	150 kVA	340 000	May 2019



Localisation des points de consommation par rapport au site de production. Source ALBAEE

Figure 18 - Possible location of new PV plant for collective self-consumption in Die (Drôme)

2.3 Legislative framework

See Pilot 2a.

2.4 The energy community

2.4.1 Players involved, their roles and contractual relationships

In this case, the energy community is a cooperative company based in Die which develops RES projects in the Drome river valley. It gathers 88 shareholders, among them inhabitants, municipalities, and local companies. The energy company, called DWATT, already operates PV projects, but also develops wood energy and wind energy plants.

2.4.2 Classification of energy community

This pilot is the closest to Class 6, “municipal utilities”.

2.5 Results

2.5.1 Scenario chosen for implementation / pilot design implemented

The sizing of the PV production leads to a 26 kWp PV plant on a farm building and a 50 kWp ground-based PV plant with tracker.

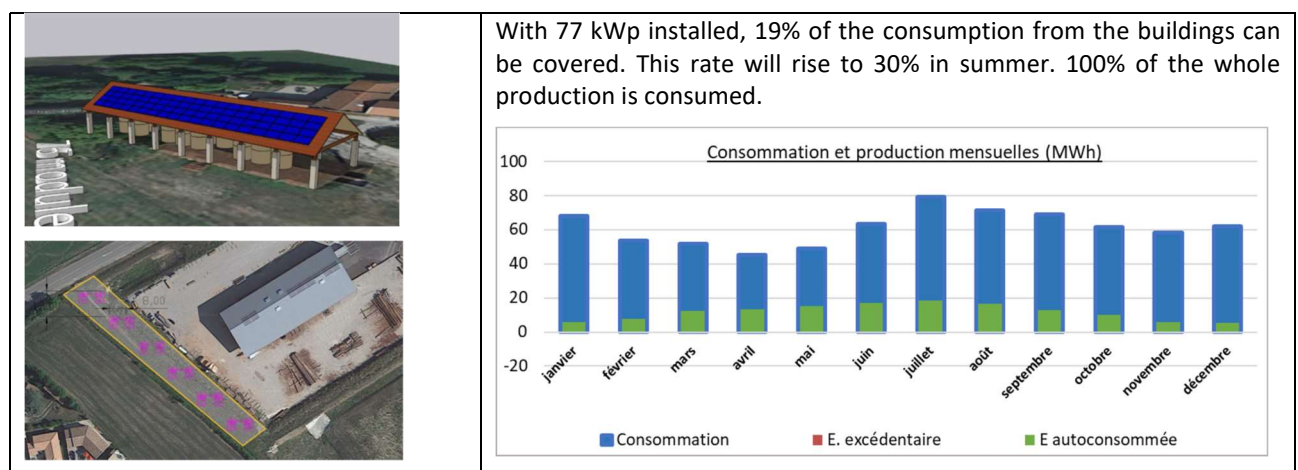


Figure 19 - Design and projected energy flows in Die Drôme)

Two scenarios have been analysed as regards the selling of energy

- Scenario 1 : steady price for the municipality
- Scenario 2 : slight decrease of the price for the municipality

The first scenario leads to a 22 years payback time for the energy community and the second one to a 26 years payback time. No subsidy are taken into consideration in the calculation.

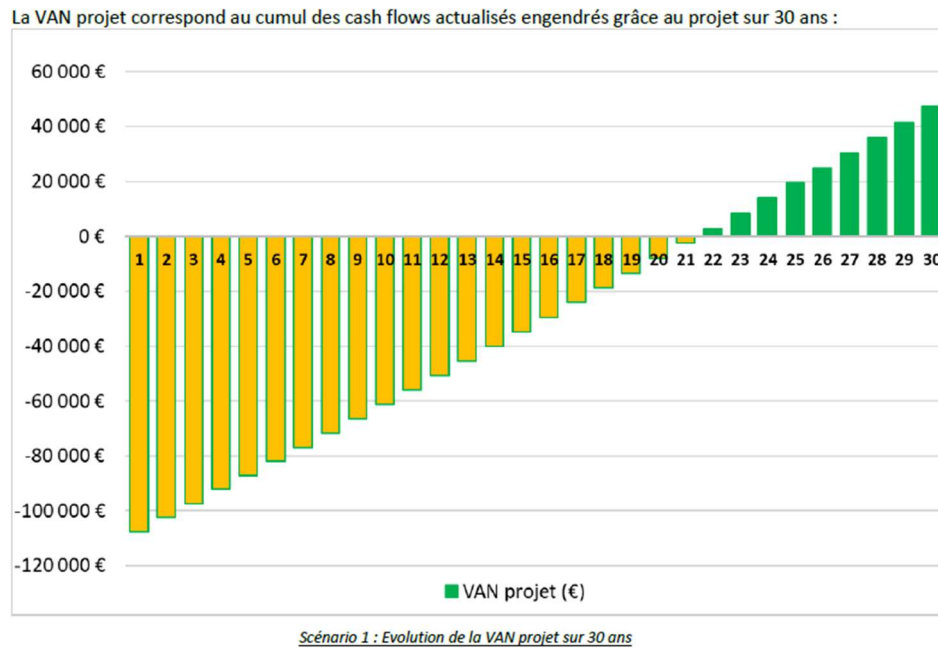


Figure 20 - Cash flow according to scenario 1 in Die (Drôme)

The variation of the investment costs have a big impact on the results. With a 10% decrease of the CAPEX, the payback time becomes 20 years (including discount rate). The results are also highly dependent on the hypothesis made on the electricity price increase. If it increases by 5,5%/year instead of 3% per year the payback time reaches 17 years and the business model becomes more attractive.

2.5.2 Obstacles encountered

Some difficulties were met to collect the load profiles of the buildings.

2.5.3 Proposals for modifications of legislative framework

See Pilot 2a.

2.5.4 Elements proposed to be included in a Alpine Microgrid Model

See Pilot 2a.

Pilot 2.e: Eurre (FR)

2.1 Context and general objectives

The pilot site of Eurre is an economic activity area located close to the village of Eurre. The municipality owns many public buildings, produces electricity with existing PV plants and plans to develop a new PV plants. The aim of the pilot project is to design a local energy loop, namely a collective self-consumption scheme, allowing the municipality to reduce its electricity bill. Island operation of the local grid will not be studied since no specific need has been identified on this issue. Thus, the objective is to set up an efficient business and legal model allowing the municipality to lower its electricity bill.

2.2 Technical description

At this stage, a list of 15 public buildings has been identified. Additional buildings might be added later. Smart meters have been installed for the ALPGRIDS project. In collaboration with the municipality, AURA-EE has requested the automatic registration of the load curves (30 min timestep). This registration is operating since October 2020. 4 possible locations have been identified for PV production.

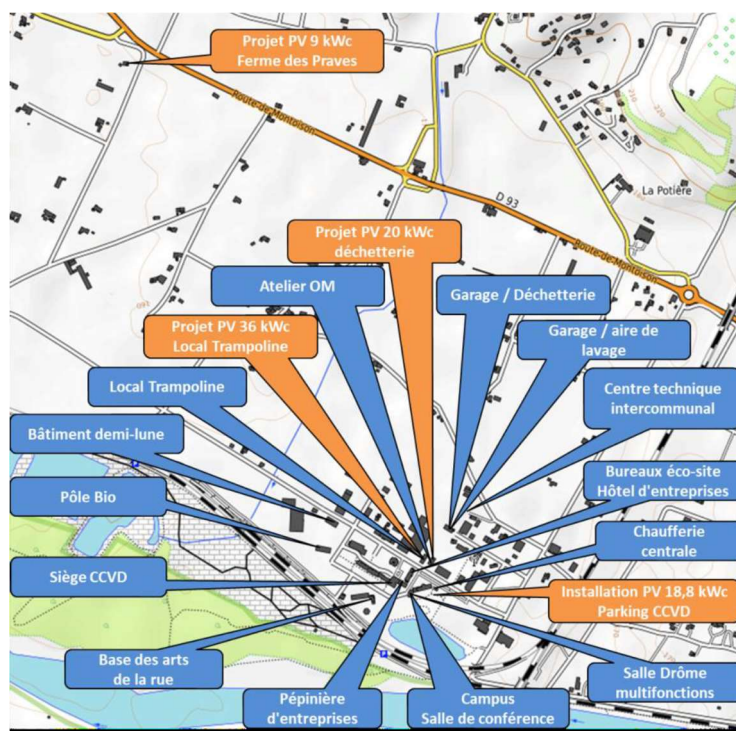


Figure 21 - Design and projected energy flows in Eurre Drôme)

2.3 Legislative framework

See Pilot 2a.

2.4 The energy community

2.4.1 Players involved, their roles and contractual relationships

The main player is the municipality which plans to be both consumer and producer.

2.4.2 Classification of energy community

This pilot is the closest to Class 6, “municipal utilities”.

2.5 Results

2.5.1 Scenario chosen for implementation / pilot design implemented

The sizing of the PV production leads to 4 plants with the respective capacity of 19 kWp, 22 kWp, 19 kWp, 10 kWp. They are located either on roofs or shadowhouses.

The economic approach shows a long payback period (about 30 years including discount rate). This is due to the fact that the investment costs take into account the refurbishment of one roof.

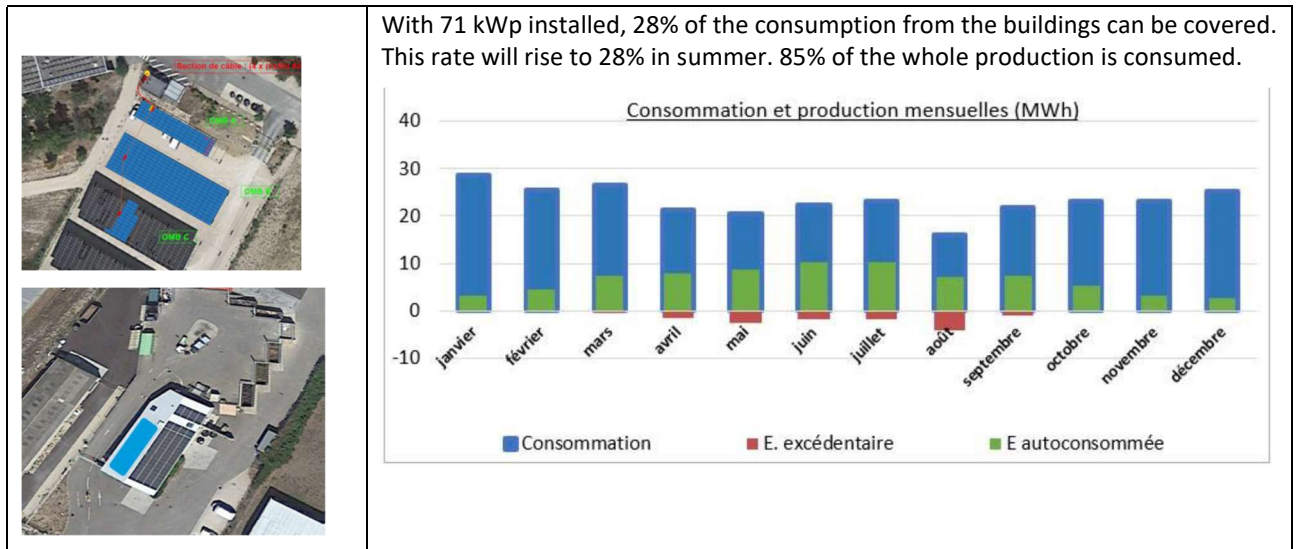


Figure 22 - Design and projected energy flows in Eurre Drôme)

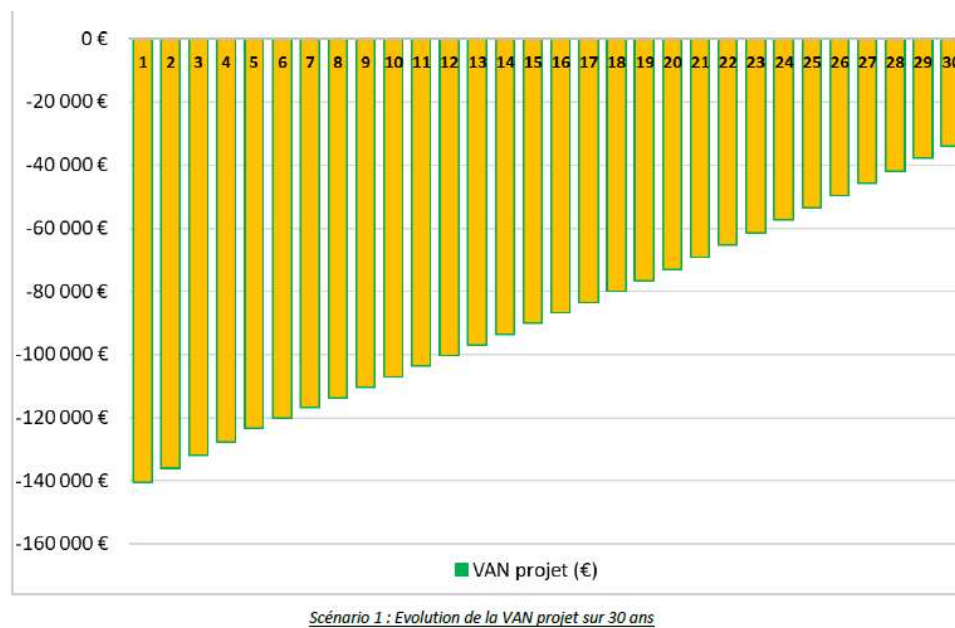


Figure 23 – Discounted payback time in Eurre (Drôme) (scenario 1)

Le projet s'amortit sur 30,3 ans (actualisé) avec un taux de rentabilité interne de 2,62%.

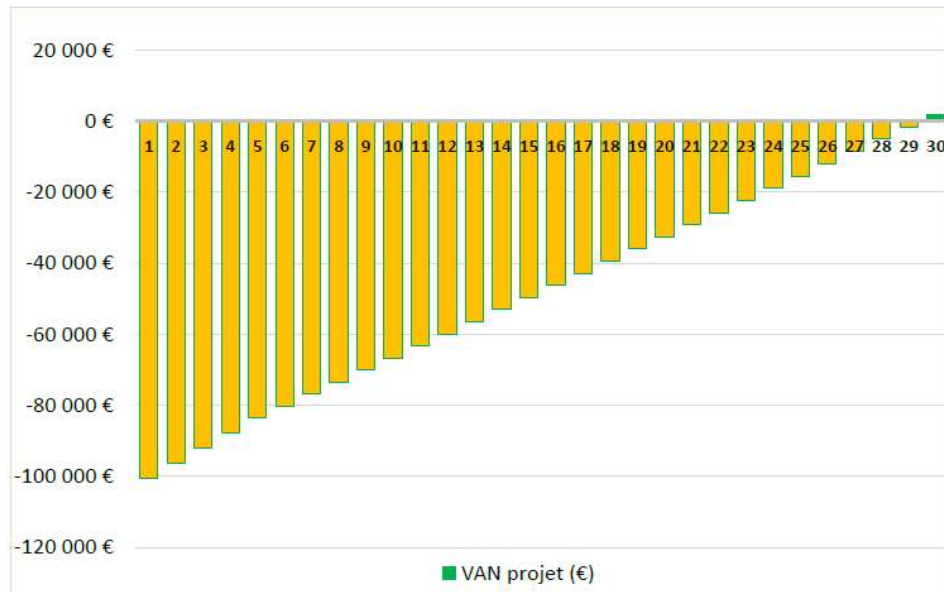


Figure 24 - Discounted payback time in Eurre (Drôme) (scenario 2)

2.5.2 Obstacles encountered

It was very difficult to obtain the load curves of the smart meters.

2.5.3 Proposals for modifications of legislative framework

See Pilot 2a.

2.5.4 Elements proposed to be included in a Alpine Microgrid Model

See Pilot 2a.

Pilot 2.f: La Roche-de-Glun (FR)

2.1 Context and general objectives

La Roche-de-Glun is a semi-urban village. The aim is to supply a retirement house by PV electricity from a PV plant about to be built by the municipality on a sports hall.

2.2 Technical description

The project is still under definition. At present, difficulties are encountered for obtaining data from the retirement house.

2.3 Legislative framework

See Pilot 2a.

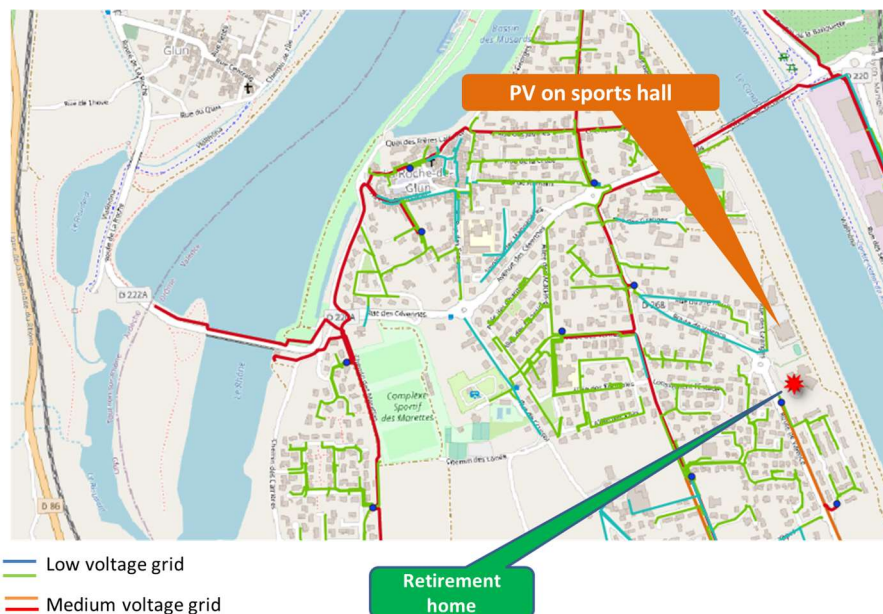


Figure 25 - Possible location of new PV plant for collective self-consumption in La Roche-de-Glun (Drôme)

2.4 The energy community

2.4.1 Players involved, their roles and contractual relationships

This project involved the municipality together with the owner of the retirement house.

2.4.2 Classification of energy community

This pilot is the closest to Class 6, “municipal utilities”.

2.5 Results

2.5.1 Scenario chosen for implementation / pilot design implemented

The sizing of the PV production leads to a 35kWp PV plant on the roof of the future sports hall of the municipality.

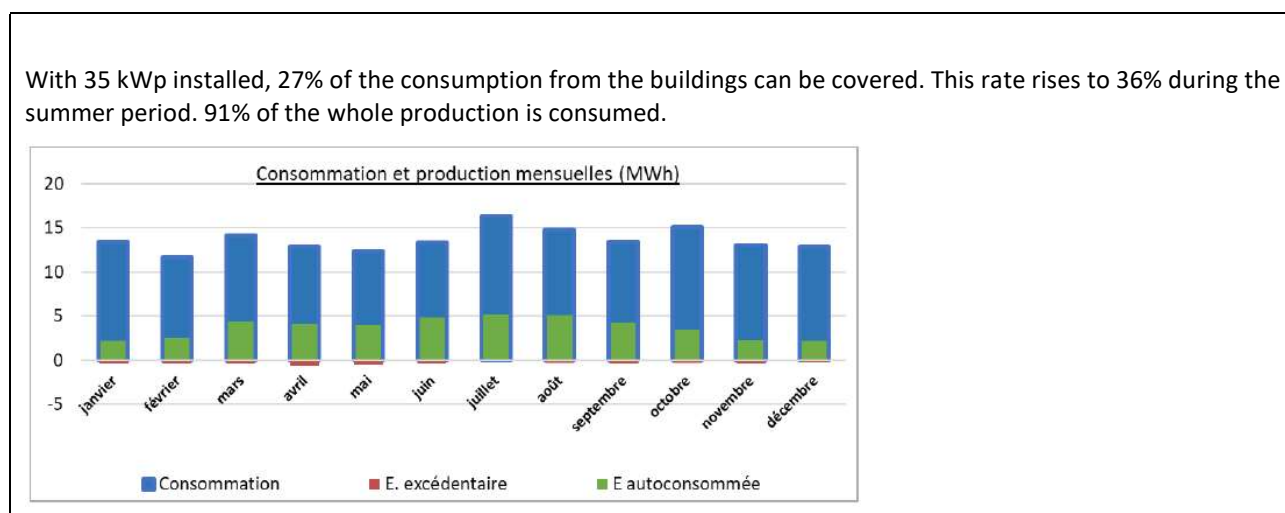
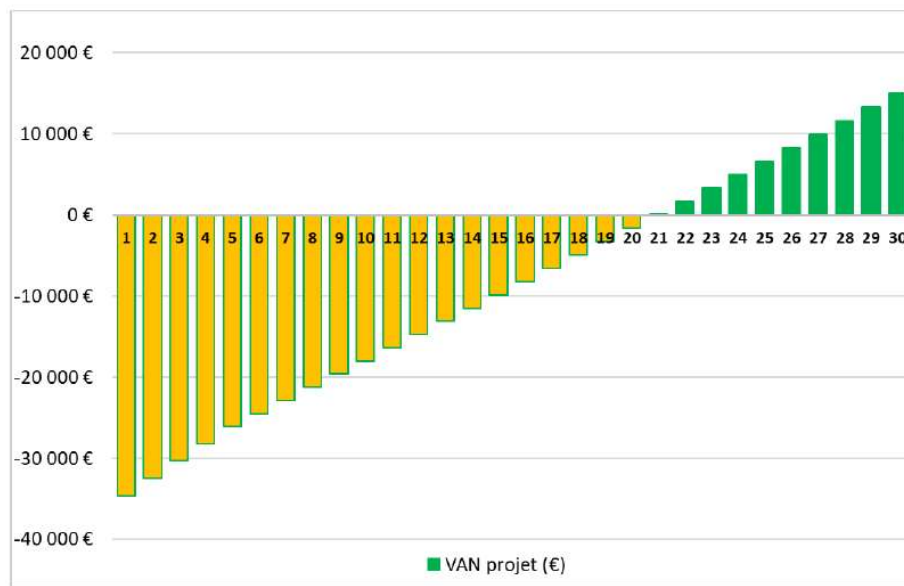


Figure 26 - Design and projected energy flows in La Roche-de-Glun (Drôme)

The economic scenario is built over 30 years. The electricity is sold by the municipality to the retirement house at 4 c€/kWh and the excess which is not consumed is injected on the grid with a feed-in tariff of 6 c€/kWh. With this hypothesis, the discounted payback time is close to 22 years.



Scénario A1 : Evolution de la VAN projet sur 30 ans

Figure 27 - Cash flow in La Roche-de-Glun (Drôme)

The variation of the investment costs have a big impact on the results. With a 10% decrease of the CAPEX, the payback time becomes 19,8 years. The results are also highly dependent on the hypothesis made on the electricity price increase. If it increases by 5,5%/year instead of 3% per year the payback time reaches 17 years and the business model becomes more attractive.

2.5.2 Obstacles encountered

No specific obstacle was met. This use case is quite specific since the electricity price is very low and it sounds difficult to be competitive with a small local PV production.

2.5.3 Proposals for modifications of legislative framework

See Pilot 2a.

2.5.4 Elements proposed to be included in an Alpine Microgrid Model

See Pilot 2a.

Pilot 3: Savona (IT)

3.1 Context and general objectives

The University Campus of Savona is powered by a polygeneration microgrid developed by the University of Genoa and Siemens since 2014. The project has been awarded the European Electricity Grid Initiative EEGI Label, an important sustainability acknowledgement at international level. The goal within the ALPGRIDS project is to carry out a study on the further development of the existing microgrid concept and its application to a new district planned in the neighbouring Legino area.

The main objectives of the further development and expansion are:

- testing the application of a sustainable power system such as the existing polygeneration microgrid in the framework of a local energy community and virtual power plant scheme
- reaching a high degree of penetration of RES in a relevant portion of the urban territory, considering different types of buildings and different patterns of final energy use
- studying a carbon-free network scheme integrating innovative technologies such as hydrogen CHP units and wind turbine generation

The pilot project study will focus on meeting the high supply reliability requirements of research labs, the demand pattern of campus housing, presently high heating and cooling demand with large cost reduction potential, and the target of achieving very low greenhouse gas and other emissions.

In particular, the pilot project study will consider two new physical microgrids capable of operating in islanding configuration. In this regard, the microgrid of the Campus is already prepared for islanding in test mode and research on this field has been carried out since 2014.

3.2 Technical description

The available areas for the new district are highlighted in yellow in Figure 28, where the boundaries of the Savona Campus are indicated with a red line. The new district has been included in the municipal urban plan in 2011, with the aim of creating new accommodations for students and social housing, thereby taking advantage by the nearby university campus to encourage the birth of a new modern urban site.

The pilot to be studied will be in this new district. It is made up of 8 distinct main function areas as reported in the following list. The buildings are located as shown in Figure 29.

1. Public football stadium – main area (existing – subject to makeover)
2. Public football stadium – locker rooms, shops, workshops, grandstand (existing – subject to makeover); stadium microgrid control centre (SMCC) (planned)
3. Public outdoor sports (existing – subject to makeover)
4. University microgrid control centre (UMCC) – main building (storage system, Hydrogen CHP, vehicle to grid) (planned)
5. Student accommodation, university spaces (planned)
6. Social housing (planned)
7. Public Park (existing – subject to makeover)
8. Swimming pool (existing)
9. University microgrid control centre (UMCC) – Microgrid plants (storage, Hydrogen CHP, mini-wind turbine vehicle to grid) (planned)

Apart from the swimming pool, the establishments are owned either by the Municipality of Savona or the University. The public football stadium needs a complete makeover. In this framework the coverage of the grandstand can be exploited to install a photovoltaic power plant with a maximum size of about 1.58 MW_p. The spaces under the stands could be used for the location of commercial activities and offices.

The swimming pool is already heated with thermal power provided by a CHP plant (TOTEM 25) with rated electrical and thermal power, respectively, equal to 25 kW_e and 57.6 kW_t.

New buildings for social housing, student accommodation, offices for the University and private companies can be located in a nearby area (5 and 6 in Figure 29), interconnected with the stadium area by cycle and pedestrian paths.

The significant amount of energy produced by the new main PV power plant could be shared among the users of the new district as actors of a new energy community.

All the buildings are planned to be equipped with PV plants as required by national legislation for new installations. Their size will be maximized through architectural integration of the PV modules.

Furthermore, the investigated solution includes the installation of distributed electrical storage systems, to optimize the use of the electricity produced by the PV plants directly in each establishment.

The new buildings will be supplied with heat and cooling power produced by reversible electricity-driven heat pumps to completely avoid the use of gas. The domestic hot water will be mainly provided by thermal solar collectors coupled with thermal storage tanks. The considered heat pumps will be able to operate as backup for the domestic hot water production. Due to the large availability of renewable electrical energy from the main and the secondary PV power plants, it will be convenient to use induction plates for kitchen uses.



Figure 28 - Available areas and Savona Campus

As part of the investigated pilot project, two physical microgrids will be designed to provide a major part of the energy needed within the district: the first one will be used to power the new University buildings (hereinafter called “Mini-Campus” to distinguish it from the nearby main University Campus), the second one will power the stadium and all the related services.

Such a microgrid scheme has been developed to meet the technical requirements for the connection to the grid of different customers, in compliance to current regulations for the connection to the grid.

The area number 4 in Figure 29 will be used for the location of a new building for the University Microgrid Control Center (UMCC). In the area number 9 the following plants are planned to be installed:

- 1 PV plant (roof of the Microgrid Control Building)
- 1 PV plant (shelter of the UMCC plants)
- 2 mini-wind turbines
- 1 CHP plant fed by hydrogen for research purpose
- 1 electrical storage system
- 1 vehicle to grid station (V1G / V2G station)

The production of hydrogen for supplying the CHP system will be done by an electrolyser fed by the exceeding electricity production from the PV plants within the district. In addition, the possibility to supply the electrolyser during the night by the power generated by nearby wind farms will be investigated, together with the optimal sizing of the hydrogen storage system. Another microgrid control centre (SMCC – Stadium Microgrid Control Centre) will be located inside the stadium building to manage the related physical microgrid.

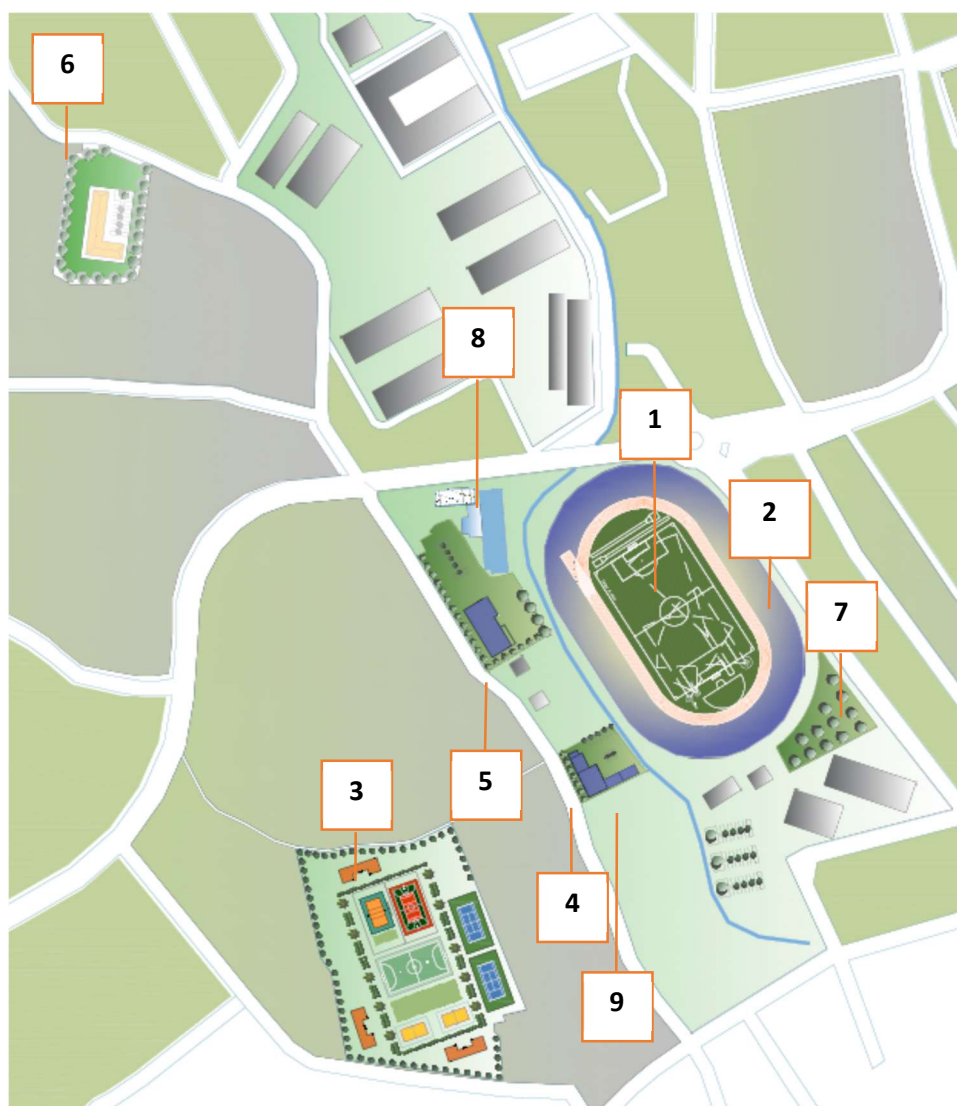


Figure 29 - Pilot Project Savona

The following table shows the electricity consumption and production, respectively, for the new buildings (forecast) and for the existing buildings operating in the new framework (data acquired from energy bills and

forecasts) as well as the main generation data of power plants (future installations). The table includes the electrical consumption of heating pumps used for meeting buildings thermal requirements.

Table 6 - Electricity consumption and generation - forecast (Savona)

building	electricity consumption		RES Plants (PV + Wind)		CHP plants	
	committed power [kW _e]	energy consumption [MWh _e /yr]	peak power	generation [MWh _e /yr]	peak power	generation [MWh _e /yr]
			[kW _p]		[kW _p]	
Football stadium (existing – subject to makeover)	699	1719	1588,0	1455,3		
Social housing (planned)	51	88,6	121,6	116,5		
Student accommodation (planned)	52	89,6	133,0	127,4		
University Microgrid Control Center (planned)	31	73,8	175,8	167,0	25	75
Outdoor sport area (existing – subject to makeover)	50	57,8	155,0	148,5		
Vehicle charging station	149	200,2	15,2	14,6		
Swimming pool	20	18,2	103,6	108,4	25	75
Public park and green areas (existing – subject to expansion)	28	117,2	4,6	4,4		
Total	972	2128	2296,8	2142,0	50	150

The pilot project conceptual scheme is shown in Figure 30.

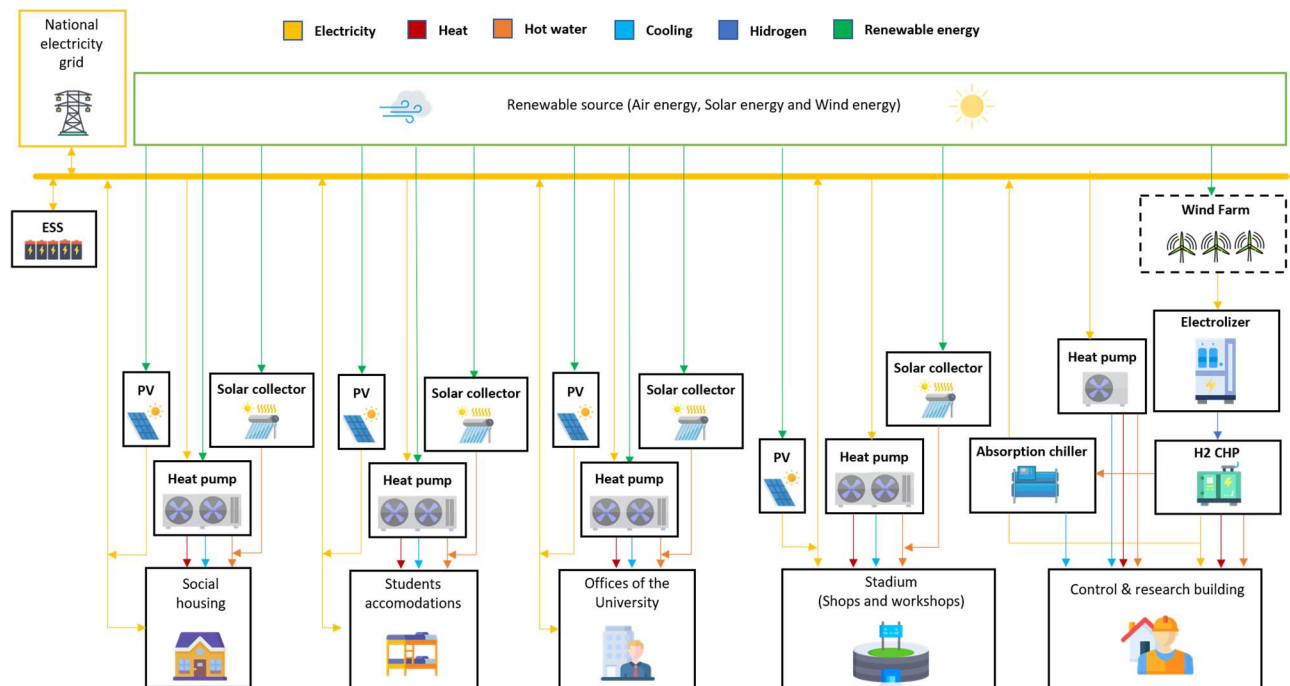


Figure 30 - Energy flow scheme (Savona)

The forecasted yearly electric energy production from renewables exceeds 2 GWh.

The size of the generation units here presented are approximated since they have been estimated based on a preliminary study of electrical and thermal loads.

The final asset of the generation plants will be evaluated by using optimal planning tools based on load profile simulation.

The microgrids will be continuously monitored and controlled by SCADA systems (System Control and Data Acquisition). The SCADA will be designed by referring to the most advanced technologies. When implemented, they will help researchers to perform comparative studies with that already installed in the existing microgrid of the Savona Campus.

All the new buildings will be equipped with a BMS (Building Management System). Such systems offer the possibility to check the operational status of all the devices installed within the buildings (generation plants and loads) and to execute commands (start up and shut down of plants, power regulation, demand response strategies, etc.). They have a fundamental role to support ordinary and extra-ordinary maintenance processes, being able to report anomalies and faults. The actual management of the energy flows of the existing microgrid (that of the Campus) is done by the software DEMS (Decentralized Energy Management System), which can provide load forecasts, the optimal scheduling of dispatchable sources and storage systems, and finally, monitor and control the power exchange with the external distribution network.

The main architecture of the SCADA System is shown in Figure 31 .

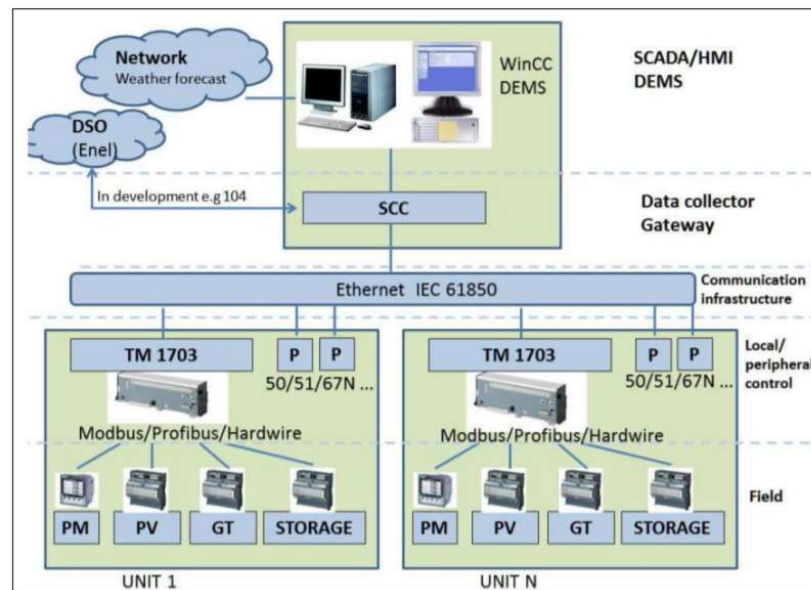


Figure 31 - SCADA Sytem Architecture (Savona)

3.3 Regulatory framework

For the present work several legislative and regulatory measures are being evaluated to investigate their possible application to the ongoing pilot project.

Regarding energy communities in Italy, only the EU's Renewable Energy Directive (RED II) has been implemented by LAW 28/02/20 n.8 introducing the concept of renewable energy community, while the transposition of the Electricity Market Directive (EMD II) is still pending. The Italian implementation of REC tends to follow the cited European directive with some minor specification. In more detail, the proximity constraint concept is implemented by allowing all the members of the same low voltage (LV) portion of the grid connected to the same secondary transformation substation to join into the same renewable energy community. In this way, the concept of energy community is addressed to maximize the local self-consumption of electricity from renewable sources; indeed, only electric renewable generation plants are considered. Moreover, the sharing of electricity, exploited by means of the already existing distribution network, is formalized by introducing the concept of "shared energy" defined as: the minimum value, in each hourly period, between the net electricity produced injected into the grid, by the renewable source plants, and the overall electricity withdrawn from all final customers associates.

On 5 August 2020, ARERA, the national authority for the regulation of energy grids and the environment, has published the document titled "REGOLAZIONE DELLE PARTITE ECONOMICHE RELATIVE ALL'ENERGIA ELETTRICA CONDIVISA DA UN GRUPPO DI AUTOCONSUMATORI DI ENERGIA RINNOVABILE CHE AGISCONO COLLETTIVAMENTE IN EDIFICI E CONDOMINI OPPURE CONDIVISA IN UNA COMUNITÀ DI ENERGIA RINNOVABILE" which defines the guidelines for the relationship between the energy community and the GSE (Gestore Servizi Energetici – the national energy services operator). The main key relations are:

- All the members of the community maintain the relationship with their energy provider.
- The energy community is a juridical entity such as a consortium, a cooperative or an association.
- The maximum size of RES plants managed by a single energy community is presently limited to 200 kW (the limit applies to the sum of nominal power of all plants managed by the energy community), but this upper bound is expected to be cancelled in of the near future by new laws that will definitively implement di European Directive by 2021.
- All the members of the community must be physically connected to the LV distribution network and powered by the same MV-LV substation.

- The shared energy is incentivized at 11 c€/kWh by GSE.
- The shared energy is also incentivized by a reduction of transmission (referring to the TRASE tariff) and distribution (referring to the highest value of the BTAU tariff for the month considered) grid fees.
- The energy injected into the grid can be sold on the electricity market or can be purchased by GSE at a guaranteed price within the regulatory system of “Ritiro Dedicato” (dedicated withdrawal), according to the AEEG’s (Autorità per l’Energia Elettrica e il Gas – the Italian Regulatory Authority for Electricity and Gas) directive n°280/07.

Furthermore, the regional law 6th JULY 2020, n. 13 has introduced several legal obligations for the energy communities regarding the acquisition and the communication of periodic data to monitor the effectiveness and results of each initiative.

In accordance with the ARERA’s directive no. 422/2018/R/EEL referring to the EU Directive 25/10/2012 no. 27 on energy efficiency, a different framework for large groups of small-scale distributed generation producers and consumers is currently studied in Italy through a pilot project concerning the so-called UVAM system shown in Figure 32 (Unità Virtuali Abilitate Miste – virtually aggregated mixed units). More precisely, the project aims to aggregate several stakeholders (operating within the Italian energy scenario) in clusters (called UVAM), to allow them to participate in the Ancillary Services Market (ASM) as a single collective unit. Each cluster is coordinated by a Balance Service Provider (BSP), that acts as an intermediary between each UVAM member and the Transmission System Operator (TSO) during the ASM sessions.

The application of these possible schemes will be studied in the pilot project with reference to the peculiarities of the different buildings.

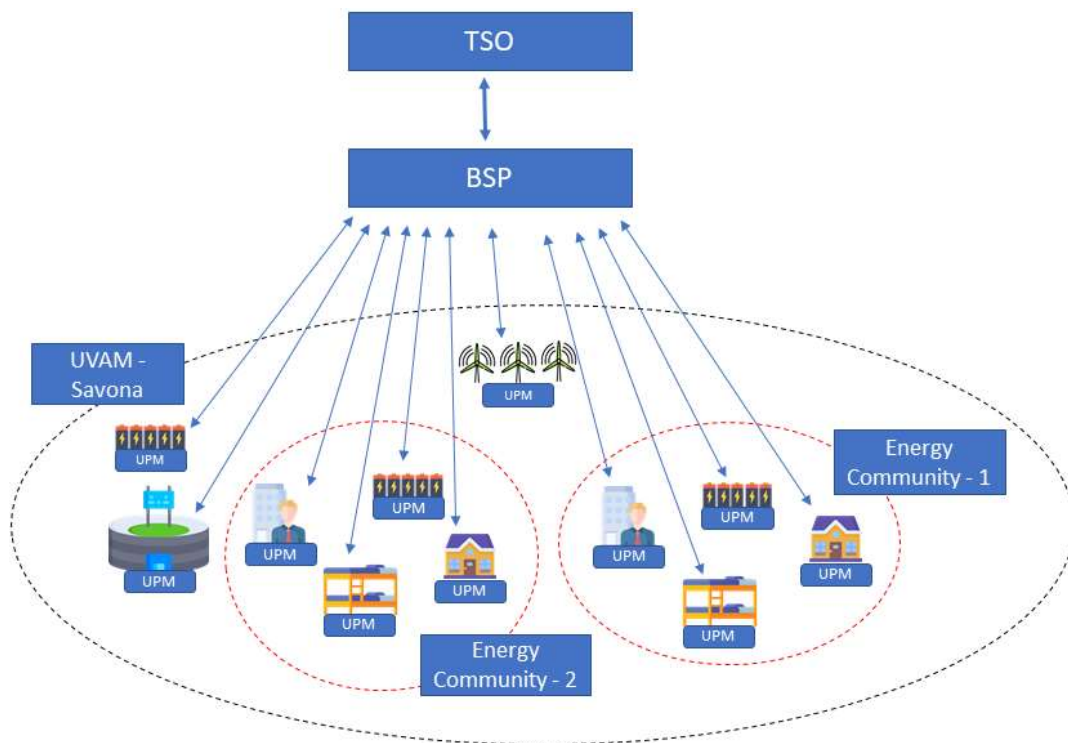


Figure 32 – UVAM - Virtually aggregated mixed units (Savona)

After the initial application phase of energy communities in Italy, some critical issues have been highlighted. As described above, only power plants with a total nominal power up to 200 kWp power plants and only LV users are admitted to the REC configuration. During several conferences and meetings that have taken place

in the last months, it emerged that the above cited constraints are too stringent and could strongly limit the possibility of many citizens to become members of the energy communities.

Moreover, on 14 July, the European Commission adopted the climate package "Fit for 55", which introduces new legislative proposals to achieve the objectives of the Green Deal by 2030. In particular, the reduction of greenhouse gas emissions by 55 % compared to 1990 levels, with the aim of reaching "carbon neutrality" by 2050.

The first important proposal regards the revision of the Energy Efficiency Directive, requiring Member States to reduce primary energy by 39 % compared to 1990. A relevant portion of energy saving must come from buildings for whose efficiency the funds of the Recovery Plan can be used.

Another fundamental point is represented by the revision of the Renewables Directive which radically increases the target of the contribution of these sources to the energy mix from 32 % to 40 % by 2030.

In this scenario, on 6 August 2021, the Italian government presented to parliament a new draft legislative decree with the aim of definitively transposing the RED II directive while introducing some correctives to overcome the previous criticalities and at the same time considering for the new targets introduced by the "Fit for 55" package.

Regarding energy communities, two important innovations are introduced with respect to the limits discussed above. In particular, the power limit of the plants admitted to the incentive system increases from 0.2 to 1 MW. The possibility of forming energy communities between users powered by the same primary HV / MV substation (and no longer secondary MV / LV) which means that the users connected to the medium voltage network through the same primary substation are enabled to reciprocally share energy.

3.4 The energy community

3.4.1 Players involved, their roles and contractual relationships

Three main different energy communities are basically considered in the Savona Pilot: the first one will include the swimming pool and the outdoor sport centre and could be successively extended to the public park. The second one includes the stadium and the associated complementary activities; the "Mini-campus" could be successively considered as part of the last-mentioned community, or it could be aggregated to the existing major University Campus. The third Community is made by the social housing building. The components of the communities are listed in the following (the numbers are referred to the previous Figure 29):

1. Renewable Energy Community REC #1: Area # 3,8 (7)
2. Renewable Energy Community REC #2: Area # 1,2 (4,5,9)
3. Renewable Energy Community REC #3: Area # 6

The hypothesis of designing three distinct energy communities basically derives from the very different size and nature of the involved actors.

The REC #1 will be composed of users connected to the LV distribution grid and probably served by the same MV-LV substation so that they fully meet the requirements set by law 28/02/20 no. 8. In this case, the community members will benefit from the incentives described in the previous section.

The players involved in REC #1 are the local municipality and private stakeholders.

The contractual relationship between the actors could be one of the following as provided by the Italian energy authority:

- i. association (Italian: Associazione)
- ii. consortium (Italian: Consortium)
- iii. cooperative (Italian: Cooperativa)
- iv. partnership (Italian: Partnernariato)

The REC #2 exceeds the limits of 200 kW set up by the above-mentioned law 28/02/20 no. 8 in terms of connected power. Even if this limit will be removed in the final version of the law, the connection to the MV distribution grid will prevent applicability of this law and reception of incentives on the shared energy under the same framework as applied to REC #1.

Nevertheless, REC #2 will still be an energy community, simply one set up outside the framework of the above-mentioned law, aiming at looking for common opportunities in the electricity market. Furthermore, it is not unlikely that the constraint on the connection level will be removed in the final version of the law, thus increasing the number of users that can have a chance to be part of this new framework.

The REC #2 will be formed by two public bodies: the University of Genova and the Municipality of Savona.

The specific type of grid connection allows the application of the so called SSPC systems (Italian: Sistemi semplici di produzione e consumo) for each of the two main microgrids of the district. In this framework the users will benefit from a discount on general system charge.

As far as the energy production from the PV plants of the two microgrids is concerned, it is currently possible to benefit from incentives by participating in an auction (Law D.M. 4/07/2019). The incentive is applied to the net energy injected into the grid. The basic tariffs are 9 c€/kWh for plants under 1 MW and 7 c€/kWh for plants over 1 MW.

The most likely contractual relationships between the actors could be the following ones:

- i. consortium (Italian: Consortium)
- ii. partnership (Italian: Partenariato)

The REC # 3 regards the social housing building and fully meets the requirements of the so-called Self-Collective Consumption scheme that is presently included in the Italian framework of incentives.

From the contractual relationship point of view, the users are already associated as inhabitants of the same building to manage the common facilities through the building administrator.

From this point of view the relations are easier than in the previous cases, as the building administrator can provide for the economic management of the Energy Community together with the other building facilities.

During the present research project, the aforesaid aspects will be investigated more in detail to define the best scheme that could be applied to the REC #2, in order to better exploit and share the renewable resources inside the microgrid and between the involved players. The energy sharing will be optimized by the presence of electric vehicles and energy storage systems whose optimal size will be determined in the next steps.

3.4.2 Classification of energy community

The Savona Pilot can be mainly identified as a Class 4 – Energy Positive District - districts with residential and business entities operating their energy supply systems under their own regime.

The present law does not allow to consider the district as a whole Energy Community but the three Energy Communities above described can act together to meet the requirements of an Energy Positive District since the global energy production overcomes the energy requirements.

The Pilot can be additionally classified as a Class 9 - Collective service providers - all types of commercial groupings of energy services (e. g. grouping of EV charging stations, aggregation of demand side management services). The reason of this classification is that the presence of the distributed storage and the control systems of the two main microgrids create advantageous conditions for providing ancillary services to the grid. This option can both significantly increase the optimal size of RES plants at the planning stage and improving the district economic performance during its life cycle.

3.5 Results

3.5.1 Scenario chosen for implementation / pilot design implemented

At present (09.2021) the Italian legislative framework is still in evolution. The scenario chosen for implementation is slightly different with respect to the initial one mainly due to the urban and hydrogeological risk constraints. All the main functions initially introduced have been maintained but located in different positions on the plan and with reduced volumes.

The users have been grouped in a different way with respect to Energy Communities to better match both legal and technical requirements.

When the new Italian law will be final, the aggregation of users could still change to form a new energy community including the previous REC#1 and REC#2 Communities since the constraints about the level of connection will probably be removed. The size of the stadium's PV system still exceeds the limit of the new law (1.58 MW vs. a new limit of 1 MW).

In this case a final solution with a plant having a size of 1 MW could be adopted to fully exploit the incentives provided by law. Alternatively, the plant will be split in two, each having a size not bigger than 1 MW, provided two plants on the same building will be allowed by Italian legislation.

3.5.2 Obstacles encountered

The main obstacles encountered in the project development are mainly given by territorial constraints and the evolution of the Italian legislative framework.

The original idea of the project (2011) was to realize a set of new buildings with large volumes and a complete substitution of the stadium. In the last 10 years our region has been affected by adverse climate events and the initially planned volumes could no longer be authorized. With the help of technicians from the University and the local public offices, it was decided to plan the new district with the minimum impact in term of use of the territory, by designing new buildings of small size and providing for a complete makeover of the stadium while maintaining its current size.

The evolution of the legislative framework had a significant impact on the decision about the most suitable configuration for the Energy Communities. In particular, the optimal size of the main PV plant on the football stadium is strongly affected by the possibility of using it as a community plant and receiving the incentives on the shared energy or being part of a wide collective self-consumption scheme.

3.5.3 Proposals for modifications of legislative framework

Even if the Italian legislative framework is significantly changing to provide for wider possibilities of receiving benefits for being part of an Energy Community, our analyses show that the measures planned so far are not sufficient to fully exploit the whole capability in term of RES that could be installed.

In the case of our pilot, the size of the PV plant on the football stadium should be limited to 1 MW to apply the REC incentives of the upcoming law. The consequence would be a reduced energy production that could prevent the new district to achieve a positive balance between produced and absorbed energy.

For this reason, we propose a legislative modification to:

- provide for more options to achieve incentives for energy sharing (including the collective self-consumption applied to users that are not located in the same building)

consider RES generators having a size larger than 1 MW.

3.5.4 Elements proposed to be included in an Alpine Microgrid Model

The first aspect that can be taken from the Savona Pilot is the approach to consider the energy community at the planning stage of a new district so that the buildings are not considered stand-alone but interactive from an energy point of view. The preliminary design stage is strongly influenced by this approach; the optimal size of RES generators (optimization based on the minimization of life cycle cost) will be higher for

those buildings that can be part of a REC than in the case of the single-building approach. Moreover, the RES optimal size increases as far as the REC framework can be applied to a larger number of users.

The second aspect that can be included in the model is the exploitation of the microgrid control facilities to provide services to the external grid. The additional gain from the services can be considered since the planning stage to reduce the cost over the life cycle of the installation.

Both above elements help energy communities in becoming attractive to private investors and public bodies, thus achieving a condition where incentives are potentially no longer needed.

Pilot 4: Thannhausen (AT)

4.1 Context and general objectives

Thannhausen is a rural region in Austria. The political leaders of the region have a strong urge to partake in the energy transition by making use of renewable energy sources. Since the aspect of regionality plays an important role in that region, the share of regional renewable energy use is a primary focus.

The municipality owns a couple of buildings at the centre of Thannhausen where PV generation plants are already installed. There is the potential to install further PV plants. The municipality does not want to make use of that potential just for covering its own electricity demand, but also for supplying the surrounding buildings (small enterprises and households). At the time, when the pilot project was developed, the Austrian legislation did not allow for direct electricity trade between different users via the public grid without an energy supplier acting as intermediary. For this reason, it was decided to create a microgrid consisting of new direct lines to allow for direct supply of neighbouring consumers with electricity. It needs to be stated, that new laws for energy communities have now been adopted, which would allow said exchange in renewable energy communities, see chapter 4.3. Nevertheless, when the new legislation came into force, the direct line system was already installed and the system operational.

The goal is to provide local and cheap energy to the users of the direct line system and further contribute to the following points:

- reduce strain on the public grid by directly using the electricity within the micro-grid
- reduce the generation peaks caused by PV
- provide the technical setup to allow energy supply in case of a failing of the public grid
- provide the technical setup to include a battery storage for further increase of the own consumption

4.2 Technical description

The pilot in Thannhausen consists of 8 different consumers (grid coupling points) which are connected to the public low voltage (230/380 V) grid. At this moment all of the consumers are still metered with classic Ferraris metering units as the roll-out of smart meters has not yet reached the region. All consumers are part of the same low voltage grid branch connected to a transformer to the medium voltage grid. The consumers are in proximity of one another, which makes the realisation of a direct line system possible.

The pilot currently considers two residential buildings, five small enterprises and the buildings of the municipality which share one connection point to the public grid. Currently there is only one PV generation plant installed at one of the municipal buildings with an installed capacity of 56 kW_p, which provides energy to the municipal building and feeds the surplus into the public grid. Currently, the PV is granted a feed-in tariff which will expire in 8 to 9 years. An additional generation capacity of 29 kW_p is planned as main energy source for the microgrid.

Table 7 shows the current consumption situation of the different users of the to-be-established direct line system. For reasons of data protection, the clear names are not shown.

Table 7 - Consumption data of the users of the direct line system (Thannhausen)

User	Annual Consumption [kWh]	Peak load [kW]
Household 1	5.000	8,4
Household 2	8.600	8,0
Small Enterprise	18.000	30,0
Municipality	46.000	13,5
Small Company 1	4.200	8,8
Small Company 2	3.000	2,0
Small Company 3	1.800	0,5
Small Company 4	4.200	2,0

The overall setup of the micro-grid (direct line system) is shown in Figure 33.

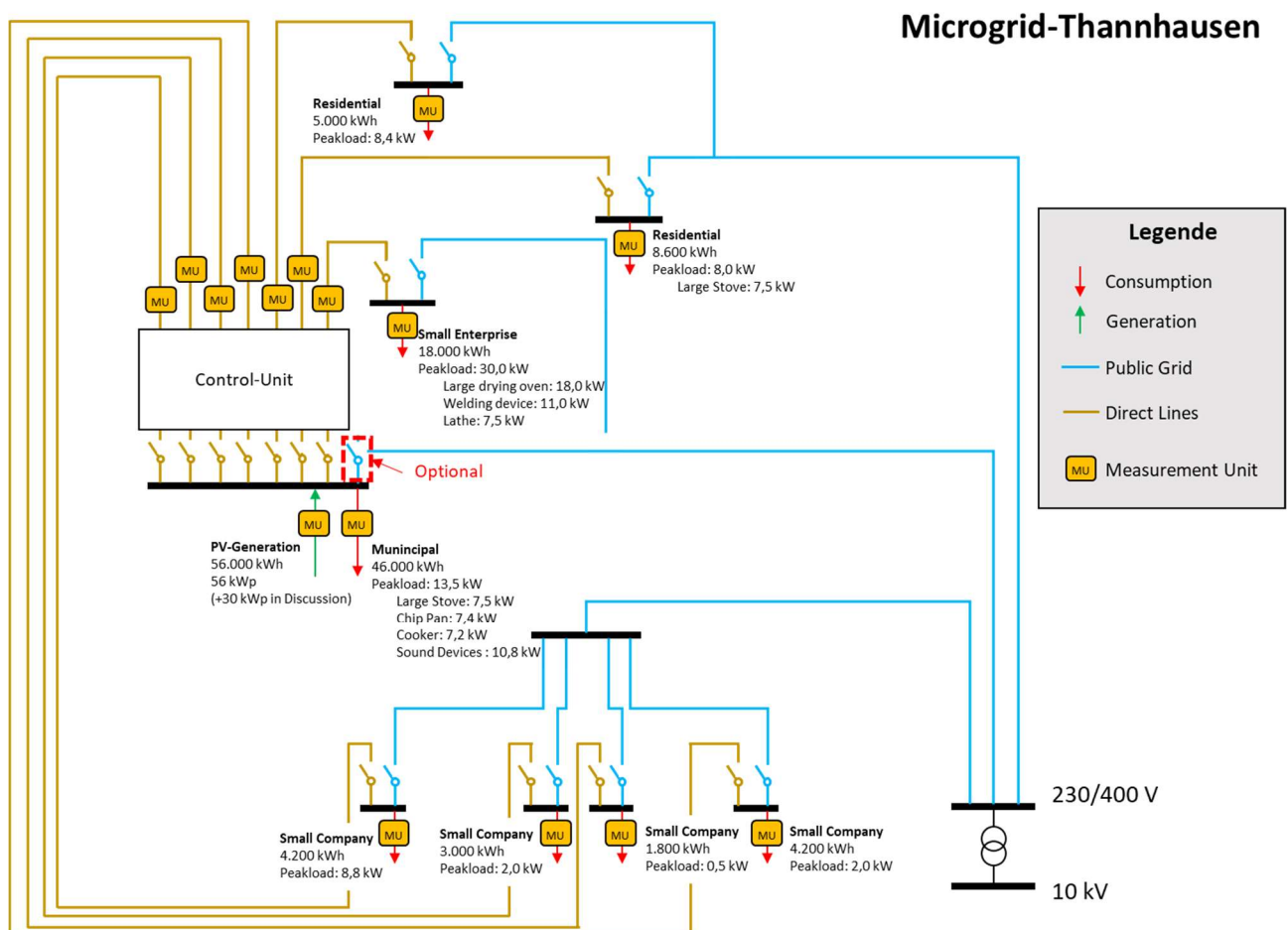


Figure 33 - Technical set-up of the pilot (Thannhausen)

The microgrid will feature the municipality's PV generator as main power source. Each of the user will be connected to the PV generator with a direct line. The direct line will be connected to the user's electrical system behind the metering system of the grid operator. The direct line can be switched on and off on both sides (for safety reasons) of the direct line. Each of the users also has a connection to the public grid which can be switched off when the entire consumption can be satisfied within the micro grid. The PV generator also has a switch which allows separation from the public grid, but this will only be used in the case that islanding is necessary. During normal operation the PV generator is connected to the grid.

Each of the users will be equipped with a measurement unit to measure the total power consumption, in addition a measurement unit will be installed on each direct line and for the PV generation and the consumption of the municipality. The measurement units at the user's sites will be installed behind the official metering units of the grid operator. These measurement units only have a purpose for the control unit, while the measurement units on the direct line also serve a metering purpose for billing and thus need to be gauged.

The control unit (an energy management system) will receive its data via Ethernet cables which are placed together with the cables for the direct lines. Ethernet cables will also be used to control the switches of the direct lines which will be implemented as air gap switch.

For the control regime the following rules apply:

- First off, the consumption of the municipal buildings will be covered, only excess energy will be provided to the direct line system.
- The control unit will then check the power consumption values of the users and will sort them according to an internal ranking system such that most of the PV generation can be used directly.
- Only users whose demand can be fully satisfied by the PV generation will be connected to the direct line system and separated from the public grid.
- The internal ranking system will ensure, that over the course of a certain period, distribution of PV generation will happen on a fair and transparent basis.
- Any remaining excess PV generation will be fed into the public grid at the coupling point of the municipal building.

In case of a disruption of the public grid, all users will be disconnected from the public grid and permanently connected to the direct line. To compensate load and generation fluctuations, a diesel generator will be used, which later on will very likely be replaced by a battery system.

4.3 Legislative framework

Operating a direct line or a direct line system is made possible by the Elektrizitäts- Wirtschafts- und Organisationsgesetz (ElWOG), Austria's federal energy law. The concept of direct line is defined in the basic provision of Section 7 (1) no.8 ElWOG as follows:

"Direct line: either a line connecting a single production site to a single customer, or a line connecting an electricity producer and utility company for the purpose of direct supply to their own permanent establishment, subsidiaries and approved customers; lines within residential complexes are not considered direct lines."

For that reason, the system must consist of multiple lines and each consumer will be connected only to one direct line and each direct line will thus only be connected to the PV generator (production site) and one user (single customer). The direct line system is operated outside the domain of the grid operator.

While the ElWOG provides only very limited rules, guidelines or general information on how to operate direct lines, the following basic principles need to be taken into account:

- Separation between direct line and public network

A direct line within the meaning of Section 7, Paragraph 1, Item 8 of the Federal ElWOG exists only if there is no direct connection between the line in question and the public network. There must

therefore be no direct exchange of electricity between the direct line and the public grid, i.e. no public electricity flows in the direct line.

Under no circumstances may the generating plant be supplied with electrical energy from the distribution network via the direct line. This also applies when the generating plant is at a standstill. *This condition is satisfied by the rule, that the PV generator is always connected to the public grid, while the user will be separated from the public grid in case of a transport of energy by the PV-plant. Furthermore, the users will only receive energy via the direct line if the PV generates enough electricity to still have a minor infeed into the public grid at its own coupling point.*

- **No PV surplus is fed into the public grid via the direct line**

Furthermore, no electricity may be fed into the distribution network via the direct line (e.g. via the customer's system). Here, too, this would otherwise lead to the direct line becoming part of the public distribution network.

If more electricity is generated than is consumed by the customer, the generating plant can also be connected directly to the distribution network so that the "excess" energy can be fed into the network. This is not detrimental for the assessment as a direct line (VwGH 04.03.2008, 2007/05/0243). But even in this case the consumers may not be supplied with electricity from the distribution network via the direct line.

It should be mentioned that the excess feed-in at the producer or consumer is (legally) insignificant for the design of the direct line.

In case of the direct line system in the Thannhausen MicroGrid, this condition is also met by the general approach for the control strategy. By disconnecting the users once they are connected to the direct line, there is no connection to the public grid anymore. Thus, no transport of PV generation will happen. It needs to be mentioned though, that there is a short period (milliseconds) during the switching process where the user is connected to both the public grid and the direct line. This is in line with the law as the Austrian Market models recognises a period of 15 minutes as the smallest time step.

- **The direct line must be operated by the producer**

According to the law, a direct line always exists when an electricity company or a producer supplies one or more customers via an electrical line system that is not directly connected to the public grid. Since the right to set up and operate the direct line belongs exclusively to the producer, the direct line must also be operated by the producer.

Since the system is operated by the Municipality Thannhausen who is also the operator of the PV-generation, this poses no problem.

- **Star network is not a contradiction to applicable electricity law**

From the definition of the term of the direct line, which speaks of the supply of a single production site with a single customer, it can be deduced that several customers may not be supplied via the line. This means that each individual consumer has to be supplied with a separate direct line. Such a star network does not contradict the requirements of the electricity law.

In addition, there is of course the possibility of supplying customers via the public network, for which the above-mentioned system service fees and other charges must be paid.

4.4 The energy community

4.4.1 Players involved, their roles and contractual relationships

At the moment (09.2021), the corresponding law enabling energy communities is already in force. Renewable Energy Communities are defined by the Erneuerbaren Ausbau Gesetz (Renewables Expansion Act) as well as the Elektrizitätswirtschafts- und Organisationsgesetz (Electricity Industry and Organisation Act).

It needs to be stated, that the Thannhausen pilot will not be set up as energy community as defined in the information provided by the Ministry of Climate Action. The reason is that the municipality in Thannhausen would also like to assess the topic of supplying the users in case of a black out. The grid operator will not be able to isolate the "Thannhausen-Island" in case of a black out, thus alternative concepts such as the direct line system are necessary.

4.4.2 Players involved, their roles and contractual relationships

As defined by the EC's renewable energy directive and the electricity market directive, membership in energy communities is limited to:

- private consumers
- small and medium enterprises
- public bodies (such as municipalities) and their commercial bodies

In either case a formal membership in the energy community is required. The energy community itself needs to take the form of a legal body ("Rechtspersönlichkeit" in German). Currently the following forms of organisation are eligible for energy communities:

- association (German: Verein)
- cooperative (German: Genossenschaft)
- business partnership (German: Personengesellschaften)
- Corporation (German: Kapitalgesellschaften)

Whichever form of organisation is chosen, the energy community must operate as non-profit organisation. The financial benefit must stay with the members of the community.

Within the community, members can exchange energy. In case of a renewable energy community it has to originate from a renewable energy sources, in case of the citizen community the exchange is limited to electricity. Citizen energy communities can contain members from all over Austria, there is no proximity requirement for them, while within renewable energy communities the members have to be in close proximity to one another.

In Austria the degree of proximity will be defined by the grid levels the members are connected to. Austria's grid is composed of 7 grid levels. The levels with a even number correspond to transformers, the levels with uneven number to grid lines. Small customers are generally connected to the low voltage level (layer 7). There will be two types of proximity possibilities an energy community can choose from:

- Regional proximity: This includes levels 5 to 7 and also the "Sammelschiene" at level 4.
- Local proximity: This includes levels 6 and 7.

When the energy community is founded, there needs to be taken a decision on the proximity type. The proximity type also influences the cost savings the members of the renewable energy community can generate. For each kWh exchanged within the energy community, the receiving member will be partially exempted from paying grid fees and from certain taxes and payments. The reduction of grid fees will be 60 % for the local proximity and approximately 30 % for energy communities of the type regional proximity.

For metering purposes smart meters need to be installed at every consumer. The grid operator will measure the consumption of each member with a resolution of 15 minutes. The total surplus fed into the energy community will be subsumed and divided amongst the members according to a distribution key provided to the grid operator. Each member will thus receive two bills, one from his regular energy supplier (which according to the EU law can be changed at will by the consumer) one from the energy community.

4.4.3 Classification of energy community

The Thannhausen Direct Line System can be identified as a Class 6 (Municipal Utility) energy community as the entire commodity is owned and operated by the municipality of Thannhausen. This refers to both the generation capacity itself as well as the direct line system.

In the future the system will be adapted further to include a battery system, which will allow Islanding and would allow to classify this energy community as a Class 5 (Energy Islands) energy community. But this is not the case as of yet.

4.5 Results

4.5.1 Scenario chosen for implementation / pilot design implemented

There have been some minor deviations in comparison to the pilot project plan presented in DT 1.2.1, which were mostly of technical nature:

- 1) When implementing the control algorithm, which is based on a simulation model with a temporal resolution of 15 minutes, it occurred that the direct lines switches frequently changed position due to partially cloudy skies. While the switches are said to outlast at least 100.000 switching actions, such situation would lead to a rather fast attrition of the switches. As such the algorithm had to be adapted to prevent overly many switching actions.
- 2) Change in the technical layout. Due to some technical issues with the grid operator regarding the legal entities behind the metering points, the technical setup of the direct line system had to be adapted. Originally it was planned to have the municipal office act as centre of the direct line system. But this was changed, making the building on which the new PV generator is situated (Garbage disposal centre) the new central node of the direct line system.

4.5.2 Obstacles encountered

During the realisation of the system the following obstacles were encountered:

- Supply bottleneck for electronics: Due to the COVID pandemic supply bottlenecks for components of the central control unit and the switching boxes occurred, which lead to some delays in the implementation of the system.
- Switching actions due to partially cloudy days:
The direct lines were frequently switched on and off during partially cloudy days, in order to meet the legal requirement of avoiding net feed-in of PV power into the public grid. These switching actions would have led to a fast attrition of the switching devices.
- ModBus communication errors:
During the testing phase of the system, some not comprehensible errors in the measured data occurred. After trying to resolve the issues, the conclusion was drawn, that the error must lie with either the Modbus Communication or the measuring devices themselves. It turned out to be a mixture of both, in some situations the error was with the measuring devices themselves, in some cases the ModBus Communication had to be reworked.
- Issues with the registration of metering points:
When setting up the system to be inspected by the local grid operator, some issues with the companies registered to the metering points came up. For one metering point in particular, which was situated inside one building, the generation meter was registered to one company, the consumption point to another. This had to be corrected for the system to operate.
- Phase order issues when connecting the direct line system:
When the direct line system and the switching boxes were connected to the public grid some measuring errors occurred, these errors resulted from the phases of the direct line system not being connected in the correct order. This was mainly due to description errors within the plans of the electric installation.

4.5.3 Proposals for modifications of legislative framework

Since the Thannhausen Pilot relies on the use of direct lines which are currently well defined in the EIWOG there is no need for an immediate modification of the legislative framework for normal operations.

4.5.4 Elements proposed to be included in an Alpine Microgrid Model

The central role of the municipality in the micro grid approach of Thannhausen can be well translated to the Alpine Space Microgrid Model, as it highlights the necessity of having a central player with a coordination role to realise such an endeavour. This is true regardless of whether a technical micro grid or an energy community is realised.

The second aspect that can be taken from the Thannhausen micro grid is the approach to fully and interactively include the users / members of the micro grid / energy community in the development approach. As the approaches need a strong backing from the members / users, it is fundamental for the success of the entire action.

Close cooperation with the existing infrastructure providers (esp. grid operators) is paramount for the success of any micro grid. As can be seen in the Thannhausen pilot, the grid operator was included all along the process of realising the micro grid. Furthermore, it was made sure, that he does have a say in the development of the solution. As such systemic errors in the development of the microgrid were identified early on, allowing for fast and effective solutions.

Another aspect that should be considered is the perception of fairness amongst the users / members. This is especially important in case of a very heterogenous group, when it comes to energy consumption or consumption profiles, of users / members. Since the distribution of energy amongst those very different members / users can become tricky, it requires a distribution mechanism that promotes trust.

From a technical perspective there are some aspects that need to be considered. When a billing system should be used in the micro grid it gauged meters need to be considered (at least in Austria). Once a direct control of devices is within the scope of the microgrid, the necessary control algorithms and devices need to reflect on the fluctuations of the power sources as well as the power sinks. While this aspect might seem a bit dull in the case of a grid connected micro grid, it becomes a lot more crucial when islanding mode is considered.

Pilot 5: W.E.I.Z. Campus (AT)

5.1 Context and general objectives

The objectives of the WEIZ pilot are the conception, the development and the implementation of a microgrid connecting the consumer WEIZ I and the prosumer WEIZ II, that is a direct-line system for the energy exchange between buildings. The aim of the system is the maximization of the autarky of both buildings, facilitated by their supplementary load profiles.

At first, the focus of the project is on the clarification of the legal and economic aspects, on finding appropriate ways of problem solving by the development and adaption of single components as well as on the integration of them in the overall system. A second focus is on the intelligent controlling and monitoring systems and moreover on the building-integrated sustainable energy supply. Thus, the foci are on the following areas:

- electricity generation with building-integrated photovoltaic plants (a high level of utilization of the generated electricity in the respective building complex is aspired)
- energy storage (usage of battery storage systems)
- development and use of an intelligent energy management and monitoring system
- development of interfaces for the connection with the electricity grid

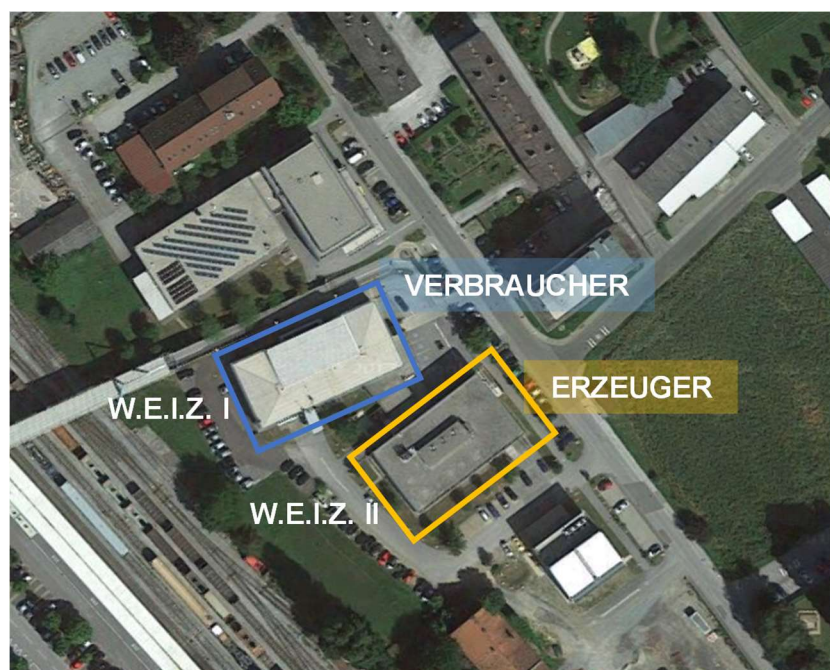


Figure 34 - WEIZ I producer and WEIZ II prosumer (W.E.I.Z. Campus)

W.E.I.Z. I - 1st passive office building in Central Europe: The W.E.I.Z. I is a compact, 3-storey office building (1,350 m²), designed in the form of a wooden frame structure, filled in with glued board stacked ceilings and prefabricated wall elements. The building envelope is optimized (U-values: (1) roof: 0.1 W / m²K, (2) walls 0.12 W / m²K, (3) windows 0.7 W / m²K). The building is heated by means of air heating. This system is used to cool buildings in summer. These basic components enable the 1st passive office building in Austria with an energy consumption of 15 kWh / m² / year.

In the W.E.I.Z. I, around 80 people work as employees in research companies (Joanneum Research Forschungs- GmbH, Human Research GmbH), business-related service providers (TB Energietechnik, EDV) and management and consulting companies. Office and laboratory facilities are installed here that require a total of approx. 200,000 kWh / a of electricity. A large part of the electrical energy for the building is required

for ventilation (approx. 90,000 kWh / a). Because of the central ventilation system, which is in operation all year round, the energy costs are 8 € / m²a.

The W.E.I.Z. I has a covered atrium (glass roof: approx. 240 m²) that is not suitable for PV equipment. The remaining roof area is equipped as a membrane roof with a lightweight wooden substructure. The load-bearing capacity is tightly calculated and, in addition to the possible snow load, offers only a few additional load reserves for a possible PV system. The electrical installations in the W.E.I.Z. I are very selective. There is a good technical separation of "general electricity" and "office / customer electricity". Therefore, for research purposes, the general power area can be supplied by direct line and any power fluctuations that may occur during the test phase cannot have a negative impact on sensitive laboratory equipment at tenants in the W.E.I.Z. I impact. The billing for the electricity supplied from WEIZ II to WEIZ I can be made clearly visible in the internal operating cost billing and billed financially clearly.

W.E.I.Z. II - Cooling and heating with the sun ("Kühle Kiste"): The building with approx. 2,200 m² is mainly dedicated to R&D and start-up activities and also offers high quality laboratory space (including clean room). The W.E.I.Z. II is structurally a "cool box". This very innovative energy concept of the 4-storey office building enables the building to be heated and cooled using geothermal probes in combination with a heat pump and district heating. The compact structure with good thermal insulation also has thermally active storage masses with concrete core activation. These and other measures lead to an energy figure of 29 kWh / m²a (lowest energy house thermal protection class A).

The W.E.I.Z. II is heated by means of a heat pump and depth probes via ceiling heating (concrete core activation). In the summer, the building is cooled without a cooling machine (the heat pump can also be operated as a cooling machine) by flushing the geothermal probe (circulation pumps pump the cooling water from the geothermal probes into the ceiling heating / cooling). This method is very energy-efficient, so that only around 40,000 kWh / a of electricity are required for year-round room conditioning (heating and cooling). The specific energy costs in the W.E.I.Z. II approx. € 2 / m²a.

The compact and efficient use of space only allows a very smart, central atrium. As a result, however, the roof area is relatively large, which in turn is favourable for the installation of a larger PV system (max. Expansion capacity: 40 kWp). A 20 kWp system was installed on the roof of the W.E.I.Z. II

5.2 Technical description

Using direct power cabling, the W.E.I.Z. I with the W.E.I.Z. II connected, with both buildings having an independent power connection to the public power grid. The detailed concept of pilot plant 1 is shown schematically in Figure 35.

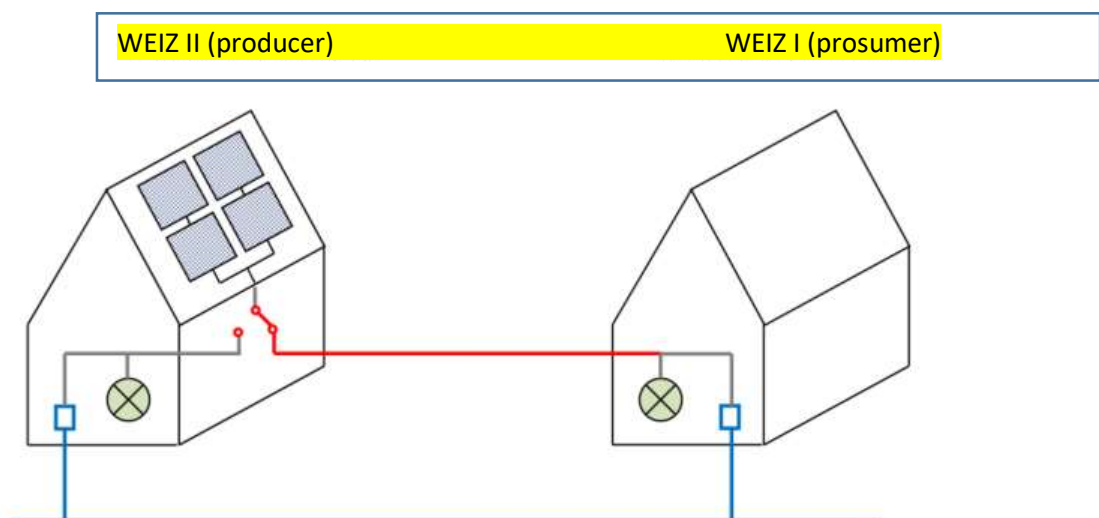


Figure 35 - Schematic visualisation of the direct line between WEIZ I and WEIZ II (W.E.I.Z. Campus)

On the basis of this basic variant, it is examined to what extent a storage facility for the intermediate storage of excess electricity makes sense, or how it must be dimensioned in order to enable economical operation. In addition, these considerations form the basis for the development of the energy management system.

5.2.1 Requirements of the energy management system

The project-related energy system basically consists of decentralized PV generation units, consumers, storage, a connecting network and ICT components. The entire energy system is to be monitored and controlled centrally. The energy consumption, supply and management system records not only the current energy requirements of the individual consumers / buildings, but also the current generation of electricity by the photovoltaic system(s) and the state of charge of the storage unit.

In principle, the current demand should be compared with the current PV generation. A decision is then made on the basis of a number of parameters as to what to do with the electricity supplied by the decentralized generating unit or how the consumers are to be supplied. A decision is made as to whether the PV electricity is to be used directly in the building, stored, made available to another building, fed into the public grid or whether electricity has to be drawn from the storage facility or from the grid.

The development and testing of the overall system presented was carried out for two different pilot plants, which is why the relevant results and milestones are presented in the following chapters using the two pilot projects.

The storage system is there to compensate for the fluctuations in the PV and to make a contribution to increasing self-consumption

In the energy centre of the W.E.I.Z. II the inverter and the supplementary 15 kWh power storage with battery inverter were installed. Both inverters are self-commuted and can be operated in "island systems" independently of the public power grid. For WEIZ connected, for demonstration purposes the PV generator installed at W.E.I.Z. II provides energy for the circulation pumps for the depth probes and ceiling heating as well as for public lighting and lift operation within the building. This limited power consumption enables the excess power of the installed PV system to be sent to the building W.E.I.Z. I using the WEIZ connected technology. A general overview of the installed hardware components in the WEIZ I is given in Figure 36.

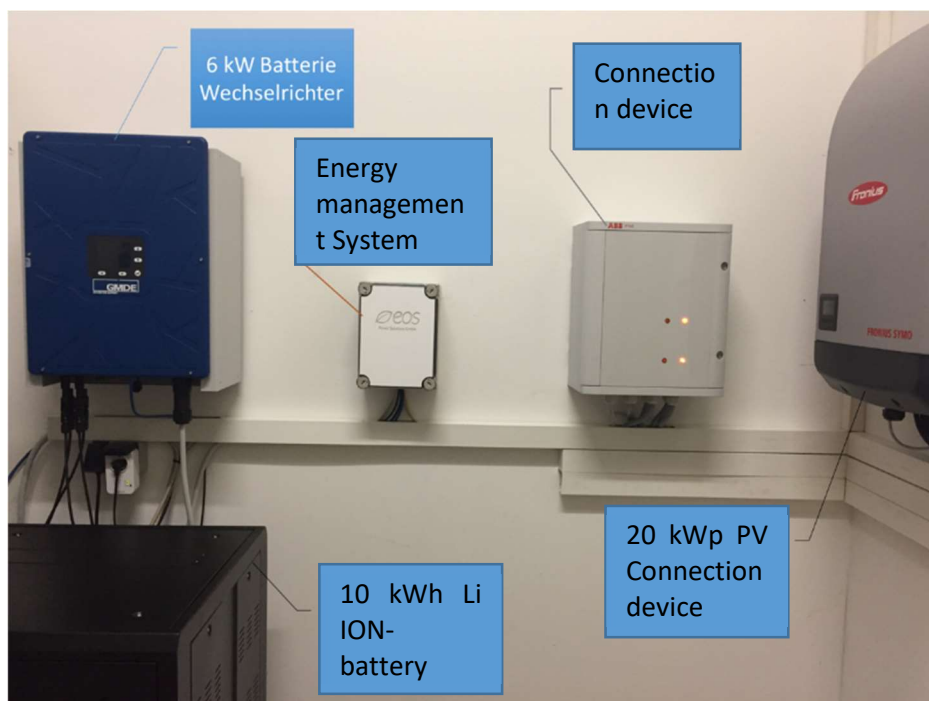


Figure 36 - installed hardware components within the WEIZ II building (W.E.I.Z. Campus)

5.2.1 The electrical plan

Microgrid-WEIZ

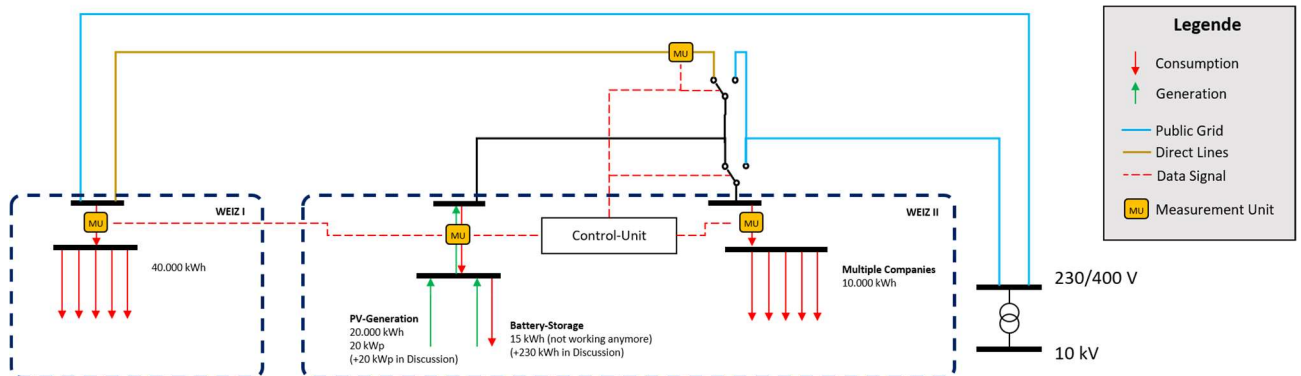


Figure 37 - Technical scheme for the microgrid WEIZ (W.E.I.Z. Campus)

Figure 37 shows the technical scheme for the microgrid in Weiz. Both buildings are connected to the public grid. While WEIZ II can be separated from the grid, WEIZ I has a permanent connection. The direct line can be switched on and off directly at WEIZ II. Also the supply system can be used to either support one of the buildings or both, by connecting it either to the direct line or WEIZ II or both. All consumption and generation values are measured, thus providing the control unit with the means to switch the switches according to the current load and generation situation.

5.2.2 Connection device

The development of the so-called “connection device” posed a major challenge. The task of the connection device is to activate the connection line whenever excess photovoltaic power is available and to forward the excess power to the connected building.

Figure 38 shows the embedding of the connection device in the existing building installation

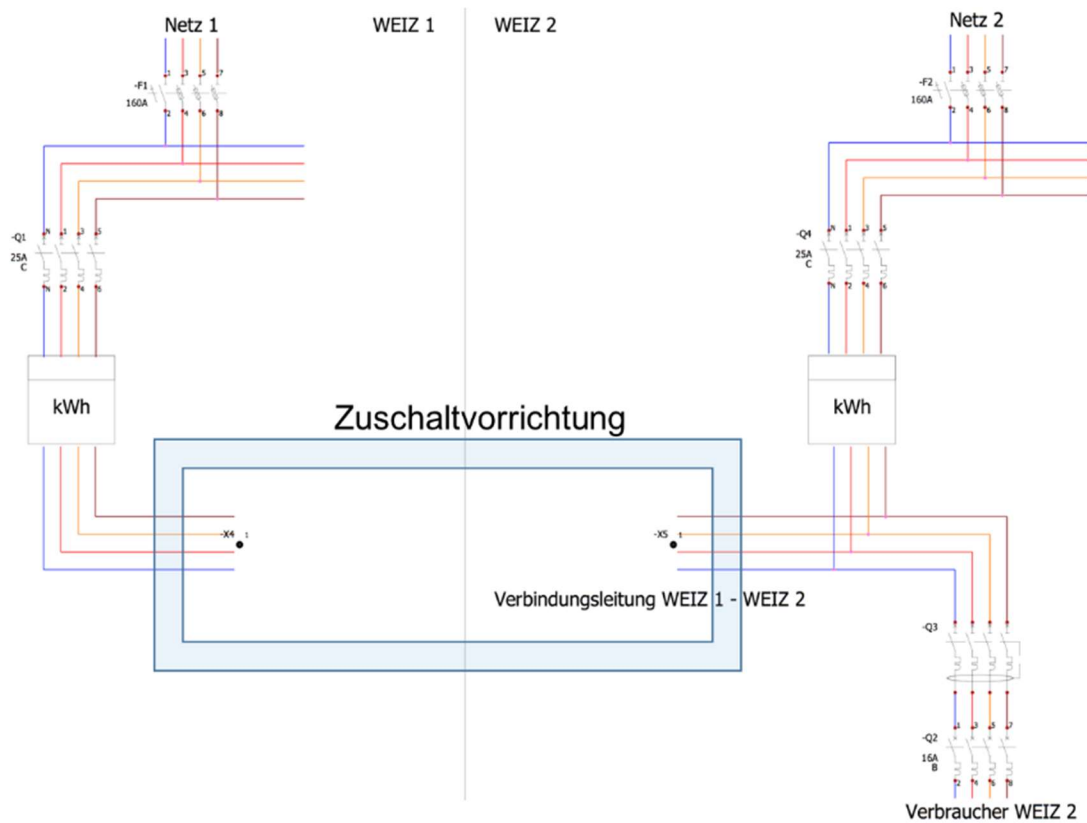


Figure 38 - Connection device for handling the switching of the direct line between WEIZ I and WEIZ II (W.E.I.Z. Campus)

The technical requirements led to the technical implementation concept shown below. The connection device essentially consists of two switching units, referred to in Figure 39 as “Schalter 1” and “Schalter 2”.

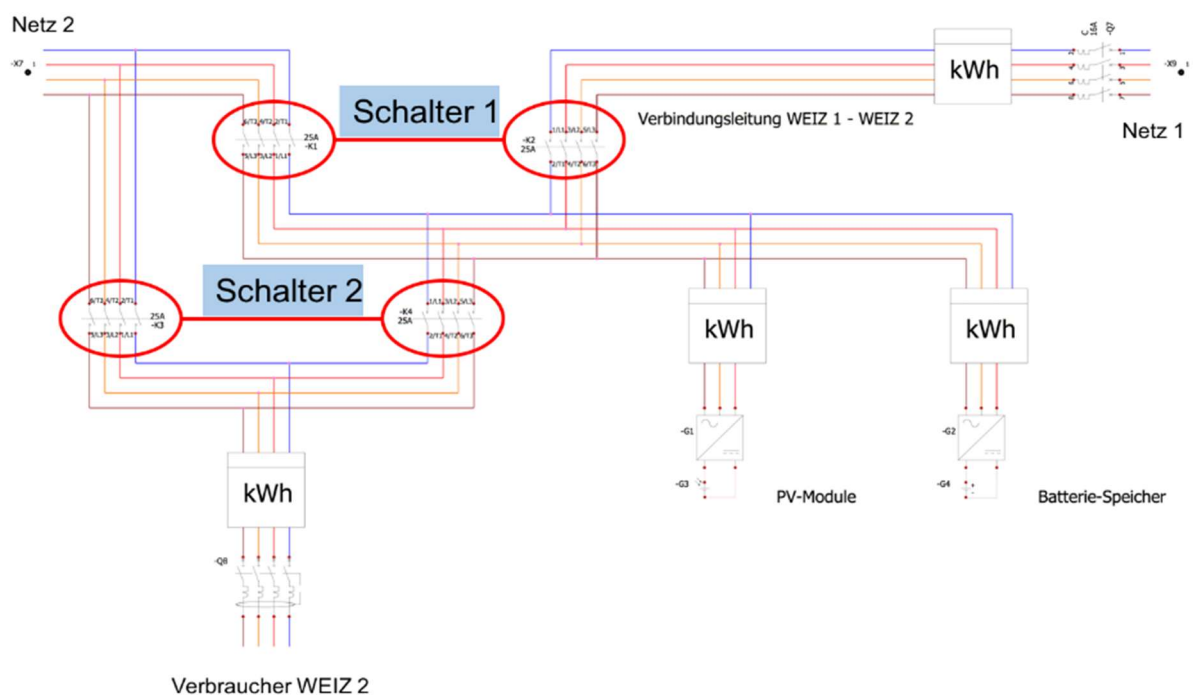


Figure 39 - Circuit diagram of the connection device (W.E.I.Z. Campus)

These two switching units are each implemented with two contactors for switching the power paths. The contactors are interlocked with one another via auxiliary contacts and a corresponding switching logic, so that only one contactor can be closed at any one time and there can never be a direct connection between network 1 and network 2 via the connection line. This is necessary to be able to comply with the technical requirements for operating the direct line at all times. Figure 40 shows the coupling of the contactors via their auxiliary contacts so that this condition is met accordingly.

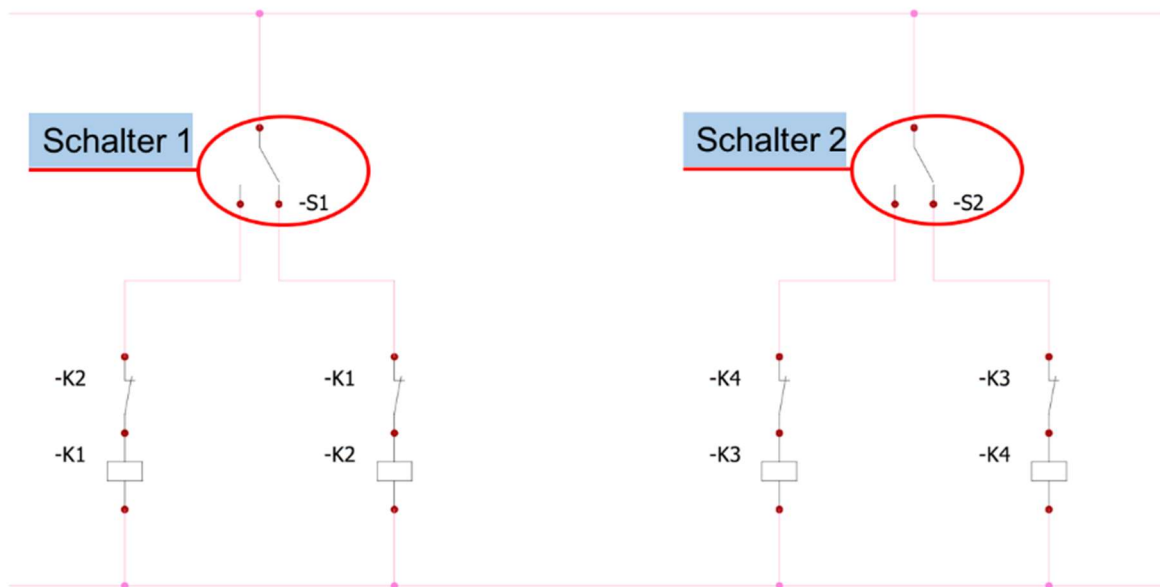


Figure 40 - Contact control with mutual locking through auxiliary contacts (W.E.I.Z. Campus)

The question now arises, why two switching units are needed for this relatively simple switchover? The answer is based on the fact that the brief interruption of the current flow during the switching process of the contactors automatically disconnects the inverters from the grid, both from the PV system and from the battery storage system. This behaviour is also correct, since all grid-connected inverters must immediately disconnect from the grid in the event of a grid failure to avoid islanding.

However, this separation also means that the inverters only connect to the grid and continue to feed in after a certain period of time after they have again identified a stable grid.

5.3 Legislative framework

The legislative framework is described within the chapter

In case of the direct line system in the WEIZ pilot system, a direct line within the meaning of Section 7, Paragraph 1, Item 8 of the Federal EIWOG exists only if there is no direct connection between the line in question and the public network. There must therefore be no direct exchange of electricity between the direct line and the public grid, i.e. no public electricity flows in the direct line (cf. also Hauer / Oberndorfer, loc. cit., margin no. 5 on § 42 EIWOG 2007).

Under no circumstances may the generating plant be supplied with electrical energy from the distribution network via the direct line. This also applies when the generating plant is at a standstill. In this case, the customer either requires a separate connection to the distribution network (to do this immediately) or another power source (such as an emergency power generator), and the generating plant must not be supplied with power via the direct line (e.g. in the event of an inspection).

If both buildings have a connection to the public network (as usual), the electricity fed into the public network or the direct line by the generator must be measured strictly separately using two different meters. In order for such a dual supply system to function, the necessary coordination of the two electricity flows (the electricity flow via the public grid and the direct line) must always take place in the electricity supplier's or the customer's own facility, under their control.

5.4 The energy community

5.4.1 Players involved, their roles and contractual relationships

This issue is described with the chapter 4.2.

5.4.2 Classification of energy community

Class 4 - Energy positive district - districts with residential and business entities operating their energy supply systems under their own regime.

5.5 Results

5.5.1 Scenario chosen for implementation / pilot design implemented

The 233 kWh Battery storage (lithium Ion) and the 30 kWh Battery (Redox Flow) are already connected to the buildings W.E.I.Z. 1 and W.E.I.Z. 2 by a common current collector.

The new 20 kWp PV plant will be installed by the End of the year, so we have more PV electricity for the implemented storages.

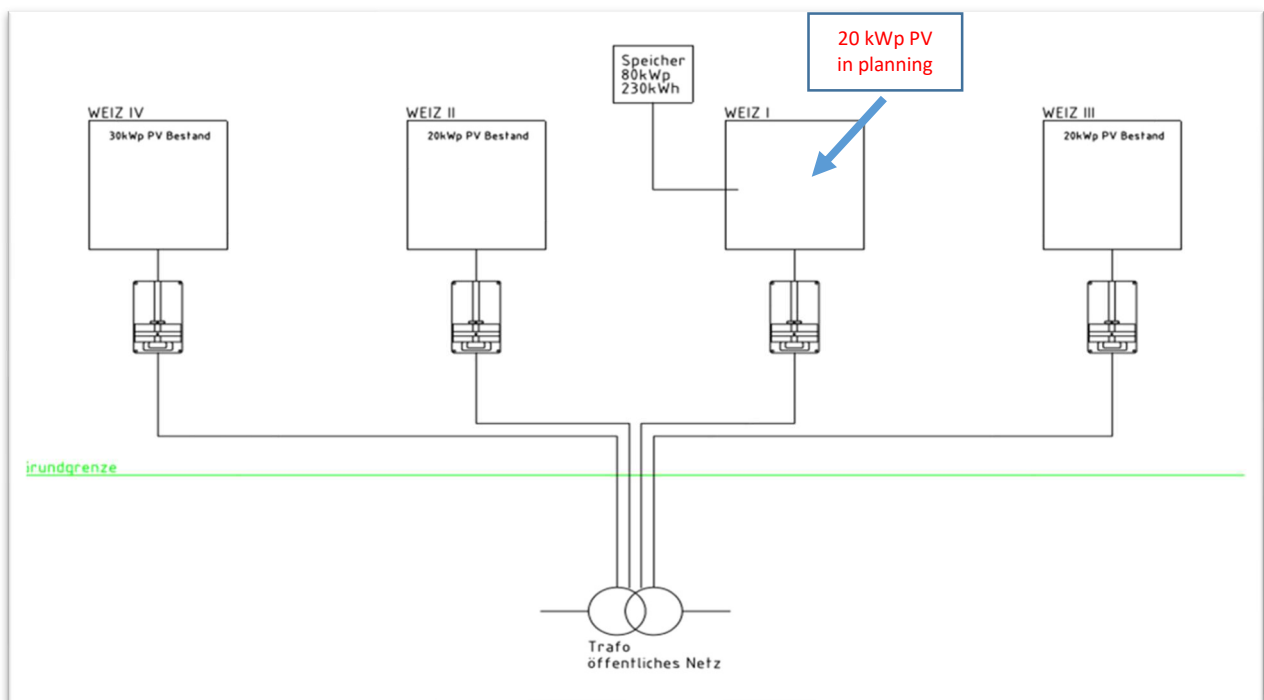


Figure 41 - Scheme (W.E.I.Z. Campus)

5.5.2 Obstacles encountered

For the development of the technical solution approach and the realization of the pilot plants, it was first necessary to determine the project-specific framework conditions and requirements that exist with regard to the realization of a cross-building power exchange.

In this context, a detailed analysis of the legal framework conditions was carried out, taking into account the ownership of the pilot plants examined. Several iteration loops had to be run through, since only after consideration and examination of a large number of different locations could the actual plants to be realized be determined and corresponding detailed plans developed.

The detailed concepts developed served as the basis for the development and programming of the necessary components of the overall system. After completion of the planning and development work, the installation and commissioning of the technical solution took place in both pilot projects.

In addition, the grid operator carried out an investigation into the effects of the voltage quality on the grid during demo operation. Finally, a profitability calculation for the plants was carried out on the basis of the recorded results of the monitoring.

After summarizing and evaluating all available results, conclusions and recommendations for action for the exploitation of the findings from the project were derived.

The solution developed in the Alpgrids project for the cross-building electricity exchange has shown that the distribution of renewable energy is technically possible even beyond the boundaries of a building and under the legal framework conditions applicable during the project period.

Due to the legal requirements developed, it has become clear that the cross-building power supply (currently) Now the law concerning the sharing over the public grid is fixed, but several administrative issues should be written down, so in our case, the share of electricity can only be meaningfully realized with a direct line.

With regard to the legal requirements, the following summary statements can be made for the cross-building power supply:

- A direct line from A (supplier/producer) to B (consumer) is legally permissible. However, A may not supply the B with energy obtained from the public grid, but only with energy that A generates itself.
- A direct line is only permitted if there is a separation of the circuits, otherwise it comes to the "mixing" of the electricity generated by the PV system and the energy from the public grid. However, the technical execution is not legally clarified.
- -Supply via the public grid - no direct line: In this variant, both (A and B) would have to belong to a balance group, supplier A would have to take over balance group responsibility (complex billing!)

The energy management and monitoring system developed is able to ensure compliance with the framework conditions based on the specified measurement and control strategy through the use of two mutually delayed switches. The integration of a battery storage system enables, on the one hand, an increase in the PV self-consumption rate in the demonstration buildings and, on the other hand, the battery storage system ensures that brief power drops in the PV system do not lead to the direct line being switched.

The functionality of the developed components and the economic operation of the overall system for cross-building electricity exchange could be verified through the implementation of two pilot systems.

5.5.3 Proposals for modifications of legislative framework

An LEC here in Austria is an association of several producers, consumers and prosumers (generation + consumption)

- enables the joint use of renewable energy
- via the public network
- without the involvement of an energy supplier

- offers economic advantages for the members

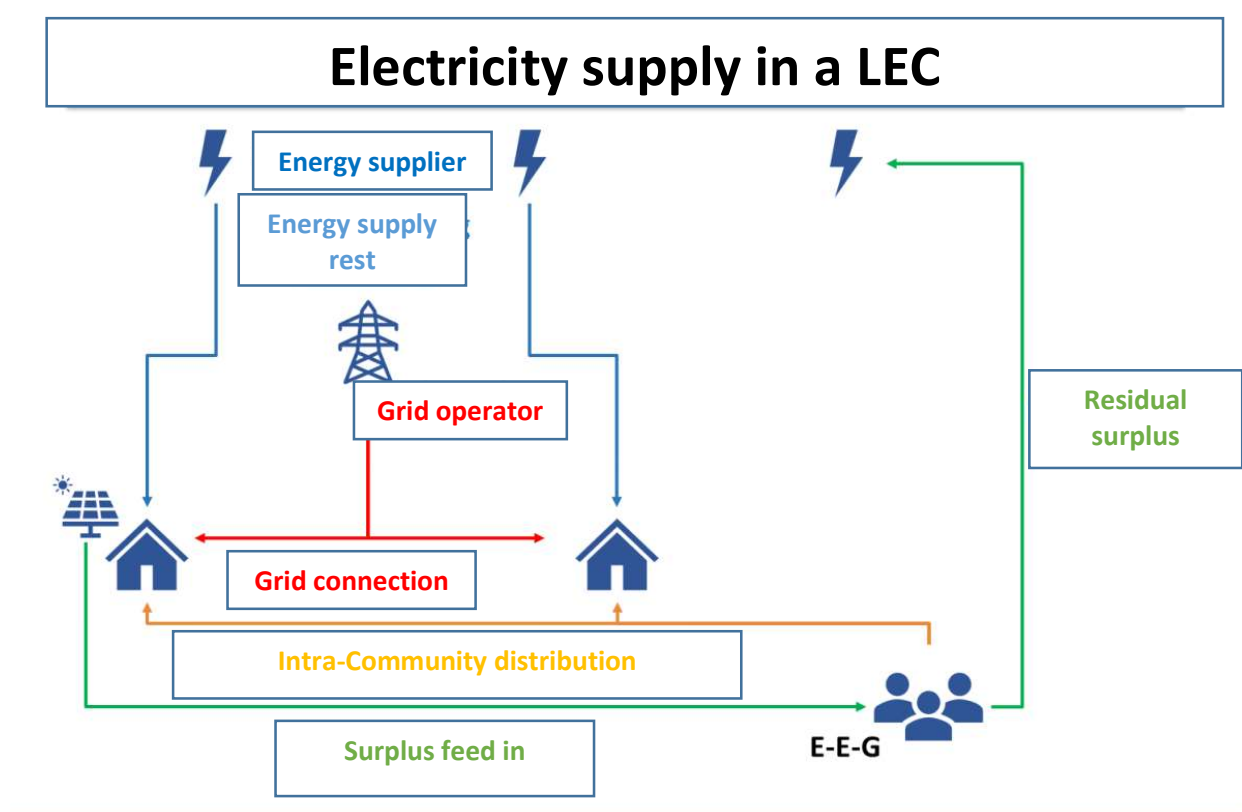


Figure 42 – Electricity supply in a LEC (W.E.I.Z. Campus)

5.5.4 Elements proposed to be included in a Alpine Microgrid Model

"Energy communities" are not "joint generation plants"

Since 2017, it has been possible in Austria to make the electricity that is generated on a building available to all residents / tenants within the building by means of a "joint generation plant" (see Electricity Management and Organization Act 2010; §16a). At the property boundary or at the grid connection point, however, it is over. Energy communities go beyond this and now allow the use of the power grid beyond the grid connection and are therefore not to be confused with community generation plants.

Energy communities should help that

- it will be more attractive for consumers to generate their own electricity. The operator should be able to generate, store, share, consume or sell his energy himself - directly or within the framework of energy cooperatives.
- regionally generated renewable energy can be generated and consumed on site.
- the energetic added value in the region remains.
- economic advantages and possibly a cheaper electricity product are offered.
- the energy system is made more ecological.
- Energy communities brings regional society (citizens, SMEs, associations, ...) closer together.
- an increase in the acceptance of renewable energy and access to additional private capital takes place on site.
- new energy concepts and business models are made possible.
- Important framework conditions for the energy community
- Ensuring open and voluntary participation must be ensured

- Energy communities should be run by citizens, municipalities and SMEs
- the main purpose of an energy community is not to generate financial gain. The members focus on social, ecological and economic benefits

Pilot 6: Selnica (SL)

6.1 Context and general objectives

In 2011, a Local Energy Concept (LEK) for the Municipality of Selnica ob Dravi was prepared. It was based on an analysis of the consumption and costs of energy of all consumers in the municipality, and of factors influencing the efficient use of energy in the municipality and the associated living comfort of citizens. The goals of the Local Energy Concept were formulated in line with the national energy goals and a corresponding action plan with local measures to achieve them was defined.

In the period 2011 - 2019, the factors influencing the implementation of the LEK action plan changed significantly, such as the support scheme for photovoltaics and available financial means for public investment. Major investments in the municipality in the sewerage network, several new constructions and others affected the available amount of funds for investment in energy projects. Nevertheless, the planned activities were carried out as far as possible.

The aim of the pilot project of the Municipality of Selnica ob Dravi within the ALPGRIDS project is to establish a pilot microgrid that would serve for modeling and finding solutions for:

- possible self-sufficiency of public buildings and related reduction of energy costs
- possible island operation of the microgrid which would provide energy even in the event of a failure of the public network caused by natural and other disasters
- legal formal establishment of an energy community in which, in addition to the municipality, interested citizens would participate and finance the installation of photovoltaic power plants at the fire station

6.2 Technical description

The Selnica ob Dravi pilot project is briefly called the Selnica Pilot. It involves the following public buildings:

- Selnica ob Dravi Primary School with a gym
- Selnica ob Dravi Kindergarten
- Culture Centre Arnold Tovornik
- Selnica ob Dravi municipal building
- Selnica ob Dravi Fire station (PGD)

Further, a photovoltaic power plant and a cogeneration plant (CHP) for the production of electricity and heat are part of the pilot project. Both installed at the primary school. The CHP and is fueled with liquefied petroleum gas. The other buildings are only energy users. The culture centre and the PGD are heated with heat pumps which represent major switchable electricity consumers.

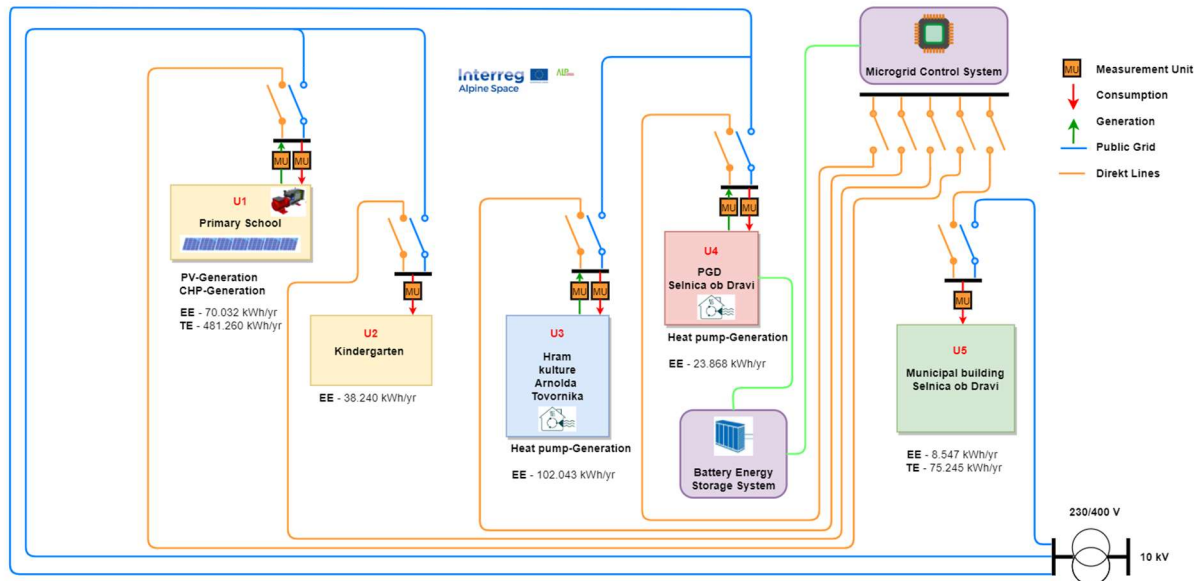


Figure 43 - Scheme of all producers and consumers in the microgrid network (Selnica)



Figure 44 - PV installation on the south-oriented part of the roof of the school building roof (Selnica)

The annual electricity consumption of the buildings in 2019 is shown in Table 8 and the heat consumption in Table 9.

Table 8 - Electricity consumption for 2019 (Selnica)

	2019
Cultural Centre of Arnold Tovornik	102.043 kWh
Selnica ob Dravi Primary School	70.032 kWh
Kindergarten Selnica ob Dravi	38.240 kWh
Selnica ob Dravi municipal building	8.547 kWh
Selnica ob Dravi Fire station	23.868 kWh
Skupaj	242.730 kWh

Table 9 - Heat consumption for 2019 (Selnica)

	2019
Cultural Centre of Arnold Tovornik	-
Selnica ob Dravi Primary School	481.260 kWh
Kindergarten Selnica ob Dravi	-
Selnica ob Dravi municipal building	75.245 kWh
Selnica ob Dravi Fire station	-
Skupaj	556.505 kWh

6.2.1 Establishment of monitoring (energy control and management system)

In the first phase of modeling the microgrid system, we found a solution for the monitoring of the consumption and production of electricity at all facilities included in the microgrid. The solution for the establishment of an energy information system is in the installation of meters or controllers to each measuring point or electric meter. The implementation for the central control system will take place in phases, namely in the first phase only consumers (all buildings) and production sources (solar power plant) will be connected to the control system. The monitoring will provide insight into real-time electricity data and thus the possibility of reducing energy consumption and costs, the possibility of reducing current loads and peak power. The communication between the controller and the main electricity meter allows us to monitor the following parameters:

- total electricity consumption
- current power consumption, voltage and current of each phase

For all buildings, automatic energy accounting will be established for targeted monitoring of energy consumption in the online application of the control system. With the automatic import of energy bills (electricity, heat, water, etc.), it will be possible to identify major deviations from the average values of energy use and determine the causes for them. It will provide insight into the condition of buildings and heating systems, thus making it easier to determine priority measures to reduce energy consumption and thus reduce costs.

The implementation of the planned activities until the installation of meters and the start of monitoring has slowed down slightly due to the current situation related to COVID-19. There were also legal obstacles in the implementation of probe connections to electricity meters. Namely, the local electricity distribution company had to allow the connection of probes to household meters, which do not allow 15 minutes of measurements.

It was also necessary to install the controllers in separate electrical cabinets with external power supply. Table 10 details the connections of the probes and controllers.

Table 10 – List of build-in controllers in buildings (Selnica)

	Number of electric power meters	Connection method (by probe or directly to Amihub controller)
OŠ SELNICA OB DRAVI	1X school	Connecting the ZMD meter to the Amihub controller
	1X kitchen	Connecting the ZMD meter to the Amihub controller
	1X total usage counter	Connecting the ZMD meter to the Amihub controller
	1X cogeneration	/
	1X PV plant	Connection to Controller (2 inverters)
VRTEC	1x kindergarten	Probe connection to the meter and then to the Amihub controller
GASILSKI DOM	1X household	Probe connection to the meter and then to the Amihub controller
	1X fire station	Probe connection to the meter and then to the Amihub controller
OBČINSKA STAVBA	2x municipality	Probe connection to the meter and then to the Amihub controller
SONČNA ELEKTRARNA	1X PV plant	Connecting the ZMD meter to the Amihub controller
HARAM KULTURE	1x household	/

Connections of individual controllers occurred at different time periods. Of all the buildings, the solar power plant was connected first, on Friday 5 June 2020. A total of 13,123 kWh of electricity was produced by 8 September 2020.

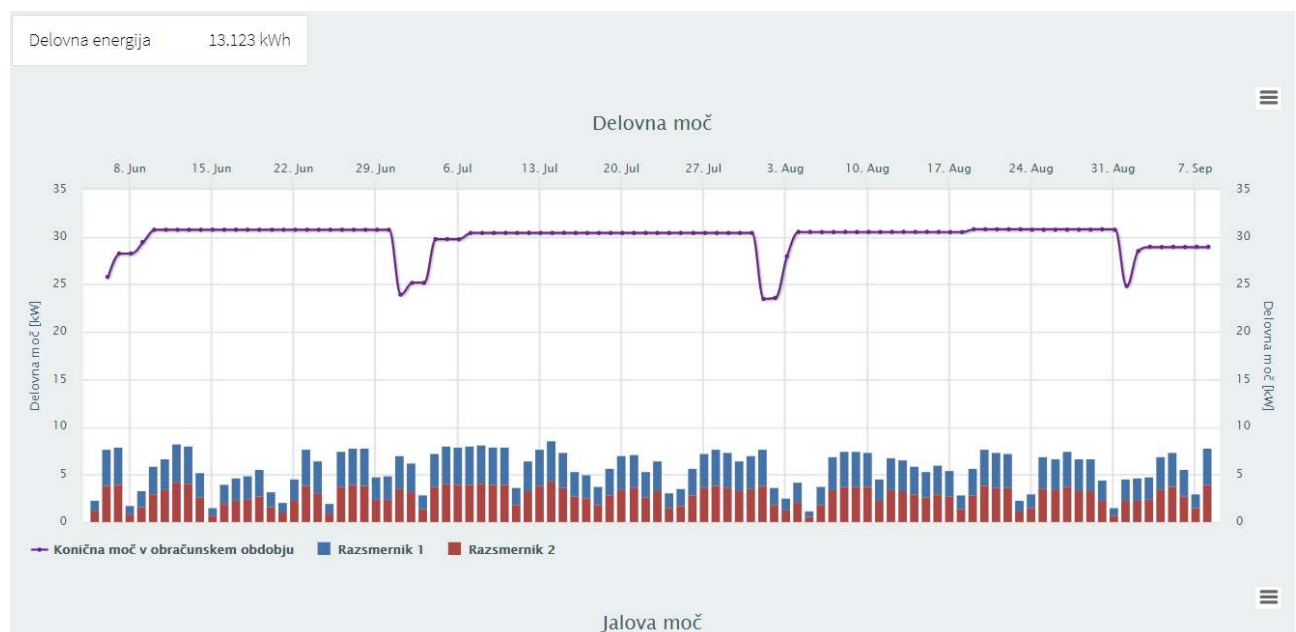


Figure 45 - Solar power plant operating power graph in kW (Selnica)

The connections of the controllers at the Selnica ob Dravi primary school, kindergarten and the municipal building were carried out on 10 August 2020. Due to the existing control systems in the first phase of energy monitoring, the connections of the controllers to the electricity meters at the Cultural Centre were not carried out. The connection of the meters at the fire station was carried out on 24.8.2020.



Figure 46 - Actual movement of true and reactive energy with the beginning of measurements at the Selnica ob Dravi primary school

6.2.2 Operation description of the built-in controller and sensors

The probe for reading the light signal of the electricity consumption meter consists of a phototransistor, with a relative spectral sensitivity of 0.6λ at a wavelength of 650 nm. To ensure robustness, an NPN bipolar transistor with a maximum collector current of up to 100 mA and a maximum collector-emitter voltage of up to 65 V has been added to the phototransistor in a Darlington connection. The probe itself does not interfere with the operation of the electricity consumption meter and also offers galvanic separation between the meter and the controller, which captures data from the probe.

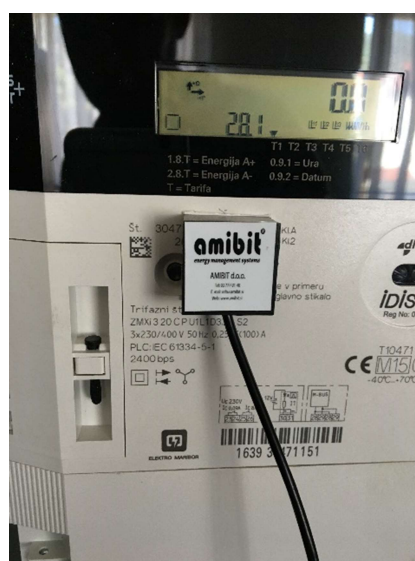


Figure 47 - Phototransistor probe connected to the electric meter (Selnica)

The signal light detected by the probe can communicate any information set by parameterizing the electricity consumption meter. Of course, the options differ from the manufacturer or meter type. The most commonly used light pulse is as a simulation of disk rotation in analog meters, where the pulse means 1/1000 of the consumed 1 kWh or 1/10, depending on how the meter is set. Of course, the meter setting data must be entered into the controller so that it can correctly display the power consumption.

The controller has eighteen 32-bit internal meters for meter reading. Each time the signal light is turned on, the phototransistor conducts current. The current flowing through the probe to the optically separate digital input makes a change in the voltage at the controller itself. On the low-level program part of the controller, a program runs that detects voltage changes at the inputs. Each time a voltage change is detected from low to high, the value of the internal 32-bit counter increases by one.

In the standard configuration of the controller, errors in reading the light pulse of the signal light can occur if the signal width is too short - below 5 ms, or the signal has too high frequency - above 100 Hz. In this case, the controller will count fewer pulses than reported by the counter. If higher frequencies are required, the low-level controller program is adjusted. Reading errors can also occur in the event of poor contact of the probe with the meter - light intrusion, or in the event of a power failure of the controller or probe.

In the standard case, the higher-level program on the controller reads the values of the internal 32-bit counters every 15 minutes and forwards them to the server. If necessary, this reading frequency or sending can be changed at the request of the user.

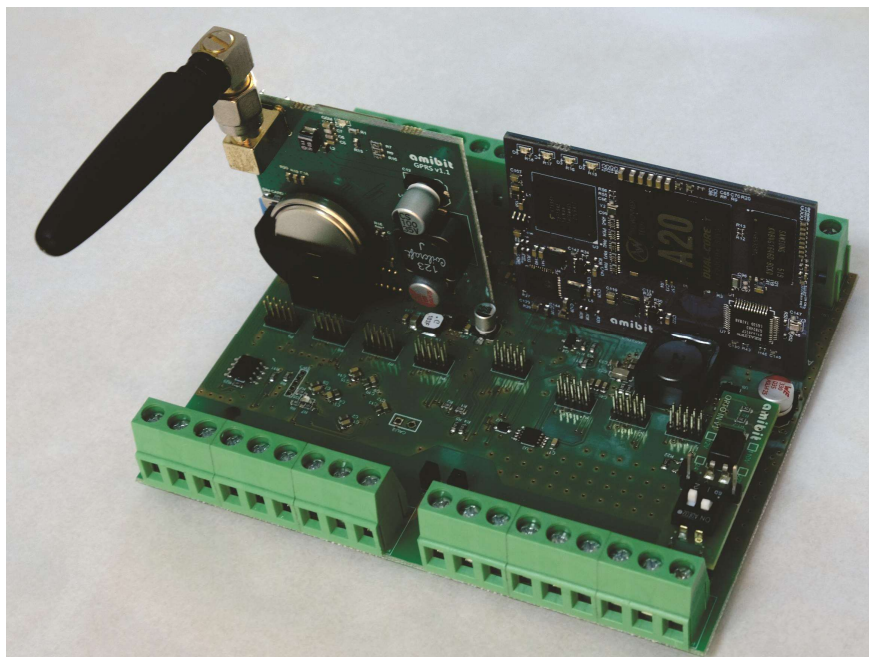


Figure 48 - The picture shows the Amihub controller with a built-in optically separated digital input (bottom right), GSM modem (Selnica)

6.2.3 Controller characteristics

The housing of the Amihub device can be attached to a DIN rail according to the IEC / EN 60715 TH35 standard

- Height without GSM / LTE module: 58.0 mm
- Height with GSM / LTE module without antenna: 64.9 mm
- Width: 106 mm (6x module width 18 mm)
- Manifold opening size: 45 mm

- Degree of protection: <IP20

Table 11 – Technical details of controller (Selnica)

Power supply	
Supply voltage	12 V DC
Average consumption at 12 V DC	300 mA
Max. consumption (USB + GSM)	1800 mA
Current protection	2 A at 24 V
Surge protection	27 V

Connections	
Power supply	2-pin terminal block
Network	RJ45 10/100 Mbps (half/ full duplex)
USB	2x USB tip A
RS232	3-pin terminal block
RS485	2-pin terminal block
M-BUS	2-pin terminal block
GSM	SMA antenna connector

Other	
Operating temperature range	From 0°C to +60°C
Storage temperature range	From -10°C to +70°C
Relative humidity during operation	< 95% (no condensation)
Housing protection	< IP20

Figure 49 shows the PV electricity generation and the consumption of all buildings included in the microgrid except the culture centre for a period of one month. There is a high level of simultaneity between generation and demand showing a high potential for local self-supply within the microgrid.

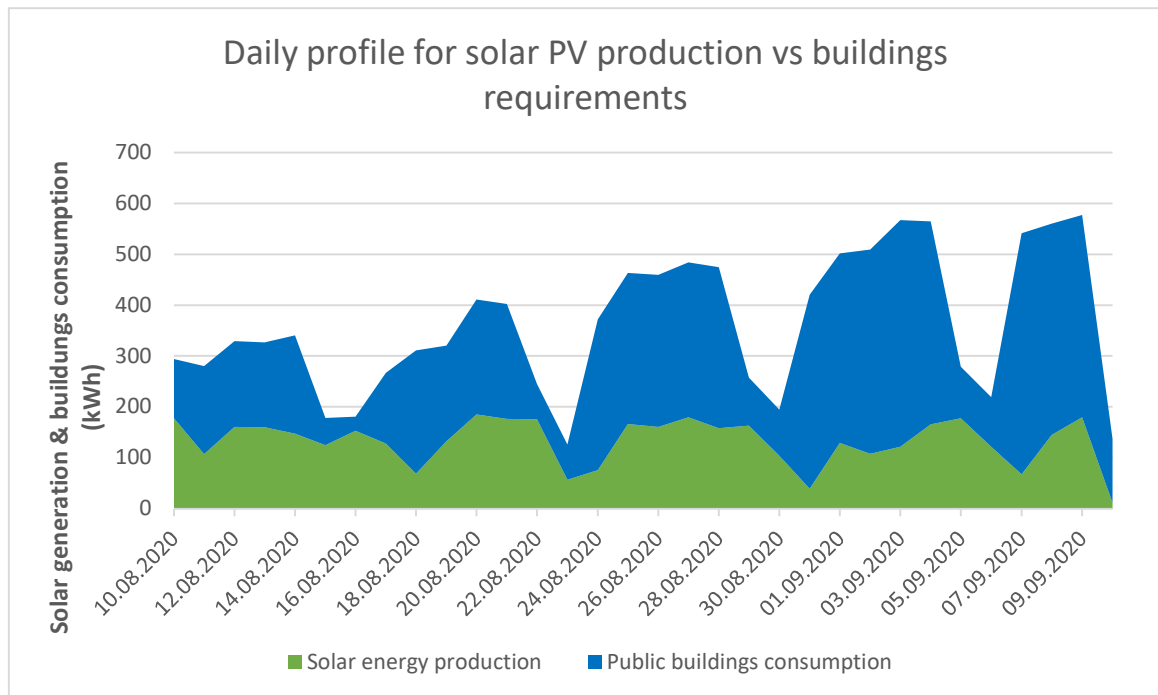


Figure 49 - The graph shows the ratio between electricity produced and consumed in all buildings together except the Cultural Centre (Selnica)

Figure 50 shows in higher resolution the two days average daily load of the primary school with annual electricity consumption of 70,032 kWh and PV-production/possible self-consumption per day (green zone).

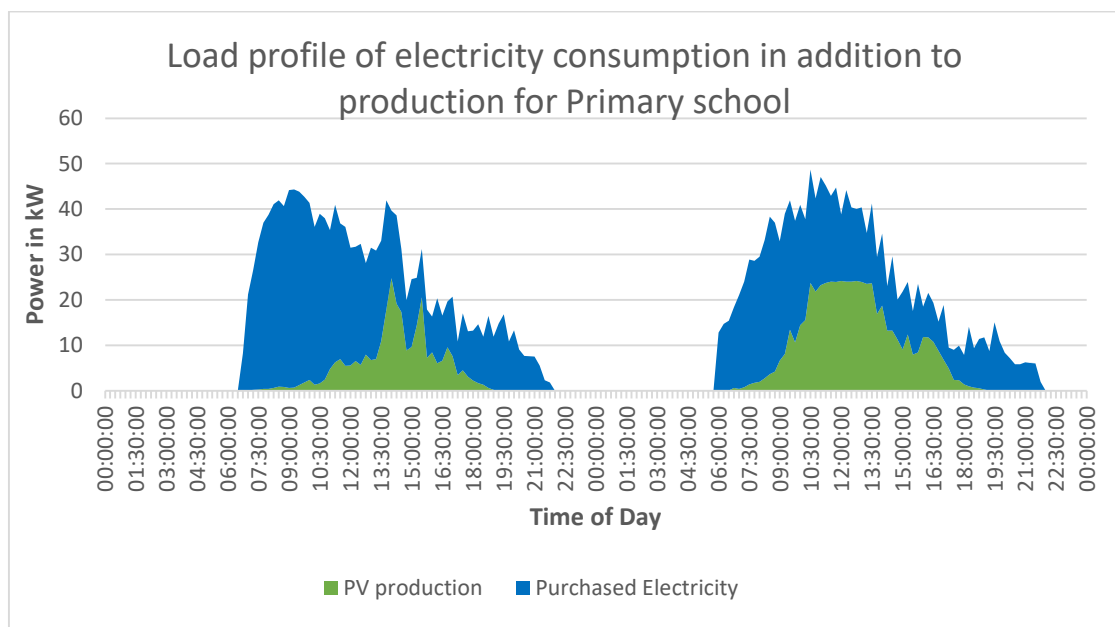


Figure 50 - The average daily load mode of a Primary school (Selnica)

Planned measures in the second phase of the pilot project:

- installation of electricity meters on the existing cogeneration plant in the primary school

- plan preparation for the installation of a solar power plant on the fire station including the battery system

6.3 Legislative framework

Energy communities are not common in Slovenia. The law on energy communities in Slovenia has recently been complemented a new by-law on the self-supply of electricity from renewable energy sources that entered into force on the 1st May 2019. The by-law is an enforcement of the first paragraph of Article 314 and Article 315 of the Energy Act and introduces the concept of 'Renewable Energy Source Community' (RESC). The main actors involved in the design of the framework were regulators, cooperatives and consumer organizations. The by-law promotes both the activity of individual as well as collective self-consumption.

6.3.1 Legal concept – Renewable energy source community

A RESC is defined as jointly acting final consumers behind the same low-voltage (LV) transformer station who are engaged in collective self-consumption. A legal entity is not required, but is allowed to be established.

Any type of entity is allowed to participate in a RESC. However, a third-party power plant owner is not allowed to have effective control over the RESC.

In order to benefit from the virtual net-metering scheme, participants in a RESC need to consume electricity through two or more metering points that are connected to a low-voltage network of the same transformer station as the production unit.

6.3.2 Activities, rights and responsibilities

The by-law views a RESC as a form collective self-consumption, which is formed by customers in buildings (houses) and/or dwellings that consume self-produced electricity via two or more measuring points that are connected to the network of the same LV transformer station as the production unit used for self-consumption purposes.

All participants are obliged to share the produced electricity amongst them, and match it to their consumption profiles. The electricity shares allocated to the different consumers' portfolio's in a RESC should match the anticipated production. If, at the end of the accounting period, the amount of electricity delivered (in kWh) by the customer is greater than the amount of electricity received (in kWh), the customer shall hand over the surplus electricity to his or her supplier. A RESC is exempted from the supply license requirement for electricity that is collectively consumed and shared by its members or shareholders behind the same low-voltage transformer station.

In case of excess electricity, the owner of the production unit cannot acquire the status of producer and sell the generated electricity to the market. The excess electricity goes to the external supplier and is directly fed into the public grid. The supplier (depending on the agreement between supplier and consumer) then pays for this energy according to the contractual price. The payment can take the form of a discount on the account of the following year. Each participant in a RESC can choose to have its own electricity supplier.

The agreed upon shares will then have to be communicated to the DSO to calculate the consumption data that needs to be applied on the electricity bill by each supplier.

The production unit does not have to be in ownership of the community members or shareholders, needs to be connected to a sperate measuring point, located behind the same low-voltage transformer station, and cannot be (or have been) included in a support scheme for the production of electricity from renewable energy sources and in high-efficiency cogeneration. The maximum installed capacity of the production unit may not exceed 80 % of the sum of the connection capacities of the individual measuring points in the community. The balancing responsibility is transferred to the supplier.

An energy storage device is also allowed to be connected to the installation or the network to which the self-consumption unit is connected. The participants of a RESC then have to agree in advance on the exact shares of electricity distributed among them. The sum of shares should equal 100 % of estimated electricity production. The distribution model can be modified, but is subject to prior communication to the DSO.

6.3.3 Relation to the Clean Energy Package documents (CEP)

The new by-law in Slovenia was not an intentional implementation of the CEP, although it is considered an important first step.⁴

The focus is on Renewable Energy Communities as a form of collective self-consumption. The associated rights, privileges and responsibilities are consequently aimed at regulating this particular type of activity. This renders the scope of the Slovenian framework considerably narrower than for REC and CEC under the CEP.

In terms of participation criteria, the concept of RESC is more broadly defined than a CEC and REC, since any entity can participate. However, the geographical limitation is stricter, as all of the participants need to be located behind the same transformer station for the purpose of collective self-consumption.

6.4 The energy community

6.4.1 Players involved, their roles and contractual relationships

When the community will be established it will involve exclusively public sector stakeholders: the municipality, a school, a kindergarten, a cultural house, and a fire station. The school will serve as a production unit and a user. If possible, the fire station will have production and small storage system also. Others will be the users. At the moment we do not know the contractual relationship yet.

6.4.2 Classification of energy community

Selnica Pilot can be identified as a Class 6 (Municipal Utility) energy community as all buildings are owned and operated by the municipality of Selnica ob Dravi.

In the future the system will be probably further adapted to include a battery system, which will allow parts of the distribution system to be operated standalone and this would allow to classify this energy community as a Class 5 (Energy Islands) energy community. But this is not the case as of yet.

6.5 Results

6.5.1 Scenario chosen for implementation / pilot design implemented

The scenario of the set microgrid scheme has not changed. Electric power measurements are performed at 15 minutes interval on all microgrid buildings. Based on the measurements, it is established that in the future it will be necessary to increase the share of electricity produced from RES and consequently install more photovoltaics in order to ensure the maximum possible self-sufficiency of the community and to reduce the electricity bill of the end users.

According to the amendment of the Act on the Promotion of the Use of Renewable Energy Sources (ZSROVE; (Official Gazette of the Republic of Slovenia, No. 121/21)), which entered into force on 7 August 2021, it will be necessary to register as self-sufficient final customers (Decree on self-sufficiency in electricity from renewable energy sources (Official Gazette of the Republic of Slovenia, nos. 17/19 and 197/20)) by 31 December 2023. The amended Act abolishes the net metering scheme in Slovenia by the end of 2023 without introducing an alternative mechanism for self-generating customer to get remunerated for surplus electricity injected into the grid.

The amended Act will on the one hand shorten the waiting times for obtaining consent and on the other hand the announced changes to the law will bring some bad news for customers. Under the new law, self-sufficient customers, despite being self-sufficient, will have to pay the variable part of the network fee for all the electricity taken from the network.

⁴ https://www.h2020-bridge.eu/wp-content/uploads/2020/01/D3.12.d_BRIDGE_Energy-Communities-in-the-EU-2.pdf#page=97&zoom=100,68,126

Until now, on the basis of annual billing and net metering the fixed network charges are always applied (zero use charge) and the variable network charge is applied only to the difference between the electricity taken from the grid and the electricity injected into the grid and only if more electricity is taken from than injected into the network. However, the changes do not happen overnight, so the law says that the payment of network charges for all self-sufficient power plants that are or will be connected to the network until 31.12.2023 will remain as it is.

The possibility of selling surplus electricity will be allowed to all existing owners of self-sufficient solar power plants that are in the self-sufficiency scheme under current regulations, or will install a solar power plant no later than 31 December 2023, when the transitional period expires.

The legal instructions to follow from the idea to the implementation and installation of a self-sufficient power plant are clear and simple which is also reflected in the growing numbers of newly installed solar power plants.

However, to establish an energy community that is a legal entity, in our case this is a municipality, we would need clear instructions on how to implement the legislation, this means precise guidelines for obtaining documentation on how to start the establishment and implementation of the energy community in practice. At the moment in Slovenia there are only cases of established energy communities where existing legal entities, i.e., existing electricity suppliers and providers of solar power plants and other energy solutions enter into contracts with individuals and allow them to reduce electricity bills for users who offer roofing in the community for the installation of solar power plants, etc.

According to the Article 3, point 39 of the new Slovenian Act on the Promotion of the Use of Renewable Energy Sources (ZSROVE), transposing Directive (EU) 2018/2001, renewable energy community with legal personality" means a legal person:

- a) based on open and voluntary participation, is independent and effectively controlled by partners or members located in the vicinity of renewable energy projects owned and developed by that legal entity;
- b) which partners or members are legal or natural persons, other than legal persons engaged in an economic activity and not SMEs;
- c) whose main objective is to provide environmental, economic and social benefits to its partners or members or the local areas in which it operates, and not so much financial gain.

Two community schemes are mentioned in the ZSROVE: community self-sufficiency (ZSROVE Article 37, paragraph 3 - in a multi-apartment building or in the territory of the Republic of Slovenia, meaning it is not necessary that all members of the RES community are located behind the same transformer station) and the RES community (ZSROVE, Article 43). The differences between the two schemes are not yet quite clarified (who can participate, conditions for inclusion, etc. ... except that the RES community is a legal entity) and it will be necessary to wait for regulations, which will define the rules or open issues in more detail. This has a significant impact on all future projects in Slovenia.

Article 43 of the ZSROVE describes the procedures for the establishment of a renewable energy community as a legal entity:

- (1) Final customers have the right to establish a community in the field of energy from renewable sources, which is a legal entity (hereinafter: this chapter: the RES community).
- (2) Legal persons engaged in economic activity may be members of the RES community, unless they perform their basic economic or professional activity within the framework of cooperation in the community.
- (3) Members of the RES community retain the rights and obligations they have as final customers with self-supply in accordance with this Act and as final customers in accordance with the law governing electricity supply.
- (4) The following also applies to the RES community:

- a) has the right to produce, consume, store and sell energy from renewable sources, including under contracts for the purchase of electricity from renewable sources;
- b) have non-discriminatory access to all relevant energy markets, both directly and through aggregation;
- c) for the purposes of this Act, shall be considered a producer of electricity;
- č) declarations and guarantees of origin may be issued for the production plant;
- d) can obtain support for electricity from RES and for the production of electricity from RES and for the production of electricity in high-efficiency cogeneration.

Energy communities are also described in the latest proposal of the Electricity Supply Act (ZOOE), transposing Directive (EU) 2019/944, which has not yet been legally adopted.

In the Article 4, point 18 of the ZOOE “citizens' energy community” means a legal person:

- (a) based on voluntary and open cooperation and effectively controlled by members or partners who are natural persons, local authorities, including municipalities, or small businesses;
- (b) whose primary purpose is to ensure the environmental, economic or social benefits of the community for its members or partners or for the local areas in which it operates, and not to generate financial benefits; and
- (c) which may participate in production, including production from renewable sources, electricity supply, consumption, aggregation, energy storage, energy efficiency storage or the provision of charging services for electric cars, or with its members or companies offering other energy services;

And in the Article 24 of the ZOOE Citizens' energy communities means:

- (1) The Energy Community of Citizens (hereinafter: the Energy Community) may be established by members connected to the distribution system in the Republic of Slovenia. Citizenship of the Republic of Slovenia is not a condition for membership in the energy community.
- (2) The energy community shall be established as a cooperative in accordance with the law governing cooperatives. The law governing cooperatives shall apply to them, unless this law provides otherwise.
- (3) In the event of a member's withdrawal from the energy community, in addition to the provisions of the law governing cooperatives, the provisions of Article 15 of this Act on the change of supplier or aggregator shall also apply. In the event of a member's exclusion from the energy community, the member must be given at least ten working days between the exclusion decision and the actual termination of the energy community member's rights and obligations to secure a new supply contract or aggregation.
- (4) Members of the energy community shall not lose the rights they have under this Act and regulations issued on the basis thereof and general acts as household customers or as active customers.
- (5) Distribution system operators, in cooperation with energy communities, must ensure that the billing of electricity transfers within these communities is facilitated. Payment for this service shall be determined by the Agency in the manner and according to the procedure established for payment for other services of electricity operators.
- (6) For energy communities, non-discriminatory, fair, proportionate and transparent procedures and payments of network charges and entry into the organized electricity market must be determined in implementing regulations and general acts. The method of determining the network charge for members of the energy community shall be prescribed by the Agency in a general act in such a way as to ensure their sufficient and balanced contribution to the sharing of the total costs of the system.
- (7) If the energy communities of citizens appear directly on the electricity market, they must be included in the balance scheme.
- (8) The energy communities of citizens shall be treated as active customers in connection with self-produced electricity in accordance with the fourth paragraph of Article 23 of this Act.

(9) Members of the energy community of citizens within this community shall, in accordance with the provisions of this Article, regulate the sharing of electricity produced by generation facilities owned by the community, provided that the rights and obligations of community members as final customers are preserved.

(10) If electricity is shared in accordance with the preceding paragraph, this shall not affect the applicable network charges, tariffs and charges. In order to determine the network charge in the case of energy sharing, the Agency shall make a transparent analysis of the costs and benefits of distributed energy sources.

To conclude only renewable energy projects can be included in the RES communities.

In the case of the Citizens Energy Communities all energy can be included in production not only RES, it can participate in energy consumption (this means that investment can be made in energy efficiency projects) and it can also provide services in the field of e-mobility and energy storage.

The table below shows the basic differences between the energy communities.

Table 12 – Differences between CEC and REC in Slovenia

	Citizen Energy Community – (CEC)	Renewable Energy Community - REC
Membership	The partners are physical persons, local authorities, including municipalities, or small companies.	The partners or members are physical persons, SMEs or local authorities, including municipalities.
Geographical limits	There are no geographical restrictions for members who are connected to the distribution system within Slovenia. Citizenship of the Republic of Slovenia is not a condition for membership.	Legal entity based on open and voluntary participation, is independent and supervised by partners or members located nearby RES plants hold, owned and developed by the REC.
Allowed activities	Limited to the electricity sector area, cooperates in the production of electricity from RES, electricity supply, consumption, aggregation, energy storage, energy efficiency services or providing e-vehicle charging services and other energy services for members.	It can operate in all energy sectors, the main objective is to provide environmental, economic and social community benefits for their own partners or members or local areas where it works.
Technologies	Technologically neutral.	Limited to RES technologies.
Legal basis	Electricity Supply Act (ZOEE)	Renewable Energy Act energy (ZSROVE)

6.5.2 Obstacles encountered

The biggest problem we face is the late adoption of legislation and other laws concerning energy communities that are still being passed. In practice, we do not have any example that would benefit us as a basis for building a legal-formal framework for establishment of an energy community.

6.5.3 Proposals for modifications of legislative framework

There is no need to change the legislation. It is necessary to prepare certain executive acts and regulations or official instruction how to approach the establishment of a community in practice (Guidebook on how to set up an energy community in practice, including the processes, administrative obligation, for example – financial accounting system for established legal person).

6.5.4 Elements proposed to be included in an Alpine Microgrid Model

The model should present clear steps on the establishment of the energy community – including legal obligation and procedures, minimum technical requirements and energy and financial analysis (a sort of Cost benefit analysis). The information about running the communities should be involved (also from management and technical point of view). As an example, a template or basic frame of the agreement could be presented.

Pilot 7: Grafing (DE)

7.1 Context and general objectives

7.1.1 City of Grafing



Figure 51 – Aerial view and map of the City of Grafing

Grafing is a city in a semi-rural environment 30 km east of Munich. With around 13,600 inhabitants and around 6,100 grid connection points, Grafing has a total yearly consumption of electric energy of approximately 24 GWh. Out of this, 10 GWh are produced locally. This results in a self-sufficiency rate at city level of around 40%.

7.1.2 Rothmoser, a family owned distribution grid operator

Rothmoser is a family-owned local distribution grid operator (DSO), combined heat and power (CHP) plant operator, district heating grid and electricity distribution grid operator with 11 employees. Rothmoser owns and operates six public charging points for electric vehicles.

7.1.3 Challenges for electric grid in Grafing: increasing EV

The ALPGRIDS pilot will address challenges the electric grid of Grafing is facing caused by charging of electric vehicles (EV) and try to increase self-consumption of renewable energy and enable local energy sharing.

7.2 Technical Description

7.2.1 Detailed Influence of EV on the electric Grid

The increase of the number of electric vehicles (EV) charged within a grid area is a challenge for every DSO. As of 2018, there are 9,545 cars registered in Grafing, 7,836 of them are passenger cars. So far only 50 of them are EV. There are six charging points for EV in Grafing out of which one is public. Monitoring and measuring charging activities is part of the investigation in ALPGRIDS. The existing charging points with 22 kW are well integrated in the grid.

Adding up standard EV charging load curves with a simultaneity factor of 0.2 shows that starting from a number of about 500 EV in Grafing, that is from a passenger car electrification rate of only 6 % onwards, EV charging will have a significant impact on the overall load profile. As Figure 52 shows, the charging load curve has peaks at the same time of the day as the present overall load curve. Hence, shifting the charging load to other hours of the day can avoid grid enforcements due to EV expansion. Combining local solar power generation and EV charging points will be one way to avoid load peaks.

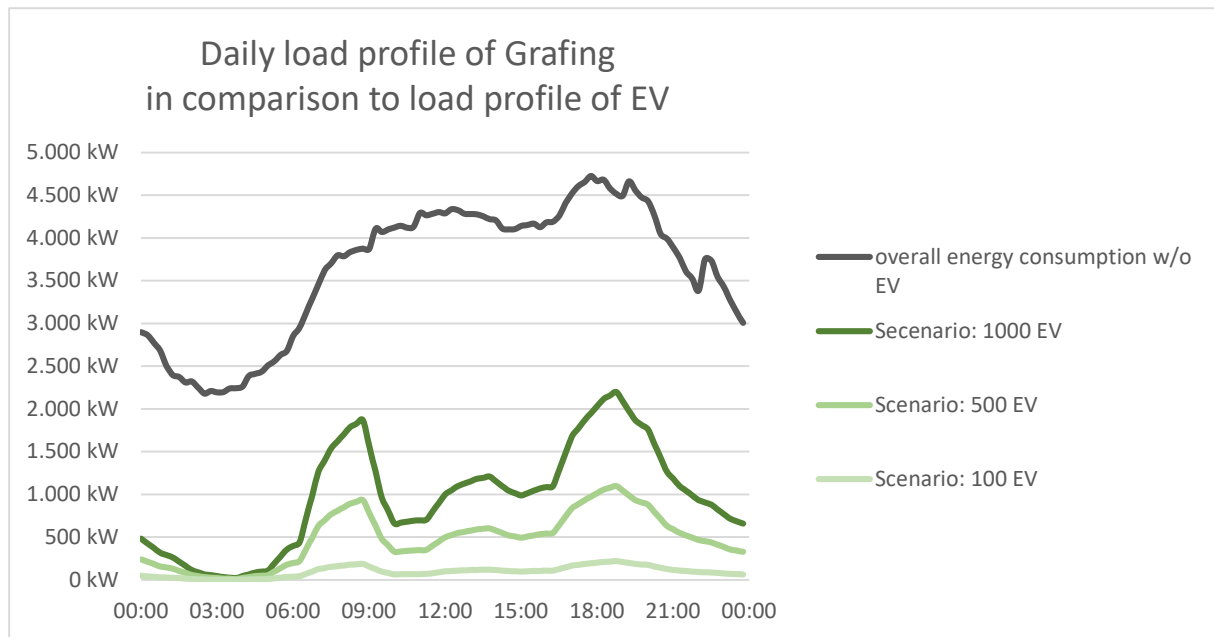


Figure 52 – Actual electric load and projected future EV load profiles (Grafing)

7.2.2 A new retirement home at Grafing

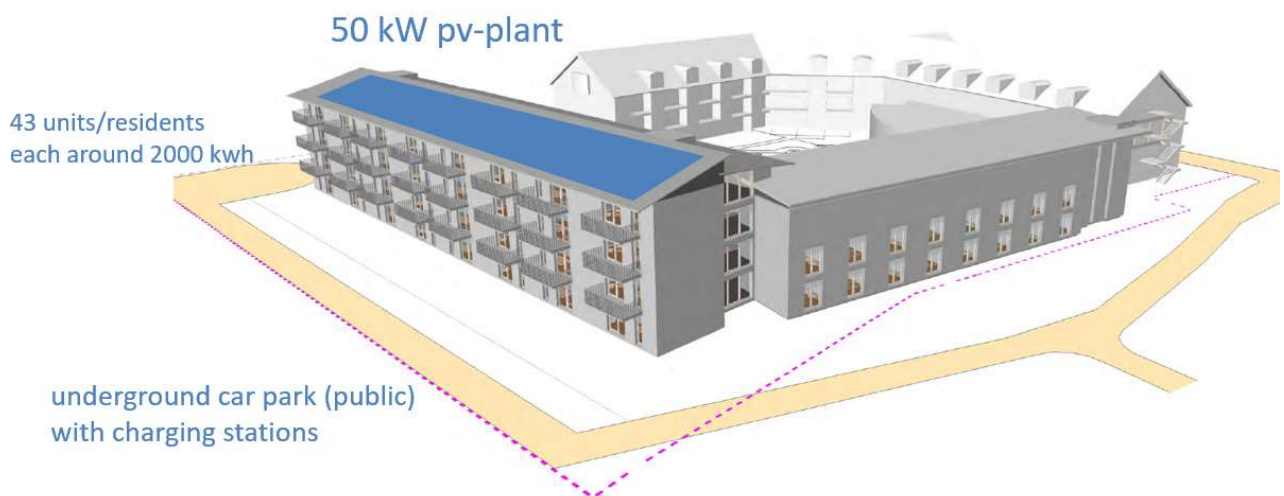


Figure 53 – New retirement home with PV plant and EV charging station in Grafing

A retirement home will be built in the center of Grafing for 43 residents. Construction is scheduled to start in 2022. This is an opportunity to explore a Microgrid solution, where a photovoltaic power plant on the roof of the building supplies the 43 appartements of the residents using the Mieterstrom model. It is planned to install electric vehicle charging in the (partial public) underground car park below the retirement home. To increase self sufficiency and use of renewable energy, the effect of storage and EV charging are analysed. Legal issues and boundaries of the Mieterstrom are explored. Existing local data of solar supply and EV charging will be used to set up a simulation model and

discover different scenarios and their effect on economics. A metering scheme that allows for correct billing of local produced energy and energy from the grid has to be set up.

7.3 Legislative Framework

7.3.1 Framework for reduced net price for wallboxes with blocking times

The pilot project described above replaces the initially planned pilot project in the District of Schönblick which was described in the ALPGRIDS deliverable DT1.2.1. The reason ist that Germany still fails to appropriately transpose the EU Renewable Energy Directive (EE-RL) into German law. In Art. 22 this directive guarantees the possibility of energy sharing for all EU citizens, but as of now, this option is not foreseen in German law. Especially the cooperation of energy communities and DSO is not defined yet. Moreover, legislation in Germany does not support the exchange of energy between prosumers to avoid grid strain, especially when both prosumers do not share the same house connection.

7.4 The energy community

7.4.1 Players involved, their roles and contractual relationships

The energy community is based on the Mieterstrommodell (tenant electricity model) according to §21 EEG (German Renewable Energy Act).

In a Mieterstrom constellation, the solar power plant on a tenant building delivers electric energy to the tenants of the building. For each kilowatt hour of locally produced and consumed energy, the operator of the power plant receives a funding of about 3 ct. Different scenarios of ownership of the solar power plant are possible. Either the homeowner or the Mieterstrom supplier can invest.

Here is one scenario where the home owner invests:

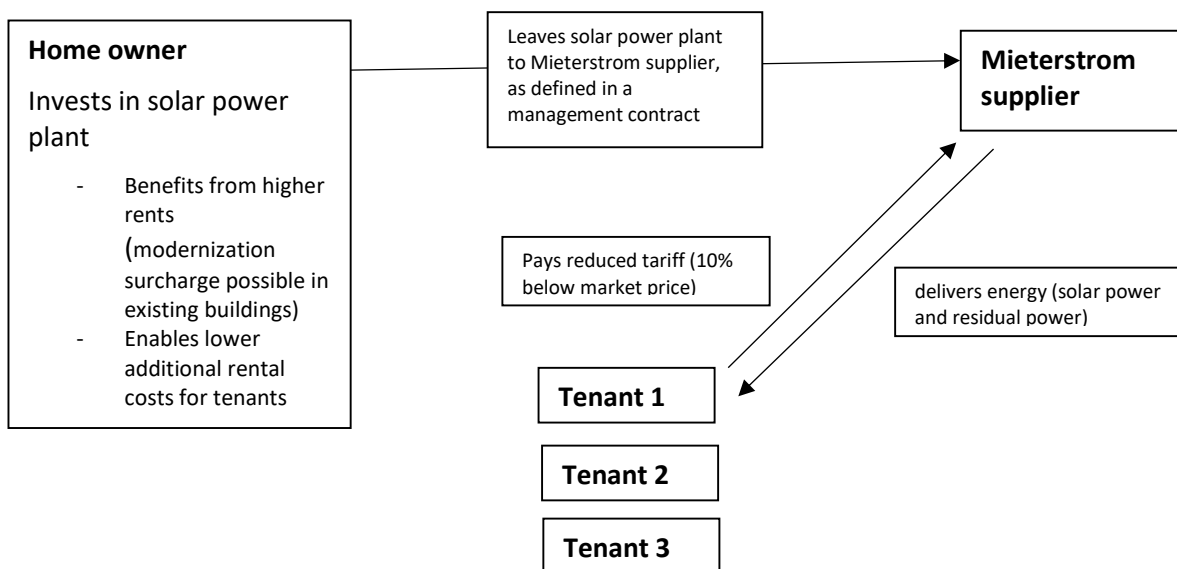


Figure 54 – Energy community scheme in Grafting

7.4.2 Classification of energy community

The described energy sharing model called Mieterstrom can be classified as Class 3 as defined by EU's Horizon 2020 Bridge Local Energy Communities Taskforce. The definition for class 3 is: generation, storage and consumption in residential cases with multiple dwellings.

7.5 Results

7.5.1 Scenario chosen for implementation / pilot design implemented

As the retirement home will be still under construction during the ALPGRIDS project duration, physical implementation of the pilot is not possible.

7.5.2 Obstacles encountered

Originally planned microgrid solutions, where using the public grid to enable energy sharing between different buildings would be necessary, but are hindered by German legislation, as the EU rules of Clean Energy Package have not been implemented. The only energy sharing mechanism that is defined in German legislation is called Mieterstrom (tenant electricity). As of §21 EEG Abs. 3 Satz 2, the shared energy shall not be transmitted over the public grid.

7.5.3 Proposals for modifications of legislative framework

Implementing of EU rules of Clean Energy Package, notably the appropriate transposition of the EU Renewable Energy Directive into German law, would enable energy sharing between buildings using the public grid. This could increase local consumption of energy and would drive local installation of renewable energy sources. Local energy sharing increases acceptance of electric infrastructure in the society and provides local value creation.

The following changes in the German Renewable Energy Act⁵ could heal this situation at least for tenant electricity models:

- In §21b Absatz 3 (included since 2017, not changed 2020) Satz 1, Nummer 2, „ohne Durchleitung durch ein Netz“ (means: without using the public grid), should be deleted. In fact, these five words imply in the majority of cases that all parties of a tenant electricity model must be located within the same building. This restricts the implementation of tenant electricity models to single buildings and prevents effectively, that they involve participants from different buildings within the same urban district - contrary to the intention of the EU Renewable Energy Directive.
- In addition, the legal term “Quartier” (quarter) which is introduced in 2020 in §21b Absatz 3 Satz 1, needs to be defined appropriately within the German Renewable Energy Act. As a general rule, legal terms need to be defined in a legal act in order to be effective. Otherwise, interpretation is left to the judicial authority, thus effectively preventing that the model offered by the law is applied by those who refrain from going to court for implementing it.

7.5.4 Elements proposed to be included in an Alpine Microgrid Model

None.

⁵ Erneuerbare-Energien-Gesetz (**Renewable Energy Act**), last modified by:

Bundesgesetzblatt Jahrgang 2017 Teil I Nr. 49, S. 2532. 2017. Gesetz zur Förderung von Mieterstrom und zur Änderung weiterer Vorschriften des Erneuerbare-Energien-Gesetzes. 17. Juli 2017.

Bundesgesetzblatt Jahrgang 2020 Teil I Nr. 65, S. 3138 ff. 2020. Gesetz zur Änderung des Erneuerbare-Energien-Gesetzes und weiterer energierechtlicher Vorschriften. 21. Dezember 2020.

Pilot 8: Udine (IT)

8.1 Local Context and general objectives

8.1.1 Local context

The Municipality of Udine aims at increasing the use of renewable energy sources (RES) and at reducing the environmental impact and the cost of electricity supply. For this purpose, the objective of the pilot is to take advantage of all the opportunities offered by the national law of February 2020 on renewable energy communities with the related subsequent implementing decrees and regulations.

The pilot includes different types of urban buildings within close proximity of one another as shown in Figure 55:

1. primary School “Lea D’Orlandi” located in via Della Roggia 52
2. kindergarten “Dire, Fare, Giocare” located in via della Roggia 48
3. Friulan Museum of Natural History located in via Cecilia Gradenigo Sabbadini 22/32
4. social housing blocks located in via Cecilia Gradenigo Sabbadini to the house number 52, 54, 56 and 58, with a total of 36 flats.

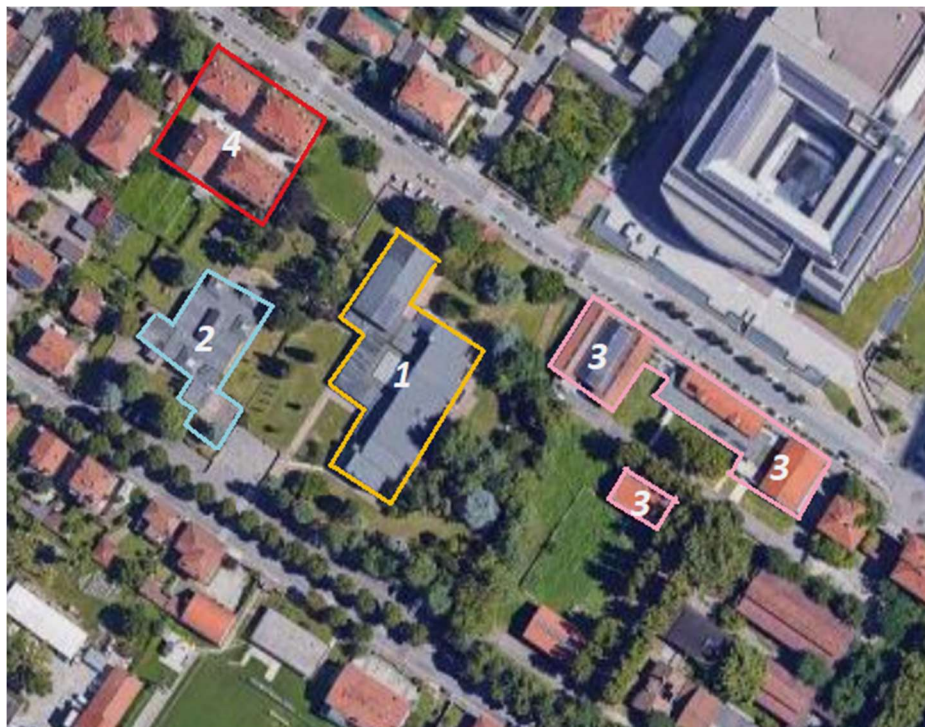


Figure 55 – Aerial photo of buildings involved in the pilot (Udine)

The primary school and the museum are prosumers equipped with PV plants, 6 kWp and 30 kWp respectively. The generated electricity exceeding the local load is fed into the public network in compliance with the rules of ‘Exchange on site’ (‘Scambio sul posto’) which in the current national legislation is the most economically advantageous mode for operating small renewable energy plants.

Heat pumps are installed in the museum and kindergarten for the annual thermal conditioning. The kindergarten also makes use of natural gas-fired boiler for winter thermal load peaks. The primary school and the four social housing blocks use natural gas-fired boilers for winter heating.

All the energy flows of the pilot were monitored for a full year, from September 2020 to October 2021, in order to have adequately representative data and to take into consideration the seasonal effects (summer-winter thermal conditioning, closing of primary school and kindergarten for some summer months, etc.).

Referring to Figure 56 showing the energy flow scheme of the entire pilot, were monitored:

- the thermal and electrical consumption of primary school and kindergarten,
- the electrical consumption of the museum and 10 apartments located in the same block,

with a rate of 1 sampling per minute.

The measuring system installed in the primary school is sketched in Figure 57.

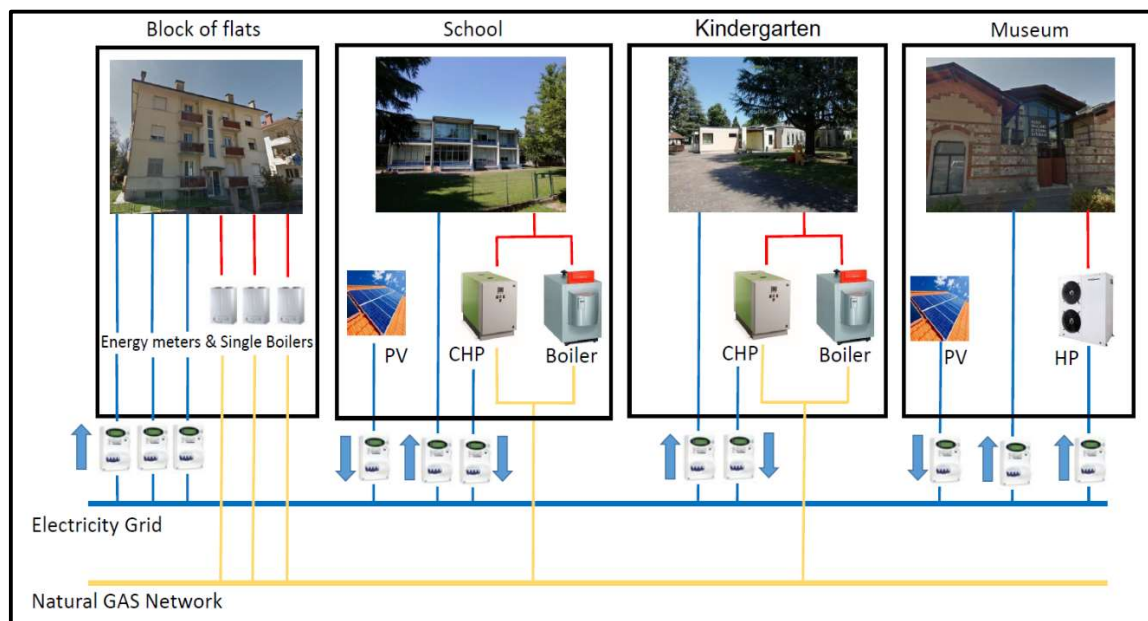


Figure 56 – Energy flow scheme of the pilot (Udine)

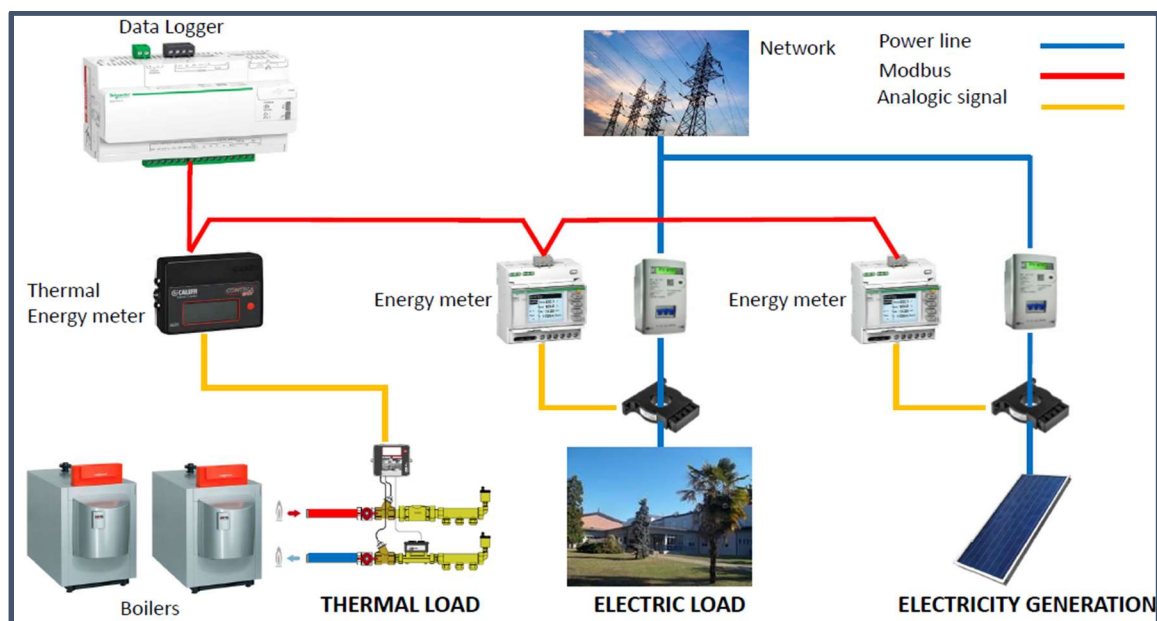


Figure 57 - Measuring system installed at primary school Lea D' Orlandi (Udine)

The annual thermal and electrical consumption values of the pilot are listed in Table 13 while Figure 58 and Figure 59 show the trend of consumption for the different months of the year.

Table 13 – Annual electrical and thermal consumption of the pilot (Udine)

building	electricity		thermal consumption [MWh _t /y]
	installed power [kW]	current from grid [MWh _e /y]	
primary school	30	29.0	300.0
kindergarten	35	28.5	119.8
museum	90	114.4	Not detected
social housing blocks	114	43.2	Not detected

For electricity, the above list shows the electricity drawn from the grid. In case of the kindergarten and the social housing blocks, this equals the electricity consumption. In case of the two prosumers, the primary school and the museum, this equals the electricity consumption minus the generation from the existing photovoltaic installations. The thermal energy consumed by the kindergarten is for the most part supplied by heat pumps: in the year the consumption of natural gas was equal to 11,800 smc. The primary school is equipped with a 480 kW_t boiler which consumed 40,800 smc in the considered period.

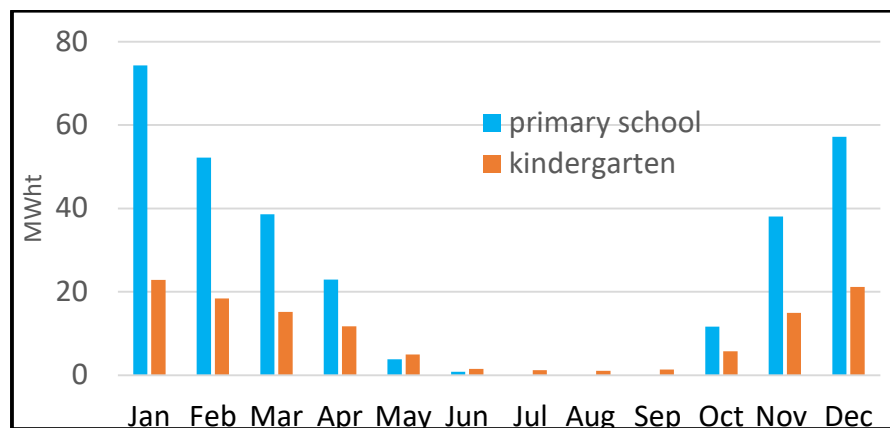


Figure 58 – Monthly thermal consumption of the pilot (Udine)

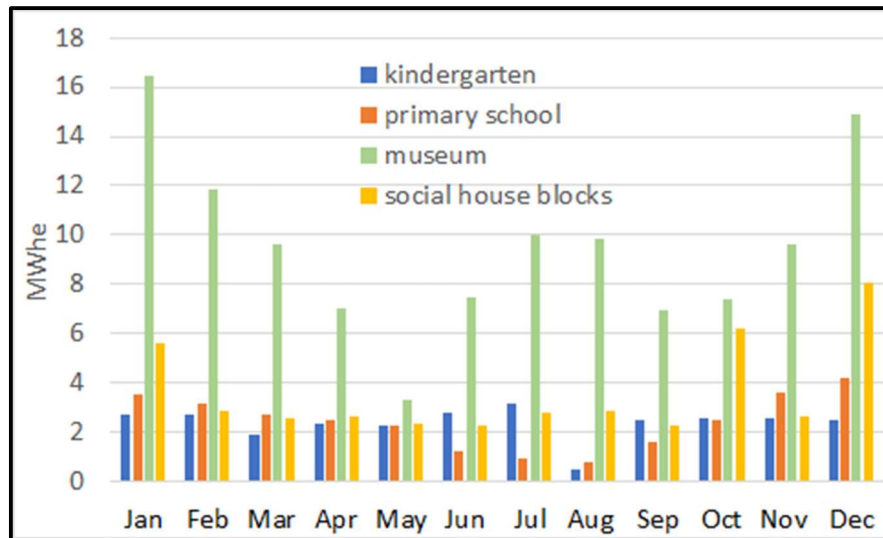


Figure 59 – Monthly electrical consumption of the pilot (Udine)

8.1.2 Objectives

The initial objective was the technical and economic feasibility of local energy community for the whole pilot according to the current national legislative and regulatory framework.

During the course of the project, as monitoring data were acquired and processed, a different approach was adopted, also on the basis the reference regulatory framework. In fact the national legislation providing a collective self-consumption scheme of renewable energy generated defines two possible ways: a) the first concerns the electricity end users located in the same building or organized in a cluster of self-consumers (condominium); this solution is specifically addressed to households classified as 'self-consumers of renewable energy acting collectively';

b) the second one provides for the possibility of a plurality of end users (including public bodies, private, small industries, shops) supplied by the same substation to establish a 'renewable energy community' with its own operating rules defined through a private writing.

In addition to addressing different types of end users, these two forms of collective self-consumption enjoy different economic benefits.

With the aim of verifying in practice all the opportunities offered by the current regulatory frame, the pilot was therefore oriented to the feasibility assessment of two energy communities:

- The first one is related to the four social house buildings, fully conforming to the above scheme a), in the full conviction that positive results pay the way for a remarkable replicability on the territory.
- The second one consists of the primary school, the kindergarten and the museum, which in this case are all public buildings but they configure the possibility for public and private entities to establish themselves in the local energy community with the specific objective of a self-consumption of renewable energy.
- This approach on the pilot has been shared and adopted by the decision makers of the Municipality of Udine.
- The general objective was to verify the technical and economic feasibility of the two types of the regulated collective self-consumption schemes, namely the concrete possibility of people and entities intending make use of renewable energy with the related environmental and social benefits for themselves and the local area to invest in renewable sources with acceptable returns of the investment made.

- Among the objectives pursued are also the verification of any organizational and regulatory barriers preventing an effective establishment of local energy community according the current regulating frame and the emerged results are accounted in section 8.5.3.

8.2 Technical description

This section describes the results of the evaluations carried out for two local energy communities considered for the pilot of Udine.

8.2.1 The social house building organized as self-consumers of renewable energy

The access to the benefits related to the self-consumers of renewable energy for the four blocks of social house requires the installation of a plant making use of renewable sources. To this purpose it has been considered the installation of a PV plant on the roof of the four buildings (see Figure 60). In order to optimize the collection of solar radiation, roof layers S-E and S-O oriented have been considered, allowing to install a maximum nominal power of the PV plant of 50 kWp.

For an optimal dimensioning of such plant reference was made to the achievable benefits according to the current regulatory framework. This provides that all the generated electricity which is fed into the public grid receives a compensation related to the 'shared energy' ('energia condivisa'). The shared energy is defined for each time slot as the total electric energy consumed jointly by all self-consumers or the electric energy generated by all renewable energy plants, whichever is less. The recognized benefit amounts to 165.676 Euro for each MWh of shared energy, over a period of 20 years.

Since the greater the shared energy the greater is the achievable benefit, the economical optimization requires to maximize the shared energy in comparison with the electricity generated by the PV plant.



Figure 60 – On-roof PV plant on the social house blocks

The PV system generation for the different months of the year has been evaluated through PVGIS (Photovoltaic Geographical Information System) simulator and therefore the hourly production in the average day of each month (see Figure 61).

Different sizes of the PV plant were considered and for each of them the generated electricity has been compared, hour by hour over the whole year, with the recorded energy consumption of the 36 end users in order to assess the corresponding shared energy.

hour	January	February	March	April	May	June	July	August	September	October	November	December
1	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
2	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
3	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
4	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
5	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
6	0,00	0,00	0,00	0,13	1,15	1,75	1,55	0,45	0,00	0,00	0,00	0,00
7	0,00	0,00	0,38	1,99	2,75	3,07	3,07	2,39	0,91	0,00	0,00	0,00
8	0,00	0,85	2,47	3,39	3,90	4,13	4,32	3,80	2,91	1,30	0,07	0,00
9	1,46	2,70	3,65	4,28	4,63	4,82	5,14	4,72	4,04	2,90	1,66	1,11
10	2,45	3,42	4,23	4,79	5,14	5,32	5,74	5,32	4,65	3,57	2,43	2,40
11	2,72	3,72	4,55	5,12	5,46	5,63	6,11	5,70	5,02	3,91	2,67	2,72
12	2,81	3,82	4,67	5,23	5,57	5,74	6,24	5,83	5,14	4,02	2,75	2,81
13	2,72	3,72	4,56	5,12	5,46	5,63	6,11	5,70	5,02	3,91	2,67	2,72
14	2,47	3,42	4,23	4,80	5,14	5,32	5,74	5,32	4,65	3,58	2,44	2,45
15	2,08	2,93	3,71	4,28	4,64	4,82	5,15	4,73	4,06	3,05	2,07	2,03
16	1,55	2,30	3,03	3,61	3,97	4,17	4,37	3,94	3,30	2,35	1,58	1,44
17	0,73	1,45	2,21	2,82	3,20	3,42	3,48	3,04	2,40	1,48	0,85	0,51
18	0,00	0,42	1,26	1,87	2,34	2,58	2,49	1,99	1,36	0,55	0,03	0,00
19	0,00	0,00	0,23	1,14	1,48	1,69	1,49	1,16	0,47	0,00	0,00	0,00
20	0,00	0,00	0,00	0,09	0,78	1,17	0,96	0,28	0,00	0,00	0,00	0,00
21	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
22	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
23	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
24	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
KWh/day	18,98	28,76	39,16	48,64	55,63	59,28	61,96	54,39	43,90	30,62	19,23	18,20
KWh/month	588,42	805,38	1214,08	1459,33	1724,54	1778,43	1920,64	1686,14	1317,12	949,12	576,77	564,22

Figure 61 – Producibility of 10 kwp on-roof PV system installed on social house blocks

The best return on investment occurs for a 13 kWp PV plant. Table 14 lists the generated electricity by PV plant in close comparison with the electrical of the 36 end users and the shared energy for the 12 months of the year. The annual shared energy amounts to 13.1 MWh, equal to 92.5 % of the electricity generated and fed into the network.

For more powerful PV system this ratio is lower, resulting in a lower economic return on investment. For instance, the annual shared energy in case of 26 kWp PV, requiring an investment about double the optimal one, would increase to 18.1 MWh in so determining an increase of the benefits only by 38 %.

Table 14 – Shared electricity for a 13 kWp PV plant for the self-consumers community

	Total Consumption [kWh]	Generated electricity [kWh]	Shared Energy [kWh]	Shared Energy vs Generated electricity
January	7,016	588	588	100,0%
February	3,599	805	800	99,4%
March	3,235	1,214	1,171	96,5%
April	3,265	1,459	1,350	92,5%
May	2,938	1,726	1,389	80,5%
June	2,845	1,778	1,431	80,5%
July	3,516	1,921	1,667	86,8%
August	3,587	1,686	1,496	88,7%
September	2,812	1,317	1,126	85,5%
October	7,743	949	945	99,5%
November	3,313	577	577	100,0%
December	10,100	564	564	100,0%
Total	53,969	14,584	13,104	92,5%

The energy and environmental benefits related to the establishment of the community of self-consumption are related to 14.6 MWh/year of renewable energy generated, equal to 24 % of the pilot's total electric consumption, and, taking into account average grid losses of 2.7 % in the distribution grid, about 0.4 MWh/year of avoided losses in the distribution network. Taking into account further, that there is potential for at least 1 million of clusters of self-consumers (condominia) in Italy similar to the pilot in Udine, of which at least a quarter of them reside in regions pertaining to the Alpine Space, there is a potential of avoiding 0.4 TWh/year of losses in the distribution grid at national scale and 0.1 TWh/year in the Alpine Space.

The financial-economic framework for the adopted solution can be summarized as follows:

- Total required investment: 15,240 Euro (including 1,410 Euro for inverter replacement after 10 years),
- Operating cost: 510 Euro/year,
- Total achievable benefits: 43,000 Euro (evaluated over a period of 20 years),
- Net Present Value: 9,730 Euro (evaluate over a period of 20 years, 3 % annual discount rate),
- IRR = 10 %.

8.2.2 The renewable energy community including the primary school, the kindergarten and the museum. Renewable energy communities are also required by the current regulations to install a renewable source and feed all the generated electricity into the public grid with a related compensation of 174.22 Euro/MWh of shared energy.

Assuming that a PV plant has to be installed, the same assessments described in the previous paragraph have been carried out. The resulting data are summarized in Table 15 showing the generated electricity, the total consumption of the three buildings and the corresponding shared energy for a PV plant with a peak power of 43 kWp and an annual production of 47.8 MWh.

The renewable energy community including primary school, kindergarten and museum, is able to locally generate 27.8 % of its electricity consumption, a result not much different from that of the self-consumers community.

Table 15 – Shared electricity for a 43 kWp PV plant for the renewable energy community

	Total Consumption [kWh]	Generated electricity [kWh]	Shared Energy [kWh]	Shared Energy vs Generated electricity
January	22,654	1,931	1,931	100,0%
February	17,704	2,643	2,582	97,7%
March	14,271	3,984	3,563	89,4%
April	11,898	4,788	4,030	84,2%
May	7,856	5,659	4,280	75,6%
June	11,416	5,835	3,769	64,6%
July	14,077	6,302	5,789	91,9%
August	11,144	5,533	4,898	88,5%
September	11,000	4,322	3,962	91,7%
October	12,505	3,114	2,862	91,9%
November	15,757	1,893	1,868	98,7%
December	21,616	1,851	1,851	100,0%
Total	171,898	47,854	41,835	86,5%

The resulting economic and financial framework:

- Total required investment: 50,000 Euro (including 5,860 Euro for inverter replacement after 10 years)
- Operating cost: 1,650 Euro/year
- Total achievable benefits: 137,700 Euro (evaluated over a period of 20 years)
- Net Present Value: 28,890 Euro (evaluate over a period of 20 years, 3 % annual discount rate)
- IRR = 9.7 %

shows that the current regulatory rules allow an acceptable return of investments related to new renewable energy plants.

Considering the thermal consumption of the primary school, 300 MWh/year and the electrical consumption of the primary school, kindergarten and museum, it has been investigated the installation of a Combined Heat and Power system (CHP) in partial replacement of the existing two natural gas fuelled boilers. In fact, the use of a CHP system shall in principle to primary energy saving compared to separate generation of heat and electricity. A heat driven CHP operation at its maximum power in presence of thermal demand. The heat generated by CHP exceeding the thermal demand is stored. When the thermal demand exceeds the maximum thermal power from CHP, at first is used the stored thermal energy and subsequently the existing boilers begin to work according to a master-slave logic.

A suitable sizing of the CHP and of the associated thermal storage allows almost a continuous operation of CHP. Figure 62 shows this situation: a 38 kW_t CHP, equipped with 15 kWh of thermal storage, works always at its maximum power for all the time thus providing about 35 % of the required thermal energy and reducing the peak load of the boiler of over 80 kW_t.

The optimal CHP size from energy point of view has been assessed on the basis of the thermal consumption of the primary school over a whole year and considering the systems available on the market.

The best performances were obtained with a CHP system, with 38 kW_t of thermal power and 16 kW_e of electric power, equipped with a thermal storage of 15 kWh_t (obtained through 500 litres of water operating in the temperature range between 45°C and 70°C).

Table 16 lists the thermal energy supplied by CHP and boilers to satisfy the primary school's thermal demand during the 12 months of the year together with the electricity generated by CHP.

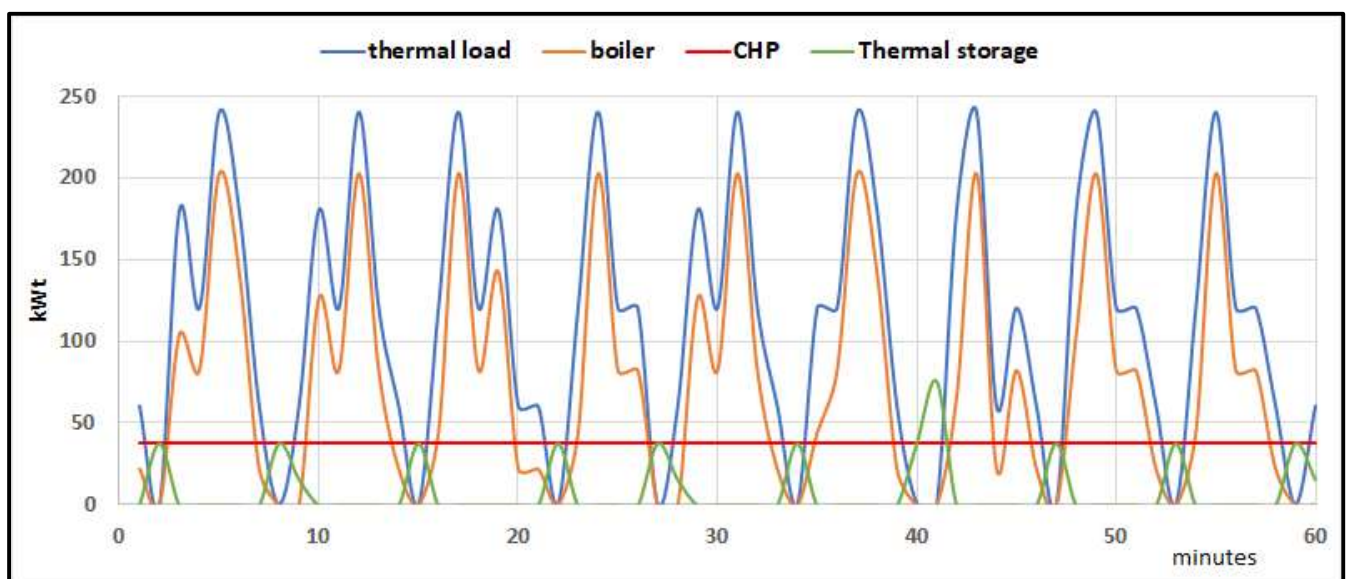


Figure 62 – Primary school: thermal load, supply by boiler and CHP, and level of thermal storage (from 6 am to 7 am on 2/11/2020)

Table 16 – Breakdown of the thermal energy to be supplied to the primary school

	Primary school thermal consumption [MWh _t]	Heat supplied by boilers [MWh _t]	Heat supplied by CHP [MWh _t]	Electricity generated by CHP [MWh _e]
January	74,9	49,7	25,2	10,4
February	52,2	35,1	17,1	7,2
March	38,6	23,9	14,7	6,2
April	22,9	13,1	9,8	4,2
May	3,8	1,5	2,3	0,98
June	0,77	0,01	0,76	0,32
July	0	0	0	0
August	0	0	0	0
September	0	0	0	0
October	11,6	4,8	6,8	2,9
November	38,0	21,0	17,0	7,2
December	57,3	33,5	23,8	10,0
Total	300,0	182,6	117,4	49,44

The CHP system is able to supply 39 % of the thermal demand of the primary school and 29 % of electrical self-sufficiency of the whole complex consisting of primary school, kindergarten and museum. The use of CHP instead of the existing boilers allows a primary energy saving of 55 MWh/year compared to the separate generation of heat and electricity at the national average efficiency. Moreover, about losses of about 1.3 MWh/year are avoided in the distribution network.

The relevant economic and financial indices result as follows:

- Total required investment: 44,000 Euro,
- Operating cost: 800 Euro/year,
- Total achievable benefits: 154,850 Euro (evaluated over a period of 20 years and considering the existing national rules for 'high efficiency cogeneration'),
- Net Present Value: 61,875 Euro (evaluate over a period of 20 years, 3 % annual discount rate),
- IRR: 16.6 %.

A close comparison of the above results with those obtained for the renewable energy community using a 43 kWp PV plant leads to the following conclusions:

- ✓ considering the energy assessment, the use of a PV system allows a similar energy self-sufficiency, but the primary energy saved is definitely greater,
- ✓ in financial terms the CHP system results in a better return on investment.

It has to be also outlined that the solution based on PV plant is currently regulated in Italy, while the use of natural gas fueled CHP only downstream of the full transposition of the EU directive concerning the 'citizen energy community' may be considered for a local energy.

8.3 Legislative framework

The pilot activities made reference to the national current legislative context, namely the Art. 42 bis of the Law n. 8 dated 28/2/2020, partially transposing the Directive on common rules for the internal market for

electricity (EU) 2019/944⁶ (Electricity Market Directive, EMD) that allows for collective self-consumption of electricity generated from renewable sources.

According to this law the electrical end users can join to become a collective prosumer in two possible ways:

- a) the end-users located in the same building or organized in a condominium may become 'self-consumers of renewable energy acting collectively'; this solution is specifically addressed to households;
- b) citizens, small and medium-sized enterprises, local authorities or municipalities may establish a 'renewable energy community' under the following conditions:
 - for each member of the community the electricity generation and the energy exchange with the public network does not constitute the principal commercial or professional activity,
 - all members of the community are supplied by the same electrical substation.

For both the above defined possibilities of clustering the following shall apply:

- each end user maintains his electricity supplier and pays the same bill for the consumed electricity and committed power (all levies, charges and taxes) as before,
- a renewable plant with no more than 200 kW in power has to be installed, at a time following the law issuance, in areas owned by the members of the community,
- all the generated electricity from renewable sources has to be fed into the existing distribution network and acquired by GSE ('Gestore dei servizi energetici'), the national company appointed to promote the sustainable development,
- GSE provides the renewable energy community or the cluster of self-consumers a refund related to the 'shared energy' ('energia condivisa') defined for each hourly period as the energy jointly consumed by renewable energy community or the energy generated by the renewable sources, whichever is less; this refund consists in:
 - an incentive equal to 110 Euro for each MWh of shared energy in the case of renewable energy community and 100 Euro for each MWh of shared energy in the case of self-consumers clustering,
 - a return of the variable components of electricity transmission and distribution rate, equal for 2020 year to 8.22 Euro per each MWh of shared energy,
 - 2.6 % of the 'zonal price' ('prezzo medio locale dell'energia elettrica') for each MWh of shared energy for the self-consumers clustering only, as a compensation for the avoided loss in the transmission and distribution network,
 - the 'zonal price' for each MWh of the electricity by the renewable plant and fed into the public network.
- the members of the renewable energy community and of the self-consumers clustering have to draw up a private agreement regulating at least the allocation of the investment for the renewable sources and of the refund received by GSE, the rules according to which any member may withdraw from the collective consumption.

8.4 The energy community

8.4.1 Players involved, their roles and contractual relationships

As stated at section 8.1.2 the considered energy communities are compliant with the existing national regulatory framework:

⁶ https://ec.europa.eu/energy/topics/markets-and-consumers/market-legislation/electricity-market-design_en; text of the directive: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv:OJ.L_.2019.158.01.0125.01.ENG&toc=OJ:L:2019:158:TOC

- the 36 end users of the four social house blocks are to clustered as ‘self-consumers of renewable energy acting collectively’,
- the primary school, the kindergarten and the museum are configured as a ‘renewable energy community’.

It has to be outlined that all the involved end users belong to the Municipality of Udine and all the electrical invoicing are paid by the Municipality. This implies some critical issues:

- at least two different end users are required to perform a cluster of self-consumers,
- it has to be clarified, in the light of the current regulation for public bodies, how the refund by GSE are allowed or not and how they are to be considered (subsidies, grant).

These issues lead to a slowdown in the implementation of the two considered collective self-consumption forms.

Whatever the solutions that will be adopted, certainly the predominant part of the investment will be the responsibility of the Municipality and consequently will be addressed the private agreement that must be defined in order to access the collective self-consumption solutions provided for by current legislation.

8.4.2 Classification of energy community

At present, the two considered energy communities may be included in Class 6 - Municipal Utilities.

8.5 Results

8.5.1 Scenario chosen for pilot design implemented

Reference has been made to the existing legislative framework which, although with various limitations, currently provides for a procedure (not completely exhaustive and facilitating) for the establishment of energy communities capable to foster the use of renewables and in view to overcoming the current constraints of the electrical system still structured according to top-down schemes.

With the aim to make available to the Municipality of Udine solutions that can be implemented on the territory the pilot project has been kept strictly in line with legislative requirements, leaving aside perhaps more energy effective technical solutions.

8.5.2 Obstacles encountered

No specific obstacles were found in the design of the pilot. On the other hand, administrative and/or regulatory real obstacles emerged in the preliminary phase for the establishment of the two considered energy communities, as described above.

8.5.3 Proposals for modifications of legislative framework

Considering the current legislative framework, it is essential for the potential members of an energy community the availability of appropriate formats, or at least detailed guidelines, supporting the draw-up of the private agreement regulating the operation of the community, from the allocation of the investment in renewable sources until the allocation of the refund paid by GSE. The adopted approach based on the development over time of a practice in this regard, without any available reference, is problematic for an effective result of the law itself.

A further neglected item in the current regulating framework concerns the possibility for end users who intend to set up an energy community to know the amount of the achievable benefits in order to size the renewable source of the community. GSE for the evaluation of the refund takes into consideration the hourly consumption of all members of the community and the hourly generation of electricity from renewable sources so to define for each time slot the shared energy to which such benefits are related. Such a process cannot be carried out by the members of the constituent community because they only know the monthly consumption. Without a clear definition of the return of the investment related to the required new renewable source of the community it's very unlikely that potential members will join it. A possible solution

is that GSE, in response to a request for the establishment of a community, should acquire for some time the hourly consumption data of the members of the community (anticipating the operation to be carried out later for the assessment of the refunds) and communicate them to the community.

The current legislation explicitly provides for arrangements encouraging the “direct participation of municipalities and public administrations in renewable energy communities”. From what described in paragraph 8.3.1 this aspect of the law is still disregarded, while it would be of extreme interest for municipalities to develop effective demonstrative solutions to be replicated in the territory.

8.5.4 Elements proposed to be included in a Alpine Microgrid Model

The Alpine Microgrid model in promoting the development of microgrids and energy communities, has to take great account of driving role of municipalities. These have public buildings distributed throughout the territory (schools, kindergartens, sports centres, cultural and meeting centres) that can constitute the aggregation point for innovative initiatives (which in fact are still both the microgrids and the energy community) involving the citizens but also commercial shops and small/medium enterprises. The concrete demonstration of the advantages acquired in social terms, energy and environment would be a sure reference for private investors who would find convenient to support similar solutions on the territory.

Annex

Alpine Microgrid Model initial release

Definition of Microgrids

Microgrids can be defined in technical terms (a-d) and in terms of organisation of energy supply (e):

(a) local (combinations of) grids with clearly defined boundaries for the exchange and distribution of

- ac electricity
- dc electricity
- heat
- cold
- gas (e.g. hydrogen, methane)
- liquids (e. g. mixtures of higher hydrocarbons such as kerosine)

(b) which group several producers, consumers, prosumers and optionally storages on the same territory;

(c) in which controllable devices (flexible loads such as storages) can be controlled as a single entity;

(d) which might be able to be operated temporarily or constantly disconnected from the respective upstream grids (islanding mode);

(e) and which are organised by a single entity which might be (i) a local Energy Community complying partially or fully with the definition of Citizens Energy Communities (CEC) or Renewable Energy Communities (REC) given by the EU directives on the internal market for electricity and on renewable energies, or (ii) an organisation such as an electric utility which involves customers actively in the organisation of the Microgrid.

Gases and liquids might not only serve as energy carrier, but also as base materials for chemical industry. They might be intermediate products which have been produced with renewable energy such as ammoniac which is an intermediate product for nitrogen fertiliser production.

The focus within ALPGRIDS is on Microgrids for ac electricity. Some pilots include heat, cold, natural gas or biogas. Other gases and liquids are included in the preliminary definition in order allow for a wider range of options to be covered by the definition. The notion of Microgrids will be specified more precisely for the Alpine Space within the project ALPGRIDS.

Potential benefits of Microgrids

Microgrids generally use locally available energy sources, which most of the time are renewable energy sources (RES). They can improve the

- local energy self-sufficiency
- energy efficiency
- sustainability
- resilience
- cost-effectiveness

of energy supply for

- municipalities
- communities of citizens
- farmers
- small enterprises
- others

Microgrids can provide benefits especially in

- rural

- mountainous
- remote locations

with missing or weak connections to upstream grids, or areas particularly vulnerable to natural hazards whose frequency and severity will increase as the anthropogenic climate change evolves. Thus, Microgrids provide a protection against the consequences of climate change. If they are based on RES, they also contribute to climate change abatement and to limiting the need of protecting against the consequences of climate change.

Multi-Vector Microgrids

Microgrids for different forms of energy might be interconnected by energy converters, thus forming a Multi-Vector Microgrid (MVM). Multi-Vector Microgrids represent a form of sector coupling, i.e. the connection of different energy and material flow systems at local scale.

The classical example of a MVM is a gas-fuelled central heat and power (CHP) plant which converts the chemical energy of gas into heat and electricity, and which feeds a local district heating grid and a local electric grid. In this case, the local gas, heat and electricity grids jointly form MVM and the CHP is the interconnecting energy converter.

Microgrids and Energy Communities

Microgrids require small-scale generation and renewable energy and smart grid technologies which are mature and readily available on the market. Though Microgrids are defined by, and have in common, some technical characteristics, non-technical aspects play an important role in their implementation. A key point is the active involvement of energy consumers which allows for exploiting the flexibility of consumers and devices such as storages which are the property of consumers for optimising the overall Microgrid operation. Often, this goes hand in hand with the establishment of an Energy Community fully or partially in pattern with the definitions given by two recent EU directives. For this reason, Energy Communities are given great significance in this guide.

Energy Community classification

Microgrids come in two flavours:

- (1) technical solutions for optimized operation of local grids including where appropriate the preparation for islanding in emergency cases
- (2) elements of local energy communities which often strive for maximising energy self-supply

The two EU directives addressing, respectively, renewable energy communities (notion defined in, and used by, the Directive on the promotion of the use of energy from renewable sources (Renewable Energy Directive 2018/2001/EU⁷) and citizen energy communities (notion defined in, and used by, the Directive on common rules for the internal market for electricity (EU) 2019/944⁸) leave it to member states to allow such energy communities to own and operate their part of the grid or not.

The following tables provide the list of energy community classes referred to in this document. While classes 1 to 5 pertain to different levels of independence from the main grid, classes 6 to 10 pertain to different forms of organisation energy communities. For this reason, the same energy community can belong to one of the classes 1 to 5 and to one of the classes 6 to 10. Nevertheless, if the level of independence from the main grid is more strongly characterising an energy community, the classification might focus on this aspect

⁷ https://ec.europa.eu/energy/topics/renewable-energy/renewable-energy-directive/overview_en;
text of the directive: <https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32018L2001>

⁸ https://ec.europa.eu/energy/topics/markets-and-consumers/market-legislation/electricity-market-design_en;
text of the directive: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv:OJ.L_.2019.158.01.0125.01.ENG&toc=OJ:L:2019:158:TOC

and only one of the classes 1 to 5 might be chosen. If the form of organisation is more strongly characterising the energy community, only one of the classes 6 to 10 might be chosen. This is the case of many Alpgriids pilots which are best classified into class 6, municipal utility.

No	Name	
class 1	Collective generation and trading of electricity	all types of territorial or commercial groupings of generators – whether active on the market or under feed-in mechanisms (often called Virtual Power Plants)
class 2	Generation-Consumption Communities	certified sourcing of electricity in a closed group of generators and consumers - not necessarily in proximity but including local or regional energy markets
class 3	Collective residential & industrial self-consumption	generation, storage and consumption in residential cases with multiple dwellings; includes Tenant-Power (Mieterstrom) - models
class 4	Energy positive districts	districts with residential and business entities operating their energy supply systems under their own regime
class 5	Energy islands	real islands or parts of the distribution system that can be operated standalone (e.g. cellular system as in SINTEG, holonic model as in PolyEnergyNet)

class 6	Municipal utilities	existing organizations for energy production, supply and grid operation under citizens' control – directly (e.g. cooperative) or indirectly (e.g. controlled by local government)
class 7	Financial aggregation and investment	a "community" of investors joins to scale the amount of or manage the investment in generation systems (without further involvement in organisation etc.)
class 8	Cooperative Financing of Energy Efficiency	citizens jointly investing in efficiency means of SMEs and municipalities, possibly in their own region (e.g. contracting / ESCO, crowd-funding)
class 9	Collective service providers	all types of commercial groupings of energy services (e.g. grouping of EV charging stations, aggregation of demand side management services)
Class 10	Digital supply and demand response systems	all types of digitally controlled energy systems (e.g. implemented with blockchain), these days possibly operated as a sandbox-model