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INTEGRATING COMMUNITY POWER IN ENERGY ISLANDS

Energy communities and energy poverty mitigation: Quantitative assessments of cases in Portugal and Spain

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EXECUTIVE SUMMARY

The aim of this report is to compare two European countries (Portugal and Spain) regarding the impact renewable energy communities (RECs) or collective self-consumption schemes (CSC) could have to reduce the energy expenditures of energy-poor households. Both countries already introduced a social tariff for electricity in 2008 and 2009 to reduce the financial burden of vulnerable or energy-poor households but both countries still have a high-energy poverty rate. Therefore, additional policy measures to fight energy poverty are necessary. The "Clean Energy for all Europeans" package introduced energy communities as a new possibility to reduce energy expenditures of vulnerable households. This analysis presents the social tariff structure of both countries and shows how the combination of the social tariff with a REC or CSC scheme can generate additional cost reductions. The analysis points out that the additional savings generated by an energy community are larger for all Spanish households due to the less favourable social tariff system. The main reason is that in Spain the discount rate can only be applied to a certain amount of energy and some groups get only a limited reduction of costs. This implies that combining the social tariff and participation in an REC/CSC scheme can lead to higher savings than receiving only the social tariff. Overall the analysis showed that it is possible to generate additional savings by combining RECs or CSC schemes with the social tariff but the outcome can heavily change depending on the energy consumption, the internal and external energy prices, the social tariff a country has and if membership fees are charged or not.

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1 INTRODUCTION

Across Europe, energy poverty is a well-known problem and is highly discussed since the early 2000's. Especially, in countries like Greece, Ireland, Portugal and Spain, who were heavily impacted by the financial crisis in 2008, low income households have big problems to satisfy their energy needs. First studies on energy poverty arose in the UK and Ireland in 2001, where the first energy poverty indicator was defined. The indicator, "spending more than 10% of income to meet energy needs", is still one of the most used indicators in energy poverty literature (Charlier, 2021). An alternative indicator uses the national median on energy spending, or twice the national median to consider price changes (Berry 2019). In 2012, Hills (2012) introduced an indicator that considers income and energy spending, which became the official definition of fuel/energy poverty in the UK. The indicator defines households as fuel/energy poor if "they have required fuel costs that are above the contemporary median level; and were they to spend that amount, they would be left with a residual income below the official poverty line". In 2018, the member state report of the EU Energy Poverty Observatory (EPO), a project with the goal to distribute knowledge about energy poverty in Europe and to innovative policies, was published. In this report, member states and their project partners collected information about energy poverty in their countries as well as actual policies to fight it. Overall, the member report gives an overview of each member states individual situation whereby the countries similarities and differences are presented. In addition, each country is compared to the EU average. The most used energy poverty indicators were "inability to keep home adequately warm", "arrears on utility bills" and "high share of energy expenditure in income".

Overall, there are three common ways to define energy poverty. First, the expenditure-based approach, where the spendings on energy goods are analysed. Second, the subjective or self-reporting approach, which depends on a households individual assessment if they can afford it to keep their home adequately, warm. Third, multidimensional approaches that consider additional information like the room temperature. For the following analysis we decided to use expenditure data of the European Household Budget Survey (HBS), therefore the indicators "inability to keep the house adequately warm" and "arrears on utility bills" like in the member state report of the EU Energy Poverty Observatory cannot be used for this analysis. As a result, expenditure based indicators in combination with income will be applied. As energy poverty is a complex phenomenon we use three different indictors to capture its multidimensional nature. By following Boardman (1991), Hills (2012), Berry (2019) and Charlier (2021) the following energy poverty indicators that combine energy spendings with income information were designed:

$$EP10 = energy\ spendings > 10\%\ of\ income\ \&\ the\ household\ lives\ at\ risk\ of\ poverty$$

$$HCLI = equivalent\ energy > national\ median\ \&\ the\ household\ lives\ at\ risk\ of\ poverty$$

$$TMed = equivalent\ energy\ spendings > 2 * national\ median$$

To define these groups we use the information on energy spendings and income from the HBS, while indicators like "the household lives at risk of poverty" and the "equivalent energy spendings" are calculated by using the information of the HBS. Equivalent energy spending are defined as the total energy expenditures divided by the consumption unit (CU) of the households and is a frequently used method of making households comparable to each other. The most common used scale is the one of

OECD where a 1 counts for a single person household, 0.5 for every additional adult (age > 13) and 0.3 for each child under 14. Households that live at risk of poverty are those who have an equivalent income smaller than 60% of the national median.

2 CASE STUDIES – PORTUGAL & SPAIN

The following section gives an overview of the current situation regarding energy poverty in Portugal and Spain, presents the corresponding pilot projects of the Horizon 2020 Project Compile and shows additional benefits of energy communities on energy poor households in both countries. To give an overview about energy poverty in Portugal and Spain the member state report of the EU Energy Poverty Observatory plus additional literature are used. The member state report uses the same indicators and methods for all analysed countries, which makes it an ideal basis to show the differences and similarities across member states of the EU and their energy poverty situation. In addition, the national law on energy communities for both countries are presented together with insights of the pilot projects and their set ups. The overview of the national laws on energy communities for the investigated countries follow Frieden et al., (2020) and Frieden et al., (2021).

2.1 PORTUGAL

2.1.1 Current Situation on Energy Poverty

According to the member state report of the EU Energy Poverty Observatory the situation in Portugal is the following: The percentage of households that were unable to keep their homes adequately warm is notably higher than the EU average (19.4% in contrast to 7.3%). In addition, the percentage of households with high energy expenditures is slightly lower in Portugal than the EU-average (15.1% in contrast to 16.2%), as well as the number of households with low energy expenses (6.8 % in contrast to 14.6%). The report also shows that the percentage of households that are unable to keep their homes adequately warm was much worse in the early 2000s. In 2005, 40% of the households were unable to heat their home sufficiently but from 2007 to 2018, the number significantly decreased from 42% to 19.4%. The decrease may be a result of the introduction of the social tariff on energy in 2008. In contrast, the number of households with arrears on utility bills stayed more or less constant over the same time horizon. According to the member state report of the EU Energy Poverty Observatory the household energy prices in Portugal have gradually increased from 0.150 EUR/kWh for electricity and 0.063 EUR/kWh for gas in 2008, to around 0.227 EUR/kWh for electricity and around 0.077 EUR/kWh for gas in 2018.

The area a household lives in seems not to be relevant for energy poverty in Portugal. The number of households that face inability to keep homes warm lies between 18.7% and 22.1% for rural, suburban and urban areas, where urban areas have the lowest performance for the ability to keep the house adequately warm. For households that have arrears on utility bills there is a similar situation with 6.2% living in urban areas, 5.3% living in suburban areas and 4.7% living in rural areas. In addition, according to the EU Energy Poverty Observatory in 2017 most energy poor households live in social housing residents (12.1% of all households with arrears on utility bills and 33.2% of all households that are unable to keep their house adequately warm). Overall, in Portugal 13% of all households live in social housing.

The interest in fighting energy poverty in Portugal has been growing for years but energy poverty measures are mainly on the national level through financial assistance via the social tariff. The social tariff was introduced in 2008 with the goal to reduce energy expenses of households. Since 2016, low-income households and households that receive certain social benefits get the social tariff automatically. Overall, these households must have a power supply contract for domestic use with

contracted power in low-voltage ≤ 6.9 kVA. In addition to the social tariff there is the Promotion of Efficiency in Electric Energy Consumption policy and the Energy Efficiency fund. The first promotes measures to improve the efficiency of electricity consumption through actions taken by third parties (ex. energy suppliers or grid operators) while the second provides financial assistance to increase the energy efficiency in several sectors.

Finally, the expenditure based energy poverty indicators presented in the previous section are presented in Table 1. It shows that the number of energy poor households according to the HBS of 2010 and 2015. It can be seen that the number of energy poor households increased for the indicators "EP10" and "HCLI" while the number decreased for the indicator "TMed". The reason for this difference may be that "TMed" does not only include households with low income as the other two indicators does. Therefore, it is possible that more affluent households with high energy expenditures reduced their energy consumption because of the steady increase of energy prices in Portugal while energy poor households and other low income households were not able to do so and ended up with overall higher expenditures for energy.

Table 1 - Number of energy poor households in Portugal by indicators on basis of the HBS of 2010 and 2015

Indicator	2010	2015
EP10	5.7%	8.1%
HCLI	5.3%	5.8%
TMed	12.6%	9.4%

2.1.2 Social tariff in Portugal

As mentioned before, since 2016 every low-income household gets the social tariff automatically. The social tariff can be applied to vulnerable households with a yearly income below a certain income threshold or recipient of the following social transfers:[1]

- Solidarity surcharge for seniors
- Social integration income
- Unemployment income
- Social old-age pension
- Family allowance

If households do not receive social benefits, their income threshold depends on the number of persons in the household. The annual income must not exceed 5,808 EUR + 50% for each additional member that does not have an income (max. 10 persons). The income thresholds can be seen in Table 2. In addition, the household must have an active contract on the regulated or liberal energy market and low-voltage installation with a contractual capacity of less than or equal to 6.9 kVA. Overall, the social tariffs grants reductions on the capacity and energy component of the network access tariff (TAR), the special electricity consumption tax (IEC) and the audio-visual contribution (CAV).

[1] Source: ERSE - Tarifa social eletricidade 2022, Available online : https://www.erse.pt/media/215ih1x0/tarifa-social-eletricidade-2022_1abril2022.pdf

Table 2 - Income thresholds for the social tariff in Portugal[2]

Number of persons	Annual income	Number of persons	Annual income
1	5,808 EUR	6	20,328 EUR
2	8,712 EUR	7	23,232 EUR
3	11,616 EUR	8	26,136 EUR
4	14,520 EUR	9	29,040 EUR
5	17,424 EUR	10	31,944 EUR

2.1.3 The Pilot and the national law on energy communities

In Portugal the transposition of the EU framework for the introduction of RECs and on collective self-consumption (CSC) in national law took place in October 2019 with the Decree Law 162/2019. For the introduction of the concept of REC into national law, the government renewed their earlier introduced law on collective self-consumption. Collective self-consumption can be part of a REC. The set-up of an REC requires three things: (1) an internal regulation that needs to include at least basic management and sharing rules (for self-consumption and potential revenues); (2) an entity responsible for the operational management of the self-consumption activities and the communication with the respective operators; (3) a responsible technician (Frieden et al., 2021).

The pilot in Portugal is located in Lisbon and contains eight buildings with overall 150 apartments where the owners of the buildings already investing in PV-panels of 9kW to cover the energy need of the common area like lightning, elevator and so on. The idea in this pilot is that the inhabitants collectively invest in more PV to cover their energy needs and form an REC. In addition, the buildings have two EV charging stations and all apartments are connected to the grid.

2.1.4 Impacts of REC/CSC on energy poverty

First, we analyse the impact of the social tariff on the energy expenses of households. Therefore, we present the reductions of the social tariff for three household types with different energy demands. To cover a large range of different household types we decided to use three examples with an annual electricity consumption between 1,900 and 5,000 kWh and two different values for the contracted power. The examples are the following:

1. A single-person household with a yearly consumption of 1,900 kWh and contracted power of 3.45 kVa
2. A family with 2 minors and a yearly consumption of 3,500 kWh and a contracted power of 6.9 kVa
3. A big family with a yearly consumption of 5,000 kWh and a contracted power of 6.9 kVa

For the analysis, we constructed an electricity bill and used a calculation sheet for the social tariff that is provided by the Energy Services Regulatory Authority (ERSE).[3] The tables below shows the tariff

[2] ERSE - Tarifa Social na Eletricidade em 2022. Available online: https://www.erse.pt/media/215ih1x0/tarifa-social-eletricidade-2022_1abril2022.pdf , page 8

[3] ERSE – Tariff information: https://simulador.precos.erse.pt (examples downloaded in March 2022) & https://www.erse.pt/atividade/regulacao/tarifas-e-precos-eletricidade/#tarifa-social ,
The calculation sheet for the social tariff provided by ERSE. Available online: https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&ved=2ahUKEwiw2PTwhoL5AhUHX_E

structure for example 1 as well as the social tariff applied. The bills as well as the reduction of the social tariff for the other two examples can be found in the appendix. For all three cases the same logic is applied.

Table 3 - Yearly electricity costs for a household that consumes 1900 kWh and with contracted power of 3.45 kVa

	Quantity x Price	Price	VAT	Price
Energy component until 1,217 kWh	1,217 x 0.1486[4]	180.85	13%	204.36
Energy component above 1,217 kWh	683 x 0.14865	101.49	23%	124.84
Capacity component (TAR - 365 days)	365 x 0.1706[5]	62.27	6%	66.01
Capacity component (365 days)	365 x 0.01425[4]	5.18	23%	6.38
Special consumption tax (IEC)	1,900 x 0.0015	1.90	23%	2.34
Audio-visual contribution (CAV - 12 months)	12 x 2.85	34.20	6%	36.25
DGEG tax for 12 months	12 x 0.075	0.84	23%	1.03
Price without VAT	386.73 EUR/year			
Price with VAT	441.20 EUR/year (0.232 EUR/kWh)			

Table 4 - Savings of the social tariff in Portugal (household with a consumption of 1,900 kWh/year and 3.45 kVa

Component	Value	Price	Total
23% VAT			
Reduction on the energy component (> 1,217 kWh)	683	0.0443	30.26
Reduction of the special consumption tax (IEC)	1,900	0.001	1.90
Discount without VAT			32.16
Discount with VAT			39.55
13% VAT			
Reduction on energy component (< 1,217 kWh)	1,217	0.0443	53.91
Discount without VAT			53.91
Discount with VAT			60.92
6%			
Reduction on capacity component (TAR)	365	0.0904	33.00
Reduction on the Audio-visual contribution (CAV) (12 months)	12	1.85	22.20
Discount without VAT			55.20
Discount with VAT			58.51
Total discount in EUR			158.98

DHVVeBzMQFnoECAsQAQ&url=https%3A%2F%2Fwww.erse.pt%2Fmedia%2F4b4hhxxf%2Fdesconto-tarifa-social-2022-eletricidade.xlsx&usg=AOvVaw3HXB0tSm4sOpINjByQTwvy

ERSE – Tarifa Social, Available online: https://www.erse.pt/media/kmidu10b/tarifa-social_eletricidade-e-gás-folheto_julho.pdf

ERSE - Tarifa Social na Eletricidade em 2022, Available online: https://www.erse.pt/media/215ih1x0/tarifa-social-eletricidade-2022_1abril2022.pdf

ERSE – Application of the VAT on electricity bills December 2020. Available online: https://www.erse.pt/media/pzievesl/ersexplica_aplicação-do-iva.pdf

[4] ERSE – Application of the VAT on electricity bills December 2020, p. 6 Tarifa Simples: Available online : https://www.erse.pt/media/pzievesl/ersexplica_aplicação-do-iva.pdf

[5] ERSE – Tariff information: https://simulador.precos.erse.pt (examples downloaded in March 2022)

It can be seen that without the social tariff the household (1,900 kWh and contracted power of 3.45 kVa) has yearly electricity costs of 441.20 EUR (0.232 EUR/kWh). The social tariff provides a discount of 158.98 EUR/year, which implies that the households ends up with yearly costs of 282.22 EUR (0.149 EUR/kWh) for electricity. Although the social tariff in Portugal significantly reduces the energy expenditure of Portuguese households, it does not solve the country's problem with energy poverty.

Therefore, this report wants to analyse the potential additional savings that can be achieved when a vulnerable household receives the social tariff and participates in an energy community. This means that the household would not only get a discount on the energy from the grid but additionally gets cheaper energy from the energy community. For the analysis we assume that members of the REC has a self-sufficiency rate (SSR) of 30% which means that 30% of the energy demand is provided by the energy community and the remaining energy has to be bought from the grid where the social tariff is applied. For example 1 this implies that 570 kWh are provided by the energy community at a price of 0.089 EUR/kWh (LCOE of the PV plant[6] of 0.073 EUR/kWh + self-consumption grid tariff with CIEG 0.016 EUR/kWh). We assume that no additional costs from being a community member arise.

Table 5 - Yearly electricity costs for a household that participates in an energy community with 30% self-sufficiency rate, a consumption of 1,900 kWh and with contracted power of 3.45 kVa

	Quantity x Price	Price	VAT	Price
Energy component until 1,217 kWh	1,217 x 0.1486	180.85	13%	204.36
Energy component above 1,217 kWh	113 x 0.1486	16.79	23%	20.65
Capacity component (TAR - 365 days)	365 x 0.1706	62.27	6%	66.01
Capacity component (365 days)	365 x 0.01425	5.18	23%	6.38
Special consumption tax (IEC)	1,330 x 0.001	1.33	23%	1.64
Audio-visual contribution (CAV - 12	12 x 2.85	34.20	6%	36.25
DGEG tax for 12 months	12 x 0.07	0.84	23%	1.03
Price without VAT	**301.46 EUR/year**			
Price with VAT	**336.31 EUR/year (0.253 EUR/kWh)[7]**			

It follows that the remaining costs from the grid are 209.09 EUR/year (336.31 EUR – 127.22 EUR see Table 6).

Table 6 - Savings of the social tariff in Portugal (household with a consumption of 1,900 kWh/year and 3.45 kVa) when participating in an energy community (SSR: 30%)

Component	Value	Price	Total
23% VAT			
Reduction on the energy component (> 1,217 kWh)	113	0.0443	5.01
Reduction of the special consumption tax (IEC)	1,330	0.001	1.33
Discount without VAT			**6.34**
Discount with VAT			**7.79**
13% VAT			
Reduction on energy component (< 1,217 kWh)	1,217	0.0443	53.91
Discount without VAT			**53.91**
Discount with VAT			**60.92**
6%			
Reduction on capacity component (TAR)	365	0.0904	33.00

[6] See Appendix section 4.1.1 Calculations for Example 2 and 3 – Portugal

[7] Note that the price in EUR/kWh increased as the capacity component and other fixed costs stays unchanged.

Reduction on the Audio-visual contribution (CAV) (12 months)	12	1.85	22.20
Discount without VAT			**55.20**
Discount with VAT			**58.51**
Total discount in EUR			**127.22**

For the energy provided by the REC the household has to pay 50.64 EUR/year (570 kWh * 0.089 EUR/kWh) and so the household ends up with costs of 259.73 EUR/year which are lower than when only the social tariff is applied (282.22 EUR/year). Therefore, the savings increase from around 159 EUR/year to 181 EUR/year. The changes in yearly costs for all three examples are presented in Figure 1.

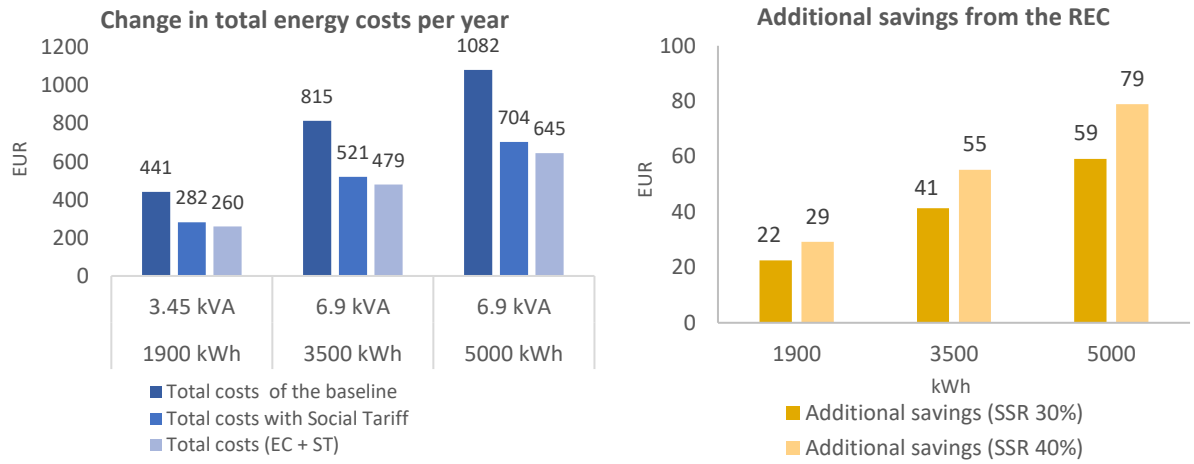


Figure 1 - Impact of the social tariff and energy communities on yearly electricity expenditures of households in Portugal (rounded values)

The Figure shows the changes of the yearly costs for all household types and it can be seen that energy communities increase the yearly savings for all three examples. Overall, there is an incentive to participate in an energy community as long as the electricity price of the community is below the price of the scenario where the households only receives the social tariff (see Table 7 column 2). In addition, Figure 1 (right graph) shows how the additional savings increase when the self-sufficiency rate (SSR) increases from 30% to 40%.

Table 7 - Electricity prices of all scenarios and all examples in Portugal

	Price per kWh before social tariff in EUR	Price per kWh after social tariff in EUR	Price per kWh in the REC in EUR
Example 1 (1900 kWh)	0.232	0.149	0.089
Example 2 (3500 kWh)	0.233	0.149	0.089
Example 3 (5000 kWh)	0.216	0.141	0.089

Next, we assume that the households that are considered as energy poor of the HBS of 2015 already received the social tariff as according to the member state report of the EU Energy Poverty Observatory the social tariff was already implemented in 2008 (see p.89). To analyse which impact the estimated additional cost savings generated by RECs may have on energy poor households we use the energy poverty indicators introduced in section 1.

Table 8 - Impact of yearly additional savings on energy poverty in Portugal

	Number of households in % in 2015	After 109.26 EUR reduction	After 232.61 EUR reduction
EP10	8.1%	7.6%	7.0%
HCLI	5.8%	5.5%	4.9%
2Med	9.4%	9.2%	8.5%
	Number of households in 2015	**change**	**change**
EP10	325,786 households	-15,751 households	-40,847 households
HCLI	232,486 households	-10,351 households	-31,126 households
2Med	380,521 households	-8,033 households	-34,147 households

Table 8 shows how the number of energy poor households would decrease if all energy poor households are part of an energy community and receive additional cost savings by participating in an energy community. To show this we subtracted the additional savings of Figure 1 from the expenditures of the energy poor households in the HBS and check afterwards how many households are still considered as energy poor. This assumption is rather unrealistic but it shows the potential that energy communities or CSC schemes in Portugal might have and how many households can be helped with. To analyse this we use the additional cost savings of example 1 (1,900 kWh yearly consumption) and 3 (5,000 kWh yearly consumption) to show the range of the potential positive impact as the HBS has no information about the consumed electricity per year. The table shows that even yearly savings of 22.48 EUR reduce the number of energy poor households by 0.5/0.3/0.2 percentage points, which can be translated in around 8,000 to 15,800 households depending on the used indicator. When the additional savings increase to 59.17 EUR/year the number of supported households increases to around 31,000 to 41,000 households.

2.2 SPAIN

2.2.1 Current Situation on Energy Poverty

In Spain, both energy poverty indicators of the member state report of the EU Energy Poverty Observatory are above the EU-average. In 2018, 9.1% of the population have difficulties to heat their homes adequately warm (EU-average is 7.3%) and 7.2% of the population have arrears on utility bills (EU-average 6.6%). From 2005 to 2018 the number of households that are not able to keep their homes adequately warm fluctuates between 5.9% and 11.1%. The percentage of households that have arrears on utility bills increased until 2014 to 9.2% but decreased to 7.2% by 2018. However, the percentage of households with high/low energy spending are lower than the EU-average. The percentage of households that have high energy spending is 14.2% (EU-average 16.2%) while the percentage of households with low energy spending lies at 13.0% (EU-average 14.6%). As in Portugal the share of energy poor households is the highest in the social housing sector followed by the private tenant sector. While the share of households that are unable to keep their homes adequately warm is larger in social housing (17.4% vs. 15.4%), it is smaller in the private tenant sector (14.6% vs. 15.3%). In 2017, these sectors account for 9% and 14% of the population. The report also indicated that energy poverty is more likely for households that live in apartment dwelling, which is the dwelling type in which 66% of the households in Spain live.

In the last ten years, energy poverty became an important topic for the Spanish government and multiple studies have been published. In early 2019, the National Strategy against Energy poverty 2019 -2024, with main goal to "guarantee the access to affordable, safe, sustainable and modern energy for all", was accepted by the government.[8] The publication claims that 3.5 to 8.1 million people suffer from energy poverty and therefore the objective of the strategy was set to reduce energy poverty by at least 25% until 2025 with the ambition to reach 50%.

Another energy poverty measure is the social bonus for electricity, which was introduced in 2009 and reworked in 2017. An additional rework took place in 2018 where a social bonus for heating was included, which is a yearly single payment to reduce expenses on heating, warm water and cooking. In 2019 over 1.100.000 vulnerable citizen benefited from it. In addition, Spain introduced the Law 8/2013 on building renovation to fight energy poverty with energy efficiency measures. There is also an emergency financial support for households that can be used in case of a disconnection risk. Municipalities have also several regional initiatives to help vulnerable households with energy audits and information regarding energy saving.

Electricity prices slightly increased over time from around 0.15 EUR/kWh in 2008 to 0.243 EUR/kWh in 2018. In contrast, the gas price was rather constant between 2008 and 2018 with the biggest increase between 2011 and 2012. In 2021, electricity prices increased drastically which demanded action of the Spanish government to prevent greater harm for the citizens. Barrella (2021) made first assessments to investigate the impacts on vulnerable households.[9] The price of electricity between 2019 and 2021 strongly increased during the winter months by 48% or 113% depending on the chosen tariff (flat-tariff or time-change tariff) (Barrella, 2021). The Spanish government reacted with some measures to mitigate the impact of the price spikes on the customers. First, the VAT was reduced from

[8] National Strategy against Energy Poverty 2019-2024 in Spain (ENPE). Available online: https://www.interregeurope.eu/good-practices/national-strategy-against-energy-poverty-2019-2024-in-spain-enpe

[9] Roberto Barrella (2021) 2021 Energy Price Crisis impacts on Energy Poverty in Spain, https://www.eppedia.eu/article/2021-energy-price-crisis-impacts-energy-poverty-spain

21% to 10% (Royal Decree-Law 12/2021 of 24 June 2021, effective from the end of June). Second, the electricity tax was reduced from 5.11% to 0.5% (Royal Decree-Law 17/2021 of 14 September 2021, effective from mid-September). Third, the demand charges were reduced (96% reduction, Royal Decree-Law 17/2021 of 14 September 2021, effective from mid-September). Finally, a cap on the regulated price of natural gas in winter 2021/22 was introduced. In addition to these reductions the Royal Decree Law 23/2021 increased the assistance programs' coverage for the electricity social tariff and the Thermal Social Allowance (TSA). The price reduction of the social tariff was increased from 25% to 60% for vulnerable households and from 40% to 70% for extremely vulnerable households until March 2022 and the budget of the TSA in 2021 was doubled and (Barella, 2021).

Table 9 - Number of energy poor households in Spain by indicators on basis of the HBS of 2010 and 2015

Indicator	2010	2015
EP10	3.2%	3.9%
HCLI	4.7%	4.5%
TMed	11.7%	11.9%

The indicators on basis of the HBS show that the indicators "EP10" and "TMed" increased from 2010 to 2015 while the indicator "HCLI" slightly decreased. In contrast to Portugal the share of "EP10" and "HCLI" in the population is smaller while the share of "TMed" in 2010 for Spain and Portugal was rather similar but in 2015 the share decreased in Portugal.

2.2.2 Social tariff in Spain

The following section will describe the social tariff for electricity according to the Royal Decree-Law 15/2018 and the ESPN Flash report. Overall, the social tariff in Spain has two requirements. First, the technical requirement is that the household must have a contract applying the so-called "Voluntary Price for the Small Consumer" tariff (VPSC or PVPC) and the contracted power supply must be 10 kW or less. Second, the social requirement that defines the discount rate and is determined by the household income level (ESPN Flash Report 2018/13). Overall, the individual or family annual income is compared to the Public Multiple Effects Income Indicator (IPREM)[10] and shows the degree of vulnerability (ESPN Flash Report 2018/13). According to the ESPN Flash Report there are three consumer categories:

1. the "vulnerable consumer" (individual or family annual income equal 1.5 times the IPREM), who receives a discount of 25% on his/her electricity bill.
2. the "severely vulnerable" consumer, (individual or family annual income below 50% of the annual IPREM) who receives a 40% discount on his/her electricity bill.
3. the "very severely vulnerable consumer", who receives assistance from the social services of a regional or local administration, which finances at least 50% of the amount of his/her electricity bill.

[10] an indicator of income used by Spanish public administrations to determine access to a series of social protection schemes

The income threshold according to the IPREM for the "vulnerable consumer" can also be increased according to household size (+0.3 times for every additional full aged family member and +0.5 times for each additional minor) or when suffering a disability, in case of gender-based violence, or being a victim of terrorism[11]. In addition, to consider the fact that single-parent families are more vulnerable than two-parent families the IPREM threshold for single-parent households is 0.5 times larger (see Royal Decree-Law 15/2018 Section IV, p. 3) [12]. For all three degrees of vulnerability there is a limit on which amount of energy (in kWh) the social tariff can be applied and varies according to the characteristics of the household. According to the Royal Decree-Law 15/2018 (p. 16-17) the limits are the following:

Table 10 - Energy limits for the social tariff

Category	kWh
Family unit without minors/single applicant	1380
Family unit/single applicant pensioner (minimum amount)	1932
Family unit with a minor	1932
Family unit with two minors	2346
Family unit, big family	4140

In 2021 and 2022, the discounts of the social tariff were increased (as mentioned in the previous section) according to the increasing energy prices and the COVID-19 situation. For this analysis we use the here described discount rates as these increases are intended to be temporarily.[13]

2.2.3 The Pilot and the national law on energy communities

Several milestones are being taken by the Spanish Government to create a more democratised energy sector. As for example the Spanish Law 7/2021 on Climate Change and Energy Transition that was approved in May 2021 or the Royal Decree 23/2020, which adopts measures in the field of energy and other areas for economic recovery which was published in June 2020. This Decree sets the basis for the transposition of the EU framework on energy communities in the national law. Currently, no final framework for energy communities is finished yet but the framework for collective-self consumption (CSC) is more advanced in Spain. Since April 2019, groups of several consumers may collectively supply themselves in an agreed manner with electrical energy on basis of the Spanish Royal Decree 244/2019. The consumed energy has to come from production facilities close the CSC consumption points (Frieden et al., 2021).

In addition to the above mentioned CSC schemes the production and consumption connection points have to fulfil three additional requirements (Frieden et al., 2021). First, all low voltage distribution lines must be connected to the same secondary substation. Second, a radius of 500 meter has to be assured between the production and the consumption points. This limitation however was extended in 2022. Third, the cadastral reference must be the same section. Moreover, CSC members must sign a document which clarifies the property of the installations and how the energy is distributed between

[11] Source: https://www.endesa.com/en/advice/ratesubsidy/rate-subsidy

[12] Example 1: Threshold for a single person household to get a 25% discount is that the annual income must not be higher than 1.5 times the IPREM.
Example 2: Threshold for a single-parent household to get a 25% discount is that the annual income must not be higher than 2 times the IPREM.
Example 3: Threshold for a couple with one minor to get a 25% discount is that the annual income must not be higher than 2.3 times the IPREM.

[13] Source: https://www.endesa.com/en/advice/ratesubsidy/rate-subsidy

the members. Overall, the CSC scheme in Spain is similar to the REC schemes, with the difference that CSCs do not have to be organised as a legal entity (Frieden et al., 2021).

The pilot in Spain is the grid of the municipality Crevillent and is managed by the Cooperative Crevillent, which is part of Enercoop. The involved participants are 13,047 households and 1,268 companies in low voltage grid and 30 participants in the medium voltage grid. Within the grid over 75.000 PV panels in solar plants and 2000 modules of PV panels on roofs are installed and provide energy for the municipality. These PV panels have a yearly production of 13.4 MW and the entire energy produced in the area is emission free. The surplus generated is reinvested in the distribution network, used to improve the used technology or is given to the society (e.g. the contributions go to a nursing home, schools for the disabled and a free mortuary for all the citizens).

2.2.4 Impacts on energy poverty

To show the impacts of the social tariff and energy communities or CSC schemes in Spain the same three examples as for Portugal were applied to make the two case studies comparable. In comparison to Portugal the Spanish social tariff is a percentage reduction of the energy bill. Therefore, the representation of the positive impacts are different to the Portuguese case.

Overall, the yearly energy costs (Table 11) reduce to 419.85/363.96/326.70 EUR for example 1 (baseline: 513 EUR/year for 1,900 kWh/a), to 786.65/691.63/628.29 EUR in example 2 (baseline: 945 EUR/year for 3,500 kWh/year) and to 1,070.55/902.88/791.10 EUR (baseline: 1,350 EUR/year for 5,000 kWh/year). For the baseline we use an energy price of 0.27 EUR/kWh as this is the same price that were used in Deliverable 7.1 to calculate the business cases of the Spanish demo. The table shows that the savings generated by the social bonus range from 93.15 EUR/year to 558.90 EUR/year depending on the energy consumed and the applied discount rate. Overall, for these examples the lowest EUR/kWh price that is achieved by the social tariff is 0.158 EUR/kWh (-41.4%) which is the case for example 3 with a discount rate of 50%.[14]

Table 11 - Cost savings of the social tariff in Spain

	Costs/year without any discount in EUR	Consumption per year in kWh	Price in EUR/kWh	- 25% in EUR/kWh	- 40% in EUR/kWh	- 50% in EUR/kWh	Threshold of the social tariff in kWh
Example 1 (1900 kWh)	513	1,900	0.27	0.203	0.162	0.135	1,380
Example 2 (3500 kWh)	945	3,500	0.27	0.203	0.162	0.135	2,346
Example 3 (5000 kWh)	1350	5,000	0.27	0.203	0.162	0.135	4,140
	Costs after 25% discount	**Costs after 40% discount**	**Costs after 50% discount**	**Savings (25% discount)**	**Savings (40% discount)**	**Savings (50% discount)**	**Average savings**

[14] Due to the fact that the social tariff cannot be applied on the entire consumption.

Example 1 (1900 kWh)	419.85	363.96	326.70	93.15	149.04	186.30	142.83
Example 2 (3500 kWh)	786.65	691.63	628.29	158.36	253.37	316.71	242.81
Example 3 (5000 kWh)	1070.55	902.88	791.10	279.45	447.12	558.90	428.49

To show the impacts of the social tariff in combination with the participation in an energy community or CSC/scheme some assumptions are needed. Again, a self-sufficiency rate of 30% is assumed to make the two examples comparable. In addition, the price of the energy provided by the energy community is 0.069 EUR/kWh, which represent the LCOE of the Spanish demo in Crevillent[15].

In comparison to Portugal, there are no transmission costs as long as the members are located in the 500m radius of the energy community or CSC/scheme. Therefore, the price for energy of an energy community in Spain is lower than the energy price of an energy community in Portugal (0.069 EUR/kWh vs. 0.089 EUR/kWh). Again, we assume that no additional member costs arise. As in Portugal, additional positive impacts can be generated when combining the social tariff with the participation in a CSC or energy community as long the electricity price in the community is lower than the price after receiving the social tariff (see Table 12).

Table 12 - Energy prices of all scenarios for all examples in Spain

	Price per kWh before social tariff in EUR	**Price per kWh after social tariff (25% discount) in EUR**	**Price per kWh after social tariff (40% discount) in EUR**	**Price per kWh after social tariff (50% discount) in EUR**	**Price per kWh in the REC/CSC scheme in EUR**
Example 1 (1900	0.27	0.221	0.192	0.172	0.069
Example 2 (3500	0.27	0.225	0.198	0.180	0.069
Example 3 (5000	0.27	0.214	0.181	0.158	0.069

By combining the social tariff with the participation in an energy community/CSC scheme even higher cost reductions can be gained. In example 1 (1,900 kWh/year) with a social tariff discount of 25% the savings doubled from 93.15 EUR/year to 204.35 EUR/year through the participation in an energy community or CSC scheme. The highest increase of savings can be seen in example 2 with a social tariff discount of 25% where the savings increased from 158.36 EUR/year to 369.41 EUR/year. Figure 2 shows the changes in total energy costs as well as the additional savings from the CSC for all three degrees of vulnerability (25%, 40% and 50% discount) (Table 13).

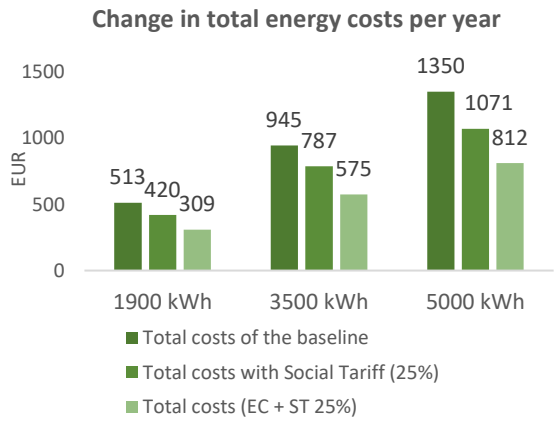
Table 13 - Cost savings of social tariff + the participation in an energy community

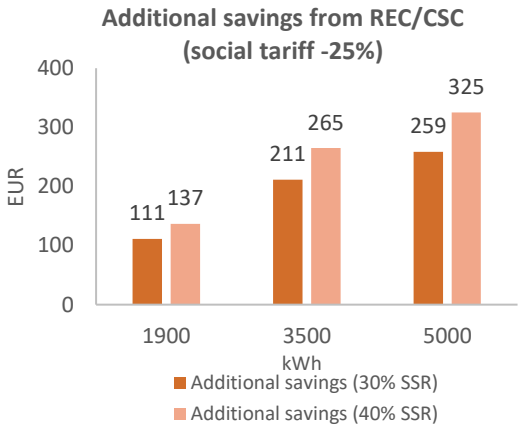
	Threshold of the social	**Energy from the EC (in kWh)**	**Costs of the EC**	**Remaining energy (in kWh)**	**Costs after**	**Costs after**	**Costs after**

[15] See Appendix Section Energy costs of the energy community

	tariff (in kWh)		energy (in EUR)		25% discount	40% discount	50% discount
Example 1 (1900 kWh)	1,380	570	39.33	1,330	269.33	215.46	179.55
Example 2 (3500 kWh)	2,346	1050	72.45	2,450	503.14	408.13	344.79
Example 3 (5000 kWh)	4,140	1500	103.50	3,500	708.75	567.00	472.5
	Total costs (EC + 25% discount)	**Total costs (EC + 40% discount)**	**Total costs (EC + 50% discount)**	**Savings (in EUR)**	**Savings (in EUR)**	**Savings (in EUR)**	**Average savings**
Example 1 (1900 kWh)	308.66	254.79	218.88	204.35	258.21	294.12	252.23
Example 2 (3500 kWh)	575.60	480.58	417.24	369.41	464.42	527.76	453.86
Example 3 (5000 kWh)	812.25	670.50	576.00	537.75	679.50	774.00	663.75

Overall, the additional savings from the CSC scheme in Spain are larger than the one in Portugal as well as the impact of an increasing SSE (see Figure 2).





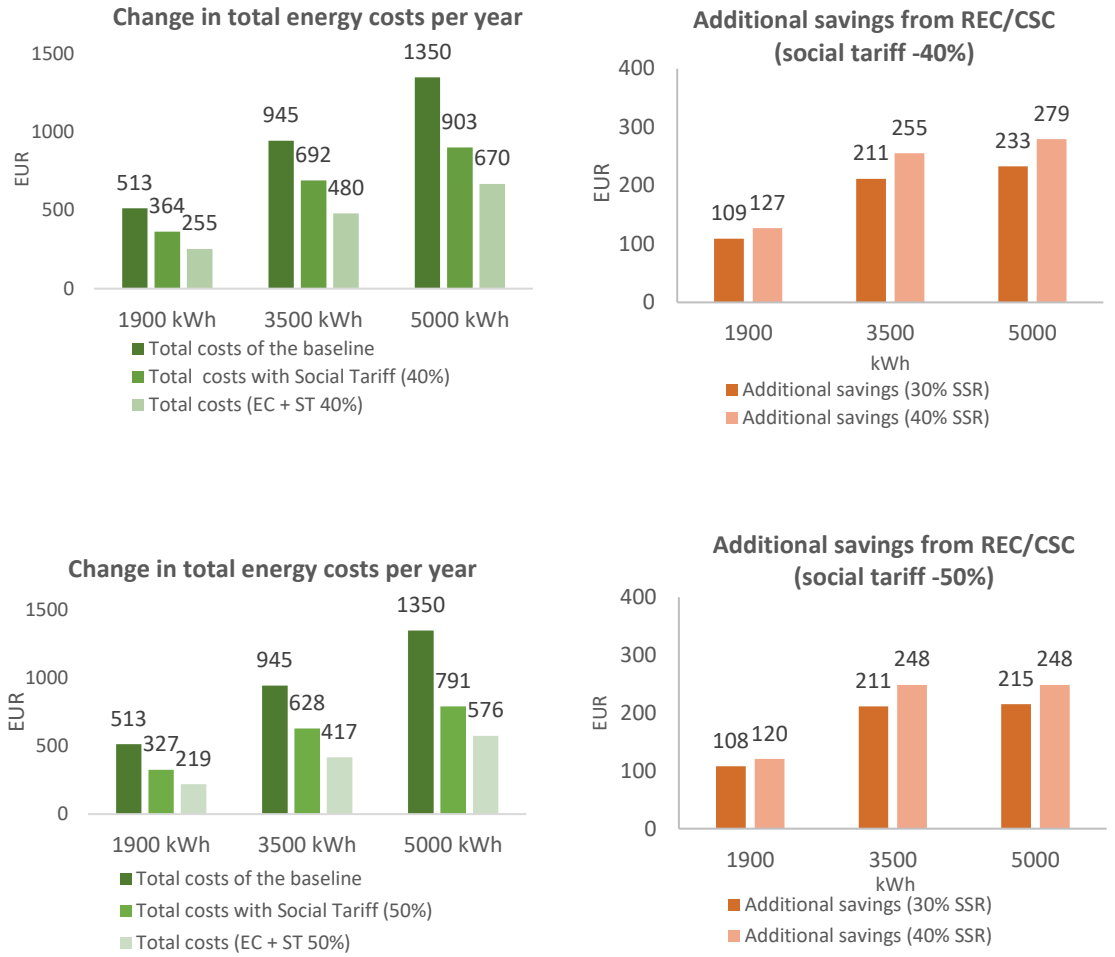


Figure 2 - Impact of the social tariff and energy communities on yearly electricity expenditures of households in Spain (rounded values)

To analyse the impacts of the additional cost savings generated by CSC schemes/energy communities we use the same method as for Portugal. To save space only the reductions of example 1 and 3 with a social tariff discount of 40% are presented as the additional savings for each example does not vary a lot between the different discount rates. Table 14 shows that additional savings of around 109 EUR/year reduces the number of energy poor households in Spain by 0.9 to 2.6 percentage points, which can be translated in around 152,000 to 395,000 households depending on the used energy poverty indicator. When the additional savings increase to 232.61 EUR the number of energy poor households reduces by 1.6 to 4.1 percentage points which is equivalent to around 293,000 to 722,000 households.

Table 14 - Impact of yearly additional savings on energy poverty in Spain

	Number of households in % in 2015	After 109.26 EUR reduction	After 232.61 EUR reduction
EP10	3.9%	3.0%	2.3%
HCLI	4.5%	3.4%	2.6
2Med	11.9%	9.6%	7.8%

	Number of households in 2015	Change	Change
EP10	696,403 households	-152,728 households	-293,121 households
HCLI	807,402 households	-189,156 households	-341,005 households
2Med	2,301,501 households	-395,308 households	-722,321 households

2.3 COMPARISON AND DISCUSSION OF BOTH COUNTRIES

The aim of this analysis is to compare two European countries (Portugal and Spain) according to energy poverty and how renewable energy communities (RECs) or collective self-consumption scheme (CSC) could be used to reduce the energy expenditures of energy poor households. Both countries already introduced a social tariff for electricity in 2008 and 2009 to reduce the financial burden of vulnerable or energy poor households but both countries still have a high-energy poverty rate. Therefore, additional policy measures to fight energy poverty are necessary. The "Clean Energy for all Europeans" package introduced energy communities as a new possibility to reduce energy expenditures of vulnerable households. This analysis presents the social tariff structure of both countries and shows how the combination of the social tariff with a REC or CSC schemes can generated additional cost reductions. The results show that in both countries the combination of the social tariff and REC/CSC scheme can lead to higher cost savings for households. Overall, the analysis shows that REC/CSC schemes in combination with the social tariff is more beneficial in Spain. This has two reasons. First, there are significant price differences between in the presented examples. The energy price within an REC/CSC scheme in the Spanish demo is lower because of lower LCOE (0.069 EUR/kWh vs. 0.073 EUR/kWh) and the fact that in Spain no transmission cost are charged within the 500m radius of the CSC/energy community (0.0 EUR/kWh vs. 0.016 EUR/kWh). In addition, the assumed electricity price of the grid in Spain is higher (0.27 EUR/kWh vs. 0.23 EUR/kWh). Second, there are structural differences between the social tariffs. In Spain, the discount of the social tariff can only be applied on a certain amount of energy while this is not the case in Portugal. To make both countries comparable we decided to present Spanish example at Portuguese prices and compare the results with the Portuguese example. First, the same prices as in the Portuguese example without any discount are assumed. Therefore, the baseline is the same as for the Portuguese case (441/815/1082 EUR/year). After that, the social tariff with a discount rate of 25% and 40%[16] are applied (see Table 15). It can be seen that the remaining costs for all three examples are larger than in the Portuguese case[17].

Table 15 - Savings of the Spanish social tariff at Portuguese prices

Only social tariff applied	Price in EUR/kWh	Costs/year baseline	Threshold of the social tariff (in kWh)	- 25% in EUR/kWh	- 40% in EUR/kWh	Costs after 25% discount in EUR	Costs after 40% discount in EUR

[16] We decided to present only the 25% and 40% discount as this are the most common ones and closer to the Portuguese case.

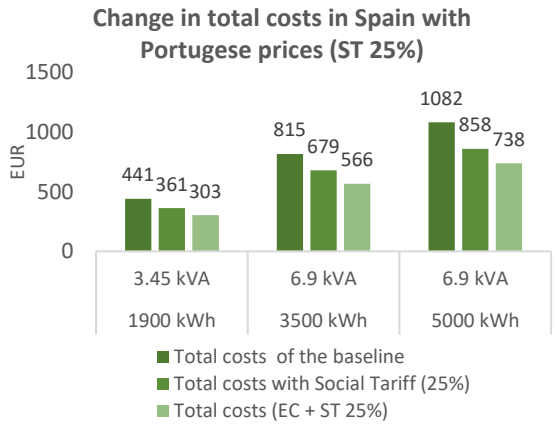
[17] Total costs after the social tariff is applied in Portugal: example 1 ca. 282 EUR, example 2 ca. 521 EUR and example 3 ca. 704 EUR.

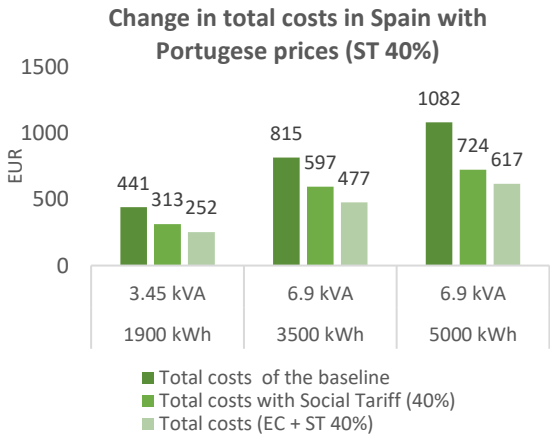
Example 1 (1900 kWh)	0.232	441.20	1,380	0.174	0.139	361.08	313.02
Example 2 (3500 kWh)	0.233	815.24	2,346	0.175	0.140	678.63	596.66
Example 3 (5000 kWh)	0.216	1082.22	4,140	0.162	0.130	858.20	723.79

After that, the social tariff is combined with the participation in a REC or CSC scheme. Therefore, a SSR of 30% and an internal price of 0.089 EUR/kWh is assumed. The remaining energy needed has to be bought from the grid where the social tariff is applied[18]. Thus, the yearly electricity costs decrease from 441 EUR to 303 EUR (25% discount)/252 EUR (40% discount) for example 1, from 815 to 566 EUR (25% discount)/477 EUR (40% discount) for example 2 and from 1082 EUR to 738 EUR (25% discount)/617 EUR (40% discount) for example 3 (see Figure 3).

Table 16 - Savings of the Spanish social tariff at Portuguese prices in combination with an REC/CSC scheme

Social Tariff (ST) + EC	Price in EUR/kWh	Energy from EC in kWh	Costs of the EC energy (in EUR)	Remaining energy (in kWh)	Total costs in EUR (ST+ EC) 25% discount	Total costs in EUR (ST+ EC) 40 % discount
Example 1 (1900 kWh)	0.253[20]	570	50.64	1,330	302.87	252.43
Example 2 (3500 kWh)	0.254[20]	1,050	93.29	2,450	566.41	477.07
Example 3 (5000 kWh)	0.230[20]	1,500	133.27	3,500	737.92	616.99





[18] Note that as in the Portuguese example the grid price in EUR/kWh increased because of unchanged fix costs.

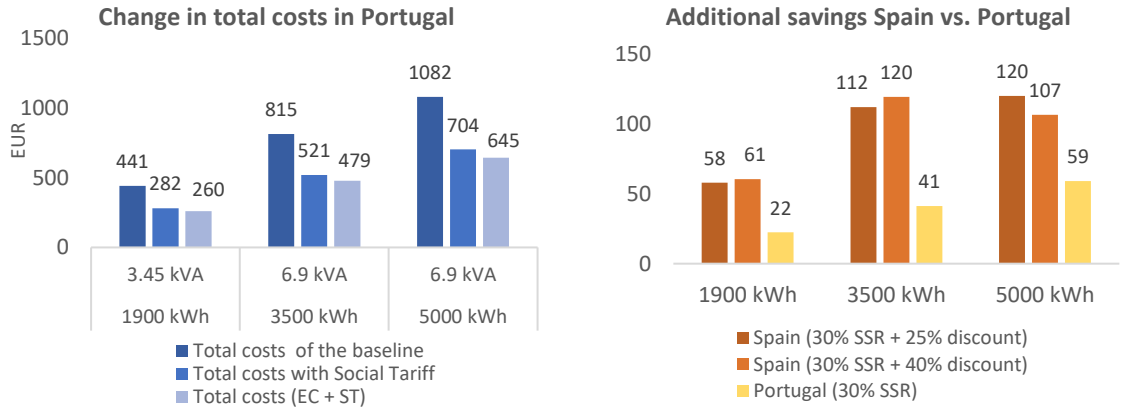


Figure 3 - Change in total costs and savings in Spain (at Portuguese prices) and Portugal (rounded values)

When comparing both countries (see Figure 3 and Table 17) it can be seen that when only the social tariff is applied Portuguese households get the higher cost reductions. The reason is that in Portugal the social tariff is applied on the entire consumption while this is not the case in Spain. In addition, there is only one social tariff applied while in Spain the discount rate as well as the amount on which the tariff is applied differs depending on the household composition and the income. When combining the participation in an REC/CSC scheme with the social tariff the yearly savings in Portugal and Spain (when the 40% discount rate is applied) are rather similar. The yearly savings for Spanish households with a lower discount rate (25%) are significantly lower (43 – 93 EUR/year depending on the household type). Overall, the additional savings generated by an energy community are larger for all Spanish households (see Figure 3 graph lower right). The main reason is that in Spain the discount rate can only be applied on a certain amount of energy. This implies that the combination of the social tariff and the participation in an REC/CSC lead to lower costs. In addition, the savings in Spain heavily depend on the applied energy tariff, the household composition/energy consumption and the discount rate that the household can get.

Table 17 - Yearly savings in EUR for Spain (at Portuguese prices) and Portugal (rounded values)

	Spain: Savings - only social tariff (25%)	Spain: Savings - only social tariff (40%)	Portugal: Savings - only social tariff	Spain: Savings of EC + social tariff (25%)	Spain: Savings of EC + social tariff (40%)	Portugal: Savings of EC + social tariff
Example 1 (1900 kWh)	80	128	159	138	189	181
Example 2 (3500 kWh)	136	218	294	249	338	336
Example 3 (5000 kWh)	224	358	378	344	465	437

Because of these differences, the additional financial benefits generated by REC/CSC schemes are lower in Portugal. Therefore, there is little scope for membership fees or maintenance costs in Portugal, as these costs were excluded in this analysis. For example, if there is a membership fee of 5 EUR per month (60 EUR/year) all additional savings of the REC/CSC schemes are lost or even become negative. This makes REC/CSC schemes unattractive for energy poor households in Portugal. In Spain, example 2 and 3 still have additional savings of at least 47 EUR/year[19].

This analysis shows that it is possible to generate additional savings by combining RECs or CSC schemes with the social tariff but the outcome strongly depend on the energy consumption, the internal and external energy prices, the social tariff a country has and if membership fees are charged or not.

[19] See Figure 3 lower right: Additional savings of example 3 with a 40% discount rate = 107 EUR/year. Membership fee = 60 EUR/year. Therefore, only 47 EUR are left.

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https://www.erse.pt/media/kmidu10b/tarifa-social_eletricidade-e-gás-folheto_julho.pdf

ERSE - Tarifa Social na Eletricidade em 2022
https://www.erse.pt/media/215ih1x0/tarifa-social-eletricidade-2022_1abril2022.pdf

ERSE – Application of the VAT on electricity bills December 2020:
https://www.erse.pt/media/pzievesl/ersexplica_aplicação-do-iva.pdf

Bono Social URL https://energia.gob.es/bono-social/Paginas/bono-social.aspx

ERSE – Tariff information: https://simulador.precos.erse.pt (examples downloaded in March 2022) &
https://www.erse.pt/atividade/regulacao/tarifas-e-precos-eletricidade/#tarifa-social

The calculation sheet for the social tariff provided by ERSE:
https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&ved=2ahUKEwiw2PTwhoL5AhUHX_EDHVVeBzMQFnoECAsQAQ&url=https%3A%2F%2Fwww.erse.pt%2Fmedia%2F4b4hhxxf%2Fdesconto-tarifa-social-2022-eletricidade.xlsx&usg=AOvVaw3HXB0tSm4sOpINjByQTwvy

4 APPENDIX

4.1.1 Calculations for Example 2 and 3 – Portugal

Example 2 – only social tariff

Electricity bill without social tariff:

Table 17 - Yearly electricity costs for a household that consumes 3,500 kWh and with contracted power of 6.9 kVa

	Quantity x Price	Price	VAT	Price inclusive
Energy component until 1,217 kWh	1,217 x 0.1486	180.85	13%	204.36
Energy component above 1,217 kWh	2,283 x 0.1486	339.25	23%	417.28
Capacity component (TAR - 365 days)	365 x 0.3244	118.41	23%[20]	145.64
Capacity component (365 days)	365 x 0.01425	5.18	23%	6.38
Special consumption tax (IEC)	3,500 x 0.001	3.50	23%	4.31
Audio-visual contribution (CAV)	12 x 2.85	34.20	6%	36.25
DGEG tax for 12 months	12 x 0.07	0.84	23%	1.03
Price without VAT	**682.23 EUR/year**			
Price with VAT	**815.24 EUR/year (0.233 EUR/kWh)**			

The discount of the social tariff for example 2 is the following:

Table 18 - Savings of the social tariff in Portugal (household with a consumption of 3,500 kWh/year and 6.9 kVa

Component	Value	Price	Total
23% VAT			
Reduction on capacity component (TAR)	365	0.1808	65.99
Reduction on the energy component (> 1,217 kWh)	2,283	0.0443	101.14
Reduction of the special consumption tax (IEC)	3,500	0.001	3.50
Discount without VAT			170.63
Discount with VAT			209.87
13% VAT			
Reduction on the energy component (< 1,217 kWh)	1,217	0.0443	53.91
Discount without VAT			53.91
Discount with VAT			60.92
6%			
Reduction on the Audio-visual contribution (CAV) 12 months	12	1.85	22.20
Discount without VAT			22.20
Discount with VAT			23.53
Total discount in EUR			294.32

As a result, the bill of example 2 reduces to 520.92 EUR/year (0.149 EUR/kWh).

[20] Only costumers with a contracted power of 3.45 kVa get 6% VAT on the capacity component. For all other costumers a VAT of 23% is used.

Example 2 – social tariff + EC

Electricity bill for the remaining 2450 kWh without social tariff:

Table 19 - Yearly electricity costs for a household that participates in an energy community with 30% self-sufficiency rate, a consumption of 3,500 kWh and with contracted power of 6.9 kVa

	Quantity x Price	Price	VAT	Price inclusive
Energy component until 1,217 kWh	1,217 x 0.1486	180.85	13%	204.36
Energy component above 1,217 kWh	1,233 x 0.1486	183.22	23%	225.37
Capacity component (TAR - 365	365 x 0.3244	118.41	23%[21]	145.64
Capacity component (365 days)	365 x 0.01425	5.18	23%	6.38
Special consumption tax (IEC)	2,450 x 0.001	2.45	23%	3.01
Audio-visual contribution (CAV)	12 x 2.85	34.20	6%	36.25
DGEG tax for 12 months	12 x 0.07	0.84	23%	1.03
Price without VAT	**525.15 EUR/year**			
Price with VAT	**622.03 EUR/year (0.254 EUR/ kWh)**			

The discount of the social tariff is the following:

Table 20 - Savings of the social tariff in Portugal (household with a consumption of 3,500 kWh/year and 6.9 kVa) when participating in an energy community (SSR: 30%)

Component	Value	Price	Total
23% VAT			
Reduction on capacity component (TAR)	365	0.1808	65.99
Reduction on the energy component (> 1,217 kWh)	1233	0.0443	54.62
Reduction of the special consumption tax (IEC)	2450	0.001	2.45
Discount without VAT			123.06
Discount with VAT			151.37
13% VAT			
Reduction on the energy component (< 1,217 kWh)	1217	0.0443	53.91
Discount without VAT			53.91
Discount with VAT			60.92
6%			
Reduction on the Audio-visual contribution (CAV) 12 months	12	1.85	22.20
Discount without VAT			22.20
Discount with VAT			23.53
Total discount in EUR			235.81

After applying the social tariff discount, the bill reduces to 386.22 EUR. The costs of the energy from the community are 93.29 EUR (1,050 kWh * 0.088 EUR = 93.29 EUR). Therefore, the final energy costs for example 2 are 479.51 EUR (386.21 EUR + 93.29 EUR).

[21] Only costumers with a contracted power of 3.45 kVa get 6% VAT on the capacity component. For all other costumers a VAT of 23% is used. Source: ERSE – Application of the VAT on electricity bills December 2020: https://www.erse.pt/media/pzievesl/ersexplica_aplicação-do-iva.pdf

Example 3 – only social tariff

Electricity bill without social tariff:

Table 21 - Yearly electricity costs for a household that consumes 5,000 kWh and with contracted power of 6.9 kVa

	Quantity x	Price	VAT	Price inclusive
Energy component until 1,217 kWh	1,825[22] x 0.1486	271.20	13%	306.45
Energy component above 1,217	3,175 x 0.1486	471.81	23%	580.32
Capacity component (TAR - 365	365 x 0.3244	118.41	23%[23]	145.64
Capacity component (365 days)	365 x 0.01425	5.18	23%	6.38
Special consumption tax (IEC)	5,000 x 0.001	5.00	23%	6.15
Audio-visual contribution (CAV)	12 x 2.85	34.20	6%	36.25
DGEG tax for 12 months	12 x 0.07	0.84	23%	1.03
Price without VAT	**906.63 EUR/year**			
Price with VAT	**1082.22 EUR/year (0.216 EUR/kWh)**			

The discount of the social tariff is the following:

Table 22 - Savings of the social tariff in Portugal (household with a consumption of 5,000 kWh/year and 6.9 kVa)

Component	Value	Price	Total
23% VAT			
Reduction on capacity component (TAR)	365	0.1808	65.99
Reduction on the energy component (> 1,217 kWh)	3,783	0.0443	167.59
Reduction of the special consumption tax (IEC)	5,000	0.001	5.00
Discount without VAT			238.58
Discount with VAT			293.45
13% VAT			
Reduction on the energy component (< 1,217 kWh)	1,217	0.0443	53.91
Discount without VAT			53.91
Discount with VAT			60.92
6%			
Reduction on the Audio-visual contribution (CAV) 12 months	12	1.85	22.20
Discount without VAT			22.20
Discount with VAT			23.53
Total discount in EUR			377.90

As a result, the bill auf example 3 reduces to 704.32 EUR/year (0.141 EUR/kWh).

[22] For a period of 30 days: Customers with a contracted power of up to 6.9 kVA are eligible for the intermediate VAT rate, for the part of their consumption that does not exceed 100 kWh. In the case of large families (5 or more members), this threshold can be increased to 150 kWh. For a larger periods the amount is determined in the following way: (number of days/30)*150 → (365/30)*150 = 1825. Source: ERSE – Application of the VAT on electricity bills December 2020: https://www.erse.pt/media/pzievesl/ersexplica_aplicação-do-iva.pdf

[23] Only costumers with a contracted power of 3.45 kVa get 6% VAT on the capacity component. For all other costumers a VAT of 23% is used. Source: ERSE – Application of the VAT on electricity bills December 2020: https://www.erse.pt/media/pzievesl/ersexplica_aplicação-do-iva.pdf

Example 3 – social tariff + EC

Electricity bill for the remaining 3500 kWh without social tariff:

Table 23 - Yearly electricity costs for a household that participates in an energy community with 30% self-sufficiency rate, a consumption of 5,000 kWh and with contracted power of 6.9 kVa

	Quantity x	Price	VAT	Price inclusive
Energy component until 1,217 kWh	1,825 x 0.1486	271.20	13%	306.45
Energy component above 1,217 kWh	1,675 x 0.1486	248.91	23%	306.15
Capacity component (TAR - 365 days)	365 x 0.3244	118.41	23%[24]	145.64
Capacity component (365 days)	365 x 0.01425	5.18	23%	6.38
Special consumption tax (IEC)	3,500 x 0.001	3.50	23%	4.31
Audio-visual contribution (CAV)	12 x 2.85	34.20	6%	36.25
DGEG tax for 12 months	12 x 0.07	0.84	23%	1.03
Price without VAT	**682.23 EUR/year**			
Price with VAT	**806.21 EUR/year (0.230 EUR/kWh)**			

The discount of the social tariff is the following:

Table 24 - Savings of the social tariff in Portugal (household that participates in an energy community with 30% self-sufficiency rate, a consumption of 5,000 kWh and with contracted power of 6.9 kVa)

Component	Value	Price	Total
23% VAT			
Reduction on capacity component (TAR)	365	0.1808	65.99
Reduction on the energy component (> 1,217 kWh)	2,283	0.0443	101.14
Reduction of the special consumption tax (IEC)	3,500	0.001	3.50
Discount without VAT			170.63
Discount with VAT			209.87
13% VAT			
Reduction on the energy component (< 1,217 kWh)	1,217[25]	0.0443	53.91
Discount without VAT			53.91
Discount with VAT			60.92
6%			
Reduction on the Audio-visual contribution (CAV) 12 months	12	1.85	22.20
Discount without VAT			22.20
Discount with VAT			23.53
Total discount in EUR			294.32

After applying the social tariff discount, the bill reduces to 511.89 EUR (806.21 EUR – 294.32 EUR).The costs of the energy from the community are 133.27 EUR (1,500 kWh * 0.089 EUR = 133.27EUR). Therefore, the final energy costs for example 3 are 645.16 EUR (511.89 EUR + 133.27 EUR).

[24] Only costumers with a contracted power of 3.45 kVa get 6% VAT on the capacity component. For all other costumers a VAT of 23% is used. Source: ERSE – Application of the VAT on electricity bills December 2020: https://www.erse.pt/media/pzievesl/ersexplica_aplicação-do-iva.pdf

[25] The social tariff calculation sheet does not consider that big families have an increased amount of energy that gets 13% VAT. Therefore, the sheet uses as in example 2 1217 kWh.

4.1.2 Energy costs in the energy community

Table 25 - Investment information of the demo projects in Portugal and Spain

	Portugal	Spain
Investment costs in EUR	57,200	110,000
Maintenance & operation costs in EUR	1,144	2,200
Electricity generated in kWh	81,623	167,228
Discount rate	5%	5%
Lifespan in years	25	25

Portugal

Table 26 - Calculation of the LCOE of the Portuguese demo project

t	$I_t + M_t + F_t$	E_t	$\frac{I_t + M_t + F_t}{(1+r)^t}$	$\frac{E_t}{(1+r)^t}$
0	57200.00	0.00	57200.00	0.00
1	1144.00	81623.00	1089.52	77736.19
2	1166.88	80806.77	1058.39	73294.12
3	1190.22	79998.70	1028.15	69105.89
4	1214.02	79198.72	998.78	65156.98
5	1238.30	78406.73	970.24	61433.72
6	1263.07	77622.66	942.52	57923.22
7	1288.33	76846.43	915.59	54613.33
8	1314.10	76077.97	889.43	51492.56
9	1340.38	75317.19	864.02	48550.13
10	1367.19	74564.02	839.33	45775.84
11	1394.53	73818.38	815.35	43160.08
12	1422.42	73080.19	792.06	40693.79
13	1450.87	72349.39	769.43	38368.43
14	1479.89	71625.90	747.44	36175.95
15	1509.48	70909.64	726.09	34108.75
16	1539.67	70200.54	705.34	32159.68
17	1570.47	69498.54	685.19	30321.98
18	1601.88	68803.55	665.61	28589.30
19	1633.91	68115.52	646.60	26955.62
20	1666.59	67434.36	628.12	25415.30
21	1699.92	66760.02	610.17	23963.00
22	1733.92	66092.42	592.74	22593.68
23	1768.60	65431.49	575.81	21302.62
24	1803.97	64777.18	559.35	20085.32
25	1840.05	64129.41	543.37	18937.59
$LCOE = \frac{\sum \frac{I_t + M_t + F_t}{(1+r)^t}}{\sum \frac{E_t}{(1+r)^t}} =$				0.073

Spain

Table 27 - Calculation of the LCOE of the Spanish demo project

t	$I_t + M_t + F_t$	E_t	$\frac{I_t + M_t + F_t}{(1+r)^t}$	$\frac{E_t}{(1+r)^t}$
0	110000.00	0.00	110000.00	0.00
1	2200.00	167228.00	2095.24	159264.76
2	2244.00	165555.72	2035.37	150163.92
3	2288.88	163900.16	1977.22	141583.12
4	2334.66	162261.16	1920.73	133492.66
5	2381.35	160638.55	1865.85	125864.51
6	2428.98	159032.16	1812.54	118672.25
7	2477.56	157441.84	1760.75	111890.98
8	2527.11	155867.42	1710.45	105497.21
9	2577.65	154308.75	1661.58	99468.80
10	2629.20	152765.66	1614.10	93784.86
11	2681.79	151238.01	1567.99	88425.73
12	2735.42	149725.63	1523.19	83372.83
13	2790.13	148228.37	1479.67	78608.67
14	2845.93	146746.09	1437.39	74116.75
15	2902.85	145278.62	1396.32	69881.50
16	2960.91	143825.84	1356.43	65888.27
17	3020.13	142387.58	1317.67	62123.23
18	3080.53	140963.70	1280.02	58573.33
19	3142.14	139554.07	1243.45	55226.28
20	3204.98	138158.53	1207.92	52070.50
21	3269.08	136776.94	1173.41	49095.04
22	3334.47	135409.17	1139.89	46289.61
23	3401.16	134055.08	1107.32	43644.49
24	3469.18	132714.53	1075.68	41150.52
25	3538.56	131387.38	1044.95	38799.06
$LCOE = \frac{\sum \frac{I_t + M_t + F_t}{(1+r)^t}}{\sum \frac{E_t}{(1+r)^t}} =$				0.069

The price for energy from the energy community is 0.069 EUR/kWh (only LCOE and no self-consumption grid tariff)