

Comparison of a Direct Line System and a Renewable Energy Community on the Basis of a Pilot Plant in Thannhausen

Robert Pratter, Thomas Nacht, Martin Ruby

(DI Robert Pratter, 4ward Energy Research GmbH, Reininghausstraße 13A, 8020 Graz, robert.pratter@4wardenergy.at)
(DI Dr Thomas Nacht, 4ward Energy Research GmbH, Reininghausstraße 13A, 8020 Graz, thomas.nacht@4wardenergy.at)
(DI Martin Ruby, EOS Power Solutions GmbH, Franz-Pichler-Straße 32, 8160 Weiz, martin.ruby@eospowersolutions.com)

1 ABSTRACT

With the renewable energy directive of the European Commission the path has been set toward more emancipated end consumers in the energy system, by allowing shared energy use schemes such as renewable energy communities. These were transposed into national law in Austria in July 2021. But even before that, energy could be shared between a producer/prosumer and one or multiple users via a so-called direct line or direct line system. While the technical and legal requirements for operating a direct line (system) are a major barrier to overcome, direct line (systems) have for a long time been the only means to exchange renewable energy between different buildings in the Austrian energy system. In the municipality of Thannhausen such a direct line system with multiple end users has been installed and is in a test phase since September 2021. During the implementation of the direct line system the legal framework for energy sharing has changed and renewable energy communities have been introduced in Austria. The question arose, whether the direct line system can compete with renewable energy communities. In this paper a comparison between these two types of energy sharing schemes, a direct line system and a renewable energy community is made on basis of the Thannhausen pilot. As mentioned before, in Thannhausen, a direct line system, consisting of multiple direct lines to connect eight consumers with one photovoltaic generator was built. For the same configuration a renewable energy community was investigated by means of a simulation model. Even if it might seem, that the direct line system is outdated by the new possibilities which are provided by the renewable energy communities, a closer look showed, that both systems have their advantages and disadvantages. For the direct line system structural measures are necessary, which result in a certain amount of investment costs which are higher than for a renewable energy community, where the public grid is used. In contrast to that, no grid fees have to be paid for the energy distributed via the direct line system. Another advantage of the direct line system is the possibility of an islanding-mode in case of a disruption of the public grid. However, it always depends very much on the initial situation. Direct line systems are an attractive solution only in cases where the consumers are located closely to each other, so that the digging effort is manageable. In case of the Thannhausen pilot, the evaluation showed, that the direct line system enables similar savings for the participants to a renewable energy community, when the subsidies granted are taken into account. Since there are no grid fees for the direct line system, a higher feed-in tariff is made possible for the municipality, which amortises the higher investment costs, so that the direct line system has even the higher net present value at the end of the period under consideration.

Keywords: energy sharing, micro grid, renewable energy community, pilot plant, direct line system

2 INTRODUCTION

To increase the share of renewable energy sources and to provide incentives to produce and use the energy locally, the EU renewable energy directive (European Commission, 2018) has planned to advance the process of emancipating the end consumers towards active participants in the energy system. Parts of that directive have been transposed to national law in the “Erneuerbaren-Ausbau-Gesetzespaket” in Austria in July 2021 (Republik Österreich, 2021), which enables the establishment of ‘renewable energy communities’. A renewable energy community is a community of producers, consumers and ‘prosumers’ amongst which renewable energy can be exchanged. In case of renewable electricity, the public distribution grid can be used. To create additional incentives the energy exchanged in the community is subject to reduced grid fees, taxes, and levies. But even before the law was established in July 2021, it was possible to share (renewable) energy, even though a much higher technical effort had to be made, by installing and operating “direct lines”, privately operated power lines outside the jurisdiction of a grid operator. Given the arrival of ‘energy communities’, direct lines might seem outdated. A closer look shows, that both systems have their advantages and disadvantages. Therefore, this paper intends to compare an operational direct line system with a fictional renewable energy community based on the municipality of Thannhausen.

The municipality of Thannhausen owns and operates a photovoltaic (PV) generation plant on one of its buildings in the village centre. Additionally, there is potential for more PV generators on other buildings in the village centre owned by the municipality. Since the existing PV-generator produced substantial surpluses, and there was an incentive to install additional capacities, the idea of sharing the electricity with neighbouring buildings via a micro grid was born. 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 which would be possible later in renewable energy communities. 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. In total eight consumers, consisting of private households, small enterprises, small companies and the municipality buildings have been identified, which were interested and suitable to participate in the microgrid. All of them are in proximity of one another, to make the realisation of a direct line system possible. The basic parameters are shown in Table 1.

Participant	Consumption per period (01.01.2022 – 30.06.2022) [kWh]	Peak load [kW]	Distance to the PV-plant/Lengh of the direct lines [m]
Household 1	1915	5.5	134
Small Enterprise	7940	19.2	28
Household 2	5338	8.9	118
Municipality	4953	5.4	62
Small Company 1	1600	3.7	62
Small Company 2	753	1.8	62
Small Company 3	1927	5.4	62
Small Company 4	1700	2.7	150

Table 1: Consumption data of the users of the direct line system in Thannhausen for the period 01.01.2022 – 30.06.2022

To supply the direct line system, a new PV generator with a maximum capacity of 29.6 kWp was installed on the roof of the waste collection centre, one of the municipality buildings. By the time the decision was made, the existing PV-generators had a high funded feed-in tariff, which made it less attractive to use them for the supply of the direct line system.

For the same configuration a renewable energy community was investigated by means of a simulation model. Following Key Performance Indicators (KPIs) have been defined for the comparison of the two kinds of energy sharing schemes.

Number	Indicator	Measurement unit	Description
KPI 1	Own consumption rate	[%]	Share of the PV-production which could be used within the energy sharing schemes (direct own consumption of the municipality + indirect own consumption of the participants of energy sharing schemes) divided by the total energy production.
KPI 2	Self supply rate	[%]	Share of the PV-production which could be used within the energy sharing schemes divided by the total energy demand of all participants of the energy sharing schemes.
KPI 3	Net present value	[EUR]	Net present value of the municipality (investor of the PV-generator respectively the direct line system) after 20 years.
KPI 4	Savings of the participants	[EUR/period]	Amount and distribution of the savings among the participants in relation to a 100 % grid consumption.

Table 2: Key Performance Indicators (KPIs) for the comparison of the two types of energy sharing schemes

In addition to the KPIs, further advantages and disadvantages of the two types of energy sharing schemes are discussed, such as the possibility of an emergency operation in case of a power failure of the public grid.

3 THE DIRECT LINE SYSTEM IN THANNHAUSEN

The pilot in Thannhausen, which is part of the FFG project SoWeiT Connected¹ and the Interreg Alpine Space project ALPGRIDS², was taken into operation at the end of 2021 and the monitoring is still ongoing but will be concluded by September 2022. It consists of the eight consumers (grid coupling points) shown in Table 1, which are connected to the public low voltage (230/380 V) grid. As shown in Figure 1, each of the users can be connected to the PV generator with an individual direct line (orange lines) or to the public grid (blue lines), depending on whether the entire consumption can be satisfied via the direct line or not. This is necessary due to the legal requirements for direct lines (Nacht T. et al., 2018). The PV generator also has a switch which allows separation from the public grid, which would effectively turn the system into a microgrid, but this will only be used in the case that islanding is necessary.

Each of the users is equipped with a measurement unit to measure the total power consumption, in addition a measurement unit was installed on each direct line and for the PV generation and the consumption of the municipality. The measurement units at the user's sites were 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) receives its data via Ethernet cables which are placed together with the cables for the direct lines. Ethernet cables are also used to control the switches of the direct lines which are implemented as air gap switch.

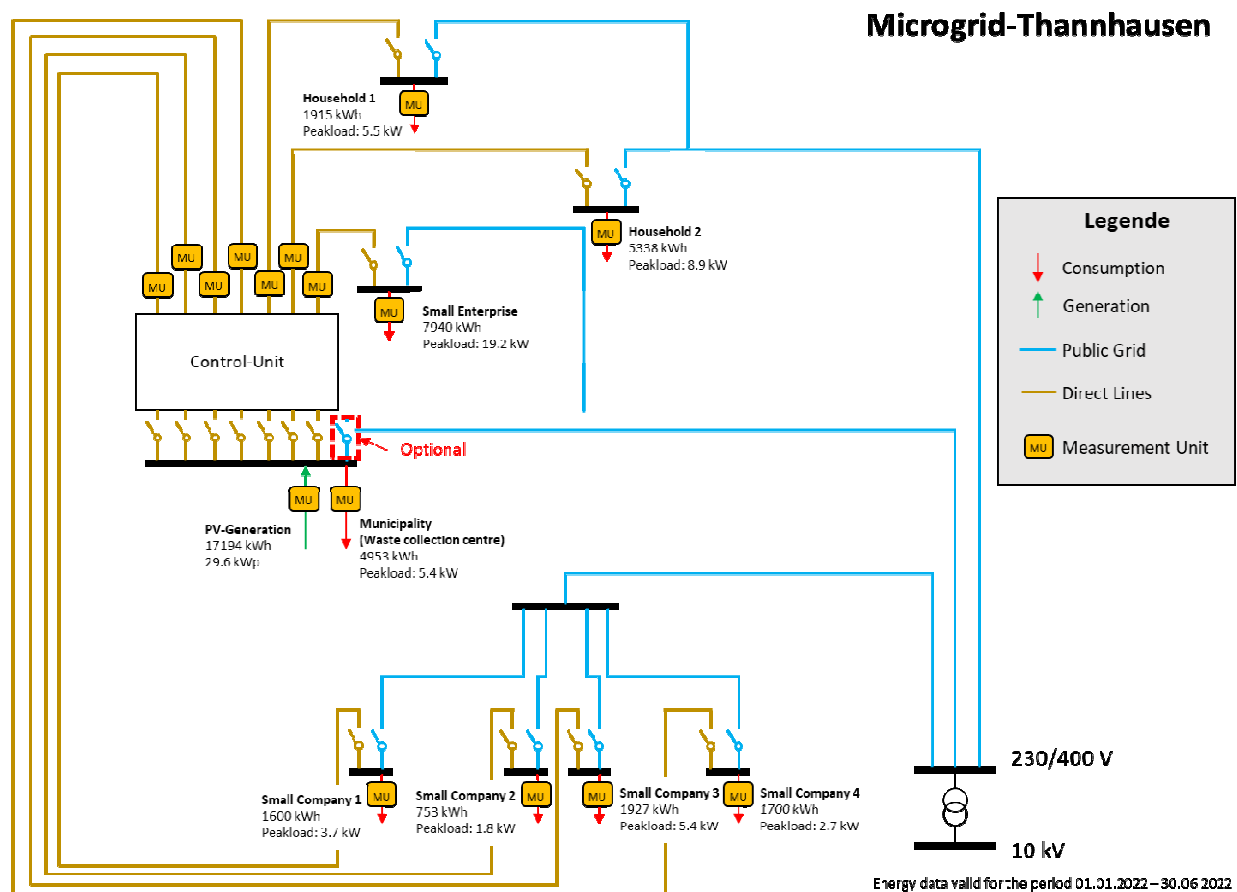


Figure 1: Technical set-up of the pilot in Thannhausen

The energy distribution within the direct line system happens because of the switching process of the direct lines. For normal operation, the following rules apply for the control regime:

- First off, the consumption of the municipal buildings will be covered, only excess energy will be provided to the direct line system.

¹ <https://nachhaltigwirtschaften.at/de/sdz/projekte/soweit-connected.php>

² <https://www.alpine-space.org/projects/alpgrids/en/home>

- The control unit will then check the power consumption values of the users and will sort them according to an internal ranking system so 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

To ensure the fair distribution of the PV generation between all users, the target function of the ranking system consists of two parts. The first part addresses the maximisation of the self-consumption within the direct line system, and the second part covers the equal distribution of the PV generation. Two weighting factors were used to determine, which part is more important for the ranking system. For the Thannhausen pilot a balanced setting was chosen, which ensures a fair distribution with only slight reductions of the self-consumption rate in comparison to the maximum possible one.

The equality of the distribution is controlled by applying a prioritising factor for each user in the target function of the optimisation algorithm, thus increasing or decreasing the importance of individual users. This factor is updated daily and reflects how much energy each user has already obtained from the direct line system. The user who got the lowest share of energy, in relation to his total energy demand by the time of the factor update gets the highest factor, and so on. A high factor means, that this user also has a higher priority for the optimiser. A low factor indicates that a user has already got a high relative share of energy in relation to the other users and therefore has a lower priority in the ranking system.

The optimisation is carried out every 15 seconds by the control system. To avoid a constant switching between the direct line system and the public grid a “clocking prevention” was implemented. This was necessary to prevent premature wear of the switching elements and increase the lifetime of the system. A certain switching contingent is available to the control system. If this switching contingent has been exceeded, users may be reconnected to the direct line system no earlier than five minutes after their switchover from the direct line system to the public grid. If this is not the case the users can be connected already after one minute. At times when no switching operations are necessary, e.g. during night time, the switching contingent is successively increased again. This ensures that the maximum number of switching operations (time when the components must be replaced) is not reached prematurely.

Switching from the direct line to the public grid is possible at any time to ensure that no more PV-energy is drawn from the direct lines than is actually available.

3.1 Legislative framework

Operating a direct line or a direct line system is made possible by the Elektrizitäts- Wirtschafts- und Organisationsgesetz (ElWOG) (RIS, 2022), 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 as well as the public grid 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 (Nacht T. et al., 2018):

- There must be separation between the direct line(s) and the public grid to avoid direct exchange of electricity between the direct line(s) and the public grid
- It is not allowed to feed PV surplus into the public grid via the direct line
- The direct line must be operated by the producer

- A star network, as used in Thannhausen, is not a contradiction to applicable electricity law

3.2 Tariff system

In Thannhausen, a uniform tariff for all participants of 8.14 cent/kWh before taxes was fixed for the first months of operation. In July, the tariff has been increased to 15.00 cent/kWh, which is still far below to the average energy costs on the market at the moment and also below the feed-in tariff which is been offered by the OeMAG at the moment (see Table 3). The municipality deliberately accepts revenue cuts to provide participants with a favourable energy supply.

In order to make the two systems easily comparable, a different direct line tariff was chosen for the calculations, so that the same savings results for the participants in both systems. In case of the direct line system, the purchase tariff of the consumers is also the feed-in tariff of the municipality. To calculate the savings in comparison to a 100 % grid consumption, current consumption and feed-in tariffs were used, as shown in Table 3.

Tariff for the consumption of electricity from the direct line system	41.86	Cent/kWh
Tariff for the feed-in of energy in the direct line system	41.86	Cent/kWh
Tariff for the consumption of energy from the public grid (incl. grid fees and taxes) – based on current marked tariffs (E-Control, 2022b)	50.17	Cent/kWh
Tariff for the feed-in into the public grid – OeMAG Tariff for the 3. Quarter of 2022 (E-Control, 2022a)	30.70	Cent/kWh

Table 3: Tariffs used for the calculation of the economic effects of the direct line system

The remaining energy, which is not supplied via the direct line system has to be purchased from an energy provider via the public grid on individual basis. For simulation purposes all users have the same grid tariff, as depicted in Table 3. The investment costs of the direct line system were taken over by the municipality. Therefore, no investment or operational costs applies to the consumers. The consumers only pay for the energy consumed via the direct line system.

4 RENEWABLE ENERGY COMMUNITY

A renewable energy community may generate renewable energy itself, consume, store, and sell self-generated renewable energy to members, act as an aggregator, and provide energy services. For these purposes the public power grid can be used, and reduced grid fees, taxes, and levies apply. A more detailed description is provided on the homepage of the Coordination office for energy communities. (Österreichische Koordinationsstelle für Energiegemeinschaften, 2022)

4.1 Legislative framework

A number of legal requirements apply to energy communities, which are regulated in the Erneuerbaren-Ausbau-Gesetzpaket (Republik Österreich, 2021) and the EIWOG (RIS, 2022). The most important ones are summarised in the following section. First, the membership in energy communities is limited to:

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

Therefore, large enterprises and energy providers are not allowed to participate. Moreover, a formal membership in the energy community is required. The energy community itself needs to take the form of a legal body (e.g. an association, cooperative, business partnership, or corporation). 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. Furthermore, the members have to be in close proximity to one another. The degree of proximity is defined by the grid levels the members are connected to (see figure 2). In this respect, a distinction can be made between two types of energy communities.

- Local energy communities: This includes levels 6 and 7.
- Regional energy communities: This includes levels 5 to 7 and also the “Sammelschiene” (collector) at level 4.

During the founding phase of the energy community, it needs to be decided whether the energy community will be implemented as local or regional energy community. 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. For local energy communities the grid fees are reduced by 57 % and for regional energy communities the reduction is 28 % for the grid levels 6 and 7 and 64 % for the grid levels 4 and 5.

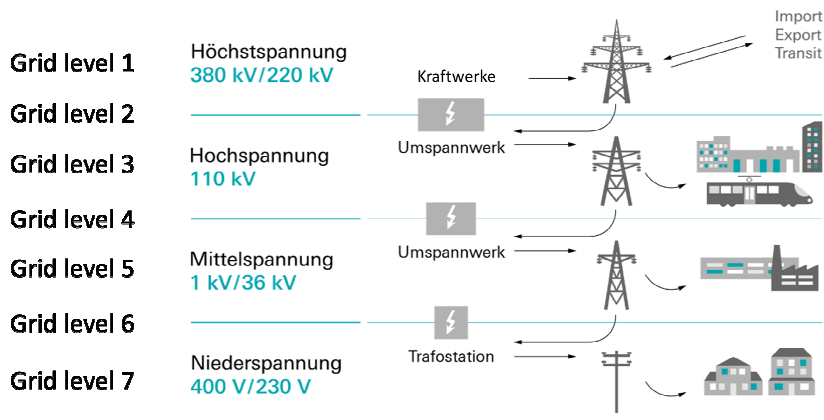


Figure 2: Grid levels in Austria, based on (Verbund, 2022)

For metering purposes smart meters need to be installed for every consumer. The grid operator will measure the consumption and generation of each member with a temporal resolution of 15 minutes. The totally available infeed by the members (omitting self-consumption) will be subsumed and divided amongst the members according to a distribution key provided to the grid operator. The distribution key describes how the available energy within the energy community is split amongst the members. Each member will thus receive two or possibly even three bills for electricity supply, one from its regular energy supplier (which according to EU law can be changed at will by the consumer) and one from the energy community. Furthermore, if the bill from the grid operator is not part of the bill from the energy supplier, this will become the third bill.

A renewable energy community with local proximity, founded as an association, was chosen for the comparative calculation of the Thannhausen pilot.

4.2 Tariff system

The renewable energy community was designed in such a way that only the costs necessary for the operation of the energy community (fees association, billing, etc.) remain in the community itself and all other savings are divided among the participants and the municipality. This is about 130 EUR per year. The current relief package of the Austrian government was not taken into account, as it was assumed that it will not be available in this form over the entire period under review.

For the calculation of the energy community, a fixed uniform tariff was chosen for all participants of the renewable energy community. The purchase tariff for electricity from the public grid was also set uniformly for all participants as specified in Table 4. The feed-in tariff of the renewable energy community was set at 32 cent/kWh. This ensures that the municipality benefits from the feed-in to the renewable energy community, despite the high feed-in tariff of 30.7 cent/kWh currently granted by the OeMAG (E-Control, 2022a). Even if these financial incentives were not decisive in the case of the municipality of Thannhausen this assumption was made because it might be in many other cases.

Tariff for the consumption of electricity from the renewable energy community	42.70	Cent/kWh
Tariff for the feed-in of energy in the renewable energy community	32.00	Cent/kWh
Tariff for the consumption of energy from the public grid (incl. grid fees and taxes) – based on (E-control, 2022b)	50.17	Cent/kWh
Tariff for the feed-in into the public grid – OeMAG Tariff for the 3. Quarter of 2022 (E-Control, 2022a)	30.70	Cent/kWh

Table 4: Tariffs used for the calculation of the renewable energy community

5 RESULTS

In this chapter the results of operating the direct line system in Thannhausen are compared with the results of the simulated renewable energy community by comparing the values of the KPIs, indicated in Table 2. The analyses are based on the monitoring data from the first half of 2022 (1st of January until 30th of June). This approach was chosen due to the reason that the final configuration of the direct line system was put in operation by the end of 2021, and therefore no full year of measurement and operational data was available. The renewable energy community was simulated with the data from that period, using the measured consumption data of the energy demands and the generation data from the PV-production as input, to compare the two possibilities to exchange renewable energy.

In Figure 3, the comparison of the own consumption rate (KPI 1 – see Table 2) for the direct line system and the energy community are shown. The direct own consumption value describes the share of energy which is consumed directly by the municipal building on which the PV-generator is installed on. Both systems, the direct line system and the renewable energy community are designed in that way, that the energy demand of the municipal building, is covered first. This share of energy is not part of the energy sharing scheme, neither in the direct line system nor in the energy community. Only the remaining PV-surplus was distributed amongst the other users/participants (which makes up the indirect own consumption). Therefore, the own consumption of the municipality is the same for both systems.

The share of energy, which can be distributed via the energy sharing schemes, is lower in case of the direct line system as compared to the renewable energy community for several reasons. The first reason is, that at each given point of time, the participants of the direct line system have to be either completely supplied via the direct line system or completely supplied via the public grid. A partial supply from both the grid and the direct line system at the same time is not allowed (Nacht T. et al., 2018). So, whenever the total consumption exceeds the available PV-surplus, one/some of the users will not be supplied via the direct line system and parts of the generation will be fed into the public grid. This is different in the case of the dynamic distribution of PV-surplus in the renewable energy community. There the whole PV-surplus can be (arithmetically) distributed between the participants, even when the energy demand exceeds the PV-surplus. The remaining demand will be supplied via the public grid. If the total energy demand within the energy community is lower than the PV-surplus, the remaining PV-energy has to be feed-in to the public grid (surplus shown in Figure 3). In this calculation scenario it was assumed, that the municipality feeds in its surplus itself.

Another reason is the implemented clocking prevention, which is described in section 3. The immediate reconnection of a user to the direct line system is prevented if he was disconnected from it a short time ago. That means that after a user is disconnected he stays disconnected for a certain time to prevent a premature wear of components. Even if these intervals are kept rather short (in most cases one minute), a slight reduction in the achievable own consumption via the direct line system must be accepted due to the clocking prevention. And finally, another reduction of the maximum achievable own consumption is consciously accepted to achieve a fair distribution between the users (see section 3).

Due to these reasons, the own consumption via the direct line system is six percentage points lower than the own consumption rate in case of a renewable energy community.

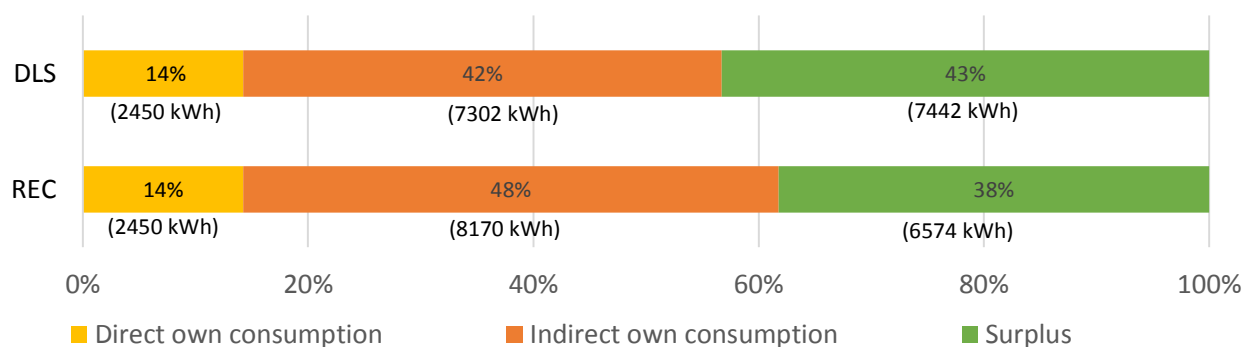


Figure 3: Comparison of the own consumption between the direct line system (DLS) and the renewable energy community (REC) based on data of the first half of 2022

The same reasons as for the own consumption also led to a lower self-supply rate in the direct line system. While an overall self-supply rate of 40 % can be reached by participating in a renewable energy community, the overall self-supply rate of the direct line system is 37 %. Figure 4 compares from which sources the demand is satisfied (direct and indirect own consumption as well as grid consumption). The direct own consumption is only possible for the municipal building on which the PV-generator is operated, while all other participants are either supplied via the direct line system/energy community or the public grid (indirect own consumption).

It has to be mentioned that the self-supply rate needs to be rated differently for both approaches. The direct line system is able to switch in an islanding mode in case of a failure of the public grid, which means that theoretically it would still be able to operate in such a case. In the current state of the direct line system this islanding operation is not possible as the required flexibilities to balance out generation and consumption (control reserve) is not yet installed. But it would technically be possible to implement the required components and thus allow for an islanding operation. This is not possible with a renewable energy community. A high self-supply rate of the renewable energy community means, that less energy has to be purchased from the public grid. However, as the public grid is used for the energy shared within the renewable energy community, the energy community is not able to operate in case of a failure of the public grid.

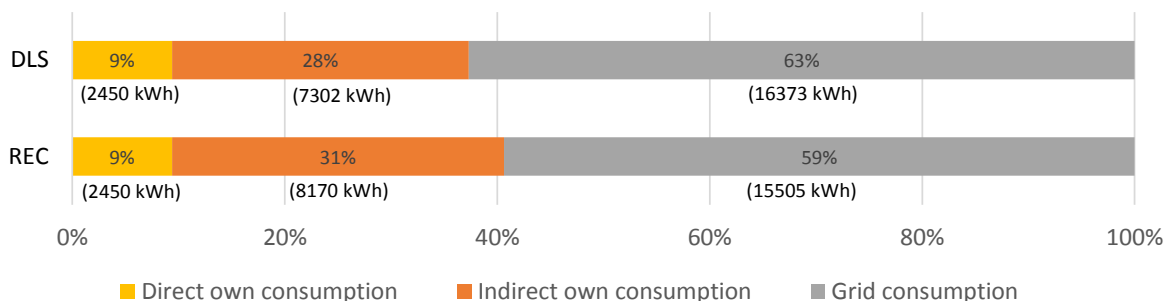


Figure 4: Comparison of the self-supply rates between the direct line system (DLS) and the renewable energy community (REC) based on data of the first half of 2022

The cost saving potentials of the participants are shown in Figure 5. In both cases this is strongly dependent on the chosen tariff system, which is described in section 3.2 for the direct line system and in section 4.2 for the renewable energy community. In the evaluation the tariff of the direct line system was set in such a way, that the total savings for the participants would be the same for both systems to make them easily comparable. Therefore, the tariff of the direct line system was defined with 41.9 cent/kWh, instead of 15 cent/kWh which is the currently used tariff in Tannhausen. The reference were the costs of grid purchase, which were assumed to be 51.7 cents/kWh incl. grid fees and taxes. (see Table 3).

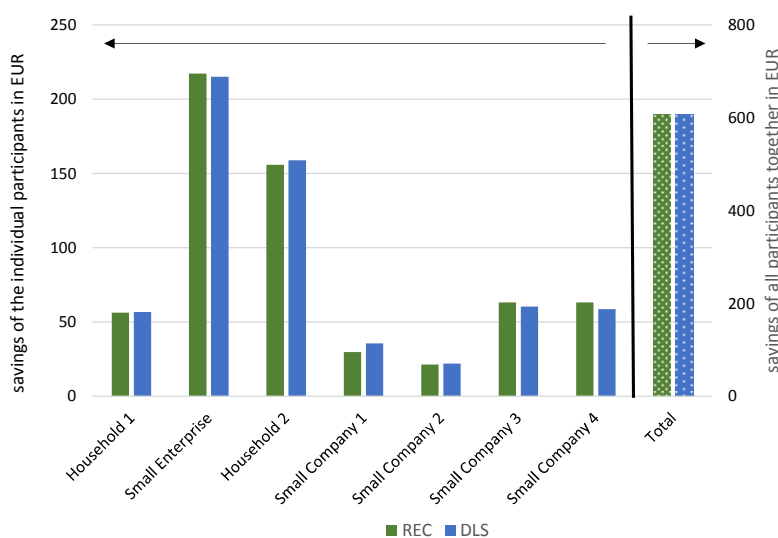


Figure 5: Cost savings of the participants of the energy sharing schemes in comparison to a 100 % grid consumption for the period of 01.01.2022 – 30.06.2022 (half year)

It was shown, that with this setting the savings of the individual participants are similar for both systems. This confirms that the algorithm of the direct line system for the equal distribution works well and that the PV-surplus is distributed in a fair way between the participants. The benchmark would be the savings of the renewable energy community, as the PV-surplus is distributed in relation to the actual consumption. Savings in comparison to a 100 % grid consumption were achieved for all participants, so that from a financial point of view, the participation is advantageous for all. The savings are in a range between 21 EUR (small company 2) and 216 EUR for the small enterprise in a half year. The savings are dependent on the energy demand of the participants as well as on the daytime when most of the energy is needed. The Small Company 2 is the participant with the lowest energy demand (see Table 1) and has further a high base load demand during night times. Therefore, only a small share of their electricity demand can potentially be supplied by the energy sharing schemes. The Small Enterprise on the other hand is the largest consumer, with most of the energy consumption occurring during daytimes. The others are in between.

In case of the direct line system no grid costs apply, which makes a higher feed-in tariff possible for the municipality in comparison with the renewable energy community. This results in higher revenues compared to feeding the energy into the public grid. While the municipality can assume additional revenues in the range of 212 Euro/year in case of an energy community, the expected revenue is significantly higher for the direct line system with about 1853 Euro/year. In contrast, however, higher investments are required for the direct line system as shown in Table 4. In case of the renewable energy community only the costs of the PV-generator incur, while for the direct line system additional costs for the direct lines, the excavation work and the energy manager apply.

	without funding	with funding*
Costs of the direct line system (without PV-generator)	50 723 EUR	27 311 EUR
Costs of the PV-generator	10 285 EUR	22 358 EUR

Table 4: Investment costs for the direct line system and the renewable energy community with and without funding. *the amount with funding corresponds to the total costs minus the funding support which could be achieved for the Thannhausen pilot.

In Figure 6 the development of the net present value is shown for both approaches. In this calculation, it was assumed that the savings and costs of the second half of the year, equals those of the first half. The selected tariffs were assumed constant over the years and the effective interest rate was defined with 2.5 % per year. The currently (08.2022) exceptionally high electricity prices in Austria have led the government to pass a relief package which reduces the taxes and levies on electricity consumption for all consumers. This also affects energy communities, as inner-community consumption would be exempt of the same taxes and levies. For the economic analysis of the energy community this relief package was neglected, as no indication exists that it will be continued after 2023.

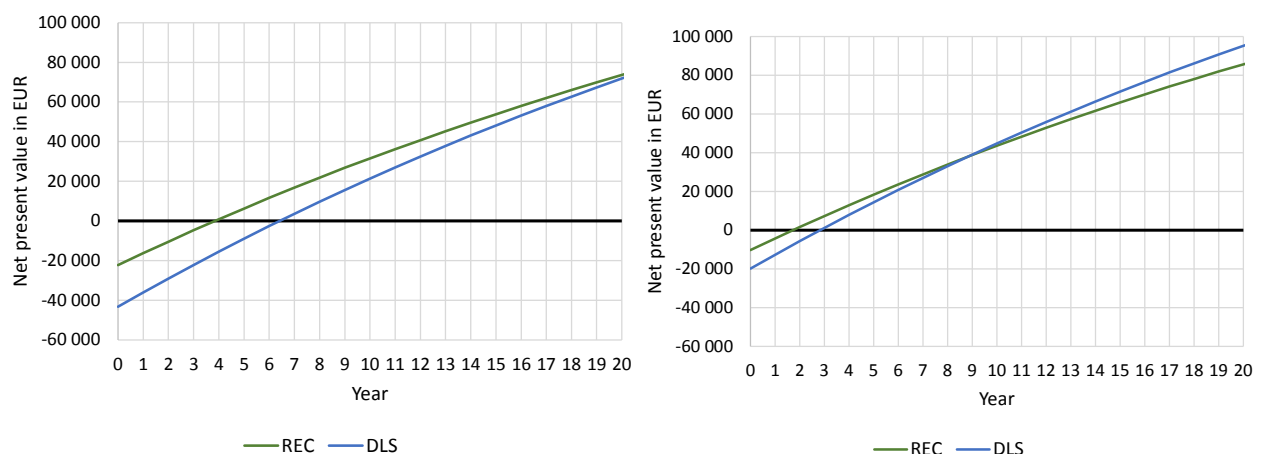


Figure 6: Comparison of the development of the net present value between the direct line system (DLS) and a renewable energy community (REC) – left: without funding of the investment costs; right: with funding of the investment costs

If no funds would be received, the investment costs would be amortised after four years in case of the renewable energy community (only the PV-generator) and after seven years in case of the direct line system (PV-generator and direct line system). At the end of their lifetime, both would have approximately the same net present value.

If the received funding money is considered, the amortisation occurs already after two, respectively three years, and after nine years, the net present value of the direct line system exceeds the renewable energy community.

Especially in times when the situation on the electricity market is changing very quickly, evaluations with assumptions of energy tariffs of the next 20 years are subject to a certain degree of uncertainty. Nevertheless, the evaluation shows, that direct line systems can still be an interesting alternative to renewable energy communities also from the financial perspective if the initial situation is appropriate.

6 CONCLUSION

The evaluation shows that in case of the Thannhausen pilot, the direct line system enables similar savings to the participants as a renewable energy community, when the subsidies granted are taken into account. In order to operate the direct line system economically, it is important that all participants are located within close proximity to each other to minimise the necessary excavation work. In addition, certain amounts of energy are required on both the generation and consumer sides to ensure amortisation of the additional investment costs within a reasonable period of time. In this respect, an energy community has greater flexibility. The distances between the participants, apart from the legal limitations, are not relevant in this case and it is easier to integrate a larger number of participants. It is therefore to be expected that energy communities will be the common type of micro grids in the near future. It would also be questionable whether the construction of a parallel grid infrastructure, as is the case with a direct line system, is to be supported on a large scale. It needs to be considered, that the direct line system is an additional infrastructure, which is operated in parallel to the existing and well working infrastructure of the public grid. This is a critical point as the macroeconomic effects of operating a direct line system are not considered in this paper.

Furthermore, the currently high electricity prices work well in favour of the direct line system, as an amortisation of the investment costs is reached earlier. While this holds true for the investment costs of the energy community as well, the total costs of the energy community are far less in relation to the energy shared than the costs of the direct line system. Thus, the energy community case would reach an amortisation even in case of lower energy tariffs.

In some cases, however, direct line systems may still be an interesting option in the future. Direct line systems enable an island operation, which means that they can also be operated in the event of a power failure of the public grid. A direct line system is therefore the better option if the focus is on fail-safe operation or blackout protection and a smaller number of participants are to be connected at a short distance. It is also possible to integrate a (central) storage into the direct line system which would further increase the self-supply rate.

7 REFERENCES

- E-CONTROL. (08.08.2022a): Aktueller Marktpreis gemäß § 41 Ökostromgesetz 2012, <https://www.e-control.at/de/marktteilnehmer/oeko-energie/marktpreis>
- E-CONTROL. (08. 08 2022b): Tarifkalkulator, <https://www.e-control.at/konsumenten/service-und-beratung/toolbox/tarifkalkulator#/>
- EUROPEAN COMMISSION: Renewable energy directive. Brussels, 2018, https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv:OJ.L_.2018.328.01.0082.01.ENG&toc=OJ:L:2018:328:TOC.
- NACHT T. et al.: Demonstration eines Gebäudeübergreifenden PV Stromaustausches. Graz, 15. Symposium Energieinnovation, 2018
- ÖSTERREICHISCHE KOORDINATIONSTELLE FÜR ENERGIEGEMEINSCHAFTEN. (09. 08 2022): Energiegemeinschaften in Österreich. <https://energiegemeinschaften.gv.at/>
- REPUBLIK ÖSTERREICH: Erneuerbaren-Ausbau-Gesetzespaket. Vienna, 2021, https://www.parlament.gv.at/PAKT/VHG/XXVII/I/I_00733/index.shtml.
- RIS: EIWOG. Vienna, 2022, <https://www.ris.bka.gv.at/GeltendeFassung.wxe?Abfrage=Bundesnormen&Gesetzesnummer=20007045>
- Verbund. (26.09.2022): Wie funktioniert das Stromnetz. <https://www.verbund.com/de-at/privatkunden/themenwelten/strom-aus-wasserkraft/stromnetz>