eCREW eSTABLISHING COMMUNITY RENEWABLE ENERGY WEBS

establishing Community Renewable Energy Webs - Rolling out a business model and operational tool creating webs of households that jointly manage energy to improve efficiency and renewables uptake

Contract No. 890362

Deliverable 2.2: Definition of the split-incentives approach in LCs

This project has received funding from the *European Union's Horizon 2020 research and innovation programme* under grant agreement No 890362.

Document Information

Title	Definition of the split-incentives approach in LCs
Editor	*Editor*
Contributors	*Hans Böhm, Johannes Reichl*
Dissemination Level	☐ **CO** Confidential, only for members of the consortium (including the Commission Services) ☐ **RE** Restricted to a group specified by the consortium (including the Commission Services) ☐ **PP** Restricted to other programme participants (including the Commission Services) ☒ **PU** Public
Reviewers	☐ EI-JKU ☐ GreenPocket ☒ SWH ☐ ADEE ☐ ACEA ☐ UEAS ☒ CIRCE ☐ UNITO ☐ IUE ☐ AEGEA
Status	☐ Draft ☐ WP Manager accepted ☒ Coordinator accepted
Action requested	☐ to be revised by Partners involved in the preparation of the deliverable ☐ to be reviewed by applicable eCREW Partners ☐ for approval of the WP Manager ☐ for approval of the Project Coordinator
Requested deadline for Action	

Versions

Version	**Date**	**Change**	**Comment/Editor**
<1.0>	18.02.2021		Initial draft
<2.0>	29.03.2021	Revision based on reviewers comments	final
<2.0>			

Disclaimer

Executive Summary

The aim of this document is to provide simulation-based information how eCREW's split-incentives approach for energy exchange in the investigated Lighthouse Communities (LCs) can be designed. Based on simulations of representative communities it provides estimates on expectable energy exchange and according monetary effects for the participating parties in different tariff models.

NOTICE: the current version of the Deliverable contains the respective analysis for the LCs in Germany and Spain. No comparably fine-grained data from the Turkish LC is available at this point. However, the Turkish LC currently installs smart meters for their customers, and as soon as the first data series over about three months are available, the respective analysis for the Turkish LC will added to this Deliverable.

Table of Contents

Table of Figures

1 Introduction

The present document describes the split-incentives approach for the stimulation of energy exchange within appropriate energy communities (CREWs). To evaluate the monetary effects for the participating entities and the general potentials for energy exchange the document also includes simulations of individual CREW compositions within the investigated Lighthouse Communities (LCs) in Germany, Spain and Turkey[1].

2 The principles of the split-incentives approach

The foundation of CREW is based on the fact that some entities/households with PV generate more electricity than they are able to consume. Most CREW participants are either prosumers, households capable of storing electricity (i.e. with battery storage), or households that only consume electricity. However, CREWs are generally open to include other entities, such as industrial companies with PV. In eCREW we develop a "**CREW contract**" together with three regional energy retailing companies ADEE, SWH, and UEDAS that hold the right (license) to establish supply contracts with consumers. In this contract, participants have some standard electricity supply and generation surplus trade tariffs with the ability to improve benefits to both producers and consumers of PV electricity. The establishment of such a promotion of energy sharing between CREW participants is referred to as the **split-incentives approach** (SIA). However, the implementation of this SIA is highly dependent on prevailing market conditions and (national) regulations, such as subsidies. Thus, there are different concepts for the SIA in a (fully) open energy market versus a subsidised integration of renewable electricity surpluses (production and/or storage).

2.1 The SIA in an open market perspective

The open market perspective presumes that in a future renewable energy system, surplus electricity generation is sold to a market player at market costs, i.e. without subsidised feed-in tariffs as it is practice today in many EU countries. Hence, in the open market perspective every citizen is allowed to sell generation surpluses to his energy provider of choice at appropriate tariff models offered by the provider. This implies that usually, the surplus PV-generated electricity is sold to a retailer/grid (depending on national legislation) for a fixed low feed-in tariff (e.g. 3 c€/kWh), while each kWh purchased from the grid costs more (e.g. 6 c€/kWh, considering only energy costs). Thus, the following benefits would arise for each participant by implementing CREWs with a split-incentives approach.

Benefits for consumers: In the eCREW concept, whenever there is excess electricity for some of the CREW members, those who need to buy electricity at this time (i.e. households without PV) are offered the excess electricity at a lower price than what is being offered from the supplier/grid (e.g. 5 c€/kWh). The difference to the supplier/grid price (e.g. 1 c€/kWh) is refunded in form of bonus payments by the CAE. Only when the supply of CREW generated electricity is less than the demand for electricity will missing quantities be purchased from the grid. Thereby, the benefit for consumers is the decrease of the electricity expense for customers participating in this tariff.

Benefits for producers: Producers who have an excess of electricity (i.e. households with PV) receive a higher rate than if they were to sell it to the grid (e.g. 4 c€/kWh). Only if the energy demand within the CREW is lower than the generated surpluses, the remainder is sold for the common feed-in tariff. The difference to the standard feed-in tariff (e.g. 1 c€/kWh) is paid as bonus by the CAE.

Benefits for the Community Administering Entity: The difference between the price the producer receives and consumer pays is the revenue of the CAE (in this example 1 c€/kWh).

[1] The simulations of the Turkish LC are awaiting the availability of appropriate client meter data and will be included in a future update of this deliverable.

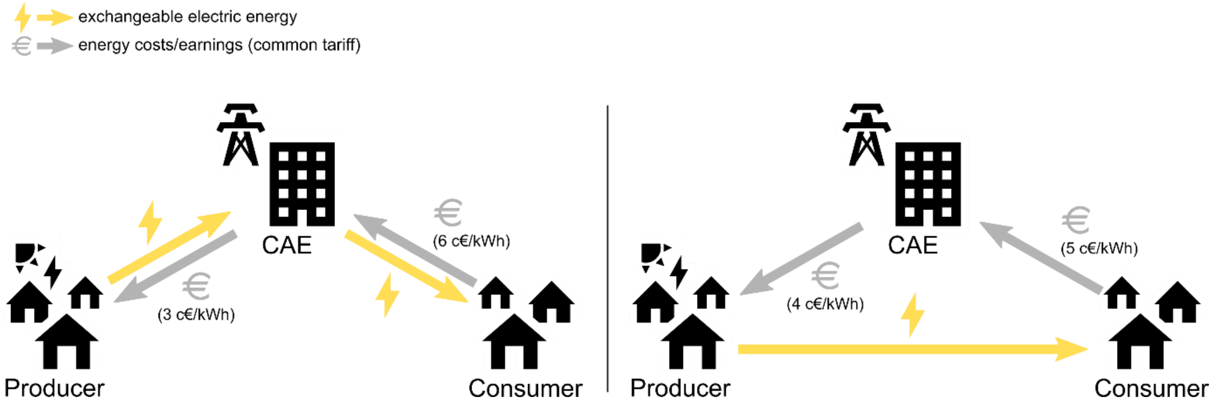

Figure 1: Illustration of the SIA for open markets (right) compared to conventional energy and cash flow (left)

2.2 The SIA in with regulated feed-in tariffs

In todays' energy systems the expansion of renewable energy sources has a significant role in many national energy plans. Thus, to promote the installation of renewable electricity production, many national regulations subsidise the production and feed-in of surplus electricity (e.g. from PV) with fixed feed-in tariffs. This often results in a situation where the feed-in tariffs for electricity supplied to the grid exceed the costs for purchasing electricity from the energy provider (merely related to energy costs without taxes, fees and margins). In this case, the approach presented in the previous section, with incentives being in-between provider-defined supply and feed-in tariffs, has to be adapted to achieve a financially viable solution. A feasible approach is the implementation of bonus payments for energy exchanged within the CREW as transitional solution towards an open tariff market. However, while such bonus results in monetary incentives for the customers to participate in a CREW, it costs the energy provider money. Therefore, the bonus system as proposed here (and implemented in eCERW) is a solution only for the transition period from heavily subsidised feed-in tariffs to market-based prices for surplus electricity. When such subsides expire, as it becomes standard with newly installed PV modules, the SIA in Section 2.1 become the price model of choice.

The benefits for the individual participants from the bonus SIA are described in the following.

Benefits for consumers: The consumer purchases the energy needed from the provider for the common energy supply tariff. For times when surplus energy is available within the CREW, the consumption of this is incentivised as bonus (e.g. 1 c€/kWh) credited against the tariff price. These incentives are refunded in form of bonus payments by the CAE at certain intervals (monthly, annually).

Benefits for producers: Surplus electricity produced is sold to the provider at common feed-in tariffs according to national regulations. For the amount of energy that could be utilized within the CREW, the CAE accumulates bonus payments (e.g. 1 c€/kWh) for the producer, which are paid out at certain intervals.

Benefits for the Community Administering Entity: The effective revenues and costs arising for the CAE as an energy provider for the supplying electric energy to and purchasing such from their clients is highly dependent on national regulations and the involved allocations of subsidies. However, for the time being, the CAE has to cover the bonus payments for both, the producers and the consumers participating in the CREW. Thus, the benefits arising for the CAE from the described approach are mainly based on attraction of new clients until profitable business models under appropriate adaptions of regulations and the implementation of a "real" split-incentives approach are feasible.

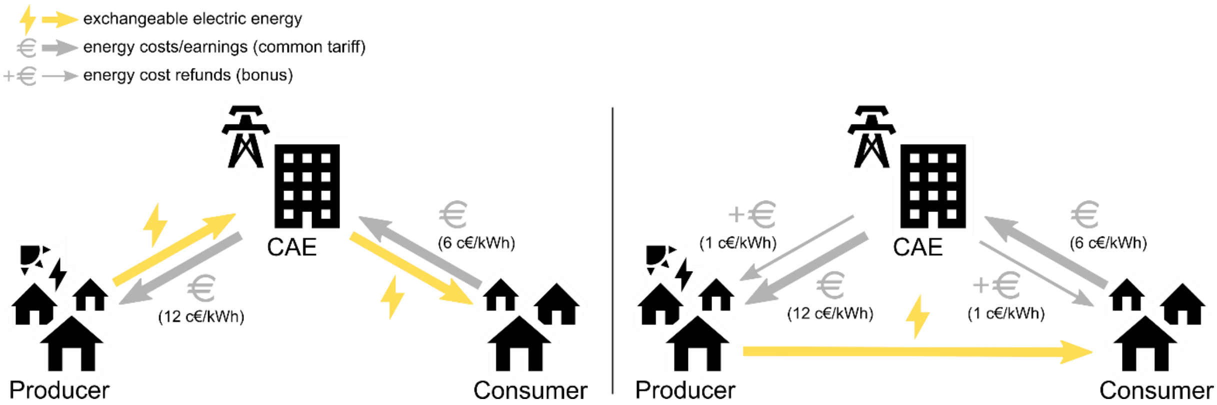

Figure 2: Illustration of the SIA for subsidised feed-in tariffs (right) compared to conventional energy and cash flow (left)

3 Requirements for tariffs in the split-incentives approach

To enable the benefits as described in Section **Fehler! Verweisquelle konnte nicht gefunden werden.**, four tariffs are defined in the CREW contracts. The first and second tariffs are not specific for CREWs, but are the usual tariffs for electricity consumers and prosumers. These are:

i. Whenever electricity is purchased from the supplier by the customer, the consumer pays the *external supply price*. This is a standard supply tariff and is part of every electricity supply contract.

ii. The *feed-in tariffs* (i.e. *external sales price*) are the remuneration that prosumers get for every kWh of electricity sold to the grid/supplier/etc. (instead of selling it to the CREW).

iii. The *internal supply price* is paid by consumers whenever their electricity demands are met by CREW prosumers' surplus PV or other renewable electricity production in the CREW.

iv. In eCREW, we denote the remuneration that prosumers get for every kWh of electricity sold to the CREW (instead of selling it to the grid/supplier/etc.) the *internal sales price*.

The eCREW approach is economically viable, including the types of benefits explained in section 2, when the price structure from the four aforementioned tariffs is in the following order:

Price Condition: in the open market perspective, consumers have monetary incentives to participate in a CREW when:

external supply price > internal supply price > internal sales price > external sales tariff

As described in Section 2.2, in many electricity markets the *external sales tariff* (feed-in tariffs) is subsidised. In the case of subsidised *external sales tariffs,* a violation of the above *Price Condition* could occur if the subsidy was large enough, because then: *internal sales price* < *external sales tariff.* Hence, in eCREW we apply the bonus SIA as outlined in Section 2.2 where a bonus very every kWh produced and consumed within the CREW is provided by the energy provider.

Specific conditions in eCREW's field trials:

As repeatedly mentioned in the previous sections, the implementation of a comprehensively beneficial split-incentives approach is dependent on several factors and most significantly national regulations. Today's subsidies for feed-in of surplus electricity, especially at small-scale (e.g. roof PV installations), distort the perspective on future market-regulated tariff models by violating the above *Price Condition*. However, the field trials implemented within the eCREW project have to deal with current market conditions and thus provide an incentive model, as outlined in section 2.2, that generates a similar attractivity for the clients as the long-term vision of the split-incentives approach.

In the long-term, national regulations have to ensure the establishment of an open market for feed-in tariffs as already widely available for supply tariffs. Hence, the before-mentioned *Price Condition* has to be met and external sale tariffs have to be lower than external supply prices (related to mere energy costs) to make an implementation of the split-incentives approach according to section 2.1 possible.

4 Assessing the economic viability of the split-incentives approach

The split-incentives approach is economically viable in the open market perspective if all of the benefits in Section 2.1 are realised, or at least if none of the three market players (consumers, producers, CAE) is made worse off. In the perspective of subsided feed-in tariffs, where the CAE provides financial incentives for consumers and producers, it will be important to assess the costs for the CAE along with the benefits for consumers and prosumers to derive a balance between incentives for participation to a CREW and costs for the CAE. Hence, in order to assess the specific configuration of the split-incentive tariff system used eCREW's field tests, the evaluation of monetary outcomes for each of these market players is performed.

Using historic load profiles of clients of CAE in combination with a virtual CREW system model, outcomes from specific tariff systems are created and market benefits and costs quantified for the three market participants: the CAE(i), the average consumer (ii) and average prosumer (iii) respectively. The results will be used to identify the best tariff system that optimizes the electricity market for each of the CREWs. The effects for the market participants moving from a tariff system without split-incentives approach (a) to on with such (b) arise as follows:

i. CAE:
   a. The revenues from selling electricity to consumers without the split-incentives approach by charging the *external supply price*, i.e. before the eCREW approach is implemented.
   b. The revenues from selling electricity to consumers in the split-incentives approach by charging the *external supply price*, i.e. when the eCREW approach is implemented. While the supply price is identical, the quantities of sold electricity are lower since CREW-internal sales do not add to the CAE's revenues, but only the respective difference between the *internal supply price* and the *internal sales price* are part of the CAE's income and are reported as a separate parameter.

ii. The average consumer:
   a. The sum of costs for purchasing all of a consumer's electricity demand for the *external supply price* without the split-incentives approach, i.e. before the eCREW approach is implemented.
   b. The sum of costs for purchasing electricity with the split-incentives approach, i.e. when the eCREW approach is implemented. A part of a consumer's total demand will be supplied by the CREW-internal production and is therefore charged the *internal supply price*, while the remaining part of a consumer's demand is purchased from the supplier and hence charged through the *external supply price*.

iii. The average prosumer (i.e. the average excess electricity production, the prosumer's consumption is represented in ii.):

   a. The revenues from selling all excess electricity to the grid/supplier/etc. through charging the *external sales price*, i.e. before the eCREW approach is implemented.

   b. The revenues from selling part of the excess electricity to the CREW through charging the *internal sales price* and from selling the remaining part of the excess electricity to the grid/supplier/etc. through charging the *external sales price*, i.e. when the eCREW approach is implemented.

Table 1: Summary of the market actor roles before and after introducing a split-incentives approach

		a – without split-incentives approach	b – with split-incentives approach
i	CAE	Charges supply tariffs for consumption, pays feed-in tariffs for production	Charges supply tariffs for consumption, pays feed-in tariffs for production. Pays additional bonuses for producing and consuming energy within the CREW
ii	Consumer	Pays supply tariff for electricity consumption to the energy supplier (CAE)	Pays supply tariff for electricity consumption to the energy supplier (CAE) Gets bonus payments from the CAE for consumed energy that was produced within the CREW
iii	Prosumer	Sells surplus electricity for according feed-in tariffs to the energy supplier (CAE)	Sells surplus electricity for according feed-in tariffs to the energy supplier (CAE) Gets bonus payments from the CAE for produced energy that was consumed within the CREW

5 Simulation of representative communities

To evaluate the effects of the split-incentives approach on the annual energy costs of participating CREW members, representative settings of such energy communities are performed. In this context, the costs for electricity consumptions of each CREW member, as well as potential revenues from energy production, are cumulated from hourly meter data (see equations Eq. 1 - Eq. 4 in appendix 6.1). The presumed energy costs are based on given tariff data for the individual region models. Revenues for energy fed into the grid are based on given national or regional regulations, if no explicit feed-in tariffs are available. The annual revenues for the CAE are defined by the individual margin on energy supply costs in the individual tariffs (see Eq. 5) and payments for producers (see Eq. 6).

The annual energy balance of the community is defined by total consumptions minus total productions (see Eq. 7). Hence, in a non-CREW (no exchange of electricity) setup the overall costs for the community are calculated by overall consumption costs reduced by potential revenues for production (see Eq. 8). The simulations assume, that surplus electricity produced within the community is also consumed therein as long as there is an appropriate demand in the according timestep, resulting in a total amount of energy that can be exchanged in the given timeframe (per year, respectively; see Eq. 9).

The split-incentives approach is implemented as a bonus system, i.e. the community member is credited with a fixed incentive for each kWh exchanged within the CREW (e.g. 1 c€/kWh, see section 2.2). This accounts for both, consumption and production, optionally at different levels (see Eq. 10 & Eq. 11). Consequently, this reduces the overall cost balance of the community by the generated bonuses (see Eq. 12). However, these incentive compensations have to be brought up by the CAE, as far as no other allocations are set up. Thus, the annual revenues for the CAE are reduced by the total bonus payments (see Eq. 13).

The following simulation results mean to provide an overview on the expected cost effects of the split-incentives approach in representative communities.

5.1 Simulation of the German Lighthouse Community

The simulation of the German Lighthouse Community (LC) is based on anonymized meter data from 46 different clients covering the different user types (number of datasets in brackets): *Consumer (15), Prosumer (12), Storage (8), Supply only ("Volleinspeiser"; 7), Industry ("RLM"; 4)*.

5.1.1 CREW simulation settings

For electricity consumption the following tariffs are defined: *'haStrom fix24'* (fixed), *'haStrom Standard'* (fixed), *'haStrom Öko'* (fixed), *'haStrom TaNa'* (time-based, 2 periods). The tariffs can be classified into fixed price (per kWh) models and time-based models where the price is dependent on the time of day (e.g. day tariff vs. night tariff). For energy production no dedicated feed-in tariffs are available due to the regulatory circumstances in Germany (Wirth, 2021).. Thus, fixed feed-in tariffs have been defined and used for the simulations. For the following calculations, tariffs have been assigned dependent on the client types, while all non-fitting use the 'default' setting (see Table 2).

Table 2: Tariff set per client type

Client type	Supply tariff	Generation sales tariff *
Consumer	haStrom Öko	8.0
Prosumer	haStrom TaNa	12.5
Storage	haStrom fix24	10.0
default	haStrom Standard	10.0
* representing feed-in compensation in ct/kWh		

The simulations were performed for random community compositions, selected from the available datasets, under following constraints:

- The simulations cover a time period of one year starting from 01.08.2019 until 01.08.2020 (latest data available).
- The following datasets have been excluded since the available data do not cover a full year: *['Storage 1', 'Storage 3', 'Storage 4', 'Storage 5', 'Storage 7']*
- Datasets of industrial users with an annual consumption or production >40,000 kWh (RLM) have been excluded: [*'RLM 1 ohne Erzeugung', 'RLM 2 ohne Erzeugung', 'RLM 3 mit Erzeugung', 'RLM 4 mit Erzeugung'*]
- The following datasets have been excluded since feed-in compensation for higher-capacity producers underlies additional regulations, which are not considered yet: *['Volleinspeiser 5 > 10 kWp', Volleinspeiser 6 > 10 kWp', 'Volleinspeiser 7 > 10 kWp', 'Prosumer 1 + Storage', 'Prosumer 6']*
- The randomized CREWs (simulations 1-3) are set to sizes of 10-15 members, of which up to 5 are producer types. The random selection of the producers tries to balance the resulting production with the average consumption of the potential remaining consumers. The rest of the community is filled with consumer-only members ('Consumer' types) until the overall annual consumption of the CREW exceeds its production.

- Simulation 4 represents a manual CREW setup consisting of only 2 producers and 13 consumer-only members with an annual consumption of 2,000-5,000 kWh/year.

5.1.2 CREW simulation results

Table 3 shows the results for the simulations of different CREW compositions under above constraints. For each setting the simulation is performed with varying split-incentive bonuses from 1 c€/kWh up to 10 c€/kWh for energy exchange within the CREW. The bonuses for consumption and production are presumed to be identical for these simulations. Consequently, the total savings for using energy from the CREW are equal to the additional revenues for supplying energy to the CREW. Based on the fixed bonus model, the resulting savings and earnings, respectively, are directly proportional to the set bonus level. The additional costs that arise for the CAE have to cover both incentive compensations and are similar for the three randomized balanced CREW scenarios (simulations 1-3) in the range of approx. 19 €/client (for 1 c€/kWh) to 228 €/client (for 10 c€/kWh). The fourth scenario (simulation 4) results in a significantly lower production compared to the consumption of the CREW. However, almost all of the surplus energy produced could be utilized within the community. Due to overall lower energy exchange potentials the resulting additional costs for the CAE are between 10 €/client (for 1 c€/kWh) and 98 €/client (10 c€/kWh).

The results also show that the additional earnings per producer are significantly higher than the individual savings for the consumers (incl. prosumers) according to the proportion of these member types. Thus, the incentives for production could be lower than those for consuming energy within the community without creating disadvantages for individual members, while decreasing compensation costs for the CAE.

Table 3: German LC simulation results for different CREW compositions and variable split-incentive bonuses (identical for consumption and production)

Simulation 1

CREW size:* 14 Producers: 5

CREW bonus in c€/kWh	Consumption[a)] in kWh	Production[b)] in kWh	Exchange[c)] in kWh	Cost balance[d)] without exchange in €	Cost balance[d)] without exchange in €/client	Cost balance[d)] with exchange in €	Cost balance[d)] with exchange in €/client	Savings (consumption)[e)] in €	Savings (consumption)[e)] in €/client	Earnings (production)[f)] in €	Earnings (production)[f)] in €/prod.	Total bonus payments[g)] in €	Total bonus payments[g)] in €/client
1	40,235	33,292	15,979	6,872	490.9	6,553	468.0	160	11.4	160	32.0	320	22.8
2,5	40,235	33,292	15,979	6,872	490.9	6,073	433.8	399	28.5	399	79.9	799	57.1
5	40,235	33,292	15,979	6,872	490.9	5,274	376.7	799	57.1	799	159.8	1,598	114.1
7,5	40,235	33,292	15,979	6,872	490.9	4,475	319.7	1,198	85.6	1,198	239.7	2,397	171.2
10	40,235	33,292	15,979	6,872	490.9	3,676	262.6	1,598	114.1	1,598	319.6	3,196	228.3

*['Prosumer 7', 'Storage 2', 'Prosumer 7', 'Prosumer 5', 'Volleinspeiser 2 < 10 kWp', 'Consumer 2', 'Consumer 4', 'Consumer 4', 'Consumer 8', 'Consumer 11', 'Consumer 2', 'Consumer 3', 'Consumer 10', 'Consumer 3']

Simulation 2

CREW size:* 15 Producers: 5

CREW bonus in c€/kWh	Consumption[a)] in kWh	Production[b)] in kWh	Exchange[c)] in kWh	Cost balance[d)] without exchange in €	Cost balance[d)] without exchange in €/client	Cost balance[d)] with exchange in €	Cost balance[d)] with exchange in €/client	Savings (consumption)[e)] in €	Savings (consumption)[e)] in €/client	Earnings (production)[f)] in €	Earnings (production)[f)] in €/prod.	Total bonus payments[g)] in €	Total bonus payments[g)] in €/client
1	35,003	24,754	16,389	6,341	453.0	6,014	400.9	164	10.9	164	32.8	328	21.9
2,5	35,003	24,754	16,389	6,341	453.0	5,522	368.1	410	27.3	410	81.9	819	54.6
5	35,003	24,754	16,389	6,341	453.0	4,703	313.5	819	54.6	819	163.9	1,639	109.3
7,5	35,003	24,754	16,389	6,341	453.0	3,883	258.9	1,229	81.9	1,229	245.8	2,458	163.9
10	35,003	24,754	16,389	6,341	453.0	3,064	204.2	1,639	109.3	1,639	327.8	3,278	218.5

* ['Prosumer 5', 'Prosumer 5', 'Prosumer 11', 'Prosumer 7', 'Volleinspeiser 2 < 10 kWp', 'Consumer 13', 'Consumer 10', 'Consumer 14', 'Consumer 5', 'Consumer 9', 'Consumer 13', 'Consumer 11', 'Consumer 3', 'Consumer 6', 'Consumer 4']

Simulation 3

CREW size:* 15 Producers: 5

CREW bonus in c€/kWh	Consumption[a)]	Production[b)]	Exchange[c)]	Cost balance[d)] without exchange		Cost balance[d)] with exchange		Savings (consumption)[e)]		Earnings (production)[f)]		Total bonus payments[g)]	
	in kWh	in kWh	in kWh	in €	in €/client	in €	in €/client	in €	in €/client	in €	in €/prod.	in €	in €/client
1	50,273	33,723	14,017	8,985	641.8	8,705	580.3	140	9.3	140	28.0	280	18.7
2,5	50,273	33,723	14,017	8,985	641.8	8,284	552.3	350	23.4	350	70.1	701	46.7
5	50,273	33,723	14,017	8,985	641.8	7,583	505.6	701	46.7	701	140.2	1,402	93.4
7,5	50,273	33,723	14,017	8,985	641.8	6,882	458.8	1,051	70.1	1,051	210.3	2,103	140.2
10	50,273	33,723	14,017	8,985	641.8	6,182	412.1	1,402	93.4	1,402	280.3	2,803	186.9

* ['Prosumer 9', 'Prosumer 3', 'Prosumer 3', 'Prosumer 11', 'Prosumer 12', 'Consumer 4', 'Consumer 4', 'Consumer 15', 'Consumer 6', 'Consumer 12', 'Consumer 4', 'Consumer 14', 'Consumer 15', 'Consumer 10', 'Consumer 11']

Simulation 4

CREW size:* 15 Producers: 2

CREW bonus in c€/kWh	Consumption[a)]	Production[b)]	Exchange[c)]	Cost balance[d)] without exchange		Cost balance[d)] with exchange		Savings (consumption)[e)]		Earnings (production)[f)]		Total bonus payments[g)]	
	in kWh	in kWh	in kWh	in €	in €/client	in €	in €/client	in €	in €/client	in €	in €/prod.	in €	in €/client
1	41,358	7,360	7,345	10,163	726.0	10,017	667.8	73	4.9	73	36.7	147	9.8
2,5	41,358	7,360	7,345	10,163	726.0	9,796	653.1	184	12.2	184	91.8	367	24.5
5	41,358	7,360	7,345	10,163	726.0	9,429	628.6	367	24.5	367	183.6	735	49.0
7,5	41,358	7,360	7,345	10,163	726.0	9,062	604.1	551	36.7	551	275.4	1,102	73.5
10	41,358	7,360	7,345	10,163	726.0	8,694	579.6	735	49.0	735	367.3	1,469	97.9

* ['Prosumer 5', 'Prosumer 8', 'Consumer 1', 'Consumer 3', 'Consumer 4', 'Consumer 6', 'Consumer 7', 'Consumer 8', 'Consumer 1', 'Consumer 3', 'Consumer 4', 'Consumer 6', 'Consumer 7', 'Consumer 8', 'Consumer 7']

[a)] Total electricity consumption of the CREW participants
[b)] Total surplus electricity production of all producing CREW participants (before exchange)
[c)] Amount of surplus electricity production that can be exchanged within the community
[d)] Total electricity cost of the CREW participants incl. supply costs, feed-in revenues and potential bonuses for exchanged energy
[e)] Total savings for electricity consumption within the CREW (consumption bonuses)
[f)] Total revenues for electricity supply within the CREW (production bonuses)
[g)] Total bonus payments by the CAE to the CREW participants for exchanged electric energy

To extrapolate these results to a future scenario with approx. 100 individual participants, some aggregated compilations of the CREW simulations presented before, have been evaluated. The results, presented in Table 4, show that, with a general incentive of 1 c€/kWh, the aggregated savings for energy supply are in a range of 750–1100 € per year for all participants, or 8–11 € annually per client. On the production side, overall additional earnings are equal to the savings (presuming homogeneous incentives), however, on a per producer basis the individual savings are significantly higher and less variable at 29–31 €/producer. With homogenous incentives for consumption and production within the CREW, the resulting compensation costs are twice as high as the consumption bonuses, both in total and on a per-client basis. However, these results are still highly dependent on CREW configurations. As the results of Simulation 4 have shown, a CREW composition targeted to optimize the energy exchange within the CREW (i.e. most of the surpluses can be consumed) could be the most cost-balanced for all participants, especially if the incentives for production are adapted in accordance to the number of producers involved.

Table 4: Aggregated CREW compilation results for German LC scenarios of around 100 participants

Number of CREWs	**CREW types**	**Total number of clients**	**Total savings (consumption)**	**Total earnings (production)**	**Total compensations costs for CAE**
			in €	**in €**	**in €**
7	Simulation 1 (3), Simulation 2 (2), Simulation 3 (2)	102	1088	1088	2175
6	Simulation 2 (2), Simulation 3 (2), Simulation 4 (2)	90	755	755	1510
7	Simulation 1 (2), Simulation 2 (2), Simulation 3 (2), Simulation 4 (1)	103	1001	1001	2002

5.2 Simulation of the Spanish Lighthouse Community

The simulation of the Spanish Lighthouse Community (LC) is based on anonymized meter data from 29 different meters. The available meter data covers annual consumptions in the range from about 177 kWh to 7,910 kWh and is gathered over slightly more than a year (from 30.01.2020 to 28.02.2021)[2]. Except for one of these datasets, the meter data does not include any records of electricity production (PV). Thus, surplus production data had to be generated independently based on simulation data.

5.2.1 Generation of PV production data

To substitute the lack of metered surplus electricity production data in the simulations of the Spanish CREW setups, synthetic PV production profiles had to be generated and added to the consumption data. The generation of these production profiles was done using historic weather data based simulations provided by Renewables.ninja (www.renewables.ninja, (Pfenninger & Staffell, 2016; Staffell & Pfenninger, 2016)). In total 9 different PV production

[2] The datasets with the IDs “CIR2082006005” and “CIR0141307038” where excluded due to incomplete data and too short (< 1 year) observation period.

profiles were generated for the location Alginet (lat: 39.2651; lon: -0.4717). Since the underlying weather data has not yet been updated to the time frame covered by the meter data[3], the profiles were generated for the years 2018 and 2019 and temporally shifted by 730 days (2 years) when mixed with the meter data. The profiles were generated with three different capacities (1 kW, 3 kW and 7 kW) and varying tilt and azimuth parameters. The parameters used are shown in Table 5.

Table 5: Parameters for PV production profiles generation for the location Alginet

Profile	Capacity	System loss	Tracking	Tilt	Azimuth
	in kW			in °	in °
1kW_180_35				35	180
1kW_180_45	1			45	180
1kW_205_45				45	205
3kW_180_35				35	180
3kW_180_45	3	0.1	No tracking (0)	45	180
3kW_205_35				35	205
7kW_180_35				35	180
7kW_180_45	7			45	180
7kW_205_35				35	205

The generated production profiles were applied to selected meter datasets as listed in Table 6. The profiles (consumption and production) were matched according their corresponding timesteps (except the 2 years deviation of the production data). Considering own consumption of generated electricity, the resulting surpluses or remaining demands are represented by the balance of production and consumption for each data point.

Table 6: Generated "Prosumer" profile characteristics

Meter ID	PV production profile	Annual supply (consumption)[a)]	Annual peak supply (consumption)[a)]	Annual surplus	Annual peak surplus
		in kWh	in kW	in kWh	in kW
CIR0141309449	1kW_180_35	895.60 (1433.16)	2.62 (2.62)	1077.26	0.756
CIR0141307132	1kW_180_45	1652.51 (2299.96)	4.20 (4.90)	952.90	0.749
CIR0141309347	1kW_205_45	2317.05 (3151.56)	4.42 (4.42)	713.99	0.7
CIR0141309346	3kW_180_35	1551.66 (3189.94)	6.75 (6.75)	3206.15	2.33
CIR0141309334	3kW_180_45	2402.29 (3765.23)	17.02 (17.02)	3438.13	2.27
CIR0141309349	3kW_205_35	2797.24 (4171.21)	5.16 (5.16)	3336.60	2.20

[3] Latest available data as of writing this document was for 31.12.2019.

Meter ID	PV production profile	Annual supply (consumption)[a)]	Annual peak supply (consumption)[a)]	Annual surplus	Annual peak surplus
		in kWh	in kW	in kWh	in kW
CIR0141307144	7kW_180_35	3018.81 (5151.03)	6.58 (6.77)	9171.46	5.41
CIR0141309330	7kW_180_45	2687.01 (5851.40)	4.15 (5.10)	8038.06	5.17
CIR0141309333	7kW_205_35	4127.71 (6865.01)	5.85 (5.85)	8254.07	5.10
[a)] Values in brackets represent raw meter data values (before applying generation profiles)					

5.2.2 CREW simulation settings

For electricity consumption two supply tariffs are currently available: *'Domestic 2.0 A'* (fixed), *'Comercial 2.0 DHA'* (time-based, 2 periods). The tariffs can be classified into fixed price (per kWh) models and time-based models where the price is dependent on the time of day (e.g. day tariff vs. night tariff). As of today, there are no dedicated feed-in tariffs available for the community in Spain. Since January 2012 the current Spanish regulations do not provide any subsidies in the form of fixed feed-in tariffs for PV installations. Thus, the Spanish PV market is more or less paralyzed in the last years (Prol, 2018). However, since granted tariffs for previous installations are still valid, the feed-in tariffs for the simulations are set to the latest available value for roof installations < 20 kW, which would be 28.3 c€/kWh (pv magazine International, 2021).

For the following calculations, two user types were defined. All clients with an annual production > 0 kWh, either from the provided raw datasets or by applying generated PV profiles as per Table 6, are defined as "Prosumer". The remaining, consumption-only clients are defined as "consumer" type. Depending on these client types, tariffs have been assigned as listed in Table 7.

Table 7: Tariff set per client type

Client type	Supply tariff	Generation sales tariff *
Consumer	Domestic 2.0 A	28.3
Prosumer	Comercial 2.0 DHA	28.3
* representing feed-in compensation in ct/kWh		

The simulations were performed for random community compositions, selected from the available datasets, under following constraints:

- The simulations cover a time period of one year starting from 01.02.2020 until 01.02.2021 (latest full-month data available).
- The following datasets have been excluded since the available data does not cover a full year or is missing datapoints over relevant periods: *['Consumer CIR0141307038', 'Consumer CIR2082006005']*
- The randomized CREWs (simulations 1-3) are set to sizes of 10-15 members, of which up to 5 are producer types. The random selection of the producers tries to balance the resulting production with the average consumption of the potential remaining consumers. The rest of the community is filled with consumer-only members ('Consumer' types) until the overall annual consumption of the CREW exceeds its production.

- Simulation 4 represents a manual CREW setup consisting of only 2 producers and 13 consumer-only members with an annual consumption of 2,500-5,000 kWh/year.

5.2.3 CREW simulation results

The results for the simulations of the different CREW compositions under above constraints are shown in Table 8. For each setting the simulation is performed with varying split-incentive bonuses from 1 c€/kWh up to 10 c€/kWh for energy exchange within the CREW. The bonuses for consumption and production are presumed to be identical for these simulations. Consequently, the total savings for using energy from the CREW are equal to the additional revenues for supplying energy to the CREW. Based on the fixed bonus model, the resulting savings and earnings, respectively, are directly proportional to the set bonus level. The additional costs that arise for the CAE have to cover both incentive compensations and are similar for the three randomized balanced CREW scenarios (simulations 1-3) in the range of approx. 10 €/client (for 1 c€/kWh) to 175 €/client (for 10 c€/kWh). For the fourth scenario (simulation 4) almost all (> 99%) of the surplus energy produced could be utilized within the community due to the lower number of producing clients (in relation to the CREW size) and thus lower amount of annual surpluses. Due to overall lower energy exchange potentials the resulting additional costs for the CAE are between 9 €/client (for 1 c€/kWh) and 88 €/client (10 c€/kWh).

Based on the used incentive model with equal bonuses for production and consumption, the additional earnings per producer are significantly higher than the individual savings for the consumers (incl. prosumers) according to the proportion of these member types. Thus, the incentives for production could be lower than those for consuming energy within the community without creating disadvantages for individual members, while decreasing compensation costs for the CAE.

Note: the cost balances indicated for the individual simulations partially result in negative energy costs, even before applying the split-incentives model (without exchange). These values should be handled with care since they are a result of simulated PV production profiles and still relatively high feed-in tariffs in relation to supply tariffs. According to Spanish regulations, these feed-in tariffs are also not valid for new PV installations from 2012 and beyond. However, the resulting generation of bonus payments, which are discussed above, and thus additional savings and earnings are independent of the underlying tariff schemes. Though, the generated surpluses from PV production should be validated with real data when appropriate meter data is available.

Table 8: Spanish LC simulation results for different CREW compositions and variable split-incentive bonuses (identical for consumption and production)

Simulation 1

CREW size:* 10 Producers: 5

CREW bonus in c€/kWh	Consumption[a)] in kWh	Production[b)] in kWh	Exchange[c)] in kWh	Cost balance[d)] without exchange in €	Cost balance[d)] without exchange in €/client	Cost balance[d)] with exchange in €	Cost balance[d)] with exchange in €/client	Savings (consumption)[e)] in €	Savings (consumption)[e)] in €/client	Earnings (production)[f)] in €	Earnings (production)[f)] in €/prod.	Total bonus payments[g)] in €	Total bonus payments[g)] in €/client
1	25,948	11,268	4,984	678	67.8	578	57.8	50	5.0	50	10.0	100	10.0
2,5	25,948	11,268	4,984	678	67.8	429	42.9	125	12.5	125	24.9	249	24.9
5	25,948	11,268	4,984	678	67.8	179	17.9	249	24.9	249	49.8	498	49.8
7,5	25,948	11,268	4,984	678	67.8	-70	-7.0	374	37.4	374	74.8	748	74.8
10	25,948	11,268	4,984	678	67.8	-319	-31.9	498	49.8	498	99.7	997	99.7

*['Prosumer CIR0141309346', 'Prosumer CIR0141309349', 'Prosumer CIR0141309347', 'Prosumer CIR0141309346', 'Prosumer CIR0141309449', 'Consumer CIR0501304076', 'Consumer CIR0141309350', 'Consumer CIR0141309338', 'Consumer CIR0141309448', 'Consumer CIR0141313497']

Simulation 2

CREW size:* 12 Producers: 5

CREW bonus in c€/kWh	Consumption[a)] in kWh	Production[b)] in kWh	Exchange[c)] in kWh	Cost balance[d)] without exchange in €	Cost balance[d)] without exchange in €/client	Cost balance[d)] with exchange in €	Cost balance[d)] with exchange in €/client	Savings (consumption)[e)] in €	Savings (consumption)[e)] in €/client	Earnings (production)[f)] in €	Earnings (production)[f)] in €/prod.	Total bonus payments[g)] in €	Total bonus payments[g)] in €/client
1	38,716	25,177	10,515	-954	-95.4	-1,164	-97.0	105	8.8	105	21.0	210	17.5
2,5	38,716	25,177	10,515	-954	-95.4	-1,480	-123.3	263	21.9	263	52.6	526	43.8
5	38,716	25,177	10,515	-954	-95.4	-2,005	-167.1	526	43.8	526	105.2	1,052	87.6
7,5	38,716	25,177	10,515	-954	-95.4	-2,531	-210.9	789	65.7	789	157.7	1,577	131.4
10	38,716	25,177	10,515	-954	-95.4	-3,057	-254.7	1,052	87.6	1,052	210.3	2,103	175.3

* ['Prosumer CIR0141309347', 'Prosumer CIR0141307132', 'Prosumer CIR0141309330', 'Prosumer CIR0141309333', 'Prosumer CIR0141309330', 'Consumer CIR0141309348', 'Consumer CIR0141309337', 'Consumer CIR0141309336', 'Consumer CIR0141309350', 'Consumer CIR0141440446', 'Consumer CIR0141309348', 'Consumer CIR0141309340']

Simulation 3

CREW size:* 15 Producers: 5

CREW bonus in c€/kWh	Consumption[a)]	Production[b)]	Exchange[c)]	Cost balance[d)] without exchange		Cost balance[d)] with exchange		Savings (consumption)[e)]		Earnings (production)[f)]		Total bonus payments[g)]	
	in kWh	in kWh	in kWh	in €	in €/client	in €	in €/client	in €	in €/client	in €	in €/prod.	in €	in €/client
1	35,280	23,186	9,046	-927	-92.7	-1,108	-92.3	90	6.0	90	18.1	181	12.1
2,5	35,280	23,186	9,046	-927	-92.7	-1,379	-114.9	226	15.1	226	45.2	452	30.2
5	35,280	23,186	9,046	-927	-92.7	-1,831	-152.6	452	30.2	452	90.5	905	60.3
7,5	35,280	23,186	9,046	-927	-92.7	-2,284	-190.3	678	45.2	678	135.7	1,357	90.5
10	35,280	23,186	9,046	-927	-92.7	-2,736	-228.0	905	60.3	905	180.9	1,809	120.6

* ['Prosumer CIR0141309330', 'Prosumer CIR0141309333', 'Prosumer CIR0141307132', 'Prosumer CIR0141309334', 'Prosumer CIR0141309346', 'Consumer CIR0141309340', 'Consumer CIR2082006005', 'Consumer CIR0141510445', 'Consumer CIR2082006005', 'Consumer CIR2082006005', 'Consumer CIR0141309448', 'Consumer CIR2082006005', 'Consumer CIR0141440446', 'Consumer CIR0141307199', 'Consumer CIR0141309337']

Simulation 4

CREW size:* 15 Producers: 2

CREW bonus in c€/kWh	Consumption[a)]	Production[b)]	Exchange[c)]	Cost balance[d)] without exchange		Cost balance[d)] with exchange		Savings (consumption)[e)]		Earnings (production)[f)]		Total bonus payments[g)]	
	in kWh	in kWh	in kWh	in €	in €/client	in €	in €/client	in €	in €/client	in €	in €/prod.	in €	in €/client
1	57,273	6,590	6,571	5,939	593.9	5,808	484.0	66	4.4	66	32.9	131	8.8
2,5	57,273	6,590	6,571	5,939	593.9	5,611	467.6	164	11.0	164	82.1	329	21.9
5	57,273	6,590	6,571	5,939	593.9	5,282	440.2	329	21.9	329	164.3	657	43.8
7,5	57,273	6,590	6,571	5,939	593.9	4,954	412.8	493	32.9	493	246.4	986	65.7
10	57,273	6,590	6,571	5,939	593.9	4,625	385.4	657	43.8	657	328.5	1,314	87.6

* ['Prosumer CIR0141309349', 'Prosumer CIR0141309334', 'Consumer CIR0141313497', 'Consumer CIR0141309348', 'Consumer CIR0141309339', 'Consumer CIR0141309344', 'Consumer CIR0141309335', 'Consumer CIR0141309331', 'Consumer CIR0141309332', 'Consumer CIR0141510445', 'Consumer CIR0141309338', 'Consumer CIR0141313497', 'Consumer CIR0141309339', 'Consumer CIR0141309344', 'Consumer CIR0141309335']

a) Total electricity consumption of the CREW participants
b) Total surplus electricity production of all producing CREW participants (before exchange)
c) Amount of surplus electricity production that can be exchanged within the community
d) Total electricity cost of the CREW participants incl. supply costs, feed-in revenues and potential bonuses for exchanged energy
e) Total savings for electricity consumption within the CREW (consumption bonuses)
f) Total revenues for electricity supply within the CREW (production bonuses)
g) Total bonus payments by the CAE to the CREW participants for exchanged electric energy

The above simulation scenarios are aggregated to CREW groups resulting in approx. 100 individual participants. Table 9 shows the resulting total savings and earnings over all included CREWs and the according compensation costs that would arise for the CAE presuming a general incentive of 1 c€/kWh. For homogenous incentives for consumption and production within the CREW the overall earnings and savings are equal in a range from 570–690 € per year, or 6–7 € annually per client. Though, if additional earnings for production are only related to the number of producers, the bonus payments result in 16–20 € per producer and year. Thus, an inhomogeneous bonus system could be reasonable the homogenize the individual incentives for consumption and supply, e.g. bonus payments for CREW-internal energy consumption being 2–3 times higher than for supply.

Table 9: Aggregated CREW compilation results for Spanish LC scenarios of around 100 participants

Number of CREWs	CREW types	Total number of clients	Total savings (consumption)	Total earnings (production)	Total compensations costs for CAE
			in €	in €	in €
8	Simulation 1 (2), Simulation 2 (3), Simulation 3 (3)	101	687	687	1373
9	Simulation 1 (1), Simulation 2 (2), Simulation 3 (2), Simulation 4 (2)	94	572	572	1145
9	Simulation 1 (4), Simulation 2 (2), Simulation 3 (2), Simulation 4 (1)	109	656	656	1313

6 Appendix

6.1 eCREW simulation – Variable definition

$W_{c,crew}(t)$, $W_{p,crew}(t)$ … total energy consumption (c) or production (p) of the CREW per timestep

$W_{c,i}(t)$, $W_{p,i}(t)$ … energy consumption (c) or production (p) of CREW member i per timestep

$W_{b,crew}(t)$ … energy balance of the CREW per timestep

$W_{ex,crew}(t)$ … theoretic potential for energy exchange within the CREW per timestep

$C_{c,crew}(t)$, $C_{p,crew}(t)$ … total energy consumption (c) or production (p) costs of the CREW per timestep (negative costs represent revenues)

$C_{c,i}(t)$, $C_{p,i}(t)$ … energy consumption (c) or production (p) costs for CREW member i per timestep (negative costs represent revenues)

$C_{b,crew}(t)$ … energy cost balance of the CREW per timestep without direct energy exchange (no split-incentives approach)

$C_{b,ex,crew}(t)$ … energy cost balance of the CREW per timestep with direct energy exchange

$c_{c,tot,i}(t)$ … specific total supply costs (supply tariff) for CREW member i per timestep (incl. taxes, fees and energy costs)

$c_{c,en,i}(t)$ … energy cost part of total supply costs for CREW member i per timestep

$c_{c,tax,i}(t)$ … cost part of taxes of total supply costs for CREW member i per timestep

$c_{p,i}(t)$ … specific production costs (feed-in tariff) for CREW member i per timestep (usually negative since representing revenues)

$r_{c,crew}$ … specific cost bonus (discount) for energy exchange within the CREW

$r_{p,crew}$ … specific feed-in bonus for energy exchange within the CREW

$\Delta C_{c,crew}(t)$ … total supply costs savings for energy exchange within the CREW per timestep

$\Delta C_{p,crew}(t)$ … total feed-in costs savings (additional revenues) for energy exchange within the CREW per timestep

$m_{c,i}(t)$ … price margin of the CAE for energy delivery to CREW member i per timestep

$R_{CAE}(t)$ … total revenues for the CAE for energy delivery to the CREW per timestep without direct energy exchange (no split-incentives approach)

$R_{ex,CAE}(t)$ … total revenues for the CAE for energy delivery to the CREW per timestep with direct energy exchange

$$W_{c,crew}(t) = \sum_{n} W_{c,i}(t) \qquad \text{Eq. 1}$$

$$C_{c,crew}(t) = \sum_{n} C_{c,i}(t) = \sum_{n} W_{c,i}(t) * c_{c,tot,i}(t) \qquad \text{Eq. 2}$$

$$W_{p,crew}(t) = \sum_n W_{p,i}(t) \quad \text{Eq. 3}$$

$$C_{p,crew}(t) = \sum_n C_{p,i}(t) = \sum_n W_{p,i}(t) * c_{p,i}(t) \quad \text{Eq. 4}$$

$$m_{c,i}(t) = c_{c,tot,i}(t) - c_{c,en,i}(t) - c_{c,tax,i} \quad \text{Eq. 5}$$

$$R_{CAE}(t) = \sum_n W_{c,i}(t) * m_{c,i}(t) + \underbrace{\sum_n W_{p,i}(t) * c_{p,i}(t)}_{=C_{p,crew}(t)} \quad \text{Eq. 6}$$

$$W_{b,crew}(t) = W_{c,crew}(t) - W_{p,crew}(t) \quad \text{Eq. 7}$$

$$C_{b,crew}(t) = C_{c,crew}(t) + C_{p,crew}(t) \quad \text{Eq. 8}$$

$$W_{ex,crew}(t) = min\big(W_{c,crew}(t), W_{p,crew}(t)\big) \quad \text{Eq. 9}$$

$$\Delta C_{c,crew}(t) = r_{c,crew} * W_{ex,crew}(t) \quad \text{Eq. 10}$$

$$\Delta C_{p,crew}(t) = r_{p,crew} * W_{ex,crew}(t) \quad \text{Eq. 11}$$

$$C_{b,ex,crew}(t) = C_{b,crew}(t) - \big(\Delta C_{c,crew}(t) - \Delta C_{p,crew}(t)\big) \quad \text{Eq. 12}$$

$$R_{ex,CAE}(t) = R_{CAE}(t) - \big(\Delta C_{c,crew}(t) - \Delta C_{p,crew}(t)\big) \quad \text{Eq. 13}$$

6.2 eCREW simulation – Datasets

Table A 1: SWH dataset

Dataset	producer	peak consumption in kW	peak production in kW	annual consumption in kWh	annual production in kWh
Prosumer 1 + Storage	yes	17.29	22.38	3,544.68	29,836.56
Prosumer 2	yes	4.14	7.67	2,542.78	8,144.87
Prosumer 3	yes	2.97	4.96	1,979.85	6,076.42
Prosumer 4	yes	6.51	8.32	5,929.05	7,657.80
Prosumer 5	yes	1.96	1.37	1,240.00	3,657.81
Prosumer 6	yes	2.74	13.56	1,332.79	16,147.46
Prosumer 7	yes	3.62	8.42	1,762.21	9,868.80
Prosumer 8	yes	2.85	3.57	1,921.15	3,679.92
Prosumer 9	yes	7.04	8.45	3,046.69	8,813.30
Prosumer 10	yes	4.25	6.20	2,580.76	6,935.90
Prosumer 11	yes	4.35	5.04	4,323.58	4,357.34
Prosumer 12	yes	6.84	8.73	7,190.57	8,217.70
Storage 1	yes	3.05	5.52	679.73	4,481.17
Storage 2	yes	5.98	7.89	1,722.22	6,618.89
Storage 3	yes	5.01	4.08	2,912.03	2,231.16
Storage 4	yes	7.43	5.15	3,602.01	3,737.75
Storage 5	yes	4.33	6.15	349.55	5,478.51
Storage 6	yes	23.52	6.66	33,060.00	2,364.40
Storage 7	yes	5.19	8.13	142.59	6,777.25
Storage 8	yes	3.72	5.05	3,202.18	2,932.84
Volleinspeiser 1 < 10 kWp	yes	4.45	5.56	2,976.56	5,901.06
Volleinspeiser 2 < 10 kWp	yes	0.01	2.57	1.22	3,112.01
Volleinspeiser 3 < 10 kWp	yes	0.00	7.52	2.44	9,578.44
Volleinspeiser 4 < 10 kWp	yes	7.05	2.13	3,732.60	1,680.39
Volleinspeiser 5 > 10 kWp	yes	-	13.08	-	17,189.70
Volleinspeiser 6 > 10 kWp	yes	3.88	12.09	5,067.79	13,235.17
Volleinspeiser 7 > 10 kWp	yes	0.01	12.64	1.51	15,873.42
Consumer 1	no	4.48	-	2,690.62	-
Consumer 2	no	2.72	-	1,116.78	-
Consumer 3	no	2.19	-	2,107.83	-
Consumer 4	no	3.63	-	2,710.32	-
Consumer 5	no	2.44	-	714.33	-
Consumer 6	no	3.99	-	2,391.44	-
Consumer 7	no	3.49	-	2,743.08	-
Consumer 8	no	4.86	-	5,032.50	-
Consumer 9	no	1.89	-	600.36	-

Consumer 10	no	7.65	-	14,757.91	-
Consumer 11	no	3.35	-	1,986.46	-
Consumer 12	no	1.82	-	796.48	-
Consumer 13	no	2.17	-	87.48	-
Consumer 14	no	2.14	-	889.10	-
Consumer 15	no	2.21	-	1,338.79	-
RLM 1 ohne Erzeugung	no	35.74	-	45,132.19	-
RLM 2 ohne Erzeugung	no	55.69	-	93,538.92	-
RLM 3 mit Erzeugung	yes	0.45	366.11	56.81	481,554.90
RLM 4 mit Erzeugung	yes	112.78	92.74	183,554.94	30,368.04

Table A 2: ADEE dataset

dataset	producer	peak consumption in kW	peak production in kW	annual consumption in kWh	annual production in kWh
CIR0141307132	no	4.90	-	2,299.96	-
CIR0141307144	no	6.77	-	5,151.03	-
CIR0141307199	no	0.92	-	544.64	-
CIR0141309330	no	5.10	-	5,851.40	-
CIR0141309331	no	3.27	-	4,412.53	-
CIR0141309332	no	5.27	-	4,851.02	-
CIR0141309333	no	5.85	-	6,865.01	-
CIR0141309334	no	17.02	-	3,765.23	-
CIR0141309335	no	3.95	-	4,292.28	-
CIR0141309336	no	0.04	-	175.86	-
CIR0141309337	no	6.04	-	5,273.17	-
CIR0141309338	no	5.65	-	4,944.24	-
CIR0141309339	no	4.12	-	3,787.23	-
CIR0141309340	no	4.46	-	5,903.35	-
CIR0141309341	yes	2.33	1.187	2,708.15	55.81
CIR0141309342	no	2.68	-	924.32	-
CIR0141309343	no	2.39	-	781.03	-
CIR0141309344	no	3.06	-	3,988.03	-
CIR0141309346	no	6.75	-	3,189.94	-
CIR0141309347	no	4.42	-	3,151.56	-
CIR0141309348	no	3.20	-	3,611.18	-
CIR0141309349	no	5.16	-	4,171.21	-
CIR0141309350	no	2.72	-	1,406.18	-
CIR0141309448	no	1.10	-	905.01	-
CIR0141309449	no	2.62	-	1,433.16	-
CIR0141313497	no	9.27	-	2,577.81	-

CIR0141440446	no	4.62	-	5,162.35	-
CIR0141510445	no	4.70	-	4,914.35	-
CIR0501304076	no	8.03	-	6,933.98	-
CIR2082006005	no	0.00	-	1.08	-
CIR0141307038	no	0.92	-	122.78	-