COME RES

Advancing Renewable Energy Communities

Deliverable 2.2

Assessment report of potentials for RES community energy in the target regions

Date: 31.08.2021

Version: V

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 953040. The sole responsibility for the content of this document lies with the COME RES project and does not necessarily reflect the opinion of the European Union.

SUMMARY

WP: 2	Starting conditions, potentials, barriers and drivers for the uptake of RES based community energy		
Dissemination level:	PU	Due delivery date:	1 August 2021
Type	R	Actual delivery date:	31 August 2021

Lead beneficiary:	TU/e
Contributing beneficiaries:	FUB, VITO, ENEA, IPE, CICERO, KAPE, INEGI, ECORYS
Authors:	Erik Laes, Kellan Anfinson (TU/e) Michael Krug, Vincenzo Gatta (FUB) Erika Meynaerts (VITO) Elena De Luca, Rossana Cotroneo, Martina Caliano (ENEA) Gaidis Klāvs, Ivars Kudrenickis (IPE) Stine Aakre, Håkon Sælen, Karina Standal (CICERO) Piotr Nowakowski, Ryszard Wnuk (KAPE) Isabel Azevedo (INEGI) Pouyan Maleki (ECORYS)

Document history				
Version	Submitted for review by	Date	Reviewed/approved by	Date
V0	Erik Laes, TU/e	01.07.2021	Håkon Sælen, CICERO	07.07.2021
V1	Erik Laes, TU/e	19.07.2021	All partners	13.08.2021
V2	Erik Laes, TU/e	13.08.2021	Michael Krug, FU Berlin Karina Standal, CICERO	25.08.2021
V3	Erik Laes, TU/e	26.08.2021	Michael Krug, FUB	30.08.2021
V4	Erik Laes, TU/e	30.08.2021	Michael Krug, FUB	31.08.2021
V5	Erik Laes, TU/e	31.08.2021	Rosaria Di Nucci, FUB	31.08,2021

ABOUT COME RES

COME RES – Community Energy for the uptake of renewables in the electricity sector. Connecting long-term visions with short-term actions – aims at facilitating the market uptake of renewable energy sources (RES) in the electricity sector. Specifically, the project focuses on advancing renewable energy communities (RECs) as per the EU's recast Renewable Energy Directive (REDII). COME RES takes a multi- and transdisciplinary approach to support the development of RECs in nine European countries; Belgium, Germany, Italy, Latvia, the Netherlands, Norway, Poland, Portugal, and Spain.

COME RES covers diverse socio-technical systems including community PV, wind (onshore), storage and integrated community solutions, investigated in nine European countries. The project has a specific focus on a number of target regions in these countries, where community energy has the potential to be further developed and model regions where community energy is in a more advanced stage of development. COME RES analyses political, administrative, legal, socioeconomic, spatial and environmental characteristics, and the reasons for the slow deployment of RECs in selected target regions. COME RES synchronises project activities with the transposition and implementation of the Clean Energy Package and its provisions for RECs in policy labs. Policy lessons with validity across Europe will be drawn and recommendations proposed.

ABSTRACT

The Renewable Energy Directive of the EU has represented a key driver for the uptake of renewable energy resources for electricity in Europe. However, there are several countries and regions within the EU where the uptake of renewables for electricity have been comparatively low so far. Current technological innovation provides opportunities for decentralised RES systems of production and energy storage that enable the rise of new collective forms of energy citizenship. The "Clean Energy for all Europeans" package puts consumers at the heart of EU energy policies; the recast Renewable Energy Directive (RED II) includes new provisions for RES community energy empowering them to participate in the energy market. There is a need to re-align national and regional policy frameworks and support schemes with RED II.

Member States have to transpose the definitions, rights and duties of renewable energy communities (RECs) pursuant to RED II and provide an enabling framework to promote and facilitate their development" (see Article 22(4) of the RED II), Furthermore, RED II requires that Member States "carry out an assessment of the existing barriers and potential of development" of RECs (Article 22(3)), COME RES and specifically the deliverable at hand aim to inform and support Member States in accomplishing this task.

Deliverable 2.2 includes rough assessments of the potentials for RECs in the COME RES target regions. These assessments rely on a common methodology and take into consideration the specific climate, energy, technological and socio-economic conditions. They are based on a cascade approach: starting from the technical RES potential (e.g. based on data such as available land, rooftop areas, housing types, climatic conditions) or politically agreed targets, an estimate is made about the fraction of this potential that could be particularly suitable to be 'unlocked' by community approaches.

CONTENTS

LIST OF TABLES

Summary

Methodology

Deliverable 2.2 includes **rough assessments of the potentials for Renewable Energy Communities (RECs) as defined in the recast Energy Directive (REDII) in selected target regions** in Belgium, Germany, Italy, Latvia, the Netherlands, Norway, Poland, Portugal and Spain. These potentials are expressed as the % of investments renewable energy projects over the period 2020-2030 that could be covered by collective citizen investments.

These REC potential assessments rely on a common methodology and take into consideration **the specific climate, energy, technological and socio-economic conditions** of the different target regions. They are based on a **cascade approach.** For each of the target regions, the REC potential calculation starts from an estimate of **the total wind and/or solar power capacity** that could be installed in the different target regions in 2030. This potential can be estimated on the basis of a bottom-up calculation (using parameters such as available land area, rooftop areas, housing types, climatic conditions) or on the basis of political commitments (e.g. political targets as expressed in climate action plans or declarations of government). This estimate also gives an idea about the total RES investments needed by all actors (not limited to the RECs) by 2030.

Next, based on annual household investment statistics, we determine the **upper limit of household investments in renewable energy** for each of the target regions. This estimate yields an upper limit because the assumption is that every household of the target region that has spare money available for investments will actually invest this money in RES production capacity.

Finally, we estimate the socio-economic investment potential for households based on the **percentage of households that could potentially invest in collective renewable energy projects** (as revealed e.g. in surveys). By splitting this investment potential over the different options for investment (rooftop PV, ground-based PV or wind power) we derive an estimate of the % of production capacity for these different technologies that could be controlled by RECs in 2030.

For the purpose of the potential assessment, we focus on **RECs that participate in the production of renewable energy in the form of ground-based and rooftop PV and onshore wind energy.** This represents only a subset of the full REC potential in the COME-RES target regions, but estimates of the potential of RECs engaging in other activities (selling, storing, or distributing energy) cannot be made on any reliable basis.

Furthermore, we assume that the proximity rule in the definition of a REC implies **that only natural persons, SMEs or public authorities residing in the target region can invest in the production of renewable energy in that target region**.

Finally, we **focus on those initiatives that put the citizen at the center, i.e. RES projects where the free and voluntary participation in the ownership structure of the project is encouraged**. It is important to underline that REDII also allows associations that only consist of SMEs and/or local governments to be classified as RECs. However, it is beyond the scope of this deliverable to provide a detailed assessment of the potential and willingness to invest of local SMEs and public authorities in the different target regions.

It should be stressed that all of these assumptions are only made for the purposes of enabling our calculation. In no way do they reflect the actual transposition of REC criteria in national laws;

nor do they imply a recommendation from our side on how key criteria should be interpreted in the transposition.

REC potential assessments for the COME RES target regions

Using the calculation rules for dividing the (minimum and maximum) socio-economic investment potential over the three RES technologies considered in the COME RES project (onshore wind energy, ground-based PV and PV on rooftops), the following Tables 1-3 indicate the REC potential assessment for the selected COME RES target regions, expressed as percentage ownership by citizens under two separate conditions (ownership for 100% financed by citizens vs. ownership for 20% financed by citizens and the rest by bank or public loans) under assumptions regarding the minimum and maximum willingness to invest in collective RES projects. Indicated in green are the cases where more than 50% of the additional investments in RES projects could be covered by citizen collectives, meaning that (on average) they take effective control over the energy transition in that particular RES technology. Indicated in dark orange are those cases where REC ownership can be considered to be challenging (less than 20% ownership).

Table 1 REC potential assessments for onshore wind energy

Target region	% financed by citizens	Min.	Max.
Apulia (Italy)	100%	3%	6%
	20%	14%	30%
Baleares (Spain)	100%	-	-
	20%	-	-
Canarias (Spain)	100%	-	-
	20%	-	-
Latvia	100%	4%	15%
	20%	18%	75%
Limburg (Belgium)	100%	11%	22%
	20%	55%	110%
West-Vlaanderen (Belgium)	100%	17%	35%
	20%	86%	173%
Noord Brabant (the Netherlands)	100%	3%	6%
	20%	14%	28%
Norway	100%	31%	62%
	20%	154%	308%
Região Norte (Portugal)	100%	-	-
	20%	-	-
Thuringia (Germany)	100%	9%	18%
	20%	45%	91%
Warmian-Masurian region (Poland)	100%	7%	13%
	20%	33%	67%

Table 2 REC potential assessments for ground-based PV installations

Target region	% financed by citizens	Min.	Max.
Apulia (Italy)	100%	4%	7%
	20%	17%	36%
Baleares (Spain)	100%	19%	38%
	20%	96%	192%
Canarias (Spain)	100%	25%	50%
	20%	125%	249%
Latvia	100%	76%	324%
	20%	378%	1622%
Limburg (Belgium)	100%	-	-
	20%	-	-
West-Vlaanderen (Belgium)	100%	-	-
	20%	-	-
Noord Brabant (the Netherlands)	100%	4%	7%
	20%	18%	36%
Norway	100%	52%	103%
	20%	258%	517%
Região Norte (Portugal)	100%	14%	28%
	20%	71%	141%
Thuringia (Germany)	100%	24%	49%
	20%	121%	243%
Warmian-Masurian region (Poland)	100%	15%	30%
	20%	74%	149%

Table 3 REC potential assessment for rooftop PV installations

Target region	% financed by citizens	Min.	Max.
Apulia (Italy)	100%	1%	2%
	20%	5%	10%
Baleares (Spain)	100%	21%	41%
	20%	103%	206%
Canarias (Spain)	100%	25%	50%
	20%	125%	249%
Latvia	100%	194%	830%
	20%	419%	1797%
Limburg (Belgium)	100%	14%	27%
	20%	36%	71%
West-Vlaanderen (Belgium)	100%	22%	43%
	20%	56%	112%
Noord Brabant (the Netherlands)	100%	3%	7%
	20%	9%	19%
Norway	100%	44%	88%
	20%	129%	259%
Região Norte (Portugal)	100%	10%	20%
	20%	50%	100%

Thuringia (Germany)	100%	15%	30%
	20%	74%	148%
Warmian-Masurian region (Poland)	100%	11%	22%
	20%	56%	112%

For a correct interpretation of these results, it is necessary to delve deeper into the specific contexts of the target regions.

The potential assessment for RECs in **Apulia (Italy)** shows that citizens can scarcely contribute to reach the political goals for wind and PV, both ground-based and on rooftops. In this region there is clearly a need for SMEs and local public authorities to complement the citizen investments. In addition, the availability of access to finance on favourable conditions (e.g. public financing, low interest rates for investment loans in RECs, etc.) seems to be a key enabler. The transposition of EU Directives including REDII can act as a driver for REC initiatives. In particular, overcoming the limit capacity of 200kW, now embedded the national regulation, is an important step for the promotion of RECs since the existing limit represents a significant barrier for the diffusion of RECs in Italy. Moreover, the Italian Recovery Plan (Piano Nazionale di Ripresa e Resilienza – PNRR), aimed to overcome the economic consequences of the COVID-19 pandemic, reserves a dowry of 2,2 billion Euro concentrated on families, micro-enterprises and public administrations in municipalities with less than 5000 inhabitants. This could possibly represent a useful support to finance public-private REC initiatives.

In the **Baleares and Canarias (Spain)**, it is likely that the political goal of 50% citizen ownership of PV capacity by 2030 can be reached without a need for complementing the citizen investments with investments by local SMEs and local authorities. Nevertheless, the availability of access to finance on favourable conditions (e.g. public financing, low interest rates for investment loans in RECs, etc.) could help reach the goal. However, as REC initiatives are in a nascent stage in Spain, there may be additional barriers to the investment and development of RECs by individual citizens that need to be addressed by adequate policies.

In **Latvia,** the potential assessment results related to solar PV even in a minimum socio-economic scenario with 100% citizen investment show a high potential contribution of RECs to the political goals set for PV capacity in 2030. The calculation results also show the potential of PV in the National Energy and Climate Plan 2030 to be significantly underestimated. These results thus clearly indicate that collectively owned PV installation can contribute significantly to the new increased GHG emission mitigation targets for 2030. Capitalizing on the latent 30% household participation in RECs over the next 10 years will however be a challenging task, given the novelty of the REC concept in Latvia. Being feasible in principle, it will require not only an adequate legislative framework and favourable financial mechanisms, but also efforts to provide information and communication in an effective way, the promotion of motivating factors and effective local leaders. Municipalities as well as regions should be considered as the support centres for RECs offering a territory for RES installations and providing municipality paid expertise on legal, economic and technical issues (complementary to support provided at national level). Participation of municipalities in RECs may provide the necessary trust for the project. Regarding the financial framework, the access to funds on favourable conditions (public co-financing of investment, low interest financing instruments available for RECs) and complementing citizen investment with investment by local SMEs and municipalities are crucial factors for capitalizing the maximum scenario of household participation in RECs.

In **Limburg and West-Vlaanderen (Belgium),** several initiatives by local governments have already been taken to promote citizen ownership of RES infrastructure. In Limburg, the provincial government decided at the end of 2013 on a minimum of 20% direct participation in the ownership and management structure of large wind turbines by the local community and local authorities. In West-Vlaanderen, the municipalities of Torhout and Oostkamp aim for a direct participation of 35% (of citizens and local authorities) in wind projects on their territory through an energy cooperative, with a minimum ownership of at least one wind turbine. Looking at the REC potential for wind projects in Table 1, a share of 20% of the investments financed by citizens for both target regions can be considered a feasible goal, while higher shares (in the range of 50–100% of the investments financed by citizens) will be very challenging. With regard to PV, the Flemish Local Energy and Climate Pact aims for an additional cooperative/ participatory project per 500 inhabitants in Flanders by 2030 (assuming an average PV project of 18 kW_p). Given the investment potential for REC PV projects, these ambitions can be considered feasible.

In the **Netherlands**, a political goal of 50% ownership of RES capacity on land by the local environment by 2030 has been set forward. The results of the REC potential calculation for **Noord Brabant** show that this target can most likely only be reached by complementing the direct citizen investments with investments by local SMEs and local authorities. In addition, the availability of access to finance on favourable conditions (e.g. public financing, low interest rates for investment loans in RECs, etc.) seems to be a key enabler. At the end of 2020, 1,3% of Dutch households were members of a cooperative. The 'latent potential' of 30% household participation in RECs by 2030 assumed in this REC potential calculation is therefore certainly challenging. It will require a significant leap in scale and professionalization of the cooperative movement.

In **Norway**, the REC ownership potential is considerable for all three technologies. Assuming minimum socio-economic investment potential and assuming that 100% of the investment is financed by households, Norwegian households could potentially own 31% of the wind energy, 44% of the collective rooftop PV and 52% of the ground mounted PV capacity installations expected between 2020 – 2030. For all three RES technologies, the minimum socio-economic investment potential is sufficiently large to ensure that more than 50% of the installed capacity between 2020 – 2030 could be effectively controlled by Norwegian households. However, realising the full investment potential could require addressing existing barriers, including regulatory barriers, a lack of enabling frameworks and support schemes for RECs. RED II (article 2(16)) requires that RECs be *effectively controlled* by shareholders or members located in the *proximity* of the RES projects. RECs have not been legally defined in Norway, and RED II is still under review. For the purposes of the REC potential calculation, the whole of Norway has been taken as one target region. If a stricter interpretation of proximity than the one used here is applied, for instance that a REC must be effectively controlled by shareholders or members located in the same county as the RES project, the potential of RECs in the energy transition in Norway could possibly be lower than is identified here. This is perhaps especially the case for wind energy, as the wind energy potential is unevenly distributed between counties. For instance, more than 20% of the wind energy capacity installation is expected in the county of Trøndelag, where around 9% of the Norwegian population resides. Another factor which could serve to limit the potential of RECs to participate in wind energy development between 2020 and 2030, is the fact that no further wind energy development is expected between 2022 – 2030 because of an ongoing change in the licensing procedure, creating uncertainty for potential investors. Thus, the potential for wind energy that we rely on here is a 'potential' that is already constructed (2020) or currently under construction (2021). Ownership of these projects is already established. The findings reported in Table 1 regarding the potential of Norwegian households to participate in financing wind energy only holds assuming that households are able invest in these projects, and assuming that the investment window is over the entire period 2020 – 2030. If the investment opportunities in wind energy are limited, the financial potential of RECs to participate in developing PV could be higher than indicated in Table 2 and Table 3.

In **Região Norte (Portugal)**, it is reasonable to consider that community PV initiatives may have an important role in the achievement of the national RES targets. However, it should also be noted that the investment potential of individual citizens alone would cover less than 30% of the required investment. Thus, to guarantee that citizens are active participants in the transition, the availability of access to finance on favourable conditions as well as the creation of community energy initiatives in collaboration with municipalities and local enterprises need to be ensured. Furthermore, as REC initiatives are in a nascent stage in Portugal, there may be additional barriers to the investment and development of RECs by individual citizens that need to be addressed by adequate policies, including mistrust regarding the concept, and lack of capacity and know-how on the procedures and best-practices by relevant stakeholders.

The REC potential assessment in **Thuringia (Germany)** seems promising. It shows that, especially with effective financial support schemes, the achievement of the political goals in Thuringia and the transition towards a 100% RES supply could be carried largely by citizens. Assuming that 20% of the needed investment cost are financed by citizens and 80% by other sources including debt capital, the new capacities of land-based PV installed by 2030 could be fully controlled by citizen collectives. For collective PV on rooftops, nearly all of the new installed capacities could be controlled by citizen collectives. Only for wind energy, the values are lower, varying between 45 and 91%. This is probably due to the fact that in the case of wind energy less new capacity needs to be installed and investment cost are proportionally higher than for the other two technologies. Assuming that 100% of the respective investment needs are financed by households, the corresponding shares of installed capacity controlled by citizen collectives vary between 9% and 18% for wind energy, 24 and 49% for land-based PV and 15 and 30% for rooftop PV. However, unlocking the 'latent potential' of household participation in RECs by 2030 and the assumed investment in RES per household in the calculations above appears very challenging. Based on internal data provided by ThEGA derived from the Core Energy Market Data Registry, we estimate that from the total installed PV capacity of 1852 MW_p in Thuringia (as of 26 August 2021, without section "other structures"), only roughly 1% is owned by citizen collectives. It has to be noted that the values we used are just proxies and might overestimate the actual potential because often they use the German average which is probably higher than the values for Thuringia, e.g. for the investment potential per household. Also, we assume that 37,7% of households in Thuringia would invest in RECs even though the value is only representative for Germany. Thuringians are usually less prone to invest in RES. Effectively tapping the potentials for REC development depends largely on a supportive legal and regulatory framework. On the one hand, Germany can be regarded as one of the pioneers in terms of community renewable energy and the share of citizen resp. community owned RES projects is relatively high compared to other European countries. On the other hand, the development of community energy has lost momentum and has been stagnating already for several years. Overall, the transition from a fixed-price support system to auctions and competitive bidding has tended to favor large players and at the same time led to a decline in the number of newly founded energy communities and energy cooperatives. Existing privileges for citizen energy companies in the auction system have not provided sufficient incentives to overcome the structural disadvantages these collective actors are facing in the auctions. Our calculations for Thuringia also show that the actual RES development is falling behind the announced objectives of the Thuringian government. In 2020, 122 MW_p of PV (total) were installed in Thuringia (ThEGA 2020). But to meet the goal of an additional 5738 MW_p in 10 years, annual net installations have to increase by 4,7 times. Nevertheless, there have been positive signals from the Thuringian Minister of Environment Anja Siegesmund who recently announced plans to increase the number of PV installations in Thuringia from 36.000 to 100.000 by 2025 (Siegesmund et al. 2021). The RED II provides new impetus for the development of community energy, but in Germany the transposition of the respective legal provisions into national law is lagging behind compared to other EU Member states. It is crucial that the federal government and also the state governments of the *Länder* create effective enabling frameworks for RECs as required by the RED II including the provision of start up financing, low interest loans or capacity development support.

The REC potential assessment for the **Warmian-Masurian Province (Poland)** looks equally promising. Despite the relatively low socio-economic investment potential, the resources brought in by RECs could enable to maintain a significant contribution of the region in the achievement of 32% of RES in the electricity sector in Poland in 2030. RES investments entirely financed by citizens seem likely to represent only a small share of the total investment needed in the region. However, assuming that 20% of the needed investment cost are financed by citizens and the rest by other sources including financial support schemes and debt capital, the new capacities of both ground-based and rooftop PV could fully be controlled by citizens on the condition of utilisation of the maximum investment potential. If one takes into account that for reasons of simplification and lack of data, the calculations for the Warmian-Masurian province do not make a distinction between individual and collective PV projects on rooftops, the percentage of collective projects under citizen control could even be higher. For wind energy, the values are lower, ranging from 33% to 67%. It shows that necessary investments in large-scale wind energy need to be accompanied by other investors/companies. Looking at Tables 1-3, it is likely that the political goal for onshore wind and PV indicated in the Polish National Energy and Climate Plan can be fully reached by complementing the citizen investments with investments by local SMEs and local authorities. However, in order to unlock this potential, an enabling framework seems to be needed. Polish citizen energy has been principally developed based on individual prosumers, triggered by a net-metering scheme introduced in 2016. Despite the intense promotion of individual prosumerism, there is still a lack of business models enabling collective actions. The legal definition of an energy cooperative and provisions for a dedicated support scheme introduced in 2019 still do not allow for the creation and operation of such entities. There is a need for new regulations, which are being prepared by the Ministries along with provisions on virtual and collective prosumption.

Introduction

General outline of Task 2.2

Task 2.2 includes **rough assessments of the potentials for RECs** in the COME RES target regions. These assessments rely on a common methodology and take into consideration **the specific climate, energy, technological and socio-economic conditions**. They are based on a **cascade approach**: starting from the technical (calculated on the basis of data such as available land, rooftop areas, housing types, climatic conditions) or political RES potential (derived from policy targets contained in energy and climate actions plans, laws, programmes or government declarations), we estimate the maximum amount of investment in RES projects by households in the different target regions over the period 2020-2030. Finally, the fraction of this economic potential that would be particularly suitable to be **unlocked by community approaches** is estimated (based on e.g. surveys revealing citizens' willingness to invest in cooperatives and other collective forms of organisation).

Key definitions and concepts

COME RES follows the definitions of renewable energy communities (RECs) established at the EU level by RED II[1] and of citizen energy communities (CECs) established by the Integrated Electricity Market Directive (IEMD)[2] which focuses on communities' capacity, inter alia, to generate, consume, store, share, and sell renewable energy (RED II, Article 22; IEMD, Article 16). In line with these Directives, we understand community energy as those initiatives where **natural persons, local authorities (including municipalities) or SMEs participate directly** in **producing, consuming, storing, sharing selling or distributing renewable energy**, either **on their own or acting in partnership with others** (RED II, Article 2, IEMD, Article 2). RECs are distinguished primarily through open, voluntary participation of natural persons, local authorities or SMEs, local ownership and control, their non-commercial purpose and orientation towards community benefits. RECs can be regarded as a subset of citizen energy community (CECs) defined in the IEMD.

The formal definitions of a REC and CEC are as follows:

Table 4 Definition of Renewable and Citizen Energy Community

	Definition
Renewable Energy Community	A legal entity: a) which, (…) is based on **open and voluntary participation**, is **autonomous**, and is **effectively controlled** by shareholders or members that are located in the **proximity of the renewable energy projects** that are owned and developed by that legal entity; b) the shareholders or members of which are **natural persons, SMEs or local authorities**, including municipalities; c) the **primary purpose** of which is to provide **environmental, economic or social community benefits** for its shareholders or members or for the local areas where it operates, rather than financial profits. The entity is entitled to **produce, consume, store and sell renewable energy**, as well as **to share** energy produced by the production units

[1] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32018L2001&from=EN

[2] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32019L0944

	owned by the REC, and **access** all suitable energy markets both directly or through aggregation in a non-discriminatory manner.
Citizen Energy Community	A legal entity that: a) is based on **voluntary and open participation** and is **effectively controlled** by members or shareholders that are **natural persons, local authorities**, including municipalities, or **small enterprises**; b) has for its **primary purpose** to provide **environmental, economic or social community benefits** to its members or shareholders or to the local areas where it operates rather than to generate financial profits; and c) may engage in **generation, including from renewable sources, distribution, supply, consumption, aggregation, energy storage, energy efficiency services** or **charging services** for electric vehicles or provide other energy services to its members or shareholders. CEC are also entitled to **own, establish, purchase or lease distribution networks** and to autonomously manage them as well as **to share electricity** that is produced by the production units owned by the community.

Assumptions for calculation purposes

For the purpose of the potential assessment, we focus on **RECs that participate in the production of renewable energy in the form of ground- and roof-based solar PV and onshore wind energy.** This represents only a subset of the full REC potential in the COME RES target regions, but estimates of the potential of RECs engaging in other activities (selling, storing, or distributing energy) cannot be made on any reliable basis.

Furthermore, we assume that the proximity rule in the definition of a REC implies **that only natural persons, SMEs or public authorities residing in the target region can invest in the production of renewable energy in that target region**.

Fig. 1 explains the different possible forms of participation in a RES project and makes a distinction between financial participation without ownership and forms of shareholding with ownership.

Financial participation without ownership encompasses every form of investment in the realization of RES installations by various parties (e.g. private banks, public authorities, citizens) without becoming a co-owner of the installation. Since the definition of a REC explicitly states that the REC should be 'effectively controlled' by shareholders or members that are located in the proximity of the RES installation, mere financial participation in a RES project does not meet the criteria for becoming a REC.

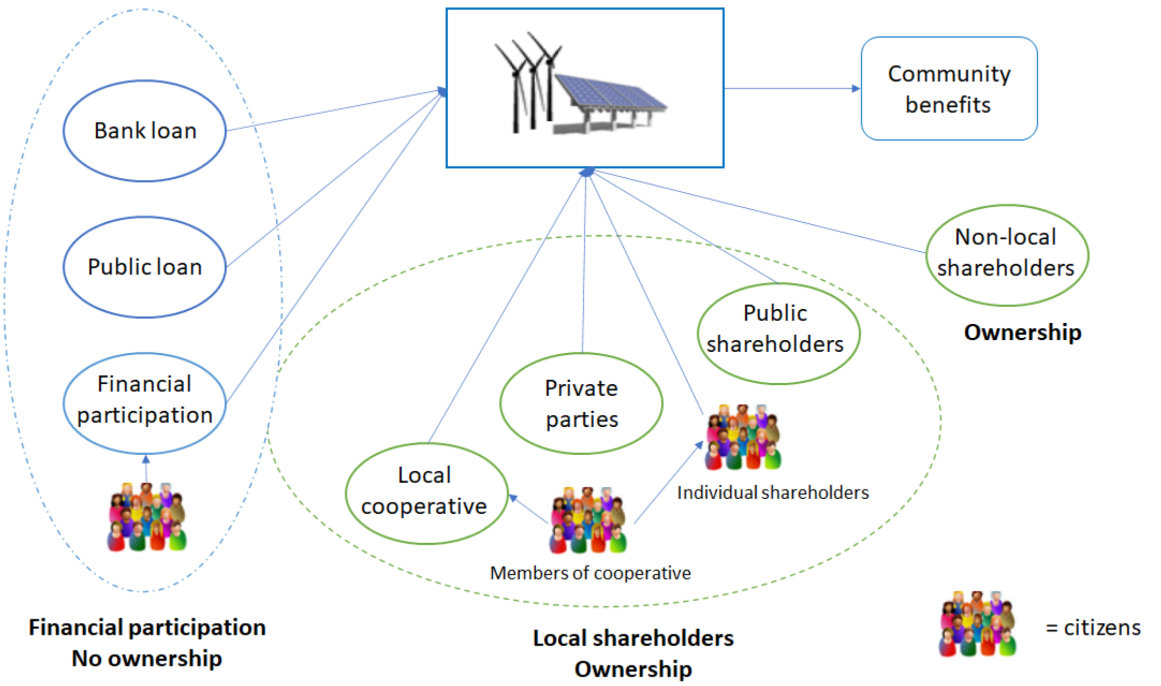

Figure 1: *Different types of participation in a renewable energy project.*
Blue = financial participation without ownership; Green = ownership by different types of shareholders

Ownership can be arranged in different ways. In practice, ownership of a RES installation is most of the time placed in the hands of a private limited company. In this case, the owners are the shareholders. The share ratio determines the distribution of ownership. The shareholders finance the installations by contribution of equity and have control in the company. If a cooperative is a shareholder, then the cooperative is (co-)owner. The members contribute "member capital" as equity capital in the company. This means that there is a financial participation of the members of the cooperative. The members are not individually "co-owners", there is collective ownership. If the members of the cooperative and participants in the project live or work in the vicinity of the project, this form of ownership can be called "local cooperative ownership". If they live elsewhere, there is only "cooperative ownership". Other forms of organizing local ownership can also be envisaged. For example, a local foundation as shareholder and (co-) owner can manage the installations on behalf of the residents. Local residents have no say and in principle cannot co-invest directly through the foundation. They often participate by purchasing shares from the limited company and the foundation represents their interests. **Effective control** of a RES project means that local citizens (possibly represented through a cooperative or foundation), SMEs or public authorities **own at least 51%** of the shares of the limited company owning the RES installation.

For the purpose of the REC potential assessment, we **focus on those initiatives that put the citizen at the center, i.e. RES projects where the free and voluntary participation in the ownership structure of the project is encouraged**. The potential assessment will be based on the **capacity of citizens to invest in renewable energy projects**. It is important to underline that REDII also allows associations that only consist of SMEs and/or local governments to be classified as RECs. However, it is beyond the scope of Task 2.2 to provide a detailed assessment of the potential and willingness to invest of local SMEs and public authorities in the different target regions.

It should be stressed that all of these assumptions are only made for the purposes of enabling our calculation. In no way do they reflect the actual transposition of REC criteria in national laws;

nor do they imply a recommendation from our side on how key criteria should be interpreted in the transposition.

Technology and time horizon

Each target region focuses on the RES technology as **specified in the thematic focus** of the COME RES project (i.e. ground- and roof-based solar PV or onshore wind energy). The COME RES project also focus in integrated solutions and target regions focusing on integrated solution provide potentials for both ground- and roof-based solar PV and onshore wind energy. Integrated community energy solutions with some form of storage technology (e.g. batteries) will most likely develop over the coming decade in order to provide flexibility services to distribution grids suffering from capacity problems. A potential assessment for integrated solutions would however require detailed knowledge about the state of the distribution grid in the different target regions, which is beyond the scope of the present exercise.

The **time horizon is set at 2030** (in accordance with NECPs for the different countries). For the calculations, we take as the starting point 1 January 2020 and as the end point 31 December 2030. This means that the calculations will be based on the **additional investment needs in community RES over a 11-year time period**.

Methodology

The methodology follows a cascade approach.

It starts from an estimate of **the total wind and/or solar power capacity installed** in the different target regions in 2030. This potential can be estimated on the basis of a bottom-up calculation (using parameters such as available land area) or on the basis of political commitments (e.g. political targets). This estimate also gives an idea about the total RES investments needed by all actors (not limited to the RECs) by 2030.

Next, we determine (based on annual household investment statistics) the **upper limit of household investments in renewable energy** for each of the target regions. This estimate yields an upper limit because the assumption is that every household of the target region that has spare money available for investments will actually invest this money in RES production capacity.

Finally, we estimate the socio-economic investment potential for households based on the **percentage of households that could potentially invest in RES production** (as revealed e.g. in surveys). By splitting this investment potential over the different options for investment (rooftop PV, ground-based PV or wind power) we derive an estimate of the individual shares (in %) of production capacity for these different technologies that could be controlled by RECs in 2030.

Technical/political potential

Potential for ground-based PV and wind power

Depending on available data, different methods can be used to estimate the potential for ground-based PV and/or wind power capacity in the target region. If available, the calculation should start from politically negotiated targets for the ground-based PV and wind power in the target region. Alternatively, if such targets are not available, a bottom-up methodology is presented.

Political potential

The preferred calculation method starts from politically agreed targets for ground-based PV and/or wind power in 2030 for the target region.

If these targets are not available on the level of the target region, **the national targets** (in % of final energy use) are used **as a proxy** for the target region. If the targets are expressed in GW of installed capacity, the area of the target region divided by the total surface area of the country can be used as a downscaling factor for the target region.

If the political targets do not specify separate targets for ground-based vs. rooftop PV, **an estimate** (e.g. 20% ground-based, 80% rooftop) is used.

Technical potential

The alternative calculation based on the technical potential starts from the **available land area** (km²) in the target region for ground-based PV or wind power. **Spatial planning provision**s (e.g. excluded Natura 2000 areas) and other **legal provisions** (e.g. limits to construction of wind power plants near airports) are taken into account.

The suitable land area (km²) in the target region is multiplied with the **average energy density** of ground-based PV or wind power plants (MW/km²) to obtain an estimate of the technical potential in the target region.

However, not all of this technical potential will be used by 2030. Estimates should therefore be based on a realistic growth path for ground-based PV and/or wind power based on e.g. expert opinion, available scenarios or trend analyses.

Potential for rooftop PV

Depending on available data, different methods can be used to estimate the potential for rooftop PV in the target region. If available, the calculation should start from politically negotiated targets for rooftop PV in the target region. Alternatively, if such targets are not available, a bottom-up methodology is presented.

Political potential

The preferred calculation method starts from politically agreed targets for rooftop PV in 2030 for the target region.

If such targets are not available on the level of the target region, **the national targets** (in % of final energy use) are used **as a proxy** for the target region. If the targets are expressed in terms of installed capacity, the built surface area of the target region divided by the total built surface area of the country is used as a downscaling factor for the target region.

If the political targets do not specify separate targets for ground-based vs. rooftop PV, **an estimate** (e.g. 20% ground-based, 80% rooftop) is used.

Next, **a distinction is made between small single household PV installations** and **larger PV rooftop installations.**[3] If no exact figures are available, an estimate is used (e.g. based on the national average).

Technical potential

The alternative calculation based on the technical potential starts from the **available rooftop area** (m²) in the target region. An overview of methods for estimating the technical PV potential in the target region can be found in NREL (2013).

Where possible, a distinction is made between **the rooftop surface available on 'collective' public or private buildings** (e.g. public buildings, apartment buildings, office buildings, schools, swimming pools etc.) and the **rooftop surface available on single-family houses**.

The available rooftop area (m²) in the target region is multiplied with a **factor reflecting the suitability of roofs** (e.g. not every roof has the right kind of orientation) and the **average energy density** of PV installations (kW_p/m^2) to obtain an estimate of the technical potential in the target region.

Not all of this technical potential will be used by 2030, however. Estimates should therefore be based on a realistic growth path for rooftop PV based on e.g. available scenarios or trend analyses.

Theoretical maximum investment potential by households

First, data about the number of households in the target region in 2020 and 2030 are obtained. The average of both figures is used as the basis for the calculations.

[3] The exact definition of 'small' and 'large' installations will likely depend on national or regional regulations. In the Netherlands for instance, small installations are defined as installations below 15 kW peak capacity, large installations include every installation beyond 15 kW peak capacity.

Next, the maximum investment in renewable energy production capacity per household over the period 2020-2030 is determined.

We assume that investment in RES depends on the **average household investments** in EU countries (available from Eurostat).[4] Household investment mainly consists of the purchase and renovation of dwellings.[5] If specific data for the target region are available, these are used instead.

Table 5 Calculation of average annual household investment per capita, expressed in Euro Purchasing Power Standard (PPS) (2015-2019)

Country	Average annual household disposable income per capita (PPS, Euro, 2015-2019)	Average annual household investment rate (% of disposable income, 2015-2019)	Average annual household investment per capita (PPS, Euro, 2015-2019)
Belgium	25752	9,42	2424,8
Germany	28796	9,65	2780,0
Italy	22047	7,75	1708,6
Latvia	14473	5,34	772,8
Netherlands	25319	10,88	2753,7
Norway	28604	12,25	3505,1
Poland	15997	6,56	1049,1
Portugal	18280	5,11	934,5
Spain	19682	5,06	996,7

We take these data as broadly indicative of the willingness to invest in (shares of) energy communities. The recent official Dutch potential assessment (AS I-search, 2019) uses different scenarios with regard to the willingness of Dutch households to invest in RES over the period 2018-2030. The maximum average investment of Dutch households over this period of time is assumed to be 2500 Euro.

Table 6 Calculation of minimum and maximum household investment in RES over 2020-2030, expressed in Euro PPS

Country	Average household size	Estimated min. investment in RES per household (Euro)	Estimated max. investment in RES per household (Euro)
Belgium	2,3	1227	2454
Germany	2,0	1223	2446
Italy	2,3	865	1729
Latvia	2,3	391	782
Netherlands	2,1	1272	2544
Norway	2,0	1542	3085
Poland	2,8	646	1293
Portugal	2,5	514	1028
Spain	2,5	548	1096

[4] www.ec.europa.eu/eurostat/databrowser/view/tec00098/default/table?lang=en

[5] The household investment rate is defined as gross investment (gross fixed capital formation; mainly dwellings) divided by gross disposable income (adjusted for the change in pension entitlements) of the household sector in national accounts. Household investment mainly consists of the purchase and renovation of dwellings. Consumer durables (which include passenger cars) are not considered as part of household investment.

Taking into account that according to Table 5, Dutch households invest on average 69393 Euro[6] over a 12-year time period, 2500 Euro represents about 4% of this total amount. **Therefore, in view of the uncertainty surrounding this figure we propose to use 4% of the average household investment over 2020-2030 as the upper limit for the estimate on investment in RES in the different target regions, and 2% as a lower limit**. The **min. and max. investment in renewable energy per household** for the target region is then multiplied with the **number of households** to get an estimate of the total min. and max. theoretical maximum investment potential by households over the period 2020-2030.

Socio-economic investment potential by households

Estimate of percentage of households potentially investing in RECs

The calculation presented in the previous section assumes that every household in the target region will invest in some way in RES production. This is of course not realistic. Therefore, in this step of the calculation we try to estimate the number of households that could potentially invest in RES over the period 2020-2030, based on sociological data.

Data to make this estimate can come from many sources. We give a few examples:

- **Public opinion surveys**: number of households that express a willingness to participate in energy communities, or a willingness to invest in PV, or a favourable attitude to RES, etc.
- **Trend analysis**: extrapolation of the growth in energy communities (no. of participating households, no. of cooperatives, or other indicators available) over the last few years (e.g. 2015-2020) to 2030.
- **Assumptions**: if no data on public opinion or trends are available, assumptions can be based on other data such as the number of communities in the target region that have signed the Covenant of Mayors, or have expressed ambitions to e.g. become climate neutral by 2050, etc.

Based on either public opinion, trend analysis or other assumptions, the socio-economic investment potential by households can be calculated.

Split of socio-economic investment potential over different RES options

Next, the total socio-economic investment potential needs to be split over the different RES technology options.

We assume that **the split between investment in either wind energy or solar PV** reflects the additional capacity for both technologies needed in the target region. E.g. if you need 2 GW additional capacity in wind energy, and 1 GW additional capacity in solar PV, then 2/3 of the citizen investments will go to wind power, and 1/3 to solar.

Calculation of wind REC potential

Starting from the technical or political potential for wind energy (in GW):

- From this potential the **already installed wind capacity** at the end of 2019 (if needed, extrapolated from the last year where data are available) in the target region is subtracted (this

[6] The average size of a Dutch household equals 2,1 persons.

step is not needed if the calculation immediately starts from the additional potential for the target region).

- The resulting figure is multiplied by the **average investment cost for wind energy** (MEuro/GW) in the target region.
- Separate calculations are made for two cases:
    - Assuming that 100% of the investment is financed by households.
    - Assuming that 20% of the investment is financed by households (and the rest via other financing sources).[7]
- This result is compared to the (min. and max.) socio-economic investment potential by households in wind energy calculated in the previous section.

The final result can be expressed as a percentage share of wind power capacity owned by citizen collectives in 2030.

Calculation of PV REC potential

Starting from the technical or political potential for ground-based and rooftop PV (in GW_p)[8]:

- From these potentials the **already installed ground-based/rooftop PV capacity** at the end of 2019 in the target region is subtracted (this step is not needed if you start from the calculation of the additional potential for the target region).
- It is assumed that **20% of the additional small PV capacity** will be available for community investments[9].
- The resulting figures are multiplied by the **average investment cost for ground-based/rooftop PV** (in $kEuro/kW_p$) in the target region.
- Separate calculations are made for two cases, reflecting two extremes of citizen financing of RES projects:
    - Assuming that 100% of the investment is financed by households.
    - Assuming that 20% of the investment for ground-based and large rooftop PV is financed by households (and the rest via other financing sources).
- The sum of the needed investment in ground-based/rooftop PV for complete citizen control is made and compared to the (min. and max.) socio-economic investment potential by households in PV calculated under step 5.

The final result can be expressed as a percentage share **of PV capacity owned by citizen collectives in 2030**.

[7] This is an assumption of the maximum risk that a bank (or other financial institution) would be willing to take on when investing in a RES project.
[8] All solar power capacities are expressed in Watt-peak. A Watt-peak equals the rate at which a photovoltaic installation generates electricity under ideal conditions (w.r.t. solar irradiation, temperature, placement of the installation, etc.).
[9] This assumption reflects our judgment that the majority of small PV installations will still be financed and owned by individual households.

References

AS I-Search (2019). Verkenning toekomstpotentieel burger-energiebeweging 2030. Energie in eigendom van de lokale gemeenschap. Rapport in opdracht van het ministerie van Economische Zaken en Klimaat, mede op verzoek van Energie Samen (samenwerkende energiecoöperaties).

National Renewable Energy Laboratory (NREL) (2013). Estimating Rooftop Suitability for PV: A Review of Methods, Patents, and Validation Techniques. NREL Technical Report TP-6A20-60593, December 2013.

Standal et al. (2021). D2.1 Assessment Report on Technical, Legal, Institutional and Policy Conditions. COME RES report https://come-res.eu/fileadmin/user_upload/Resources/Deliverables/COME_RES_D2.1__Assessment_report_FINAL.pdf

Target region potential assessments

Apulia (Italy)

Political/technical potential

The long-term goals of relying on sustainable energy sources for Italian energy provision in 2050 are established at national level within the National Integrated Plan for Energy and Climate (PNIEC). Italian national targets are set for 2030 in terms of RES share (30% of final consumption, 21,6% for mobility consumption), energy efficiency (-43% vs PRIMES scenario 2007) and reduction of CO_2 emissions (-33% vs 2005) (MiSE, 2020). According to PNIEC, the following RES capacities could be installed in Italy by 2030:

- Wind energy: 19,3 GW
- PV: 50,9 GW_p

In order to evaluate the potential for the Apulia target region some approximations were carried out based on the share (%) of regional wind and PV capacity with respect to the national installed capacity (Table 7 and Table 8) (GSE, 2019).

Table 7 Installed wind capacity in the Apulia Region and Italy in 2019

2019	Tot (MW)	Micro onshore wind (<1MW)	Small and large onshore wind
Installed wind capacity - Apulia Region	2571	131	2440
% for wind installed type for Apulia	-	5%	95%
Installed wind capacity – Italy	10740	458	10282
% for wind installed type for Italy	-	4%	96%
% share of wind already installed in Apulia with respect to Italy	**24%**	**29%**	**24%**

Table 8 Installed PV capacity in the Apulia Region and Italy in 2019

2019	Tot	Micro PV (up ≤20kW_p)	Small and large PV	Land	Rooftops
Installed PV capacity - Apulia Region (MW_p)	2.826	259	2.567	2.120	707
% for PV type - Apulia	-	9,2%	90,8%	75%	25%
Installed PV capacity – Italy (MW_p)	20865	4486	16379	8763	12102
% for PV type for Italy	-	21,5%	78,5%	42%	58%
% installed PV capacity in Apulia with respect to Italy	**13,5%**	**5,8%**	**15,7%**	**24,2%**	**5,8%**

Therefore, based on the national political goals for wind energy (19,3 GW by 2030), in Italy 8560 MW should be installed, corresponding to an increase of 80% to the installed capacity. Since 24% of the total Italian wind energy capacity is installed in Apulia, this percentage has been considered to estimate the investment cost for Apulia, with respect to the total estimated cost for Italy (12840 MEuro), which is 3074 MEuro (Table 9).

Table 9 Investment need for wind energy in the Apulia Region and Italy

Political target in 2030	Unit	Comment	Source
19,3	GW	Italy - wind political goal in 2030	MiSE, 2019
10740	MW	Italy - installed capacity in 2019	GSE, 2019
8560	MW	Italy - to be installed over the period 2020-2030	MiSE, 2019
12840	MEuro	Italy - assumed investment cost = 1,5 MEuro/MW	GSE, 2017
3074	**MEuro**	Apulia - estimated investment cost for Apulia	ENEA's elaborations

The national political goal for PV energy is 50,9 GW_p by 2030. Therefore, in Italy 30,034 GW_p should still be installed, which corresponds to an increase of 59% to the installed capacity. 13,5% of the total Italian wind capacity has been installed in Apulia and this percentage has been considered to estimate the investment cost for Apulia, with respect to the total estimated cost for Italy (55564 MEuro), resulting in an estimated investment of 7526 MEuro (Table 10).

Table 10 Investment need for PV energy in the Apulia Region and Italy

Political target in 2030	Unit	Comment	Source
50,9	GW_p	Italy - PV political goal in 2030	MiSE, 2019
20865	MW_p	Italy - installed capacity in 2019	GSE, 2019
30034	MW_p	Italy - to be installed over the period 2020-2030	MiSE, 2019
55564	MEuro	Italy - assumed investment cost = 1,5 MEuro/MW	GSE, 2017
7526	**MEuro**	Apulia - estimated investment cost for Apulia	ENEA's elaborations

Although there was no differentiation between the targets for PV rooftops and ground-based installations, estimates of the investment costs were made considering the share of rooftop and ground-based installations already existing in Italy and Puglia (Table 8).

Table 11 shows the investment need for large and small collective installations for the Apulia Region and Italy which is 4118 and 415 MEuro for large and small installation in Apulia and 25982 and 7491 MEuro in Italy.

Table 11 Investment need for PV on rooftops in in Apulia and Italy

Political target in 2030	Unit	Comment	Source
29,5	GW_p	Italy – estimated PV on rooftops political goal in 2030	ENEA's elaborations
13675	MW_p	Italy – estimated political goal for large (+15 kWp) collective installations	ENEA's elaborations
3745	MW_p	Italy – estimated political goal for small (-15 kW_p) collective installations	ENEA's elaborations
9500	MW_p	Italy – large collective installations installed in 2019	GSE, 2019
2602	MW_p	Italy – small installations installed in 2019	GSE, 2019

25982	MEuro	Italy – investment need for large collective installations. assumed investment cost = 1,9 MEuro/MW_p installed	ARERA, 2018
7491	MEuro	Italy – investment need for small collective installations. assumed investment cost = 2 MEuro/MW_p installed	ARERA, 2018
4118	**MEuro**	Apulia – investment need for large collective installations. assumed investment cost = 1,9 MEuro/MW_p installed	ENEA's elaborations
415	**MEuro**	Apulia – investment need for small collective installations. assumed investment cost = 2 MEuro/MW_p installed	ENEA's elaborations

Table 12 shows the investment need for large and small collective installations for the Apulia Region and Italy which amounts to 2558 and 258 MEuro respectively, for large and small installation in Apulia, compared to 15844 and 5017 MEuro in Italy.

Table 12 Investment need for ground-based PV in Apulia and Italy

	Unit	Comment	Source
21,378	GW_p	Italy – estimated land-based PV political goal in 2030	ENEA's elaborations
9902	MW_p	Italy – estimated political goal for large (+15 kW) collective installations	ENEA's elaborations
2712	MW_p	Italy – estimated political goal for small (-15 kW) collective installations	ENEA's elaborations
6879	MW_p	Italy – large collective installations installed in 2019	GSE, 2019
1884	MW_p	Italy – small installations installed in 2019	GSE, 2019
15844	MEuro	Italy – investment need for large collective installations. assumed investment cost = 1,6 MEuro/MW installed	ARERA, 2018
5017	MEuro	Italy – investment need for small collective installations. assumed investment cost = 1,85 MEuro/MW installed	ARERA, 2018
2558	MEuro	Apulia – investment need for large collective installations. assumed investment cost = 1,6 MEuro/MW installed	ENEA's elaborations
258	MEuro	Apulia – investment need for small collective installations. assumed investment cost = 1,85 MEuro/MW installed	ENEA's elaborations

Socio-economic investment potential of citizens

According to the Italian National Institute of Statistics (ISTAT) (ISTAT, 2018 and 2011), the Apulia Region counted on average 1568135 households between 2011 and 2018.

Using the figures of Table 6 (on the min. and max. investment in RES per household), we obtain the following min. and max. theoretical investment potential by households in Apulia over the period 2020-2030:

- Min. theoretical investment potential: **1326 MEuro**
- Max. theoretical investment potential: **2771 MEuro**

Regarding PV, some studies report that on average, only 5% of the Italian households would be willing to invest in PV while 40% would be willing to invest in thermal insulation of buildings and other energy efficiency improvements (Qualenergia, 2020). So, 5% is considered as a proxy of the willingness to invest in RES. Moreover, 30% is the proportion of homes suitable for PV estimated for whole Italy (EC, 2016). We estimated that this value can be increased to 45% for Apulia because its latitude and the favourable climate.

The min. and max. theoretical investment potential by households in Apulia over the period 2020-2030 will be:

- Min. theoretical investment potential: **19,9 MEuro**
- Max. theoretical investment potential: **41,6 MEuro**

However, these figures could be underestimated, especially if one takes into account the attractive financial incentives recently introduced to support the spread of energy communities.

Potential assessment for RECs

Using the calculation rules for dividing the (minimum and maximum) socio-economic investment potential over the three RES technologies, Table 13 indicates the REC potential assessment for Apulia, expressed as percentage ownership by citizens under two separate conditions (ownership for 100% financed by citizens vs. ownership for 20% financed by citizens).

Table 13 REC potential assessment for Apulia

Investment potential	Min.	Max.	Unit
Wind energy	88,3	184,4	MEuro
% ownership (100% financed by citizens)	**3%**	**6%**	
% ownership (20% financed by citizens)	**14%**	**30%**	
Ground-based PV	98	204	MEuro
% ownership (100% financed by citizens)	**4%**	**7%**	
% ownership (20% financed by citizens)	**17%**	**36%**	
Collective PV on rooftops	44,90	93,8	MEuro
% ownership (100% financed by citizens)	**1%**	**2%**	
% ownership (20% of large installations financed by citizens)	**5%**	**10%**	

Looking at Table 13, the potential assessment for RECs in Apulia shows that citizens can scarcely contribute to reach the political goals for wind and PV, both ground-based and on rooftops. In this region there is clearly a need for SMEs and local public authorities to complement the citizen investments. In addition, the availability of access to finance on favourable conditions (e.g. public financing, low interest rates for investment loans in RECs, etc.) seems to be a key enabler.

The transposition of EU Directives including REDII can act as a driver for REC initiatives. In particular, removing the limit capacity of 200kW, currently embedded in the national legislation, is an important step for the promotion of RECs since the existing limit represents a significant barrier for the diffusion of RECs in Italy. Moreover, the Italian Recovery Plan (Piano Nazionale di Ripresa e Resilienza – PNRR), aimed to overcome the economic consequences of the COVID-19 pandemic, reserves a dowry of 2,2 billion Euro concentrated on families, micro-enterprises and public administrations in municipalities with less than 5000 inhabitants, that could possibly represent a useful support to finance public-private REC initiatives.

References

ARERA (2018) Valutazioni sui costi e sulla possibile remunerazione degli interventi per consentire la progressiva copertura del fabbisogno delle isole minori non interconnesse attraverso energia da fonti rinnovabili, ai fini dell'attuazione del DM 14.02.2017

EC (2015) "Study on "Residential Prosumers in the European Energy Union", JUST/2015/CONS/FW/C006/0127

GSE (2019) Solare Fotovoltaico - Rapporto Statistico 2019

GSE (2017) il punto sull'eolico Ministry of Economic Development (MiSE) (2020) National Integrated Plan for Energy and Climate

ISTAT (2011) Population Census 2011

ISTAT (2018) Bilancio demografico della popolazione residente 2018

Italian Government (2021) https://www.governo.it/sites/governo.it/files/PNRR.pdf

Ministero dello sviluppo economico (2019), III PIANO NAZIONALE INTEGRATO PER L'ENERGIA E IL CLIMA

Qualenergia (2020) https://www.qualenergia.it/articoli/poverta-energetica-e-abitudini-di-consumo-energetico-delle-famiglie-italiane/

Baleares (Spain)

Political/technical potential

The Spanish National Energy and Climate Plan (NECP) has set the objective of generating 74% of its energy needs through renewable sources by the end of the decade.[10] In line with the national climate ambitions, the region of Baleares has adopted measures in order to significantly increase its renewable energy installed capacity by 2030. The following RES capacities could be installed in the region by 2030 to meet the sustainable energy share ambition:

- PV on rooftops: 338 MW_p
- Ground-based PV: 286 MW_p

For estimating the rooftop PV capacity, the Spanish target expressed in the NECP has been multiplied by a factor equal to the ratio of the built-up area in the Baleares and the built-up area in Spain. For estimating the ground-based PV capacity, the Spanish target expressed in the NECP has been multiplied by a factor equal to the ratio of the total surface area of the Baleares and the total surface area of Spain.

The following tables calculate the corresponding investment needs for the different RES technologies.

Table 14 Investment need for ground-based PV in Baleares

	Unit	Comment	Source
286	MW	Political goal for 2030	
161	MW	Installed capacity in 2019	
125	MW	To be installed over the period 2020-2030	
372	**MEuro**	Assumed investment cost = 1300 Euro/kW	Solarplus (2021)

Table 15 Investment need for PV on rooftops in Baleares

	Unit	Comment	Source
338	MW	Political goal for 2030	
101	MW	Political goal for large (>10 kW) collective installations, assumption: 30% share in 2019 is kept constant	UNEF
47	MW	Political goal for small (<10 kW) collective installations. Assumption: 70% share in 2019 is kept constant. Assumption: 20% of small installations will be collective	UNEF
21	MW	Large collective installations installed in 2019	
49	MW	Small installations installed in 2019	
81	MW	Large collective installations capacity to be installed over the period 2020-2030	
47	MW	Small collective installations capacity to be installed over the period 2020-2030. Assumption: no small collective PV installations yet	
121	**MEuro**	Investment need for large collective installations. Assumed investment cost = 1300 Euro/kW	Solarplus (2021)
71	**MEuro**	Investment need for small collective installations. Assumed investment cost = 1300 Euro/kW	Solarplus (2021)

[10] https://ec.europa.eu/energy/sites/default/files/documents/es_final_necp_main_es.pdf

Socio-economic investment potential of citizens

According to the Spanish National Statistics Institute, Baleares will count on average 476223 households between 2020 and 2030. Using the figures of Table 6 (on the min. and max. investment in RES per household), we obtain the following min. and max. theoretical investment potential by households in Baleares over the period 2020-2030:

- Min. theoretical investment potential: **261 MEuro**
- Max. theoretical investment potential: **521,9 MEuro**

We assume that 30% would be indicative of the percentage of households in the Balearic Islands that would be willing to invest in RECs over the period 2020-2030, and therefore we obtain the following figures for the socio-economic investment potential by households:

- Min. socio-economic investment potential: **78,3 MEuro**
- Max. socio-economic investment potential: **156,57 MEuro**

Potential assessment for RECs

Using the calculation rules for dividing the (minimum and maximum) socio-economic investment potential over the two RES technologies, Table 16 indicates the REC potential assessment for the region of Baleares, expressed as percentage ownership by citizens under two separate conditions (ownership for 100% financed by citizens vs. ownership for 20% financed by citizens).

Table 16 REC potential assessment for Baleares

Investment potential	Min.	Max.	Unit
Ground-based PV	31,2	62,5	MEuro
% ownership (100% financed by citizens)	19%	38%	
% ownership (20% financed by citizens)	96%	192%	
Collective PV on rooftops	39,6	79,2	MEuro
% ownership (100% financed by citizens)	21%	41%	
% ownership (20% of large installations financed by citizens)	103%	206%	

Looking at Table 16, it is likely that the political goal of 50% ownership of RES capacity on land by local actors by 2030 can be reached without a need for complementing the citizen investments with investments by local SMEs and local authorities. Nevertheless, the availability of access to finance on favourable conditions (e.g. public financing, low interest rates for investment loans in RECs, etc.) could help arrive to the goal.

References

Solarplus (2021). Paneles solares fotovoltaicos y sus precios en 2021, available at https://solarplus.es/precios-paneles-fotovoltaicos

Spanish Government (2020). Plan Nacional Integrado de Energía y Clima 2021-2030, available at https://ec.europa.eu/energy/sites/default/files/documents/es_final_necp_main_es.pdf

Unión Española Fotovoltaica, available at https://unef.es/

Covenant of Mayors for Climate and Energy, available at https://www.covenantofmayors.eu

Canarias (Spain)

Political/technical potential

The Spanish National Energy and Climate Plan (NECP) has set the objective of generating 74% of its energy needs through renewable sources by the end of the decade.[11] In line with the national climate ambitions, the region of Canarias has adopted measures in order to significantly increase its renewable energy installed capacity by 2030. The following RES capacities could be installed in the Canarias by 2030 to meet the sustainable energy share ambition:

- PV on rooftops: 444 MW_p
- Ground-based PV: 429 MW_p

For estimating the rooftop PV capacity, the Spanish target expressed in the NECP has been multiplied by a factor equal to the ratio of the built-up area in the Canarias and the built-up area in Spain. For estimating the ground-based PV capacity, the Spanish target expressed in the NECP has been multiplied by a factor equal to the ratio of the total surface area of the Canarias and the total surface area of Spain.

The following tables calculate the corresponding investment needs for the different RES technologies.

Table 17 Investment need for ground-based PV in Canarias

	Unit	Ccomment	Source
429	MW	Political goal for 2030	Canary Government (2017)
170	MW	Installed capacity in 2019	
259	MW	To be installed over the period 2020-2030	
558	**MEuro**	assumed investment cost = 1300 Euro/kW_p	Solarplus (2021)

Table 18 Investment need for PV on rooftops in Canarias

	Unit	Comment	Source
444	MW	Political goal for 2030.	Canary Government (2017)
133	MW	Political goal for large (>10 kW) collective installations, assumption: 30% share in 2019 is kept constant	UNEF
62	MW	Political goal for small (<10 kW) collective installations. Assumption: 70% share in 2019 is kept constant. Assumption: 20% of small installations will be collective.	UNEF
7	MW	Large collective installations installed in 2019.	
16	MW	Small installations installed in 2019.	
126	MW	Large collective installations capacity to be installed over the period 2020-2030	
59	MW	Small collective installations capacity to be installed over the period 2020-2030. Assumption: no small collective PV installations yet	
163,8	**MEuro**	Investment need for large collective installations. Assumed investment cost = 1300 Euro/kW	Solarplus (2021)
76,7	**MEuro**	Investment need for small collective installations. Assumed investment cost = 1300 Euro/kW	Solarplus (2021)

[11] https://ec.europa.eu/energy/sites/default/files/documents/es_final_necp_main_es.pdf

Socio-economic investment potential of citizens

According to the Spanish National Statistics Institute, Canarias will count on average 882489 households between 2020 and 2030. Using the figures of Table 6 (on the min. and max. investment in RES per household), we obtain the following min. and max. theoretical investment potential by households in Canarias over the period 2020-2030:

- Min. theoretical investment potential: **483,6 MEuro**
- Max. theoretical investment potential: **967,2 MEuro**

We assume that 30% would be indicative of the percentage of households in the Canary Islands that would be willing to invest in RECs over the period 2020-2030, and therefore we obtain the following figures for the socio-economic investment potential by households:

- Min. socio-economic investment potential: **145,1 MEuro**
- Max. socio-economic investment potential: **290,1 MEuro**

Potential assessment for RECs

Using the calculation rules for dividing the (minimum and maximum) socio-economic investment potential over the two RES technologies, Table 19 indicates the REC potential assessment for the Canary Islands, expressed as percentage ownership by citizens under two separate conditions (ownership for 100% financed by citizens vs. ownership for 20% financed by citizens).

Table 19 REC potential assessment for Canarias

Investment potential	Min.	Max.	Unit
Ground-based PV	84	168	MEuro
% ownership (100% financed by citizens)	25%	50%	
% ownership (20% financed by citizens)	125%	249%	
Collective PV on rooftops	61,1	122,2	MEuro
% ownership (100% financed by citizens)	25%	50%	
% ownership (20% of large installations financed by citizens)	125%	249%	

Looking at Table 19, it is likely that the political goal of 50% ownership of RES capacity on land by the local environment by 2030 can be reached without a need for complementing the citizen investments with investments by local SMEs and local authorities. Nevertheless, the availability of access to finance on favourable conditions (e.g. public financing, low interest rates for investment loans in RECs, etc.) may contribute towards achieving the goal.

References

Canary Government (2017). Estrategia Energética de Canarias 2015-2025, available at https://www.gobiernodecanarias.org/cmsweb/export/sites/energia/temas/planificacion/EECan25_DocumentoPreliminar_junio2017.pdf

Solarplus (2021). Paneles solares fotovoltaicos y sus precios en 2021, available at https://solarplus.es/precios-paneles-fotovoltaicos

Spanish Government (2020). Plan Nacional Integrado de Energía y Clima 2021-2030, available at https://ec.europa.eu/energy/sites/default/files/documents/es_final_necp_main_es.pdf

Unión Española Fotovoltaica, available at https://unef.es/

Covenant of Mayors for Climate and Energy, available at https://www.covenantofmayors.eu/

Latvia

Political/technical potential

In line with EU climate ambitions, Latvia has adopted the long-term goal to be climate-neutral. "Latvia's Strategy towards Climate-Neutrality by 2050" (MEPRD, 2020) provides for almost 100% renewable energy sources in 2050 (the remaining very minor fossil fuel share shall be compensated by carbon sequestration). The feasibility of the climate neutrality goal has been evaluated by the Institute of Physical Energetics (IPE, 2019).

For the year 2030, an ambition level of 50% renewable energy in total gross final energy consumption has been stated (ME, 2020a). The technical and economic feasibility of this goal has also been evaluated by IPE in the process of the development of *Latvia National Energy and Climate Plan 2021-2030 (NECP 2030*). The NECP 2030 anticipates that the RES share will increase both in the electricity, heating and transport sectors in order to meet the overall RES target for 2030. The NECP 2030 only fixes the RES sub-target for the transport sector, in its turn, the RES sub-targets in the electricity and heating sectors are set as desirable ones to meet the overall RES target meaning that some inter-sectorial compensation could take place. The following wind and solar electricity annual production could be provided in Latvia by 2030 to meet the noted 50% renewable energy share ambition (ME, 2020a):

- Wind energy: 2,21 TWh/year
- PV energy: 0,031 TWh/year.

Based on these projected RES-electricity generation data, the following **additional onshore wind and solar PV capacities** could be installed:

- onshore wind: 403 MW
- grid connected solar PV: 29,5 MW_p

The remainder of the necessary RES-electricity capacity to reach the 50% renewable energy target is filled in by a share of the offshore wind capacity projected to be installed in 2030.

Onshore wind capacity is calculated based on 2100 equivalent hours of full load annually. Solar PV capacity is calculated based on 1050 equivalent hours of full load annually.

20% (5,9 MWp) of total solar PV capacity is allocated as ground-based and 80% (23.6 MWp) - as roof-based. One third (7,9 MWp) of rooftop based solar PV would be larger scale (> 11.1 kWp) and two thirds (15,7 MWp) – smaller scale (≤ 11.1 kWp). This assumption is based on the information on installed capacities provided by the power distribution system operator (PDSO) assuming that the shares of larger scale and smaller scale PV installations in 2019 are kept constant in 2030.

This 11,1 kWp capacity is the current Latvian threshold determining the connection rules if it is intended to connect the electricity generation facility to the grid.[12] For the smaller installations the simplified procedure is applied. Thus, this distinction shows what counts as a larger project and what counts as a smaller one. For instance, smaller solar PV projects are well suited for the start-up of collective actions in multi-apartment buildings and row-houses.

The information provided by PDSO indicates that 20% of larger scale rooftop solar PV installations are owned by individual households and 80% by companies. The share of installations owned by individual

[12] see pages 110 and 111 in the COME RES Deliverable 2.1

households in 2019 is kept constant also for 2030, meaning that 80% of larger scale roof-based PV installations will be available for community investments.

Regarding the small scale (≤11,1 kW_p) rooftop PV installations, it is assumed that 20% of it will be available for community investments, following the methodology as described above. The following tables show the investment needs calculation for the different RES technologies.

Table 20 Investment need for additional onshore wind energy capacity in Latvia

	Unit	Comment	Source
1054	MW	Political goal for 2030: total wind energy capacity (both onshore and off-shore)	Latvia NECP2030: Target Scenario
454	MW	Political goal for 2030: onshore wind energy capacity	Latvia NECP2030: Target Scenario
51	MW	Installed capacity in March 2021	Power Distribution System Operator SC "Sadales tīkli" (PDSO)
403	MW	To be installed onshore over the period 2020-2030	
483	**MEuro**	Investment need, assumed investment cost = 1,2 MEuro/MW	Latvia's NECP2030 Technical Annex

Table 21 Investment need for ground-based PV capacity in Latvia

	Unit	Comment	Source
5.9	MW_p	Political goal for 2030	Latvia NECP2030: Target Scenario
0	MW_p	Installed capacity	
5.9	MW_p	To be installed over the period 2020-2030	
5.6	**MEuro**	Investment need, assumed investment cost = 950 Euro/kWp	Latvia's NECP2030 Technical Annex

Table 22 Investment need for PV capacity on rooftops in Latvia

	Unit	Comment	Source
23.6	MW_p	Political goal for 2030: total capacity (both individual and collective)	Latvia NECP2030: Target Scenario
6.4	MW_p	Associated goal for large (> 11.1 kW) collective installations, assumption: 80% of large installations will be collective	
3.1	MW_p	Associated goal for small (≤ 11.1 kW) collective installations, assumption: 20% of small installations will be collective	
0	MW_p	Large collective installations installed in 2020	
0	MW_p	Small collective installations installed in 2020	
6.4	MW_p	Large collective installations capacity to be installed over the period 2020-2030	
3.1	MW_p	Small collective installations capacity to be installed over the period 2020-2030.	
7.4	**MEuro**	Investment need for large collective installations, assumed investment cost = 1150 Euro/kWp	Latvia's NECP2030 Technical Annex
3.6	**MEuro**	Investment need for small collective installations, assumed investment cost = 1150 Euro/kWp	

To interpret the results calculated for solar PV on roofs, we have also estimated the technical potential of roof-top based collective solar PV.

The data on total floor area of multi-apartment buildings and non-residential buildings are based on the latest Latvia's Long-Term Strategy for the Renovation of Buildings (ME, 2020b). The following non-residential buildings have been considered as potentially suitable for collective PV installation: education sector buildings, libraries, sport buildings, health sector buildings, buildings for large scale events as well as office buildings. Thus, commerce office buildings have also been considered as perspective participants in RECs. The likelihood of various roofs to be "offered" for collective installations has been projected for non-residential buildings (varied from "1" for education sector and municipal public buildings down to "0.15" for commerce office buildings). The percentage of total rooftop area suitable for PV installation is based on the summary table of findings of studies concerning constant-value methods (NREL, 2013). As a result, the technical potential of rooftop based collective solar PV has been evaluated 644 MW_p for apartment buildings and 240 MW_p for non-residential buildings (among them the education sector buildings account for the largest share – 139 MW_p). This means that there is plenty of available rooftop space to meet the political target and from the technical point of view the optimal sites for collective PV installations might be selected. The result also demonstrates that long-term strategy is necessary to capitalise all the rooftop collective solar PV potential.

Socio-economic investment potential of citizens

According to the Central Statistics Bureau of Latvia (CSB), Latvia will count on average 817900 households between 2020 and 2030. Using the figures of Table 6 (on the minimum and maximum investment in RES per household), we obtain the following minimum and maximum theoretical investment potential by households in Latvia over the period 2020-2030:

- Minimum theoretical investment potential: **319,8 MEuro**
- Maximum theoretical investment potential: **639,6 MEuro**

Socio-economic investment potential

Currently 29 % of dwellings are in single-family (detached) houses and row houses and 71% in apartment buildings (CSB, 2021).

To evaluate the number of households – potential participants of RECs, we exclude the households which would install individual solar PV. As described above, to meet the political target of total solar PV capacity, the total capacity of individual solar PV in 2030 would be around 14 MW_p. 30% of detached houses in rural areas are assumed as potential installers of this capacity.

Thus, **775080** households in Latvia are considered as the potential participants of RECs.

Minimum socio-economic investment potential

For this scenario we have assumed that on average ***14% of the households in Latvia would be willing to join an energy community over the period 2020-2030***. The choice of this percentage is based on the study by Brauwer and Cohen (2020). By applying the *Choice Experiment* method, this study has estimated the respondents' willingness to invest in a community wind farm. The representative study has covered all EU-28 countries, including 600 respondents in Latvia. The attributes characterising the community wind farm in this *Choice Experiment* were: 20-year holding period, country-specific market-based (unsubsidized) annual profit rate, park is visible to the investor. The probability that respondents will invest in a community wind farm in Latvia was evaluated 14,73%.

In the preparatory phase for COME-RES, in spring 2020 we consulted a M.Sc. thesis on the social acceptance of wind energy and suggested to also examine the willingness to invest in community wind farms based on the best practice cases of the WinWind[13] project. The respective survey (Dance, 2020) was conducted in Latvia and covered 129 respondents from whom 15,5% answered that they would participate in a community wind farm. Even being a non-representative survey, the results compare well to the above-noted *Choice Experiment.*

Even if the data used for the minimum socio-economic investment potential focus on community wind projects, it makes sense to use them as a proxy for each of RES technologies since wind has to contribute the most to achieve the political RES target.

Maximum socio-economic investment potential

To evaluate the maximum socio-economic investment potential scenario we have used both the higher value of investment presented in Table 6 as well as the increased share of household participation. For this scenario we use the overall data on household potential interest to participate in an energy community independently on the RES technology. In turn, solar PV is the most promising option which might attract other interested households.

The upper (latent) share of the household participation in RECs is set at 30%.

This share is based, e.g., on the share of Estonian households - one third of total number (Enefit, 2021) - which would like to choose green electricity. Estonia is Latvia's neighbour and currently is undergoing an active implementation of solar PV in households, thus the Estonian experience is valuable also for Latvia. We have also used the results of several academic studies (Broughel and Hampl, 2018; Curtin et al., 2019) to evaluate the share of households which would like to participate in energy communities. Based on these studies, the share of "rather yes/likely" participation might be assumed up to 40% while 30% is a cautious threshold.

Therefore, we obtain the following figures for the socio-economic investment potential by households in Latvia:

- Minimum socio-economic investment potential: **42,4 MEuro**
- Maximum socio-economic investment potential: **181,8 MEuro**

Potential assessment for RECs

Table 23 indicates the REC potential assessment for Latvia under two separate conditions:

1. 100% financed by citizens, without using any other financial instruments,
2. 20% financed by citizens and the rest 80% covered with a bank loan and/or other financial instruments.

In the calculation, citizens' investments in wind and solar PV has not been distributed proportionally to the RES-electricity generation data projected by the NECP 2030. As it has been underlined in the introduction, the NECP 2030 figures for RES-electricity generation are desirable ones and a shift between the technologies might be possible.

[13] WinWind project resources. Deliverables 4.2 and 4.3, https://winwind-project.eu/home/

Based on the trends of RES capacity installed over the last two years (information provided by PDSO), we use the following projections for citizens' investment distribution: 40% for wind energy, 10% for ground-based solar PV and 50% for rooftop solar PV. Thus, this projection reflects the acceptability of RES technologies in Latvia and the currently ongoing active installation of solar PV.

Table 23 REC potential assessment for Latvia

Investment potential	Min.	Max.	Unit
Wind energy onshore	17,0	72,7	MEuro
% ownership (100% financed by citizens)	**4%**	**15%**	
% ownership (20% financed by citizens)	**18%**	**75%**	
Ground-based PV	4,2	18,2	MEuro
% ownership (100% financed by citizens)	**76%**	**324%**	
% ownership (20% financed by citizens)	**378%**	**1622%**	
Collective PV on rooftops	21,2	90,9	MEuro
% ownership (100% financed by citizens)	**194%**	**830%**	
% ownership (small installations 100% financed by citizens large installations 20% financed by citizens)	**419%**	**1797%**	

The total investment need for additional RES-electricity capacity amounts to around 500 MEuro, not including offshore wind farms. Latvia's minimum socio-economic investment potential could provide around 8,5% and maximum socio-economic investment potential around 36,4% of this investment need, calculated on the basis of 100% investment financed by citizens. Effective information and communication channels, the availability of public financing to support REC projects development, one stop agencies providing the necessary expertise, and pilot projects as examples are crucial factors for capitalizing the minimum scenario of household participation in RECs.

The calculation results related to solar PV even in a minimum socio-economic scenario with 100% citizens' own investment show a high potential contribution of RECs to reaching the political goal for solar PV. The calculation results show that the potential of solar PV technologies in the NECP 2030 was significantly underestimated. On the other hand, these results show the potential of solar PV, particularly owned by RECs, to contribute to the new increased GHG emission reduction targets for 2030.

Capitalizing the latent 30% household participation in RECs over next 10 years will be a challenging task. Being feasible in principle, it will require not only an adequate legislative framework and favourable financial mechanisms, but also efforts to provide information and communication in an effective way, the promotion of motivating factors and effective local leaders. Municipalities as well as regions should play the role of support centres for RECs offering sites for RES installations and providing publicly funded expertise on legal, economic and technical issues (complementary to support activities provided at national level). Participation of municipalities in RECs can provide the necessary trust for such projects. Regarding the financial framework, the availability of access to funds on favourable conditions (public co-financing of investment, low interest financial instruments available for RECs) and complementing citizen investment with investment by local SMEs and municipalities are crucial factors for capitalizing the maximum scenario of household participation in RECs.

References

Brauwer de Pons-Seres C. and Cohen J.J (2020). Analysing the potential of citizen-financed community renewable energy to drive Europe's low-carbon energy transition. *Renewable and Sustainable Energy Reviews, 122 (2020) 110300*

Broughel A.E. and Hampl N. Community financing of renewable energy projects in Austria and Switzerland: Profiles of potential investors. *Energy Policy 123 (2018), 722-736*

Curtin J., McInerney C., Gallachóir B.Ó., Salm S. (2019). Energizing local communities—What motivates Irish citizens to invest in distributed renewables? *Energy Research & Social Science, 48 (2019). 177-188.*

Dance Baiba. Possible driving forces for social acceptance and social inclusive use of wind energy in Latvia (Iespējamie virzītājspēki vēja enerģijas akceptēšanai un sociāli iekļaujošai izmantošanai). M.Sc. thesis, Faculty of Geography and Earth Sciences, University of Latvia, Riga, 2020, available on request https://dspace.lu.lv/dspace/handle/7/51051

Danish Catalogue of Technology Data for Energy Technologies (2019). Published by the Danish Energy Agency and Energinet, available at https://ens.dk/en/our-services/projections-and-models/technology-data

Enefit (2021). Enefit offers 100% sun or wind for household (Enefit piedāvā izvēlēties 100% saules vai vēja enerģiju mājoklim). Enefit news, 16th April 2021, available at https://www.enefit.lv/majai/zinas/Enefit-piedava-izveleties-100-saules-vai-veja-energiju-majoklim

Institute of Physical Energetics (IPE) (2020). Latvijas tautsaimniecības attīstības iespējamo scenāriju līdz 2050.gadam izstrāde atbilstoši Eiropas Savienības ilgtermiņa attīstības redzējumam. Authors of the report: Klāvs G., Reķis J., Kudreņickis I. (IPE), Bērziņa L. (Latvia University of Life Sciences and Technologies), Knite M. (Oxfor Research Baltic), available at http://petijumi.mk.gov.lv/sites/default/files/title_file/FEI_atskaite_scenariji2050_GK_final.pdf

Ministry of Economics (ME) (2020a). Latvia National Energy and Climate Plan 2021-2027. Approved by the Cabinet of Ministers Order No 46 (4th February 2020), available at https://ec.europa.eu/energy/sites/ener/files/documents/lv_final_necp_main_en.pdf

Ministry of Economics (ME) (2020b). Latvia Long-Term Strategy for Renovation of Buildings. Viewed by the Cabinet of Ministers, 10th November 2020, available at https://ec.europa.eu/energy/sites/default/files/documents/lv_2020_ltrs_official_translation_en.pdf

Ministry of Environmental Protection and Regional Development (MEPRD) (2020). Informative Report "Latvia Strategy towards Climate-Neutrality by 2050" (Informatīvais ziņojums "Latvijas stratēģija klimatneitralitātes sasniegšanai līdz 2050.gadam), accepted by the Cabinet of Ministers 28th January 2020, available at POLSIS (Policy planning documents database), http://polsis.mk.gov.lv/documents/6641

National Renewable Energy Laboratory (NREL) (2013). Estimating Rooftop Suitability for PV: A Review of Methods, Patents, and Validation Techniques. NREL Technical Report TP-6A20-60593, December 2013.

Limburg and West-Vlaanderen (Belgium/Flanders)

Political/technical potential

In the Flemish Energy and Climate Action Plan 2030[14] (VR 2019 0912 DOC.1208/3BIS) targets are set for wind onshore and PV by 2030, namely:

- Wind: 2,5 GW installed capacity by 2030
- PV: 6,7 GW_p installed capacity by 2030

Given that open space is scarce in Flanders, PV is mainly installed on roofs. Also, the target for PV focuses on rooftop PV and is based on the solar map of the Flemish Energy and Climate Agency.[15] This map shows the available roof areas in Flanders, whereby only roof surfaces with an optimal orientation, without shading and with a sufficient surface area are selected.

As there are no targets set for wind and PV by 2030 on the level of the target regions, the Flemish targets are used as a proxy. The capacity installed in the target region in 2020 divided by the capacity installed in 2020 in Flanders, is used as a downscaling factor:

- Wind: 20% (province of Limburg) and 14% (province of West-Vlaanderen)[16]
- PV: 20% (province of Limburg) and 22% (province of West-Vlaanderen)[17]

For PV a distinction can be made between installations <= 10 kW_p (small scale) and installations > 10 kW_p (large scale). Based on the "Visienota Zonneplan 2025"[18] (VR 2020 2711 DOC.1327/1TER), we assume that 60% of the additional PV capacity to be installed is <= 10 kW_p and 40% of the additional PV capacity to be installed is > 10 kW_p. As stated in the methodology section, it is assumed that 20% of the additional PV capacity <= 10 kW_p will be available for community investments. Also for the target regions, we focus on the potential for rooftop PV and do not calculate a potential for ground-mounted PV.

Table 24 Investment need for wind energy in Limburg

	Unit	Comment	Source
2,49	GW	Political goal Flanders in 2030	Flemish Energy and Climate Action Plan 2030
0,51	GW	Goal of province of Limburg in 2030, downscaling factor: 20% (installed capacity of wind in 2020 in Limburg divided by installed capacity of wind in 2020 in Flanders)	https://www.energiesparen.be/energiekaart (consulted on: 2/04/2021)
280,2	MW	Installed capacity in 2020 in province of Limburg	https://www.energiesparen.be/energiekaart (consulted on: 2/04/2021)
229	MW	To be installed over the period 2020-2030	
298	**MEuro**	Average investment cost = 1,3 MEuro/MW	VEKA (2020b)

[14] https://www.energiesparen.be/vlaams-energie-en-klimaatplan-2021-2030 .
[15] https://www.energiesparen.be/zonnekaart
[16] Based on installed capacity of wind in 2020 in Flanders and the target regions as reported in: https://www.energiesparen.be/energiekaart (consulted on: 2/04/2021).
[17] Based on installed capacity of PV in 2020 in Flanders and the target regions as reported in: https://www.energiesparen.be/energiekaart (consulted on: 2/04/2021).
[18] https://energiesparen.login.kanooh.be/sites/default/files/atoms/files/Zonneplan2025.pdf .

Table 25 Investment need for PV on rooftops of Limburg

	Unit	Comment	Source
6,7	GW_p	Political goal of Flanders for 2030	Flemish Energy and Climate Action Plan 2030
1,34	GW_p	Goal of province of Limburg in 2030, downscaling factor: 20% (installed capacity PV in 2020 in Limburg divided by installed capacity PV in 2020 in Flanders)	Energiekaart (consulted on: 2/04/2021)
791	MW_p	Installed capacity in 2020 in province of Limburg	Energiekaart (consulted on: 2/04/2021)
219	MW_p	Large scale PV (> 10 kW_p) capacity to be installed over the period 2020-2030 assumption: 40% of additional capacity is PV > 10 kW_p	Visienota Zonneplan 2025
66	MW_p	Small scale PV (<= 10 kW_p) capacity to be installed over the period 2020-2030 assumption: 60% of additional capacity is PV <= 10 kW_p, of which 20% is collective	Visienota Zonneplan 2025
229	**MEuro**	PV > 10 kW_p; assumption: average investment cost = 1043 Euro/kW_p	VEKA (2020a)
69	**MEuro**	PV <= 10 kW_p; assumption: average investment cost = 1043 Euro/kW_p	VEKA (2020a)

Table 26 Investment need for wind energy in West-Vlaanderen

	Unit	Comment	Source
2,49	GW	Political goal of Flanders for 2030	Flemish Energy and Climate Action Plan 2030
0,36	GW	Goal of province of West-Vlaanderen in 2030, downscaling factor: 14% (installed capacity of wind in 2020 in West-Vlaanderen divided by installed capacity of wind in 2020 in Flanders)	Energiekaart (consulted on: 2/04/2021)
197,56	MW	Installed capacity in 2020 in province of West-Vlaanderen	Energiekaart (consulted on: 2/04/2021)
162	MW	To be installed over the period 2020-2030	
210	**MEuro**	Average investment cost = 1,3 MEuro/MW	VEKA (2020b)

Table 27 Investment need for PV on rooftops of West-Vlaanderen

	Unit	Comment	Source
6,7	GW_p	Political goal of Flanders for 2030	Flemish Energy and Climate Action Plan 2030
1,47	GW_p	Goal of province of West-Vlaanderen in 2030, downscaling factor: 22% (installed capacity PV in 2020 in West-Vlaanderen divided by installed capacity PV in 2020 in Flanders)	Energiekaart (consulted on: 2/04/2021)
868	MW_p	Installed capacity in 2020 in province of West-Vlaanderen	Energiekaart (consulted on: 2/04/2021)
241	MW_p	Large scale PV (> 10 kW_p) capacity to be installed over the period 2020-2030 assumption: 40% of additional capacity is PV > 10 kWp	Visienota Zonneplan 2025

72	MW_p	Small scale PV (<= 10 kW_p) capacity to be installed over the period 2020-2030 assumption: 60% of additional capacity is PV <= 10 kW_p, of which 20% is collective	Visienota Zonneplan 2025
251	**MEuro**	PV > 10 kWP; assumption: average investment cost = 1043 Euro/kW_p	VEKA (2020a)
75	**MEuro**	PV <= 10 kWp; assumption: average investment cost = 1043 Euro/kW_p	VEKA (2020a)

Socio-economic investment potential of citizens

According to Statistics Flanders, the province of Limburg will count on average 375118 households over the period 2020-2030. The province of West-Vlaanderen will count on average 543075 households over the period 2020-2030.[19] Using the figures of Table 6 (on the min. and max. investment in RES per household), we obtain the following min. and max. theoretical investment potential by households over the period 2020-2030:

- Min. theoretical investment potential: **460 MEuro** (province of Limburg) and **666 MEuro** (province of West-Vlaanderen)
- Max. theoretical investment potential: **921 MEuro** (province of Limburg) and **1333 MEuro** (province of West-Vlaanderen)

In a survey of the Flemish Energy and Climate Agency in 2018 on the public support for wind, 16% of the respondents replied that "*they would certainly participate financially if a wind turbine would be installed in their neighbourhood*".[20] We take the percentage of 16% to be indicative of the percentage of households in the target regions that would be willing to invest in RECs over the period 2020-2030. As such, we obtain the following figures for the socio-economic investment potential by households in the target regions:

- Min. socio-economic investment potential: **74 MEuro** (province of Limburg) and **107 MEuro** (province of West-Vlaanderen)
- Max. socio-economic investment potential: **147 MEuro** (province of Limburg) and **213 MEuro** (province of West-Vlaanderen)

We want to point out that the 'latent potential' of 16% household participation in RECs by 2030 and the assumed investment in RES per household in the calculations above are challenging. Based on data provided by REScoop Vlaanderen[21], we estimate that approximately **0,7% of PV capacity** installed in Flanders in 2020 was owned by energy cooperatives, compared to **4,1% of wind capacity** installed. In 2020 there were 73500 cooperants in Flanders or approximately **2,6 % of the private households** in Flanders. Cooperants invested on average 1098 Euro per cooperant in 2020.

Potential assessment for RECs

Using the calculation rules for dividing the (minimum and maximum) socio-economic investment potential over the two RES technologies, Table 28 and Table 29 indicate the REC potential assessment

[19] www.statistieken.vlaanderen.be/QvAJAXZfc/opendoc.htm?document=svr%5Csv-demografie-projectieshuishoudens-20180226.qvw&host=QVS%40cwv100154&anonymous=true (consulted on: 08/04/2021)
[20] Draagvlak windenergie. Resultaten uit de enquête 2018 (Vlaams Energieagentschap, 2018). Available at: https://www.energiesparen.be/sites/default/files/atoms/files/draagvlak_windenergie_2018.pdf .
[21] Mail communication with Dhr. Jan de Pauw (dd. 6/04/2021).

for respectively the province of Limburg and the province of West-Vlaanderen, expressed as percentage ownership by citizens under two separate conditions (ownership for 100% financed by citizens vs. ownership for 20% financed by citizens).

Table 28 REC potential assessment for Limburg

Investment potential	Min.	Max.	Unit
Wind energy	32,8	65,6	MEuro
% ownership (100% financed by citizens)	**11%**	**22%**	
% ownership (20% financed by citizens)	**55%**	**110%**	
Ground-based PV	-	-	
% ownership (100% financed by citizens)	**-**	**-**	
% ownership (20% financed by citizens)	**-**	**-**	
Collective PV on rooftops	40,8	81,7	MEuro
% ownership (100% financed by citizens)	**14%**	**27%**	
% ownership (20% of installations > 10 kWp financed by citizens)	**36%**	**71%**	

Table 29 REC potential assessment for West-Vlaanderen

Investment potential	Min.	Max.	Unit
Wind energy	36,3	72,6	MEuro
% ownership (100% financed by citizens)	**17%**	**35%**	
% ownership (20% financed by citizens)	**86%**	**173%**	
Ground-based PV	-	-	
% ownership (100% financed by citizens)	**-**	**-**	
% ownership (20% financed by citizens)	**-**	**-**	
Collective PV on rooftops	70,3	140,6	MEuro
% ownership (100% financed by citizens)	**22%**	**43%**	
% ownership (20% of installations < 10 kWp financed by citizens)	**56%**	**112%**	

End of 2013, the province of Limburg decided on a minimum of **20%** direct participation in the ownership and management structure of large wind turbines by the local community and local authorities.[22] The municipalities of Torhout and Oostkamp, located in the province of West-Vlaanderen, aim for a direct participation of **35%** (of citizens and local authorities) in wind project on their territory through an energy cooperative, with a minimum of at least one wind turbine [23] [24]. Looking at the investment potential for wind projects (expressed in %) in Table 28 and Table 29, a share of 20% of the investments financed by citizens can be considered feasible. A share of 50 – 100% of the investments financed by citizens will be very challenging.

The Local Energy and Climate Pact[25] aims for an additional cooperative/participatory renewable energy project per 500 inhabitants in Flanders by 2030 (assuming an average PV project of 18 kW_p). Given that the province of Limburg counts 899748 inhabitants by 2030[26], this would imply an investment of **32,4 MEuro** (cf. assumption in Table 25 of 1043 Euro investment per kW_p). For the province of West-Vlaanderen that counts 1236201 inhabitants by 2030[27], this would imply an investment of **46,4 MEuro**. Looking at the investment potential for PV projects (in Euros) in Table 28 and Table 29, these ambitions can be considered feasible.

References

Besluit Provincieraad Limburg (20/11/2013), available at: https://www.rescoopv.be/sites/default/files/PRB_LIMBURG_20131120-draagvlakmodel_windenergie.pdf

Een Lokaal Energie- en Klimaatpact tussen de Vlaamse Regering en de Vlaamse steden en gemeenten., available at: https://www.bartsomers.be/swfiles/files/Lokaal-Energie--en-Klimaatpact.pdf .

Energiekaart (consulted on: 2/04/2021). Available at: https://www.energiesparen.be/energiekaart

Notulen gemeentraad Oostkamp (18/01/2018), available at: https://www.rescoopv.be/sites/default/files/20180118%20Oostkamp.pdf

Notulen gemeenteraad Torhout (29/01/2018), available at: https://www.rescoopv.be/sites/default/files/GRB_Torhout%20windenergie.pdf

Statistiek Vlaanderen (consulted on: 8/04/2021), available at: https://statistieken.vlaanderen.be/QvAJAXZfc/opendoc.htm?document=svr%5Csv-demografie-projectieshuishoudens-20180226.qvw&host=QVS%40cwv100154&anonymous=true

Statistiek Vlaanderen (consulted on: 8/04/2021), available at: https://statistieken.vlaanderen.be/QvAJAXZfc/notoolbar.htm?document=SVR%2FSV-Demografie-ProjectiesBevolking-20180226.qvw&host=QVS%40cwv100154&anonymous=true

[22] Besluit Provincieraad Limburg (20/11/2013). Available at: https://www.rescoopv.be/sites/default/files/PRB_LIMBURG_20131120-draagvlakmodel_windenergie.pdf .

[23] Notulen gemeenteraad Torhout (29/01/2018). Available at: https://www.rescoopv.be/sites/default/files/GRB_Torhout%20windenergie.pdf

[24] Notulen gemeentraad Oostkamp (18/01/2018). Available at: https://www.rescoopv.be/sites/default/files/20180118%20Oostkamp.pdf

[25] Een Lokaal Energie- en Klimaatpact tussen de Vlaamse Regering en de Vlaamse steden en gemeenten. Available at: https://www.bartsomers.be/swfiles/files/Lokaal-Energie--en-Klimaatpact.pdf

[26] https://statistieken.vlaanderen.be/QvAJAXZfc/notoolbar.htm?document=SVR%2FSV-Demografie-ProjectiesBevolking-20180226.qvw&host=QVS%40cwv100154&anonymous=true (consulted on: 08/04/2021)

[27] https://statistieken.vlaanderen.be/QvAJAXZfc/notoolbar.htm?document=SVR%2FSV-Demografie-ProjectiesBevolking-20180226.qvw&host=QVS%40cwv100154&anonymous=true (consulted on: 08/04/2021)

VEKA (2020a). RAPPORT 2020/1 Rapport OT/Bf voor projecten met een startdatum vanaf 1 april 2020, available at: https://www.energiesparen.be/monitoring-en-evaluatie/rapporten

VEKA (2020b). RAPPORT 2020/3 Rapport OT/Bf voor windprojecten op land met een startdatum vanaf 15 september 2020, available at: https://www.energiesparen.be/monitoring-en-evaluatie/rapporten

Visienota Zonneplan 2025. Ter-nota aan de Vlaamse Regering (VR 2020 2711 DOC.1327/1TER). Betreft: visienota Zonneplan 2025, available at: https://energiesparen.login.kanooh.be/sites/default/files/atoms/files/Zonneplan2025.pdf

Vlaams Energieagentschap (2018). Draagvlak windenergie. Resultaten uit de enquête 2018, available at: https://www.energiesparen.be/sites/default/files/atoms/files/draagvlak_windenergie_2018.pdf

Vlaams Energie en Klimaat Actieplan 2030. Algemeen kader voor de geïntegreerde energie- en klimaatplannen (VR 2019 0912 DOC.1208/3BIS), available at: https://omgevingvlaanderen.login.paddlecms.net/sites/default/files/atoms/files/VR%202019%200912%20DOC.1208-3%20VEKP%2021-30%20-%20bijlageBIS.pdf

Noord Brabant (the Netherlands)

Political/technical potential

In line with national climate ambitions, the province of Noord Brabant has adopted the long-term goal of relying on 100% sustainable energy sources for its energy provision in 2050.[28] For the year 2030, an ambition level of 50% has been formulated. The technical and spatial feasibility of these goals has been evaluated by the University of Eindhoven (TU/e, 2021). Three different scenarios ('conservative', 'innovative' and 'disruptive') incorporating different energy system transition pathways have been formulated. According to the middle ('innovative') scenario (which we will use to base our potential assessment on), the following RES capacities could be installed in Noord-Brabant by 2030 to meet the 50% sustainable energy share ambition:

- PV on rooftops: 9,5 GW_p
- Ground-based PV: 7,5 GW_p
- Wind energy: 1,4 GW

The remainder of the needed capacity to reach the 50% goal is filled in by a share of the total offshore wind energy capacity projected to be installed in 2030.

The following tables calculate the corresponding investment needs for the different RES technologies.

Table 30 Investment need for wind energy in Noord-Brabant

	Unit	Comment	Source
1,4	GW	Political goal for 2030	TU/e (2021)
225	MW	Installed capacity in 2019	Centraal Bureau Statistiek[29]
1175	MW	To be installed over the period 2020-2030	
1410	**MEuro**	Assumed investment cost = 1,2 MEuro/MW	AS-I Search (2019)

Table 31 Investment need for ground-based PV in Noord-Brabant

	unit	Comment	source
7,5	GW_p	Political goal in 2030	TU/e (2021)
95	MW_p	Installed capacity in 2019	Centraal Bureau Statistiek
7405	MW_p	To be installed over the period 2020-2030	
7035	**MEuro**	Assumed investment cost = 950 Euro/kW_p	AS-I Search (2019)

Table 32 Investment need for PV on rooftops in Noord-Brabant

	unit	comment	source
9,5	GW_p	Total political goal for 2030	TU/e (2021)
4,47	GW_p	Political goal for large (+15 kW_p) collective installations, assumption: 47% share in 2019 is kept constant	Centraal Bureau Statistiek
1,01	GW_p	Political goal for small (-15 kW_p) collective installations, assumption: 53% share in 2019 is kept constant Assumption: 20% of small installations will be collective	Centraal Bureau Statistiek

[28] https://publicaties.brabant.nl/energietransitie-in-brabant/inhoudsopgave/
[29] https://www.cbs.nl/nl-nl/maatwerk/2019/49/regionale-energiestrategieen-regio-s-in-nederland

494	MW_p	Large collective installations installed in 2019	Centraal Bureau Statistiek
553	MW_p	Small installations installed in 2019	Centraal Bureau Statistiek
3971	MW_p	Large collective installations capacity to be installed over the period 2020-2030	
1007	MW_p	Small collective installations capacity to be installed over the period 2020-2030. assumption: no small collective PV installations yet	
3971	**MEuro**	Investment need for large collective installations. Assumed investment cost = 1000 Euro/kW_p	AS-I Search (2019)
1007	**MEuro**	Investment need for small collective installations. Assumed investment cost = 1000 Euro/kW_p	AS-I Search (2019)

In addition, the national climate agreement stipulates a political goal (for the whole of the Netherlands) that 50% of the ground-based RES capacity (excluding PV on rooftops) should be owned by 'the local environment'. AS I-Search and Bosch & Van Rijn (2020) specify that 'owned by the local environment' means that everyone in the local area surrounding the RES project has the opportunity to invest and become co-owner and that actors from the broad environment are involved as co-owner (often in the form of a collective partnership). Therefore, the 50% ownership goal includes but is not limited to ownership by citizens (as individuals or organized in a collective).

Socio-economic investment potential of citizens

According to the Dutch Central Statistics Bureau, the province of Noord-Brabant will count on average 1211400 households between 2020 and 2030.[30] Using the figures of Table 6 (on the min. and max. investment in RES per household), we obtain the following min. and max. theoretical investment potential by households in Noord-Brabant over the period 2020-2030:

- Min. theoretical investment potential: **1540,9 MEuro**
- Max. theoretical investment potential: **3081,8 MEuro**

AS I-Search (2019) reports that on average, 30% of the Dutch households would be willing to join an energy cooperative. We take this percentage to be indicative of the percentage of households in Noord-Brabant that would be willing to invest in RECs over the period 2020-2030, and therefore we obtain the following figures for the socio-economic investment potential by households in Noord-Brabant:

- Min. socio-economic investment potential: **462,3 MEuro**
- Max. socio-economic investment potential: **924,6 MEuro**

Potential assessment for RECs

Using the calculation rules for dividing the (minimum and maximum) socio-economic investment potential over the three RES technologies, indicates the REC potential assessment for Noord-Brabant, expressed as percentage ownership by citizens under two separate conditions (ownership for 100% financed by citizens vs. ownership for 20% financed by citizens).

[30] https://bevolkingsprognose.brabant.nl/hoofdstuk/veranderingen-huishoudenssamenstelling.html

Table 33 REC potential assessment for Noord-Brabant

Investment potential	Min.	Max.	Unit
Wind energy	40,1	80,1	MEuro
% ownership (100% financed by citizens)	**3%**	**6%**	
% ownership (20% financed by citizens)	**14%**	**28%**	
Ground-based PV	252,5	505,0	MEuro
% ownership (100% financed by citizens)	**4%**	**7%**	
% ownership (20% financed by citizens)	**18%**	**36%**	
Collective PV on rooftops	169,7	339,5	MEuro
% ownership (100% financed by citizens)	**3%**	**7%**	
% ownership (20% of large installations financed by citizens)	**9%**	**19%**	

Looking at Table 33, it is likely that the political goal of 50% ownership of RES capacity on land by the local environment by 2030 can only be reached by complementing the citizen investments with investments by local SMEs and local authorities. In addition, the availability of access to finance on favourable conditions (e.g. public financing, low interest rates for investment loans in RECs, etc.) seems to be a key enabler.

According to AS I-search and Bosch & Van Rijn (2020), currently (in 2020) **4,0% of ground-based PV capacity** in the Netherlands can be classified as 'owned by the local environment', compared to **13,4% of wind energy capacity**. **25% of planned wind energy capacity** in Noord-Brabant will be owned by cooperatives (private communication).

According to Hier Opgewekt (2021), **1,3% of Dutch households** were members of a cooperative by the end of 2020. The 'latent potential' of 30% household participation in RECs by 2030 assumed in this calculation is therefore certainly challenging. The official Dutch REC potential assessment (AS I-Search 2019) concludes that: "*We see that the ambitions for local ownership* [i.e. 50% ownership by the local environment] *seem in principle feasible when looking at the growth opportunities in the number of cooperatives and financing of projects by citizens. It's not wishful thinking. Citizen cooperatives can fill a significant part of this and are already putting in the effort. However, the options will differ by region and municipality. It does require a significant leap in scale and professionalization of the cooperative movement. It certainly will not go by itself: it is ambitious, challenging yet at the same time conceivable. It is of great importance that the cooperative movement is able to attract more people. Public research shows that many Dutch people are positive about local energy initiatives and that they are willing to join an energy collective. The trick is to capitalize on that latent support so that more people participate, for example with an investment in a local energy project or the purchase of locally generated electricity. When taken together, many small contributions make one large contribution. Or to stay in the terms of the energy sector: "when acting together, many small consumers become large consumers*".

References

AS I-Search (2019). Verkenning toekomstpotentieel burger-energiebeweging 2030. Energie in eigendom van de lokale gemeenschap. Rapport in opdracht van het ministerie van Economische Zaken en Klimaat, mede op verzoek van Energie Samen (samenwerkende energiecoöperaties).

AS I-Search, Bosch&Van Rijn (2020). Monitor participatie hernieuwbare energie op land - Resultaten nulmeting. Rapport in opdracht van het Ministerie van Economische Zaken en Klimaat, juni 2020.

Hier Opgewekt (2020). Lokale energiemonitor 2020, available at https://www.hieropgewekt.nl/lokale-energie-monitor

TU/e (2021). Brabant op 100% wind, water en zon. Haalbaarheidsonderzoek energietransitie in Noord-Brabant, available at https://publicaties.brabant.nl/energietransitie-in-brabant/toekomstbeelden/

Norway

Political/technical potential[31]

There are no politically agreed, quantitative RES targets for 2030, nor for specific RES technologies. Norway is not an EU member, and has not submitted a National Energy and Climate Plan (NECP) outlining targets, objectives, policies and measures for RES and RES community energy. We therefore calculate technical potentials.

Full technical potential

NVE (2009) estimates that the available land area in Norway is 128200 km^2 (taking into account spatial planning provisions and other legal provisions), of which 88100 km^2 has avg. wind speeds > 6m/s and 16,980 km^2 has avg. wind speeds > 8m/s. The technical potential for onshore wind energy (no time horizon) is between 419 and 1847 TWh/year, depending on requirements with regard to avg. wind speeds. Assuming an avg. energy density of 8MW/km^2 (NVE 2009), the theoretical potential for onshore wind energy is between 136 and 705 GW installed capacity.[32]

Marstein et al. (2020) estimate a theoretical potential for rooftop and façade PV of between 32 TWh and 50 TWh/year (roughly corresponding to between 30 and 50 GW$_p$ installed capacity). The lower estimate is based on a report by Multiconsult and Asplan Viak (2018), which calculates a theoretical potential assuming that PV is installed on all available rooftop and façade. Rooftop PV accounts for ~60% of the estimated 32 TWh/year potential. The report does not quantify the relative shares of small (<15kW$_p$) and large (>15kW$_p$) PV potential, nor the shares on 'collective' buildings versus single-family houses.[33]

To our knowledge, there exists no estimate of the technical potential for ground mounted PV in Norway.

Realistic technical potential 2020-2030

The Norwegian Water Resources and Energy Directorate's 2020 – 2040 energy market analysis (NVE 2020) provides RES growth paths in the period 2020 – 2030. In the basic scenario, onshore wind energy is expected to reach approximately 18 TWh (installed capacity 5085 MW) and PV is expected to reach slightly below 2 TWh (installed capacity 1796 MWp) by 2030. The PV potential is *mainly* on rooftops and façades, and any ground mounted PV potential up to 2030 is not quantified. We therefore assume that the identified PV potential in NVE (2020) is entirely on rooftops and façades. To estimate the relative shares of small (<15kWp) and large (>15kWp) installations, we assume that the relative shares in 2020 (small and large installations account for 36% and 64% of installed capacity, respectively (NVE 2021a)), are kept constant in 2020 – 2030.

Marstein (private communication) estimates that ground mounted PV could reach between 0,5 – 1 TWh by 2030. Relying on the lower-end estimate, and assuming a specific yield of 1250 kWh/kW$_p$ (Marstein et al. 2020), installed capacity for ground mounted PV is expected to reach 400 MW$_p$ by 2030.

The following RES capacities could be installed in Norway by 2030:

- On-shore wind energy: 5085 MW

[31] We would like to thank our COME RES partner the Norwegian Water Resources and Energy Directorate for useful feedback.

[32] The national framework for wind energy development (NVE 2019) identified 13 areas with a total of total of 29,000 km^2 as suitable for onshore wind energy development, mostly located along the coast and in mountainous areas, and mostly in southern Norway. The framework was contested, and the government later decided to discard it.

[33] The Co-operative Housing Federation of Norway (NBBL) estimates that housing cooperatives have a rooftop area of ~12.3 km^2 suitable for PV installation, equivalent to 0.9 – 1.3 TWh/year (Ask and Haugstulen 2020).

- PV on rooftops and façades: 1796 MW_p
- Ground-mounted PV: 400 MW_p

It should be noted that the identified onshore wind energy potential is expected to be developed in the period 1 January 2020 – 31 December 2021. NVE (2020) anticipated no further development between 2022 and 2030 in the basic scenario. The licensing process for onshore wind energy is currently under review.[34] Moreover, projects that already have a license are, as a general rule, required to become operational by 31 December 2021. To allow for the possibility that some projects could be developed in the period 2022-2030, NVE (2020) includes 3 TWh wind energy in their high scenario, but it is noted that this is uncertain. The government aims to eventually resume the licensing process, pending legal review. Amendments of relevant legislation will be presented in Parliament in spring 2022 at the earliest (GoN 2021a). It could take several years before new projects become operational once the licensing process resumes (GoN 2020). On 17 June 2021, the Ministry of Petroleum and Energy notified that NVE could resume processing already *existing* project applications, at the request of host municipalities (GoN 2021b). The Norwegian Wind Energy Association has identified eight existing project proposals that could potentially be developed post 2021 (NORWEA 2020). Excluding applications that have since been rejected and projects that do not satisfy the criteria set out in the letter by the Ministry of Petroleum and Energy, these projects amount to approximately 5 TWh. It is uncertain whether this potential will be developed. Given the uncertainty regarding both the timing and outcomes of wind energy projects post 2021, we rely on NVE's (2020) basic scenario in our calculations. The following tables calculate the investment needs for the different RES technologies. It should be noted that the cost estimates are uncertain, especially for PV (NVE 2021b). NVE (2020) does not quantify the relative shares of rooftop vs façade PV potential. For calculation purposes, we rely on cost estimates for rooftop PV when estimating the investment needs.

Table 34 Investment need for onshore wind energy in Norway

	Unit	Comment	Source
5085	MW	Technical potential in 2030	NVE (2020)
2475	MW	Installed capacity at the end of 2019	NVE (2021c)
2610	MW	To be installed over the period 2020-2030*	
2592	**MEuro**	Assumed investment cost = 993 MEuro/MW[35]	NVE (2021b)

**See discussion.*

Table 35 Investment need for PV on rooftops in Norway

	Unit	Comment	Source
1796	MW_p	Technical potential in 2030	NVE (2020)
1149	MW_p	Technical potential for large (>15kWp) installations. Assumption: 64% share of installed capacity in 2020 is kept constant	NVE (2021a)
129	MW_p	Technical potential for small (<15 kWp) collective installations. Assumptions: 1) 36% share of installed capacity in 2020 is kept constant; 2) 20% of small installations will be collective[36]	NVE (2021a)
77	MW_p	Large installations installed at the end of 2019. A total of 120 MW was installed at the end of 2019. Assumption: 64% of installed capacity at the end of 2019 was large installations	NVE (2021a)

[34] Licenses are required for wind energy projects exceeding 5 turbines and an installed capacity of 1 MW. Licenses are also required for repowering projects. Regarding repowering potential, close to 90% of the total installed capacity at the end of 2020 has been installed in recent years (after 2010).
[35] Investment costs onshore wind = 10071 NOK/kW, exchange rate EURO/NOK 10.14. Data retrieved 10.06.21.
[36] In line with the methodology for COME RES Deliverable 2.2.

43	MW_p	Small installations installed at the end 2019. A total of 120 MW installed at the end of 2019. Assumption: 36% of installed capacity at the end of 2019 was small installations	NVE (2021a)
1073	MW_p	Large installations capacity to be installed over the period 2020-2030	
129	MW_p	Small collective installations capacity to be installed over the period 2020-2030. Assumption: no small collective PV installations at the end of 2019[37]	
688	**MEuro**	Investment need for large installations. Assumed investment cost = 641 Euro/kWp[38]	NVE (2021b)
147	**MEuro**	Investment need for small collective installations. Assumed investment cost = 1134 Euro/kWp[39]	NVE (2021b)

Table 36 Investment need for ground mounted PV in Norway

	Unit	Comment	Source
400	MWp	Technical potential in the period 2020-2030	Marstein (private communication)
237	**MEuro**	Assumed investment cost = 592 Euro/kWp[40]	NVE (2021b)

Socio-economic investment potential of citizens

Norway will count 2783162 households between 2020 and 2030.[41] Using the figures of Table 6 in this deliverable (on the min. and max. investment in RES per household), we obtain the following min. and max. theoretical investment potential by households in Norway over the period 2020 – 2030:

- Min. theoretical investment potential: **4292,4 MEuro**
- Max. theoretical investment potential: **8584,7 MEuro**

According to CICERO's annual survey of public responses to climate policy instruments in Norway (Aasen et al. forthcoming), 41% responded "matches very well" or "matches fairly well" to the statement "the production of onshore wind energy should be increased" in 2020. For rooftop PV, 88% think that rooftop PV should be increased (Kantar 2020). To our knowledge, there exists no estimate of the willingness of Norwegian households to *invest* in a REC. As in the North Brabant target region, we therefore assume a 30% willingness to invest in a REC over the period 2020 – 2030. We obtain the following estimates of the socio-economic investment potential by households in Norway:

- Min. socio-economic investment potential: **1287,7 MEuro**
- Max. socio-economic investment potential: **2575,4 MEuro**

Potential assessment for RECs

Using the calculation rules for dividing the (minimum and maximum) socio-economic investment potential over the three RES technologies, Table 37 indicates the REC potential assessment for Norway,

[37] To date, small PV installations are mainly single household PV installations (e.g. Ask and Haugstulen 2020). There are a few existing examples of small collective PV, but these are excluded due to a lack of reliable data.
[38] Investment costs large, flat roofs = 6500 NOK/kWp, exchange rate EURO/NOK 10.14. Data retrieved 10.06.21.
[39] Investment costs small roofs = 11500 NOK/kWp, exchange rate EURO/NOK 10.14. Data retrieved 10.06.21.
[40] Investment costs ground mounted PV = 6000 NOK/kWp, exchange rate EURO/NOK 10.14. Data retrieved 10.06.21.
[41] We use the average of the population in 2020 (5367329) and population projections for 2030 (5765319), and a household size of 2.0. Data from Eurostat (data retrieved 29.04. 21).

expressed as percentage ownership by citizens under two separate conditions (100% of the investment is financed by households vs. 20% of the investment is financed by households).

Looking at Table 37, the REC ownership potential is considerable for all three technologies. The total investment required to develop the projected RES growth between 2020 – 2030 is 3663 million Euro (2592 million Euro for wind energy, 834 million Euro for collective rooftop PV and 237 million Euro for ground mounted PV). Assuming minimum socio-economic investment potential and assuming that 100% of the investment is financed by households, Norwegian households could potentially own 31% of the wind energy, 44% of the collective rooftop PV and 52% of the ground mounted PV capacity installation expected between 2020 – 2030. For all three RES technologies, the minimum socio-economic investment potential is sufficiently large to ensure that more than 50% of the installed capacity between 2020 – 2030 could be effectively controlled by Norwegian households. However, realising the full investment potential could require addressing existing barriers, including regulatory barriers, a lack of enabling frameworks and support schemes for RES community energy (Standal et al. 2021; Standal et al. forthcoming).

Table 37 REC potential assessment for Norway

Investment potential	Min.	Max.	Unit
Wind energy*	797,9	1595,8	MEuro
% ownership (100% financed by citizens)	**31%**	**62%**	
% ownership (20% financed by citizens)	**154%**	**308%**	
Ground-based PV	122,3	244,6	MEuro
% ownership (100% financed by citizens)	**52%**	**103%**	
% ownership (20% financed by citizens)	**258%**	**517%**	
Collective PV on rooftops	367,5	735,0	MEuro
% ownership (100% financed by citizens)	**44%**	**88%**	
% ownership (20% financed by citizens)	**129%**	**259%**	

**See discussion*

RED II (article 2(16)) requires that RECs be *effectively controlled* by shareholders or members located in the *proximity* of the RES projects. For calculation purposes, in this Deliverable we assume that these two criteria are met to the extent that shareholders or members residing in the target region own at least 51% of the shares of the legal entity owning the RES installation. In the case of Norway, the country as a whole is the target region. RECs have not been legally defined in Norway, and RED II is still under review (Standal et al. 2021). If a stricter interpretation of proximity than the one used here is applied, for instance that a REC must be effectively controlled by shareholders or members located in the same county as the RES project, the potential of RECs in the energy transition in Norway could possibly be lower than what we identify here. This is perhaps especially the case for wind energy, as the wind energy potential is unevenly distributed between counties. For instance, more than 20% of the wind energy capacity installation is expected in the county of Trøndelag[42], where around 9% of the Norwegian population resides. Our assessment indicates that households in Trøndelag would be capable of fully financing between 14% – 28% (effectively controlling between 28% – 55%) of the technical potential for wind energy in Trøndelag, depending on assumptions with regard to the socio-economic investment potential. We do not have data on the geographical distribution of the PV potential in Norway, and therefore use regional shares of the national built surface area and total surface area[43] to estimate regional shares of the national technical potential for rooftop PV and ground mounted PV, respectively. We find that households in Trøndelag would be capable of fully financing between 20% – 40% (effectively controlling 39% – 79%) of the technical rooftop PV potential and between 24% – 47% (effectively controlling 46% – 93%) of the technical ground mounted PV potential in Trøndelag county, depending on assumptions with regard to the socio-economic investment potential.

Another factor which could serve to limit the potential of RECs to participate in wind energy development between 2020 and 2030, is the fact that no further wind energy development is expected between 2022 – 2030 (see discussion above). Thus, the technical potential for wind energy that we rely on here is potential that is already constructed (2020) or currently under construction (2021). Ownership of these projects is already established. The finding in Table 37 above regarding the potential of Norwegian households to participate in financing wind energy only holds assuming that households are able invest in these projects, and assuming that the investment window is over the entire period 2020 – 2030. If the investment opportunities in wind energy are limited, the financial potential of RECs to participate in developing PV could be higher than indicated in Table 37.

References

Aasen, M. et al. (forthcoming). Folk og klima: Nordmenns holdninger til klimaendringer, klimapolitikk og eget ansvar. Oslo: CICERO Senter for klimaforskning 2021; Volum 2021. CICERO Report.

Ask, A.O. and Haugstulen, K.B. Norske boligbyggelag: Solceller på tak kan redusere behovet for upopulær vindkraft. *Aftenposten* 15.07.21, available at: Norske boligbyggelag: Solceller på tak kan redusere behovet for upopulær vindkraft (aftenposten.no) (accessed 20.04.21).

Government of Norway (GoN) (2020). Vindkraft på land — Endringer i konsesjonsbehandlingen (Meld. St. 28 (2019-2020).

Government of Norway, (GoN) (2021a). Energi til arbeid – langsiktig verdiskaping fra norske energiressurser (Meld. St. 36 (2020–2021)).

Government of Norway (GoN) (2021b). Konsesjonsbehandling av vindkraft, available at: Konsesjonsbehandling av vindkraft (regjeringen.no) (accessed 03.08.21).

Kantar (2020) Klimabarometeret 2020. https://www.forskningsradet.no/contentassets/b8513ab2d46f47769707649e4c941f9e/klimabarometer-2020-kantar.pdf (accessed 20.04.21)

Marstein, E.S. et al. (2020). Veikart for den norske solkraftbransjen mot 2030. Available at: solenergiklyngen-veikart-sol.pdf (tornado-node.net) (accessed 15.04.21).

Multiconsult and Asplan Viak (2018). Solcellesystemer og sol i systemet. Available at: Rapport-solkraft-markedsutvikling-2017.pdf (multiconsult.no) (accessed 15.04.21).

[42] Data on installed capacity in 2020 (MW) and wind energy currently under construction is taken from NVE (2021c). For wind energy currently under construction, we rely on maximum allowed installed capacity to calculate technical potential (https://www.nve.no/konsesjonssaker).

[43] Data from Statistics Norway (https://www.ssb.no/statbank/table/11342/; https://www.ssb.no/statbank/table/09594/, retrieved 8.06.21)

The Norwegian Wind Energy Association (NORWEA) (2020). Nesten tom vindkraftportefølje etter 2021. Available at: https://norwea.no/norwea-mener/2020/10/21/nesten-tom-vindkraftporteflje-etter-2021 (accessed 03.08.21).

NVE (2009). Vindkart for Norge. Rapport nr 9/2009. Available at: https://www.nve.no/media/2470/vindkart_for_norge_oppdragsrapporta10-09.pdf (accessed 15.04.21).

NVE (2019). Forslag til nasjonal ramme for vindkraft. Rapport nr 12/2019. Available at: http://publikasjoner.nve.no/rapport/2019/rapport2019_12.pdf (accessed 10.04.21).

NVE (2020). Langsiktig kraftmarkedsanalyse 2020 – 2040. Available at: http://publikasjoner.nve.no/rapport/2020/rapport2020_37.pdf (accessed 10.04.21).

NVE (2021a). Nøkkeltall: utvikling i solkraft i Norge. Available at: https://www.nve.no/media/11755/datagrunnlag-solkraft-i-norge_01-03-2021.xlsx (accessed 20.04.21).

NVE (2021b). Kostnader for kraftproduksjon. Available at: Kostnader for kraftproduksjon - NVE (accessed 7.06.21).

NVE (2021c). Vindkraftdata. Installert effekt [MW] – aggregert per år, 2019. Available at: https://www.nve.no/energiforsyning/kraftproduksjon/vindkraft/vindkraftdata/ (accessed 15.04.21).

Standal, K. et al. (2021). Assessment report on technical, legal, institutional and policy conditions. COME RES Deliverable 2.1. Available at: COME_RES_D2.1__Assessment_report_FINAL.pdf (come-res.eu) (accessed 20.04.21). Standal, K. et al. (forthcoming) Summary: Thematic Workshop and Policy Roundtable of the Norwegian Country Desk. COME RES WP3.

Região Norte (Portugal)

Political/technical potential

The Portuguese Government established medium and long-term targets for the integration of renewable energy sources (RES) in the power sector, with specific targets for centralized and decentralized[44] solar PV. For the year 2030, the Portuguese National Energy and Climate Plan (NECP) 2030 estimates an installed capacity of 9 GW_p of solar PV, of which 7 GW_p is centralized and 2 GW_p decentralized (Presidência do Conselho de Ministros, 2020). The projected values correspond to over four times the existing capacity in 2019, implying the installation of around 7 GW_p of solar PV generation in the period between 2020 and 2030.

Region specific targets have not yet been established in Portugal, neither by national nor by regional public authorities. Thus, in order to estimate the political potential for RECs in Região Norte, national targets for solar PV were downscaled based on the surface area. Moreover, as national targets do not differentiate between ground-based and rooftop installations, this disaggregation was performed based on the assumption that half of the capacity of decentralized PV corresponds to rooftop installations[45], while all remaining PV installations correspond to ground-based installations. Based on these assumptions, the following RES capacities for Região Norte can be estimated for 2030:

- PV on rooftops: 340 MW_p
- Ground-based PV: 1,9 GW_p

The following tables calculate the investment needed for the different RES technologies in order to achieve the desired capacity by 2030.

Table 38 Investment need for PV on rooftops in Região Norte

	Unit	Comment	Source
340	MW_p	Regional target for PV on rooftops assumed to correspond to 50% of total decentralized PV. National target for 2030 was downscaled based on the ratio between regional and national surface area.	Presidência do Conselho de Ministros (2020) Instituto Nacional de Estatística (2020)
32	MW_p	Installed capacity in 2019	DGEG (2021)
308	MW_p	Capacity to be installed over the period 2020-2030	
40	MW_p	Capacity to be installed as collective installation over the period 2020-2030. The share of collective PV rooftop installations was assumed to be equal to the share of collective (multi-apartment) buildings (13%), assuming that the distribution between individual and collective PV rooftop installations will be proportional to the available rooftop area of individual and collective buildings.	Instituto Nacional de Estatística (2013)
30	**MEuro**	Assumed investment cost = 750 Euro/kW_p	Expert judgement based on commercial offers for installation in Portugal

[44] Decentralized PV installations refer to small-scale production units, which are located in the vicinity of the consumption site. The installed capacity is normally under 1MW_p.
[45] In Portugal, as the registry of PV installations does not differentiate between ground-based and rooftop installations, the projection of the share of decentralized PV to be installed on rooftops was based on expert judgement.

Table 39 Investment need for ground-based PV in Região Norte

	Unit	Comment	Source
1,9	GW_p	Regional target for ground-based PV is assumed as 100% of the target for centralized PV plus 50% of the target for decentralized PV. National target for 2030 was downscaled based on the ratio between regional and national surface area.	Presidência do Conselho de Ministros (2020) Instituto Nacional de Estatística (2020)
1,7	GW_p	Regional target for centralized PV	Presidência do Conselho de Ministros (2020) Instituto Nacional de Estatística (2020)
0,2	GW_p	Regional target for decentralized PV, assuming that 50% of total decentralized PV corresponds to rooftop installations and 50% to ground-based installations.	Presidência do Conselho de Ministros (2020) Instituto Nacional de Estatística (2020)
74	MW_p	Centralized installations in 2019	DGEG (2021)
32	MW_p	Decentralized installations in 2019	DGEG (2021)
1611	MW_p	Centralized capacity to be installed over the period 2020-2030	
209	MW_p	Decentralized capacity to be installed over the period 2020-2030.	
806	**MEuro**	Assumed investment cost for centralized installations = 500 Euro/kW installed	Expert judgement based on commercial offers for installation in Portugal
157	**MEuro**	Assumed investment cost for decentralized installations = 750 Euro/kW installed	Expert judgement based on commercial offers for installation in Portugal

Socio-economic investment potential of citizens

According to the Portuguese National Statistics Office, Região Norte will have on average 3544223 inhabitants between 2020 and 2030[46]. Using the figures of Table 6 (on the min. and max. investment in RES per household) and the comparison between the national and regional disposable income of private households (Eurostat, 2021), we obtain the following min. and max. theoretical investment potential in Região Norte over the period 2020-2030:

- Min. theoretical investment potential: **463 MEuro**
- Max. theoretical investment potential: **926 MEuro**

In the absence of studies with the focus on the willingness of the Portuguese population to join an energy cooperative, it was assumed that, similarly to the Dutch households, 30% of the households would be willing to join an energy cooperative and to invest in RECs over the period 2020-2030. Based on this assumption and on the estimate of the theoretical investment per capita, the socio-economic investment potential by individual citizens in Região Norte is estimated to be the following:

- Min. socio-economic investment potential: **139,0 MEuro**

[46] https://www.ine.pt/xportal/xmain?xpid=INE&xpgid=ine_indicadores&indOcorrCod=0010035&contexto=bd&selTab=tab2

- Max. socio-economic investment potential: **277,9 MEuro**

Potential assessment for RECs

Using the calculation rules for dividing the (minimum and maximum) socio-economic investment potential over the two RES technologies, Table 40 indicates the REC potential assessment for Região Norte, expressed as percentage ownership by citizens under two separate conditions (ownership for 100% financed by citizens vs. ownership for 20% financed by citizens).

Table 40 REC potential assessment for Região Norte

Investment potential	Min.	Max.	Unit
Ground-based PV	136,0	271,9	MEuro
% ownership (100% financed by citizens)	**14%**	**28%**	
% ownership (20% financed by citizens)	**71%**	**141%**	
Collective PV on rooftops	3,0	6,0	MEuro
% ownership (100% financed by citizens)	**10%**	**20%**	
% ownership (20% of large installations financed by citizens)	**50%**	**100%**	

Looking at Table 40 with the socio-economic investment potential in collective solar installations, it is reasonable to consider that community energy initiatives may have an important role in the achievement of the national RES targets. However, it should also be noted that investment potential of individual citizens alone would cover less than 30% of the required investment. Thus, to guarantee that citizens are active participants in the transition, the availability of access to finance on favourable conditions as the creation of community energy initiatives in collaboration with municipalities and local enterprises need to be ensured.

Furthermore, as community energy initiatives are in the first steps in Portugal, there may be additional barriers to the investment and development of RECs by individual citizens, including mistrust regarding the concept, and lack of capacity and know-how on the procedures and best-practices by relevant stakeholders.

References

DGEG (2021). Renováveis: Estatísticas Rápidas nº 196, março 2021., available at https://www.dgeg.gov.pt/pt/estatistica/energia/publicacoes/estatisticas-rapidas-das-renovaveis/

Eurostat (2021). Disposable income of private households by NUTS 2 regions (Last update: 25/06/2021), available at https://ec.europa.eu/eurostat/databrowser/view/NAMA_10R_2HHINC/default/table?lang=en

Instituto Nacional de Estatística (2020). Superfície terrestre (km2) das unidades territoriais por Localização geográfica (NUTS – 2013); Não periódica (Last update: 12/07/2020), available at https://www.ine.pt/xportal/xmain?xpid=INE&xpgid=ine_indicadores&indOcorrCod=0009777&contexto=bd&selTab=tab2

Instituto Nacional de Estatística (2013). Proporção de edifícios com um alojamento (%) por Localização geográfica (à data dos censos 2011); Decenal (Last update: 09/03/2013), available at https://ine.pt/xportal/xmain?xpid=INE&xpgid=ine_indicadores&indOcorrCod=0007127&contexto=bd&selTab=tab2

Presidência do Conselho de Ministros Governo Português (2020). Resolução do Conselho de Ministros nº 53/2020 - Plano Nacional Energia e Clima 2030. Diário da República n.º 133/2020, Série I de 2020-07-10, 2 - 158.

Thuringia (Germany)

Political/technical potential

Our primary starting point is the political target of the Thuringian government to cover 100% of gross energy consumption (electricity, heat, fuel) from RES by 2040 "on the balance sheet" – enshrined in the Thuringian Climate Act, §4. In a study (LIE 2018) commissioned by the Thuringian Ministry of Environment (TMUEN) to support the drafting of the law, the Leipziger Institut für Energie developed different scenarios. In the active scenario, LIE (2018, p. 156) estimates that in 2030 6,53 TWh of wind-based electricity will be needed to achieve the political target of 100% RES production. This corresponds to a capacity of 3377 MW, considering average full load hours of 1933,5 between 2020 and 2030 (Wesselak 2021, p. 10).[47]

In 2020, the cumulated nominal wind energy capacity in Thuringia reached 1640 MW (ThEGA 2021).[48] Hence, 1737 MW of capacity remain to be installed by 2030. According to a study by the Fraunhofer Institut für Solarenergie (Fraunhofer ISE 2021a, p. 11), the minimum investment cost for onshore wind energy in 2021 amounted to 1400 Euro/kW (CAPEX, without VAT). To reflect future price reductions, we use this minimum value and not an average. The total investment cost, therefore, are expected in the range of 2432 MEuro.

The scenarios mentioned above which form the basis of our calculations also take into account that pursuant to §4(2) of the Thuringian Climate Act,[49] 1% of the country's total area shall be set aside for the use of wind energy. Presently, only 0,33% of the territory are used for wind energy (ThEGA 2021; BWE n.d.). This 1% goal also considered forest areas, but in December 2020, a political decision was taken that prohibited the use of wind energy in forest areas (see §67 in the amended Thuringian Forest Act). Nevertheless, the 1% area goal and the overall RES target for 2040 remained unchanged so far. Yet, in the context of the current political developments at federal level,[50] the Minister of Environment of Thuringia, Anja Siegesmund, in a recent public statement supported the goal of achieving arithmetical 100% RE supply in Thuringia already by 2035 (Klimapavillon 2021). Hence, due to federal climate policy ambitions, the political goal in Thuringia might have to be corrected upwards soon.

Table 41 Investment need for wind energy in Thuringia

	Unit	Comment	Source
3377	MW	Political goal of 100% RES supply by 2040 broken down for 2030	LIE (2018, p. 156); Wesselak (2021, p. 10)
1640	MW	Installed capacity in 2020	ThEGA (2021)
1737	MW	To be installed over the period 2020-2030	
2432	MEuro	Assumed investment cost = 1400 Euro/kW	Fraunhofer ISE (2021, p.11)

[47] Our calculations are based on data for Thuringia recently presented by Prof. Viktor Wesselak (Hochschule Nordhausen) who reported 1860 full load hours for 2020 and 2300 for 2050 (Wesselak 2021, 10). We assumed a linear development between 2020 and 2050 and calculated with an average 2020/2030 of 1933,5 full load hours.

[48] Deutsche WindGuard (2021, 12) uses slightly different values (1657 MW).

[49] Thüringer Gesetz zum Klimaschutz und zur Anpassung an die Folgen des Klimawandels (Thüringer Klimagesetz - ThürKlimaG -) 18. Dezember 2018.

[50] Following a ruling of the Federal Constitutional Court, and with a view to the new European climate target for 2030, the Federal government passed amendments to the Climate Change Act in June 2021 which envisage to reach GHG neutrality already by 2045 (instead of 2050).

Considering ground-based PV, LIE (2018, p. 156) estimates that in 2030 2,85 TWh/year of electricity from PV (total) will be necessary in order achieve the 2040 overall target. This scenario envisages a sharp increase of the installed PV capacity between 2030 and 2040 resulting in an overall production from PV of 13,14 TWh. However, we consider a balanced growth between 2020 and 2040 more realistic. Assuming a linear development between the achieved level of 1,72 TWh in 2020 (ThEGA 2020) and a necessary level of 13,14 TWh in 2040 we end up with a level of 7,43 TWh PV (total) to be reached in 2030.

In 2017, the ratio of ground-mounted PV vs rooftop/facade PV was 45,6% to 54,4% (AEE n.d.). In August 2021, we identified the following ratios: ground-based PV 37,5%, rooftop PV 57,3 %, other PV structures 5,2% (including several other types like PV on carports, agri-PV etc.).[51] Without considering the "other structures" section, the respective ratio of ground-mounted vs. rooftop PV is approximately 40%/60%. It is rather difficult to assess the future development and future ratio which depends on various factors including technical potentials, market design, political priorities at federal, regional and local level and availability of financial and other support. Furthermore, we found differing expert opinions concerning the future ratio. Expert estimates concerning the future ratio of ground-based PV vs. rooftop PV in Thuringia range between 80:20 and 40:60 for 2040.[52] For our calculations, we took an average value ending up with a ratio of 60:40 to be expected in 2040. Assuming a linear development from now to 2040, we expect a ratio of 50% to 50% in 2030. This means that in 2030 electricity production from ground-mounted PV would reach a level of 7,43 TWh x 0,5=3,715 TWh which corresponds to an installed capacity of 3791 MW_p needed in 2030, based on 980 equivalent hours of full capacity. In their trend scenario, the TSO assume an average of approx. 980 full load hours for PV ground-mounted systems in Germany 2020-2025 and approx. 910 hours for rooftop systems (Fraunhofer ISE 2021b, p. 45, ÜNB 2020, p.78).

In 2020, 1812 MW_p of PV (total) were already installed in Thuringia (ThEGA 2020). Assuming a ratio of 40% for ground-mounted PV and 60% for PV on rooftops in 2020 (see above) leads us to a value of 725 MW_p. Subtracting the already installed capacity from the necessary capacity level for 2030, 3066 MW of capacity remain yet to be installed in the next decade. According to a study by the Fraunhofer Institut für Solarenergie (Fraunhofer ISE 2021a, p. 11), the minimum investment cost for ground-mounted PV in 2021 amount to 530 Euro/kW (CAPEX, without VAT). To reflect future price reductions, we use this minimum value and not an average. Therefore, the total investment cost for ground-based PV until 2030 are expected in the range of 1625 MEuro.

Table 42 Investment need for ground-based PV in Thuringia

	Unit	Comment	Source
3791	MW_p	Political goal of 100% RES supply by 2040 broken down for 2030	LIE (2018, p. 156)
725	MW_p	Installed capacity in 2020	ThEGA (2020), own calculations based on Core Energy Market Data Registry
3066	MW_p	To be installed over the period 2020-2030	
1625	MEuro	Assumed investment cost = 530 Euro/kW_p	Fraunhofer ISE 2021a, p. 11

[51] based on the data of the Core Energy Market Data Registry (*Marktstammdatenregister*) of the Federal Network Agency (*Bundesnetzagentur*); retrieved 26 August 2021, 10:00.

[52] Personal communications with Prof. Reinhard Guthke (Bürgerenergie Thüringen e.V) and Marcel Weiland (ThEGA).

Still assuming a linear growth for PV (total) and the same ratio of 50% ground-mounted and 50% rooftop PV, 3,715 TWh of electricity from rooftop/facade PV will be necessary in 2030. Assuming an average of 910 equivalent hours of full capacity (Fraunhofer ISE 2021, p. 45; ÜNB 2020, p. 70; see above), this corresponds to a capacity level of 4082 MW_p in 2030 which will be necessary to reach the political target for 2040. In 2020, 1087 MW_p of PV on rooftops were installed (based on data provided by ThEGA (2020, assuming a ratio of ground-mounted vs. rooftop PV of 40%/60%, see above). Hence, the capacity to be installed by 2030 amounts to 2995 MW. Presently, the total capacity of rooftop PV installations in Thuringia amounts to 1119 MW_p.[53] 174 MW_p (or 16% of the installed capacity) can be attributed to small installations <15 kW_p, 945 MW_p (84%) can be attributed to large installations >15kW_p. We assume that these shares remain the same by 2030 and that 20% of the small-scale PV rooftop capacity is suitable for investments by citizen collectives. The total PV rooftop capacity to be installed (only share of collective large-scale PV rooftop and collective small-scale PV) amounts to 2672 MW_p (see below, Table 43).

According to a study by the Fraunhofer Institut für Solarenergie (Fraunhofer ISE 2021a, p.11), the minimum investment cost for PV rooftop systems in 2021 amount to 875 Euro/kW_p (CAPEX, without VAT, average value for PV ≤ 30 kW_p and PV >30 kW_p). To reflect future price reductions, we use this minimum value and not an average. Hence, the total investment cost for rooftop PV (only collective) until 2030 are expected in the range of 2338 MEuro.

Table 43 Investment need for PV on rooftops in Thuringia

	unit	Comment	Source
4082	MW_p	Political goal of 100% RES supply by 2040 broken down for 2030	LIE (2018, p. 156)
1087	MW_p	Installed capacity in 2020	ThEGA (2020), own calculations based on Core Energy Market Data Registry
2995	MW_p	To be installed over the period 2020-2030 (total)	
2576	**MW_p**	Large scale PV (> 15 kW_p) capacity to be installed over the period 2020-2030 Assumption: 84% of additional capacity is PV > 15 kWp	
96	**MW_p**	Small scale PV (<= 15 kW_p) capacity to be installed over the period 2020-2030 Assumption: 14% of additional capacity is PV <15 kW_p, of which 20% is collective	
2672	**MW_p**	Total capacity to be installed (only share of collective large-scale PV rooftop and collective small-scale PV)	
2338	**MEuro**	Assumed investment cost = 875 Euro/kW_p	Fraunhofer ISE 2021a, p. 11

Socio-economic investment potential of citizens

In 2018, the number of private households in Thuringia was 1104000. For 2030, the Statistical Office of Thuringia expects 1022000 households (Drygalla 2020, p. 41). We use an average number of 1063000 households. We could not find any concrete data on the theoretical investment potential for Thuringia.

[53] Data provided by ThEGA, based on Core Energy Market Data Registry. 26 August 2021, 10:00.

Using the averaged data for Germany from Eurostat (Table 6), we obtain the following min. and max. theoretical investment potential in Thuringia over the period 2020-2030:[54]

- Min. theoretical investment potential: **1300,0 MEuro**
- Max. theoretical investment potential: **2600,1 MEuro**

In a survey of 550 persons conducted in 2014, 37,7% of the respondents were willing to invest in an energy cooperative (Masson et al. 2015, p. 202).[55] Although this survey had an exclusive focus on energy cooperatives, we consider this value as a useful proxy to assess the general willingness to invest in collective energy ownership models in Thuringia over the period 2020-2030.[56] Therefore, we obtain the following figures for the socio-economic investment potential in Thuringia:

- Min. socio-economic investment potential: **489,7 MEuro**
- Max. socio-economic investment potential: **979,3 MEuro**

Potential assessment for RECs

Using the calculation rules for dividing the (minimum and maximum) socio-economic investment potential over the three RES technologies based on the ratio of the capacity to be installed (23%/41%/36%), Table 44 indicates the REC potential assessment for Thuringia, expressed as percentage ownership by citizens under two separate conditions (ownership for 100% financed by citizens vs. ownership for 20% financed by citizens).

Table 44 REC potential assessment for Thuringia

Investment potential	Min.	Max.	Unit
Wind energy	112,7	225,5	MEuro
% ownership (100% financed by citizens)	**9,1%**	**18,2%**	
% ownership (20% financed by citizens)	**45,4%**	**90,9%**	
Ground-based PV	200,9	401,9	MEuro
% ownership (100% financed by citizens)	**24,2%**	**48,5%**	
% ownership (20% financed by citizens)	**121,2%**	**242,5%**	

[54] These data have to be treated with caution. The values for Thuringia (and generally for the East German federal states) can be expected to be lower than the average values for Germany which is also the case for other key socio-economic indicators, e.g. GDP per capita, households' disposable income or households' savings rates. In 2019, GDP per capita in Thuringia was 28 per cent below German average (Institut der Deutschen Wirtschaft 2021), disposable income per person 13 per cent (Statistisches Landesamt 2021a), and savings rates 37 per cent (Statistisches Landesamt 2021b).

[55] 24.0% of the respondents could "possibly" imagine becoming member of an energy cooperative and 9,9% could imagine this "well". 2,3% had thought specifically about becoming a member, but have not realized their plans yet, whereas 1,5% had concrete plans to become members and were committed to carry them out in the near future.

[56] However, it must be noted that support for the energy transition and renewable energy in Thuringia is generally below corresponding German average values (Green City AG; IASS 2018).

Collective PV on rooftops	176,4	352,9	MEuro
% ownership (100% financed by citizens)	**14,8%**	**29,6%**	
% ownership (20% of large installations financed by citizens)	**74,0%**	**148,0%**	
Total	**490,0**	**980,3**	MEuro

Looking at Table 44, the potential assessment for RECs in Thuringia appears promising. The total cost for meeting the political goals in 2030 for all three RES technologies would amount to 6395 MEuro. It shows that, especially with effective financial support schemes, the achievement of the political goals in Thuringia and the transition towards a 100% RES supply could be carried largely by citizens. Assuming that 20% of the needed investment cost are financed by citizens and 80% by other sources including debt capital, the new capacities of land-based PV installed by 2030 could be fully controlled by citizen collectives. For collective PV on rooftops, nearly all of the new installed capacities could be controlled by citizen collectives. Only for wind energy, the values are lower, varying between 45 and 91%. This is probably due to the fact that in the case of wind energy less new capacity needs to be installed and investment cost are proportionally higher than for the other two technologies.

Assuming that 100% of the respective investment needs are financed by households, the corresponding shares of installed capacity controlled by citizen collectives vary between 9% and 18% for wind energy, 24 and 49% for land-based PV and 15 and 30% for rooftop PV.

However, unlocking the ‘latent potential’ of household participation in RECs by 2030 and the assumed investment in RES per household in the calculations above appears very challenging. Based on internal data provided by ThEGA derived from the Core Energy Market Data Registry, we estimate that from the total installed PV capacity of 1852 MW in Thuringia (as of 26 August 2021, without section “other structures”), only roughly 1% is owned by citizen collectives.

It has to be noted that the values we used are just proxies and might overestimate the actual potential because often they use the German average which is probably higher than the values for Thuringia, e.g. for the investment potential per household. Also, we assume that 37,7% of households in Thuringia would invest in RECs even though the value is only representative for Germany. Thuringians are usually less prone to invest in RES. In addition, we did not include the costs for energy storage systems in our calculations. With more energy produced from RES, more energy storage will be needed and therefore augment the costs.

Effectively tapping the potentials for REC development depends largely on a supportive legal and regulatory framework. On the one hand, Germany can be regarded as one of the pioneers in terms of community renewable energy and the share of citizen resp. community owned RES projects is relatively high compared to other European countries. On the other hand, the development of community energy has lost momentum and has been stagnating already for several years. Overall, the transition from a fixed-price support system to auctions and competitive bidding has tended to favor large players and at the same time led to a decline in the number of newly founded energy communities and energy cooperatives. Existing privileges for citizen energy companies in the auction system have not provided sufficient incentives to overcome the structural disadvantages these collective actors are facing in the auctions. The award rates for citizens' energy companies in the wind energy auctions decreased steadily to 13,9% in 2018, 9,7% in 2019 and 4,3% in 2020 (FA Wind 2021).

Our calculations for Thuringia also show that the actual RES development is falling behind the announced objectives of the Thuringian government. In 2020, 122 MW_p of PV (total) were installed in Thuringia (ThEGA 2020). But to meet the goal of an additional 5738 MW_p in 10 years, annual net installations have to increase by 4,7 times. Nevertheless, there have been positive signals from the Thuringian Minister of Environment Anja Siegesmund who recently announced plans to increase the number of PV installations in Thuringia from 36.000 to 100.000 by 2025 (Siegesmund et al. 2021). The RED II provides new impetus for the development of community energy, but in Germany the transposition of the respective legal provisions into national law is lagging behind compared to other EU Member states. It is crucial that the federal government and also the state governments of the *Länder* create effective enabling frameworks for RECs as required by the RED II including the provision of start up financing, low interest loans or capacity development support.

Acknowledgements:

The authors would like to thank the following persons for their valuable comments:

Ramona Rothe, Frank Schindler and Marcel Weiland (Thüringer Energie- und GreenTech-Agentur)
Prof. Reinhard Guthke and Marcel Schwalbach (Bürgerenergie Thüringen e.V.)

References

Agentur für Erneuerbare Energie (n.d.). Anteil Freiflächenanlagen an der installierten PV-Leistung - Solar - TH - Daten und Fakten zur Entwicklung Erneuerbarer Energien in einzelnen Bundesländern. https://www.foederal-erneuerbar.de/landesinfo/bundesland/TH/kategorie/solar/auswahl/991-anteil_freiflaechena/#goto_991.

Bundesverband WindEnergie (n.d.). Der Landesverband Thüringen. https://www.wind-energie.de/verband/lvs/thueringen/.

Deutsche Windguard (2021). Status des Windenergieausbaus an Land in Deutschland – Jahr 2020.

Fraunhofer Institut für Solarenergie ISE (2021a). Stromgestehungskosten Erneuerbare Energien. https://www.ise.fraunhofer.de/content/dam/ise/de/documents/publications/studies/DE2021_ISE_Studie_Stromgestehungskosten_Erneuerbare_Energien.pdf

Fraunhofer Institut für Solarenergie ISE (2021b). Aktuelle Fakten zur Photovoltaik in Deutschland. Fassung vom 6.8.2021. https://www.ise.fraunhofer.de/content/dam/ise/de/documents/publications/studies/aktuelle-fakten-zur-photovoltaik-in-deutschland.pdf

Fraunhofer Institut für Solarenergie ISE (2020): Photovoltaics report. Prepared by Fraunhofer Institute for Solar Energy Systems, ISE with support of PSE Projects GmbH. Freiburg, 16 September 2020

Green City AG and NKI (2018). Erneuerbare Energien aus Sicht von Finanzentscheidern in privaten Haushalten. 8f. https://issuu.com/greencityag/docs/studie_nki_gc_final.

Klimapavillon (2021). Ringvorlesung Wissenschaft und Gesellschaft im Klimapavillon in Nordhausen: Wie viel Windkraft braucht Thüringen? 15.06.2021. https://www.youtube.com/watch?v=WlPnB03kN28, 55:10.

Leipziger Institut für Energie LIE (2018). Gutachten zur Vorbereitung einer Energie- und Klimaschutzstrategie für Thüringen.

Masson, Torsten; Centgraf, Salina; Rauschmayer, Felix and Simke, Romy (2015). Mitglieder-Zuwachspotenzial für Energiegenossenschaften in Deutschland. *Zeitschrift für das gesamte Genossenschaftswesen* 65 (3). 191-208.

Institute for Advanced Sustainability Studies IASS (2018). Social Sustainability Barometer of the Energy Transition.

Siegesmund, Anja et al. (2021). Thüringen lässt die Sonne rein – gemeinsam für 100.000 Solaranlagen. Grünes Autor*innenpapier von Anja Siegesmund, Matthias Golle, Heiko Knopf und Maximilian Ramezani. 23.08.2021. https://www.anja-siegesmund.de/wp-content/uploads/2021/08/Solarpapier-2.pdf

Statista (2021). Bruttoinlandsprodukt (BIP) je Erwerbstätigen in Deutschland nach Bundesländern im Jahr 2020. https://de.statista.com/statistik/daten/studie/254144/umfrage/bruttoinlandsprodukt-je-erwerbstaetigen-in-deutschland-nach-bundeslaendern/.

ThEGA (2020). Photovoltaik in Thüringen - Zahlen für Landkreise und Städte. https://www.thega.de/themen/erneuerbare-energien/servicestelle-solarenergie/photovoltaik-in-thueringen-zahlen-fuer-landkreise-und-staedte/.

ThEGA (2021). Anzahl der Thüringer Windräder erhöht sich 2020 nicht. https://www.thega.de/aktuelles/detail/anzahl-der-thueringer-windraeder-erhoeht-sich-2020-nicht/.

ÜNB (2020). Mittelfristprognose zur deutschlandweiten Stromerzeugung aus EEG-geförderten Kraftwerken für die Kalenderjahre 2021 bis 2025, erstellt im Auftrag der 50Hertz Transmission GmbH, Amprion GmbH, TenneT TSO GmbH, Trans-netBW GmbH, enervis energy advisors GmbH, Oktober 2020. https://www.netztransparenz.de/portals/1/Content/EEG-Umlage/EEG-Umlage%202021/2020-10-07%20Endbericht%20enervis.pdf

Wesselak, Viktor (2021). Wieviel Windkraft brauchen wir? Ringvorlesung Wissenschaft und Gesellschaft im Klimapavillon in Nordhausen. Hochschule Nordhausen. Institut für Regenerative Energietechnik (in.RET). 15.06.2021. https://www.youtube.com/watch?v=WlPnB03kN28.

.

Warmian – Masurian Region (Poland)

Political potential

As part of meeting the EU-wide 2030 target and according to the National Energy and Climate Plan for 2021-2030 (NECP), Poland has set a political goal of a 21%-23% share of RES in gross final energy consumption (aggregate consumption in the electricity sector, heating and cooling sector, and in transport) by 2030. The 23% target is achievable only if Poland is granted additional funds, including those allocated for a just transition. By 2030, the share of RES in the heating and cooling sector is estimated to grow on average by 1,1% annually. In transport, a 14% share of renewable energy is expected to be achieved by 2030. In order to attain the above targets, RES will be supported through existing and new support and promotion mechanisms. There are also plans to use advanced biofuels, develop offshore wind energy, and add momentum to the development of RES-based micro-installations.[57]

Despite the fact that the national RES target has been set out, targets on a regional level in Poland have not been established. For the purpose of the REC potential estimation in the Warmian-Masurian region, the analytical annex to the National Energy and Climate Plan for 2021-2030 entitled "Impact assessment of policies and measures" (ECP scenario) has been used. It presents an 'Energy and Climate Policy' (ECP) Scenario containing an analysis (assessment) of the impacts of policies and measures, demonstrating how and with what effect the objectives will be achieved in the five dimensions of the Energy Union, including the 'climate and energy targets'.

In the ECP scenario (Annex 2 to the NECP, p. 64) it is estimated that in 2030, 23,8 TWh/year will be produced from onshore wind. This corresponds to a total capacity of 9510 MW in Poland, considering average full load hours of 2500, between 2020 and 2030 (Annex 2 to the NECP, p. 16). In 2019, the cumulated nominal wind energy capacity in Poland reached 5917 MW and in the Warmian-Masurian region 357 MW (ERO, 2021)[58], thus representing a share of 6,03% of total wind power capacity. Hence, assuming the same share in 2030, 217 MW of wind power capacity remain to be installed by 2030 in the Warmian-Masurian region. According to a recent report by Polish Wind Energy Association in cooperation with Baker Tilly TPA, "On-shore Wind Energy in Poland 2021" (PWEA 2021, p. 100), the estimated cost of 1 MW of installed capacity is currently around EUR 1,5 million.

Table 45 Investment need for wind energy in the Warmia-Masuria Province

	Unit	Comment	Source
574	MW	Political goal in 2030	NECP of Poland (2019)
357	MW	Installed capacity in 2019	ERO (2021)
217	MW	To be installed over the period 2020-2030	Calculation
325	**MEuro**	Assumed investment cost = 1500 Euro/kW	PWEA, Baker Tilly TPA (2021)

Considering ground-based PV, the ECP scenario (Annex 2 to the NECP, p. 64) estimates that in 2030, 6,8 TWh/year will be produced by PV installations (total). However, at the time of preparation of the NECP, the total electricity produced from PV was assumed to amount to 2 TWh/year in 2020, which corresponds to around 2000 MW_p installed capacity. In fact, at the end of 2020, the total capacity was

[57] The National Energy and Climate Plan of Poland for 2021-2030, Ministry of National Assets, December 2019.
[58] The National Potential of RES in numbers, Energy Regulatory Office, 2021.

equal to 3936 MW_p. Therefore, in the analysis the current status of capacity installed has been taken into account and combined with the dynamic foreseen in the ECP scenario of the NECP. Assuming the dynamic of PV growth, the total PV capacity will reach 13,29 GW_p in 2030.

The ratio of ground-mounted to rooftop PV in Poland is unknown (there is no registry on such distinction). Polish regulations make a distinction between two groups of PV installations:

- Micro-installations with a capacity up to 50 kW_p;
- Small and large installations with a capacity above 50 kW_p.

For the purposes of this analysis it has been assumed that 100% of micro-installations are rooftop and 100% of small and large installations are ground-based.

In 2020, the ratio of micro- to small and large PV was 75% to 25%.[59] But according to the forecast of IEO, we assume a ratio of 50% ground-based to 50% rooftop/facade PV by 2030 (IEO 2021, p.39). This means that in 2030 in Poland the total installed capacity of ground-based PV would reach a level of 6650 MW_p, which corresponds to an electricity production of 6,65 TWh/year in 2030, based on 1000 equivalent hours of full capacity. This is an estimated value used in the ECP scenario (Annex 2 to the NECP, p. 16).

The total PV capacity installed in the target region at the end of 2020 was 358 MW_p, of which 90 MW_p were ground-based PV systems. The share of total PV capacity installed in the target region compared to the total capacity in Poland was equal to 9,09% in 2020. Hence, assuming the same share in 2030, 515 MW_p of capacity remain to be installed by 2030 in the Warmian-Masurian region, which corresponds to 0,515 TWh.

Table 46 Investment need for ground-based PV in the Warmia-Masuria Province

	Unit	Comment	Source
604	MW_p	Political goal for ground-based PV until 2030	Calculation/estimation
89	MW_p	Installed capacity in 2020	ERO (2021)
515	MW_p	To be installed over the period 2021-2030	Calculation
347	**MEuro**	Assumed investment cost = 675 Euro/kW	IEO (2021)

In 2020, 268 MW_p of PV on rooftops were installed (assuming 75% of total capacity installed). Assuming the same ratio of 50% for ground-mounted and rooftop PV in 2030, 336 MW_p needs to be installed over the years 2021-2030.

According to data provided by the Institute of Renewable Energy IEO (2021), average prices for a typical 10 to 50 kW_p PV installation were around 900 Euro/kW_p in 2020. Taking into account that the average capacity of a micro-installation in Poland is 6,6 kW_p, the price for the above-mentioned range seems to be appropriate for a 10-years perspective. Moreover, the same price is foreseen in the ECP scenario (Annex 2 to the NECP). If we assume that 336 MW_p of PV on rooftops will have to be installed, the total investment need amounts to 302 MEuro.

[59] PV Market in Poland, IEO 2021

Table 47 Investment need for PV on rooftops in the Warmia-Masuria Province

	Unit	Comment	Source
604	MW_p	Political goal for rooftop PV until 2030	Calculation/estimation
268	MW_p	Installed capacity in 2020	ERO (2021)
336	MW_p	To be installed over the period 2021-2030	Calculation
302	**MEuro**	Assumed investment cost = 900 Euro/kW	IEO (2021)

Socio-economic investment potential of citizens

According to the Central Statistics Office of Poland, the province of Warmia-Masuria will count on average 564000 households between 2020 and 2030.[60] Using the figures of Table 6 (on the min. and max. investment in RES per household), we obtain the following min. and max. theoretical investment potential by households in Warmia-Masuria over the period 2020-2030:

- Min. theoretical investment potential: **364,3 MEuro**
- Max. theoretical investment potential: **729,3 MEuro**

AS I-Search (2019) reports that on average, 30% of the Dutch households would be willing to join an energy cooperative. It should be underlined that collective investments in RES infrastructure have not been developed so far in Poland, mainly due to the lack of an enabling framework. Citizen energy has been developed mainly on the basis of individual prosumer installations. The only examples of ‘collective’ RES projects in Poland are rooftop PV installations on multi-family buildings. However, the electricity produced by such installations can be used only to energize the common parts of the buildings. Therefore, in practice these installations are operated in exactly the same way as individual PV installations. In spite of upcoming regulatory changes enabling virtual and collective prosumption, the interest in collective investments might be limited. Worth mentioning are the data of the recently conducted poll among rural and semi-rural municipalities. The respective questionnaire was sent to 245 municipalities and was intended to measure the willingness of the selected municipalities to establish pilot energy cooperatives. Only 39 (16%) of them responded positively. In spite of the fact that the poll was sent to the municipalities only, it reflects the attitude and interest of the citizens as well. We take this percentage to be indicative of the percentage of households in Warmia-Masuria that would be willing to invest in RECs over the period 2020-2030, and therefore we obtain the following figures for the socio-economic investment potential by households in Warmia-Masuria:

- Min. socio-economic investment potential: **54,65 MEuro**
- Max. socio-economic investment potential: **109,39 MEuro**

Potential assessment for RECs

Using the calculation rules for dividing the (minimum and maximum) socio-economic investment potential over the three RES technologies, Table 48 indicates the REC potential assessment for Warmia-Masuria, expressed as percentage ownership by citizens under two separate conditions (ownership for 100% financed by citizens vs. ownership for 20% financed by citizens).

[60] https://stat.gov.pl/download/gfx/portalinformacyjny/pl/defaultaktualnosci/5469/9/4/1/prognoza_gospodarstw_domowych_na_lata_2016-2050_002.pdf

Table 48 REC potential assessment for Warmia-Masuria

Investment potential	Min.	Max.	Unit
Wind energy	11,3	22,5	MEuro
% ownership (100% financed by citizens)	**7%**	**13%**	
% ownership (20% financed by citizens)	**33%**	**67%**	
Ground-based PV	26,4	52,8	MEuro
% ownership (100% financed by citizens)	**15%**	**30%**	
% ownership (20% financed by citizens)	**74%**	**149%**	
Collective PV on rooftops	17,2	34,4	MEuro
% ownership (100% financed by citizens)	**11%**	**22%**	
% ownership (20% of large installations financed by citizens)	**56%**	**112%**	
Total	**54,65**	**109,39**	MEuro

Looking at Table 48, the potential assessment for RECs in the Warmian-Masurian Province looks promising. It shows that, citizens of the region can contribute to the achievement of the national goal of 23% share of RES in gross final energy consumption by 2030 on the same level as it was until 2020 without collective investments. It means that the development of onshore wind and PV systems can be maintained on the same level as it was until 2020 based on contribution of citizens. Despite the relatively low socio-economic investment potential, the resources could enable to maintain significant contribution of the region in achievement of 32% of RES in the electricity sector in Poland in 2030. In overall, RES investment that are entirely financed by citizens could represent rather low share of the total investment needed in the region. However, assuming that 20% of the needed investment cost are financed by citizens and the rest by other sources including financial support schemes and debt capital, the new capacities of both ground-based and rooftop PV could be fully controlled by citizens on the condition of utilisation of the maximum investment potential. For wind energy, the values are lower, ranging from 33 to 67%. It shows that necessary investments in large-scale wind energy need to be accompanied by other investors/companies.

Looking at Table 48, it is likely that the political goal for onshore wind and PV set out in the NECP can be fully reached by complementing the citizen investments with investments by local SMEs and local authorities. However, in order to unlock this potential, an enabling framework seems to be needed. Polish citizen energy has been principally developed based on individual prosumers. The net-metering scheme introduced by legal order in 2016 was a trigger for the development of the prosumer sector in Poland. Therefore, the development of micro-scale RES installations by individuals, SMEs and public authorities has been growing in the last years. Moreover, a number of financial incentives targeted at individuals resulted in a rapid development of micro-PV installations and allowed the attainment 3 GW_p at the end of last year: These incentives included:

- Grant support,
- Tax reliefs,
- Simplified construction procedures.

Despite the intense promotion of individual prosumerism, there is still a lack of business models enabling collective actions. The definition of an energy cooperative and provisions on the dedicated support scheme introduced into the legal framework in 2019 still do not allow the creation and running of such entities. There is a need of respective regulations, which are being prepared by the Ministries along with provisions on virtual and collective prosumption.

References

AS I-Search (2019). Verkenning toekomstpotentieel burger-energiebeweging 2030. Energie in eigendom van de lokale gemeenschap. Rapport in opdracht van het ministerie van Economische Zaken en Klimaat, mede op verzoek van Energie Samen (samenwerkende energiecoöperaties).

AS I-Search, Bosch&Van Rijn (2020). Monitor participatie hernieuwbare energie op land - Resultaten nulmeting. Rapport in opdracht van het Ministerie van Economische Zaken en Klimaat, juni 2020.

Energy Regulatory Office – RES potential in numbers, available at https://www.ure.gov.pl/pl/oze/potencjal-krajowy-oze

ENERGY AND CLIMATE POLICY (ECP) SCENARIO - Impact assessment of policies and measures: Annex 2 to the National Energy and Climate Plan for 2021-2030
Handbook of topology of residential buildings with examples of the measures reducing energy consumption, NAPE, 2011, avaialble at:
https://episcope.eu/fileadmin/tabula/public/docs/brochure/PL_TABULA_TypologyBrochure_NAPE.pdf

Hier Opgewekt (2020). Lokale energiemonitor 2020, available at https://www.hieropgewekt.nl/lokale-energie-monitor

IEO Report PV Market 2020, available at https://ieo.pl/pl/raport-pv

National Energy and Climate Plan for the years 2021-2030, available at https://www.gov.pl/web/aktywa-panstwowe/krajowy-plan-na-rzecz-energii-i-klimatu-na-lata-2021-2030-przekazany-do-ke

NREL. Estimating Rooftop Suitability for PV: A Review of Methods, Patents, and Validation Techniques

Polish Wind Energy Association in cooperation with Baker Tilly (2021). On-shore Wind Energy in Poland in 2021.

CONTACT

COME RES Project
info@come-res.eu
www.come-res.eu

PARTNERS

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 953040. The sole responsibility for the content of this document lies with the COME RES project and does not necessarily reflect the opinion of the European Union.