Toolkit for Policy Assessment

A Framework for Analysing the Impacts of Social Innovations in the Renewable Energy Sector

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WIP Renewable Energies coordinates the SocialRES project.

The consortium involves 13 partners in 9 European Countries. The logos of the partners cooperating in this project are shown below and information about them is available in this report and at the website: www.socialres.eu

This report has been written by Jakob Hoffmann, Jan Fjornes, Joscha Gretzschel, Kathrin Anger and Andreas Schneller from adelphi. The authors thankfully acknowledge the valuable contributions from all project partners.

Disclaimer

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List of Abbreviations

CF	Crowdfunding
CO_2e	Carbon Dioxide Equivalents
DER	Decentralised Energy Resources
DSO	Distribution System Operator
EC	Energy community
EU	European Union
EV	Electric Vehicle
FiT	Feed-in Tariffs
GHG	Greenhouse Gas
GW	Giga Watt
IA	Impact Assessment
ICT	Information and Communication Technology
IEMD	Internal market for electricity directive
kW	Kilowatt
kWh	Kilowatt hour
MW	Mega Watt
MWh	Mega Watt hours
NPO	Non-Profit Organization
LTECV	Energy Transition Law for Green Growth (France)
RE	Renewable energy
REC	Renewable energy community
REDII	Recast renewable energy directive
RES	Renewable energy sources
PV	Photovoltaic
P2P	Peer-to-peer
SME	Small and Medium Enterprises
TSO	Transmission System Operator
UK	United Kingdom
USAID	United States Agency for International Development

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1. Introduction

Social innovations are one key instrument to increase energy democracy, citizen participation and inclusion in the energy transition. In order to support social innovations in the energy sector, governments and authorities need to be able to assess their benefits properly. In this regard, easy-to-understand empirical data is crucial in the policy process, to reach all important stakeholders, decision makers as well as the general public.

This paper and the toolkit presented therein seek to increase the attention given to alternative approaches for enhancing the energy transition by providing stakeholders in the policy process a tool to highlight the multiple benefits of social innovations, and to increase knowledge and best practice exchange within and across countries.

The paper is structured across four core chapters. After the introduction firstly chapter 2 portrays the necessity for comprehensive analysis of social innovations, underlined by the results of expert interviews as well as academic publications. Chapter 3 provides methodologies to assess the impacts that RES communities, RES aggregators and crowdfunding platforms active in RES have, focusing specifically on the social, economic, and environmental impacts of each. The chapter draws from theoretical impacts explored in the past and empirical case study data.

Based on the work of various empirical studies and impact assessments of social innovation in the energy sector, this paper presents a toolkit in the form of a taxonomy for measuring impacts of social innovations in chapter 4. The taxonomy provides information for each impact, including indicators, scope of the impacts, methodological approaches, as well as potential data sources for the measured impacts. A taxonomy is developed for each of the three focal social innovations of the SocialRES project. The taxonomies follow the same structure but show slight differences as they are adapted to the specificities of each social innovation. Lastly, the chapter provides an overview of the applications for use of the taxonomy for both policymakers and practitioners.

Finally, in chapter 5, the taxonomy is applied to illustrate the social economic and environmental impacts that select case study partners from the SocialRES project have had. It also provides a description of the case studies to try and shed light on the soft impacts that the social innovations are having.

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2. Reasoning

Social innovations in the energy sector such as renewable energy communities, energy aggregators and crowdfunding projects have the potential to play an important role in the energy transition and in reaching the goals of the European Green Deal (Hoffmann *et al.*, 2021). These social innovations have seen increased popularity since the introduction of legal definitions of these terms in recent EU regulations. Namely, the Directive (EU) 2018/2001 on the promotion of the use of energy from renewable sources, Directive (EU) 2019/944 on common rules for the internal market for electricity (IEMD) and the Regulation (EU) 2020/1503 on European crowdfunding services providers for business provide clear legal terminology. Besides the framework regulations laid out by the European Union, national and regional policy makers all over Europe have also been introducing policies aimed at increasing citizen participation in the renewable energy sector and strengthening energy democracy by supporting social innovations. In 2015 France introduced the *Energy Transition Law for Green Growth (LTECV)* and the B*onus Participatif* alongside it to promote the financial involvement of local stakeholders in renewable energy projects (Hoffmann *et al.*, 2021; Sebi and Vernay, 2020). In 2011 Scotland set ambitious targets for community ownership of installed renewable energy capacity, with similar efforts now adopted in Wales, the Netherlands and other countries (Bolle, 2019).

Recently, studies by authors such as Leonhardt *et al.* (2022)[1] and Hoffmann *et al.* (2021) have started to compare policy instruments available to governments to support social innovations (such as energy communities). They observed strong national differences within the EU in both the policy and socio-cultural environment regarding the local energy markets. Hence, the differing national and regional characteristics impede a comparative analysis of a legislation's policy effectiveness to support social innovations (such as energy communities, aggregators or crowdfunding platforms). The SocialRES *White Paper on Good Policy Practice* highlights the vast differences in regulatory and policy approaches in this field, outlining the most important barriers and enablers and how these are influenced by local specificities.

Therefore, this paper does not look at the specific policy outcomes in various countries. Neither does it evaluate the effectiveness of a policy in supporting the creation of social innovations, rather it evaluates the impacts of social innovations, and describes the important role of impact assessments within the policy process.

[1] This article will be published in the January 2022 volume of Energy Research & Social Science, but has been available online through Open Source access since October 2021 at https://doi.org/10.1016/j.erss.2021.102350

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The focus is on the "why" policy makers should support social innovations, rather than the "how" they should best support them.

The recent examples of legislation passed to support these social innovations, operate under the assumption that they are generally beneficial to society. This assumption is largely shared by academia. A multitude of studies assume that social innovations in the energy sector contribute to social cohesion, community engagement, and strengthen local economies (Hoppe and Vries, 2019). However, these assumed benefits often lack concrete evidence (van der Waal, 2020). At the same time, social innovations like energy communities are not universally seen positively and can be found controversial if the local population does not benefit equally (Walker and Devine-Wright, 2008). To further promote their uptake, tools to accurately assess the impacts of these social innovations are needed. Currently, only a few studies systematically approach impact assessments of renewable energy communities (RECs), energy aggregators or crowdfunding (Berka & Creamer, 2018). The lack of a systematic approach is related to the diverse characteristics of these social innovations, as two given projects can differ significantly in features such as scope, degrees of community involvement and even activities (Caramizaru and Uihlein, 2020; Walker and Devine-Wright, 2008). A comprehensive framework for analysis needs to account for these differences. Simultaneously, such a framework needs to be generic enough to be applicable to a wide array of social innovations in the energy sector. Thus, an effective framework for impact assessments (IAs) analyses particulars of a single project and finds application in the analysis across a multitude of projects.

Perspectives of policy makers and practitioners

adelphi has interviewed a number of policy makers and experts to assess the need for information by authorities on measuring the impacts of social innovations in the energy domain. Employing a semi-structured interview guide, the authors of this report consulted experts from Croatia, Germany, France, Portugal, Romania Spain, and the UK. In total, we interviewed 23 professionals working in regional governments, city councils, energy agencies, and as mayors of municipalities. These interviews showed that in general, many authorities on different levels of government across Europe already try to assess the impacts of new policies. However, the scope of conducted impact assessments and the level of systemisation of the applied methodology varies greatly. A few interviewees described that they use IAs for most proposed policies, while most interviewees said that impact assessments are only conducted in a certain policy domain and with a limited number of aspects in consideration. For example, an interviewee from Southern Germany described how they assessed the impacts of three wind turbines the municipality had built. Because of a lack of resources and know-how, only basic economic indicators such as the amortisation period could be assessed in that case. Other interview partners from small municipalities in Croatia and Spain acknowledged that they do not use impact assessments at all.

Only a few interviewees described having assessed the impact of policies in the specific domain of RECs, aggregators or crowdfunding, with most efforts again focusing only on the economic effects. One interviewee said that they had used an external agency to assess a proposed project involving a renewable energy cooperative, as they did not have the know-how how to conduct a systematic impact assessment.

Most importantly, the overall opinion from the interviewed experts was that a framework for impact assessments of social innovations presents a valuable tool to give an initial overview and can help in designing new and adapting existing policies in the renewable energy domain. However, some interviewees pointed out that the main challenge of promoting the uptake of renewable energy in general and specifically social innovations is not the assessment of impacts. Instead, navigating the legal framework and contractual requirements in the energy sector acts as a barrier. Addressing these challenges exceeds the scope of this toolkit.

Nonetheless, establishing a toolkit for systematic IAs should benefit all stakeholders involved in social innovations in the energy sector. In the following paragraphs, some exemplary stakeholder interests are portrayed.

Benefits for stakeholders

Data driven policies backed by systematic impact assessments should facilitate better decision-making **for authorities and local governments** when designing new regulations. The established administrative and bureaucratic processes in energy regulations today are often advantageous especially for large, vertically integrated firms that have characterized the energy sector in Europe for the past decades (Hoffmann *et al.*, 2021). With a systematic impact assessment at hand, policy makers can ideally design legislation in way that boosts the benefits of the described social innovations while mitigating their shortcomings. Beyond the more obvious effects of a social innovation, an IA can highlight impacts that may previously have passed under the radar, but can be important for policymakers to be aware of and have evidence of. These are importantly the social and environmental impacts of these innovative organisational models. The economic aspects are important in so far as the focus should not only be on the money generated, but also who it flows to and who benefits (Slee and Harnmeijer, 2017).

Furthermore, accurate impact assessments should also increase **citizen** support for social innovations in energy. Gauging potential benefits while also disclosing possible drawbacks increases the transparency of proposed projects. Thus, citizens can better evaluate such projects and forge an informed opinion. The dismantling of

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information asymmetries can reduce citizen resistance to new projects and increase citizen support by showing pathways of participation. This is especially true for cases of renewable energy communities and crowdfunding, as these rely heavily on community participation in their projects.

For project sponsors and companies involved in these social innovations, conducting systematic IAs with an established procedure or framework gives credibility to the findings of those analyses. For instance, a company that is a member of a renewable energy community will naturally promote the benefits of their projects, regardless of the availability of empirical evidence. Members of energy communities will likely also support regulatory policies that enhances their business model. With a systematic impact assessment at hand, outside stakeholders can evaluate the plausibility of such claims. Thus, members of RECs, enterprises active in energy aggregation and crowdfunding platforms have an interest in showcasing and validating the assumed benefits of their business models in a structures fashion presentable to stakeholders within and outside their organisation, including government authorities. At the same time, IAs highlight possible negative impacts, which allows actors of these social innovations to mitigate shortcomings.

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3. Background: Impact assessments

The preceding chapter portrayed the need for data driven tools to analyse social innovations. This chapter first describes how impact assessments are conducted, portraying both different frameworks and methodological approaches that are commonly used. Then, impact assessments and empirical studies specifically of renewable energy communities, energy aggregators and crowdfunding platforms for RE projects are presented and assessed. This builds the foundation of the taxonomy for impact assessments of these social innovations that is depicted in chapter 4.

3.1 Impact Assessments in general

What is an impact assessment?

Impact assessments (IA) are structured processes, aimed at analysing possible implications of proposed or existing actions or existing projects. By considering impacts for people and their environment, an impact assessment supports policymakers and others in the decision-making process. It can be applied in a variety of circumstances, from designing legislation to the evaluation of specific projects (European Commission, 2017; Fortuny, 2021).

Procedure

Impact assessments do not underlie a strict set of pre-defined methodological steps that can be applied to any case. Rather, the exact procedure of conducting IAs depends on the entity or institution commissioned and the context of the project, policy or other subject that the IA is analysing. The most common IA frameworks are depicted in table 1, based on Simsa (2014).

Table 1: Examples of Common IA Frameworks

IA Framework	Description	Application
Social Return of Investment	SROI-Analysis measures social value created in monetary terms and contrasts this value to the amount of invested capital to calculate an aggregated ratio of social return of investment.	SROI-analyses are best used for benchmarking investments but lack a standardized approach. Thus, this method should be used with a per-case approach as a comparative tool.
Cost-Benefit-Analysis	Cost-Benefit-Analysis (CBA) is a specific form of economic evaluation, contrasting the costs of a project with its monetarised impacts.	Comparison of investment opportunities

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Global Reporting Initiative (GRI)	Global Reporting Initiative (GRI) is a complex set of indicators mostly used by large enterprises to report impact dimensions to investors.	Stakeholder reporting focused on non-financial impacts.
Impact Reporting & Investment Standards (IRIS)	Impact Reporting & Investment Standards (IRIS) are used by impact investors to assess investment opportunities. Consists of catalogue of key figures analysing the financial, ecological and social success of an organisation or investment.	Used mostly by impact investors
Social Reporting Standard (SRS)	Social Reporting Standard (SRS) is a framework to standardize social reporting.	Works as a template to structure an impact assessment without outlining specific indicators.
Social Accounting and Auditing	Social Accounting and Auditing provides a framework to define a process of selecting performance and impact indicators.	Primarily used by SMEs and NPOs to assess their own organization.
Logical Framework Approach	The Logical Framework approach is used as a project monitoring system, providing a linear impact model that serves as the foundation upon which a project evaluation and monitoring system can be build.	Developed by USAID in the 1960s, it is used most commonly in development aid.
Outcome / Change Mapping	Outcome mapping aims at assessing the changes in behaviour of stakeholders involved in program or project.	Used for internal learning and self-evaluation.

With so many different existing frameworks as presented in **Error! Reference source not found.**, it can be difficult to compare impact assessments of projects of the same domain but conducted according to varying frameworks. However, the number of dissimilar frameworks is not the only factor that highlights the differences in impact assessment approaches for projects.

For policy proposals, a different procedure altogether is needed to assess possible impacts. One of the best-known approaches for impact assessments of policy proposals is the standardized procedure of the European Commission. This process has long been established as a key part of the development of new regulation. In the EU's IA procedure, the impact assessment answers the question what problem a policy proposal should solve, and subsequently analyses and compares various options regarding their economic, social and environmental impact. The findings of

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this process are summarized in an impact assessment report (European Commission, 2018a), that includes:

- "the environmental, social and economic impacts, including impacts on small and medium enterprises and competitiveness, and an explicit statement if any of these are not considered significant
- who will be affected by the initiative and how
- the consultation strategy and the results obtained from it"

Methodological Approaches

The preceding section on procedural frameworks for impact assessment have highlighted the diversity of available options. The methodological approaches to accumulate data for impact assessments are similarly disparate. **Error! Reference source not found.** lists the most common methods to gather data and their application, based on guidelines by the International Institute for Sustainable Development (2016).

Table 2: Examples of Common IA Methodologies

Method	Description
Expert Judgement	• Reporting based on opinions of professional experts • Used when data availability is limited
Quantitative Physical and Mathematical Models	• Modelling that is used in particular to study physical relationships of environmental systems • Availability of quantitative data is a prerequisite
Cumulative Impact Assessment	• Assessment of relationship of successive impacts reinforcing each other, possibly leading to more serious consequences
Matrices and Interaction Diagrams	• Pre-defined matrices for the assessment of projects in a particular industry, adjusted to the characteristics of the project • Mostly used for visualizing available data
Rapid Impact Assessment Matrix	• Assessment of four aspects using qualitative data gathered by multidisciplinary teams: physical-chemical, biological, human, economic • Public participation in data collection • Creates an impact portfolio that allows for comparison of development options
Battelle Environmental Evaluation System	• Assessment focused on environmental impacts, divided into four categories: ecology, pollution, aesthetics and human interest

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	• Parameters are chosen to compare project alternatives

As table 1 and table 2 show, the high number of alternatives both in framework and methodological approaches make it possible to customize the exact procedure of an IA to the specific needs of a project. However, the lack of standardization makes it difficult to compare and contrast IAs of different projects.

The following subchapter presents examples of impact assessments and empirical analyses of projects in the field of renewable energy communities, energy aggregators and related crowdfunding projects that exemplify this problem.

3.2 Impacts of Social Innovations in Renewable Energy

In the following, we depict the impacts of social innovations in renewable energy most commonly described in the literature. For energy communities, impact assessments of single projects have been published in the past. Hence, the methodology as well as the impacts described in those studies are presented here. To form a comprehensive perspective, we furthermore portray impacts of RECs described in empirical studies that use different empirical methodological approaches. For energy aggregators and crowdfunding platforms for RES projects, we rely on aggregate studies to assess the impacts of these social innovations.

Renewable Energy Communities

Citizen-owned Renewable Energy Communities (RECs) have existed since the 1990s. First popular in Germany and Denmark, the concept has today spread throughout the European Union. Today, about 3400 RECs operate in its 27 member countries. (RESCoop Mecise, 2019). RECs are mostly comprised of a group of local citizens that collectively own, manage and operate assets to produce renewable energy. The passage of the *Directive (EU) 2018/2001 of the European Parliament and of the Council on the promotion of the use of energy from renewable sources (2018)* by the European Union ensures that RECs exist to serve the local community. The definition of RECs in that legislation guarantees that RECs cannot not be used in the economic interest of large energy companies, energy-intensive companies, or single investors (Hoffmann *et al.*, 2021). The various impacts that characterize renewable energy communities are assessed and described in the following sections.

Methodological Procedure

A model illustration of how impact assessments for renewable energy communities are conducted is Van der Waal's analysis of a wind turbine located on the Scottish Orcadian islands, published in *Energy Policy* (2020). This case study uses a mix of the

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methods presented in chapter 3.1 for data gathering, but complements the assessment with a change mapping approach to illustrate the project's local impact. Van der Waal's method highlights how research participants experience and perceive changes caused by the project, illustrating both positive and negative outcomes.
In contrast to the systematic analysis of a single project, Kirsch *et al.* (2015) present an assessment of the impacts of all RECs in one country.
A third approach to impact assessments of social innovations is presented by Preenen *et al.* (2014). Here, the authors have developed an IA method that allows for both the analysis of impacts of a social innovation as well as the ex-ante analysis of the impacts of policy options on these social innovations. This contrasts with the approaches taken by Van der Waal and Kirsch et al., as their approaches do not analyse the effects of different policy alternatives. This makes the approach taken by Preenen *et al.* likely more useful for policy makers.
Besides the described impact assessments, the impacts of RECs illustrated in the following sections are portrayed by Bauwens and Devine-Wright (2018) who rely on a large set of survey data on REC membership. Furthermore, evidence from case studies are used (Caramizaru and Uihlein, 2020), as well as findings from literature reviews (Caramizaru and Uihlein, 2020; Slee and Harnmeijer, 2017; Tarhan, 2015). In addition, Wierling *et al.* (2018) analysed different databases of energy communities to evaluate their collective impact.

Economic Impacts
Renewable Energy Communities entail various positive socioeconomic impacts. Most of these effects stem from the revenue created by the REC. Here, the comparison to hosting commercial power plants is significant. Studies estimate that communities can expect up to €15.000 per installed MW of capacity for hosting commercial wind farms, largely through tax revenues and leasing contracts. Community projects can generate over €115,000/MW per year for the involved stakeholders (Slee and Harnmeijer, 2017; van der Waal, 2020). This way, RECs contribute considerably to local wealth creation. Kirsch *et al.* (2015) found that the assessed projects had returned 3.5 million AU$ for community investors.

The revenue generated from RECs is directly related to the installed capacity. Thus, the installed capacity is another important indicator for impact assessment in this domain. However, the available data for this is often incomplete. Many small cooperatives lack the resources for publishing their data, therefore researchers have to rely on approximations. For example, Wierling *et al.* (2018) estimate that in the UK, energy cooperatives account for 150 MW of installed capacity. Similar exemplary estimates are related to the capital invested in RECs. Wierling *et al.* approximate that in Germany, about 600 million € are invested in shares of energy cooperatives.

Moreover, RECs lead to the creation of local jobs. In van der Waal's analysis, the Orcadian REC is now one of the main employers of the municipality (van der Waal, 2020). Similar results are found in the assessment by Kirsch *et al.* (2015). Job creation and improved employment opportunities are a significant result even in small scale projects. The inception and operation energy cooperatives also enable its members to acquire various vocational skills. It the case of the Scottish REC, REC members acquired comprehensive knowledge about project management aspects and RE technologies. These professional skills are easily transferrable to other jobs, contributing to the overall attractiveness of the local area for other businesses and enhancing the employability of its citizens. In addition, the project indirectly created employment opportunities in the transportation network of the island, as the proceeds finance a ferry service. This cross-financing of the local infrastructure increases the quality of life for residents overall (van der Waal, 2020).

Environmental Impacts

In general, the main environmental impact of RECs are the greenhouse gas emissions avoided by substituting conventional fossil-fuel based energy sources with renewables. The scope of the impact depends on two main factors: the amount of renewable energy produced and the composition of the local electricity supply and the associated mean carbon emissions. Some countries' energy system mostly run on coal-fired power plants. Hence the amount of GHG-emissions avoided in those regions will be higher than in countries which already have a large renewable share. The Australian REC study provides data for both of these indicators. The authors find that until the end of 2014, Australian RECs accounted for 50,000 MWh of clean energy fed into the grid. Kirsch *et al.* calculate that this avoided has 43,000 tonnes CO_2e.

Social Impacts

While much harder to quantify than economic and environmental effects, RE communities also have a significant social impact. van der Waal (2020) found that the observed community-owned windfarm positively contributed to social cohesion by funding an expanded public transportation service with the proceeds of the windfarm. This enabled especially elderly citizens to more easily take part in community life.

Furthermore, the involvement of the local citizens has likely contributed to lowering opposition to the erection of the wind turbines. Even though the Orkney islands are known for the beauty of their natural landscape, the citizens surveyed by van der Waal have largely refrained voicing negative perceptions of the presence of the community wind farm. Negative impacts of the project in any domain were found to be limited and curbed by the involvement of the community in the development process and the operation of the venture. Thus, the majority of residents view the wind farm as a necessary trade-off for more sustainable electricity generation from which the community benefits as well. Consequently, an independent poll found 77% of voters approving of the wind park (van der Waal, 2020).

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Further social impacts of renewable energy communities are portrayed by Caramizaru and Uihlein (2020) among others. By involving the local community in a shared endeavour from which local stakeholders benefit directly, social cohesion and participation in community life is promoted. For example, energy communities may include their members in the approval and ratification of decisions of the energy community's managing body, i.e. how a surplus of revenue is distributed among stakeholders. This democratization and citizen engagement in energy systems empowers citizens to act jointly to address energy poverty, reduce carbon emissions and combat climate change on a local level (Caramizaru and Uihlein, 2020). Similarly, Bauwens and Devine-Wright (2018) found that through the engagement with local stakeholders, RECs can overcome uncertainty and indifference towards renewable energy of local citizens, even those not directly involved with RECs. In this way, RECs facilitate a fast and socially acceptable energy transition towards renewables.

Energy Aggregators

Changes in the electricity market like the shift to renewables, more sophisticated information and communication technology (ICT), and increasing adoption of decentralised energy resources (DERs) are providing new opportunities for aggregators to create value across the energy supply chain. The business models for aggregators have been explored as part of the SocialRES project (Lizarralde, 2020) as well as in other projects such as the BestRES project (Fleischhacker *et al.*, 2017).

For our purposes we look specifically to aggregators with retail activities, mass prosumer aggregators, and peer-to-peer (P2P) energy trading service providers. As we are most interested in the social, economic, and environmental impacts that aggregators can have on individual citizens or a community, we look at business models where individual consumers and prosumers are directly involved. The data on these impacts is still scarce as not many of these types of aggregators are active in the EU yet due to technological and regulatory barriers (Hoffmann *et al.*, 2021). However, the following section will look more closely at some of the impacts and value creation that has been explored as well at the methodologies employed to do so.

Methodological Procedure

Measuring the impact of mass consumer RE aggregators is difficult on an empirical level as their spread is limited across the world. The main methodological approaches have been case studies and system modelling. The case studies tended to be smaller in size, with the results then being modelled on a national scale. Further approaches have looked at effects and impacts of variable pricing schemes and what these impacts can tell us about the impact that aggregators may have (Eid *et al.*, 2016). Many of the impacts explored focused on the effects on the energy

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grid, such as peak load shaving and congestion management. The economic impacts were frequently analysed at an aggregated level, across the economy, rather than at the household level. Environmental impacts were commonly derived from the demand reduction, especially peak load reduction, although empirical data here is still limited. Lastly, the social and potential behavioural impacts were largely unexplored.

Scott Burger *et al*. (2016) explored the value of aggregators in the electricity system, identifying three categories of value that aggregators have within the electricity system and using data from two case studies to empirically back their arguments. Barbiero, Blasi and Schwidtal (2021) looked at the impact that end user aggregation has on the electricity business ecosystem. Their paper, relying on 4 case studies, also looks at value creation by actor group, and explores who is able to capture value from aggregation in different aggregation business models. The paper also looks beyond economic value and includes the environmental value of emission reduction.

Economic impacts

In a post subsidy era, as characterised by the phase out or significant reduction in feed-in-tariffs in many EU countries, prosumers are left looking for alternative business models through which to increase returns on their RE investments. In Brown, Hall and Davis's (2019) paper exploring the business model options that prosumers have in the UK, aggregation featured heavily, as it is the only way prosumers can access markets and provide services which they are excluded from on an individual basis. Owners of distributed energy resources (DERs) participating as part of an aggregator reduces transaction costs on both sides; the wholesale side only needs to interact with one actor as opposed to many small ones, and the DER owners save the cost of to learning how the markets work and the cost of developing market strategies (Glachant, 2019).

The economic benefits to prosumers participating in an aggregator can be manifold. The first and most significant is the direct income that prosumers can earn through participation in an aggregator. Aggregators can provide ancillary services on the electricity market such as demand response, through offering the consumption and generation flexibility of their members. The members of the aggregator are then compensated for the flexibility they make available. This opens up revenue streams for private households in a segment of the electricity market previously reserved for large centralised companies (Barbiero, Blasi and Schwidtal, 2021).

A further important economic impact is that aggregators, through allowing households to monetise their consumption flexibility, increase the value of other technologies (Brown, Hall and Davis, 2019). Many products and systems, such as smart appliances, heat pumps, and electric cars, will be critical in creating flexibility in both consumption and supply for the aggregator. This means they will serve a

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secondary purpose beyond their primary function. The ability to integrate these technologies into the electricity grid and their ability to generate revenue for the household as part of an aggregator, can also increase their attractiveness as an investment for individual households.

Beyond generating revenues for their members, aggregators can also save them money. Aggregators respond to price signals from the wholesale markets, which determine the times in which they sell energy, or when they reduce demand. Aggregators can sell demand reduction to DSOs and TSOs during times of peak demand, thus monetizing the flexibility of the aggregated DERs, as well as reducing strain on the energy system as a whole (Albadi and El-Saadany, 2008). A case study from Nevada, analysed by Scott Burger *et al.* (2016) found that peak hour demand reductions resulted in $33 in savings per year. This sum would likely be too small to motivate an individual or a household to actively manage their energy consumption, however, the aggregator makes this a passive process. While impacts at the household level may be small, the same case study estimates that demand reduction during peak hours via aggregation could save 140 MW of generating capacity in Nevada and 4.5 GW across the USA (Scott Burger *et al.*, 2016). Savings, however, can also be higher as demonstrated by a separate case study in Nevada, USA which saved customers around $100 per year or 635 KWh in electricity and 527 KWh in gas (ecofactor, 2014).

Aggregated demand response also brings significant value to grid operators, which is why DSOs and TSOs are the parties interested in purchasing flexibility (Valarezo *et al.*, 2021). Beyond these, peak demand reduction comes with a number of benefits for all electricity market participants. Firstly, it contributes to a reduction in price volatility. Near maximum generation capacity, electricity price increase exponentially as peaking plants are activated. Peak time demand reduction means that peaking plants are called upon less frequently (Albadi and El-Saadany, 2008). Secondly, increased flexibility means less capacity needs to be installed. A case study from Vermont, USA found a 13.5% decrease in peak demand events which equalled $190,000 in annualised savings for the utility running the pilot (Pratt and Erickson, 2020). A lot of capacity is currently installed to serve only very few peak hours of demand. Increased flexibility offered by aggregators can avoid these investments (Bray, Woodman and Connor, 2018). Furthermore, investments in expensive grid reinforcement, necessary to deal with the strain on the grid during peak hours of demand can also be avoided or deferred (Bray, Woodman and Connor, 2018; Schittekatte, Reif and Meeus, 2021; Scott Burger *et al.*, 2016).

Environmental impacts

The main way in which aggregators impact the environment and contribute to GHG emission reduction is through more efficient use of energy. Demand may be ramped up when electricity prices are low, for example during a time of high RE generation.

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Customers enrolled in the aggregator Voltalis in France saw an average reduction of 10% on their electricity bill due to the aggregator software interrupting their heating in response to grid (from TSO) and price signals (Eid *et al.*, 2016). Energy savings through energy management systems naturally leads to positive environmental impacts. Thus, a dual benefit of cost saving for the consumer and reduce emissions is achieved via aggregation. Casals and Corchero (2020), studying two buildings involved in aggregated demand response found that both electricity bills and emissions were reduced. For each kWh shifted, between 0.024 and 0.027 Kg of CO_2 were saved in each building. This shows the environmental benefits of buildings participating in offering ancillary services through an aggregator.

Aggregation can also play an important role in the expansion of renewable energy resources. As more renewable energy sources come online and coal and gas plants close, flexibility will play an increasingly important role in overcoming the intermittency challenge (Bray, Woodman and Connor, 2018; Brown, Hall and Davis, 2019), thus, aggregators' role in providing that flexibility will be crucial in adapting power systems to even higher rates of renewables.

Lastly, as mentioned previously, a main goal of aggregated demand response is peak time demand reduction, and thus avoiding activating or ramping up expensive peaking plants. Peaking plants are most commonly fossil fuel powered as, particularly gas turbines have high ramp rates. The flexibility from demand response through aggregated load curtailment and shifting as well as aggregated battery storage reduces the need for these expensive fossil fuel burning plants (Barbero, Casals and Corchero, 2020).

Social impacts

Aggregation offers consumers the chance to participate in the electricity market, thus allowing consumers to profit in a market that has traditionally been captured by large firms. This means aggregators allow consumers to capture some energy market profits and thus can have redistributive effects. Inclusion in an aggregator also sensitises consumers to the complexities of the electricity market, such as peak load pricing or balancing. This understanding can help citizens become more "aware" consumers, who through their inclusion in an aggregator change their behaviour in a way that reduces their climate impact and saves them money.

Participating in an energy P2P trading platform means that prosumers who used to passively consume and produce energy (and sell it to the utility) now take a more active role. Participants become sensitive to the volatility of the electricity price, and understand electricity markets in terms of day-ahead and intraday prices. This knowledge can affect their consumption behaviour, for example they may postpone their energy intensive activities to a day with low electricity prices (when lots of

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sunshine is forecast), for example charging their electric car or running energy intensive household appliances.

A further social impact is the increased acceptance of the energy transition through an active participatory stake which aggregators offer citizens (Schill, Zerrahn and Kunz, 2019). Inclusion in an aggregator can increase the incentive to install smart meters in countries that still lag behind in the rollout, as having one is often a prerequisite for participation. Beyond this, consumers may be incentivised to adopt other technologies sooner, such as EVs, heat pumps, battery storage, or smart appliances as these increase their marketable flexibility. This may prove to be a positive social impact as buying decisions may include more environmental and energy efficiency considerations.

Crowdfunding

The preceding two subchapters have presented actors that open formerly inaccessible revenue streams to private households by engaging them in the energy market. Similarly, crowdfunding presents a direct opportunity for individuals participate and profit from taking part in energy markets by financing RE projects.
Article 2 of the *Regulation (EU) 2020/1503 of the European Parliament and of the Council on European crowdfunding services providers for business* 2020 defines crowdfunding services as the “matching of business funding interests of investors and project owners through the use of a crowdfunding platform”. This definition does not only pertain to renewable energy crowdfunding platforms, but nonetheless opens the market for independent retail investors to finance renewable energy projects more easily.

Methodological Procedure

As the impact of crowdfunding platforms largely correlate with the projects they finance, separating the impact of crowdfunding platforms from their subjects is challenging. This chapter relies on the findings of a multitude of empirical studies analysing various platforms and cases. Lam and Law (2016), Vasileiadou, Huijben and Raven (2016), Bonzanini, Giudici and Patrucco (2016), as well as Nigam, Mbarek and Benetti (2018) use a case study approach to investigate why and how features of and phenomena related to crowdfunding projects appear. Hossain and Oparaocha (2017) present a conceptual approach, focusing especially on the motives of crowdfunding. Gabison (2015) offers an assessment of the current literature on crowdfunding. To present the perspective of practitioners, Picón Martínez, Cafferkey and Gianoncelli (2021) conducted expert interviews with both crowdfunding platforms and related organizations.

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Economic Impacts
As a financial vehicle, the most significant impacts of RES crowdfunding platforms relate to economic indicators. Investing in energy projects is costly, regardless of the energy source. While the installation costs of renewables have vastly fallen in the past years, building utility-scale RES projects still require significant up-front investments. In 2020, the global weighted-average installations cost of utility-scale solar PV amounted to €776/kW (IRENA, 2021). Even for smaller project sites of 1MW of installed capacity, this can result in capital requirements of close to 1 million €. In face of scarce funding for start-ups and other ventures, RES crowdfunding presents a viable funding alternative for RES project administrators (Gabison, 2015; Hossain and Oparaocha, 2017).

Moreover, offering their project on a crowdfunding platform allows fund-seekers to tailor the terms of their campaign to the project's needs, thus retaining more flexibility than relying on financing terms offered by banks and venture capital (Gabison, 2015). In comparison with other funding options, crowdfunding may be cheaper for RE projects, as the low fixed and transaction costs of crowdfunding platforms may be passed on to the entrepreneur (Lam and Law, 2016).

An additional benefit of crowdfunding is that it acts as a social insurance for innovation. Building a wind park or a PV-facility is inherently risky, as the success of a single project is often dependent on a number of technical and political factors. Distributing the financial risk among a number of funders shifts the liability from a single funder assuming all the risk to a larger population of contributors, thus decreasing the risk profile of each investor. This potentially results in a greater number of RE projects being realized, as both the cost of capital for fund-seekers and the default risk for investors is lower than conventional financing (Gabison, 2015).

Crowdfunding furthermore offers other, non-financial benefits and resources for RE projects, potentially contributing to a higher success rate of such projects. By disclosing information about their projects on crowdfunding platforms, entrepreneurs enable the wider public to comment and provide feedback on the endeavour (Gabison, 2015) . This likely improves the success rate of crowdfunded RE projects, enabling further positive environmental and social impacts.

Lastly, crowdfunding of renewable energy sources can also indirectly enable job creation. Two-thirds of the European workforce are employed by small and medium-sized enterprises or SMEs (European Parliamentary Research Service, 2019). At the same time, many renewable energy projects are operated by SMEs. Still, SMEs often struggle to raise sufficient financial resources. Crowdfunding offers these companies an alternative to fund the development of innovative projects (European

Commission, 2018b). Consequently, this also applies for the financing of renewable energy projects by SMEs.

Environmental Impacts

Much like the job creation aspect of crowdfunding, the environmental impact of crowdfunding is based on providing access to funding alternatives for renewable energy projects. Hence, crowdfunding for renewable energy sources have only an indirect the environmental benefit through the projects that are backed by crowdfunding. Nevertheless, crowdfunding is at times the best financing option for RES projects that avert emissions from fossil fuel-based energy alternatives. An example for this is the Resilient Energy Great Dunkilns Project, based in Gloucestershire, UK. This crowdfunded, community-owned wind farm generates around 1,315 MWh per year, supplying 317 households with energy. It saves about 565 tonnes of CO_2 emissions per year, compared to fossil fuel energy (Lam and Law, 2016).

Social Impacts

In many ways, crowdfunding of RES projects can have a significant impact and be an important facilitator for the social acceptance of the transition towards renewable energy. For one, crowdfunding makes impact investing available for anyone. Impact investing, also called venture philanthropy, refers to the notion that investors support a social purpose through providing funding to maximize the social impact of the beneficiary organisation or project (EVPA, 2020). Through crowdfunding, retail investors with middle-class incomes have the opportunity to promote societal change (Picón Martínez, Cafferkey and Gianoncelli, 2021). On specific platforms that focus on crowdfunding for RES projects, funders are offered investment opportunities that promote environmental sustainability and the renewable energy transition (Bonzanini, Giudici and Patrucco, 2016). This citizen engagement offers members of the public opportunities to financially profit from the energy transition and may also lead to greater knowledge and understanding of the technological challenges associated with it. This way, crowdfunding can help alleviate the “not in my backyard” issue. Proposed RES projects often face significant opposition of local residents near development sites (Gurzu, 2018). By giving residents a financial interest in local RES projects, crowdfunding can lower local resistance to such projects. By actively engaging citizens in energy systems, crowdfunding can thus increase societal support for the renewable energy transition (Nigam, Mbarek and Benetti, 2018). The citizen engagement aspect can further lead to increased political support for RES projects, warranting a positive feedback loop of technological, market, social and political dimensions of energy system transformation (Vasileiadou, Huijben and Raven, 2016).

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4. A Taxonomy for Impact Assessment

The following section outlines a taxonomy to be used by stakeholders to quantify and assess the multiple impacts of social innovations. The taxonomy has been developed based on the literature on social innovations in the energy sector (Barbiero, Blasi and Schwidtal, 2021; Bauwens and Defourny, 2017; Bauwens and Devine-Wright, 2018; Hoppe and Vries, 2019; Kirsch *et al.*, 2015; Koltunov and Bisello, 2021; Preenen *et al.*, 2014; RESCoop Mecise, 2019), as well as the applied impact assessments of Koltunov and Bisello (2021) and van der Waal (2020) who conducted impact assessments of RE communities in Italy and Scotland respectively using different methodologies. The methodology used for this assessment toolkit is based on the work of Koltunov and Bisello (2021), the taxonomy approach was one that can easily be translated across social innovations. Impacts and indicators change across the social innovations, but there is sufficient overlap and the categories of impacts that will be looked at remain the same. Another benefit of a taxonomy is the flexibility it allows in measuring and assessing impacts. Users can choose to focus only on economic impacts, for example, if these are the ones the deem most important to their situation. It also allows flexibility in terms of using the data that users have available. Users can start from the data-set and choose which impacts they can measure based on the data and resources they have available. This is because large parts of the impacts included in the taxonomy can be assessed using only secondary data, while users wanting a more in-depth analysis can choose to include other methodologies and conduct primary qualitative research to gain a more holistic image of the multiple effects social innovations can have. As the multiple impacts of social innovations cannot be fully captured by a single quantitative or qualitative methodology, it is recommended to use the full range of methodological approaches in order to portray the full value of the impacts that social innovations can have on different aspects of society.

This section outlines applications for use of the taxonomy, both for policymakers, who may want to assess their social innovation support policies by looking beyond the outcomes at the impacts of the social innovations. Applications for use are also suggested for practitioners, that is owners or managers of the social innovations in question. The second section will present the taxonomy, explaining the structure and offering a quick overview of the included impacts, which are discussed in more detail in the previous section.

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4.1 Applications for Use

For Authorities

Authorities at the local level can use the tool to conduct ex-ante or ex-post impact assessments. Impact assessments allow authorities to see what types of impacts and in what sectors effects are observed or can be expected. This can help when a municipality or city is deciding whether to support a social innovation project through a policy or whether to join the project. Conducting an impact assessment as part of the policy process can have multiple reasons as explored by Anett Großmann *et al.* (2016) such as: providing information, identifying procedural steps, promoting transparency, explaining policy decisions, and increasing public participation. A better understanding of the potential direct and indirect outcomes means that policies can be tailored more specifically to achieve the desired effect.

Ex-ante the indicators can be filled in using expected values based on the size of the project, which will usually be found in investment concepts or feasibility studies. A taxonomy allows for an overview of the full range of impacts stemming from one of the social innovation projects in one place, which can aid decision making in the policy process. These diffuse impacts may often be scattered between different sources and may not be at the forefront of the discussion when decisions are being made. Furthermore, the aim of the taxonomy is to bring attention to the various stakeholders that can benefit locally from RE social innovations and introduce impacts into the discussion beyond economic ones, in particular social impacts that a socially innovative business model may bring.

An ex-post application of the taxonomy can also be beneficial for evaluating and validating a policy decision. A positive observed outcome ex-post can increase support for the continuation or expansion of a support policy targeting RE social innovations. Knowledge exchange and policy diffusion is another important reason for conducting ex-post impact assessments. During the interviews conducted and questionnaires filled out by policymakers as part of the research for this paper, all but one respondent reacted positively to the idea of having access to impact assessment data from other municipalities and regions. Many of the respondents did not work specifically with social innovations yet, thus learning from case studies and implementing best practice is often one of the best approaches available. An interviewee from France noted that while transferring policy approaches across the EU is difficult due to the heterogeneity of contexts, case studies are still a valuable political tool to empirically demonstrate the value and impact that social innovations have had in other regions and can thus increase political support for including social innovations in renewable energy and climate policies.

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For Practitioners

Partnerships with local governments

The ability of social innovations to demonstrate their value in both quantitative and qualitative terms across a range of political issues put them in a stronger position to gain the support of or form a partnership with their local government and other authorities. Social innovations can position themselves, based on the impact assessment, as partners of the municipality which can help these achieve their political ambitions. This can focus on hard factors such as economic growth, with social innovations potentially contributing to job creation and increased local capital investment. Soft factors could however, also be interesting to local authorities. Impacts such as increased political mobilisation around green issues can be very important to local politicians pushing a green agenda, however even beyond political agendas social innovations can increase the social capital of community members and can lead to more active participation in other areas beyond energy (Bauwens and Defourny, 2017).

Advertisement and self-promotion

Socially innovative businesses can also benefit from an impact assessment as they can use the outcomes to further promote their businesses and win members and customers. The results of an impact assessment can be communicated both internally and externally. For internal purposes seeing the impacts that the organisation is having can be a motivating factor for members. Externally, the impact assessment can be used to attract more members and convince ones that may have previously been hesitant. The outcomes can easily be translated onto communication materials based on what factors are the most important to the target audience.

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4.2 Description of Indicators

The proposed taxonomy identifies a range of indicators in the broad categories of economic, social, environmental, and health impacts. The impacts vary slightly across the social innovation being assessed, however many remain the same across all three. The following table gives an overview of the measured impacts, which social innovation they are measured for and the reasoning behind their inclusion.

Table 3: Description of Indicators for Social Innovation IAs

Indicator	Social Innovation Indicator is Measured for	Reasoning
Consumer Savings	RECs, Aggregators	RECs can lead to financial savings for members due to reduced energy prices compared to traditional utilities. Aggregators can improve energy efficiency at home and reduce expenditures that way.
Job Creation	RECs, Aggregators, CF	Jobs created both during the implementation and construction phase of the projects, as well as during the operation phase which included management and maintenance.
Participant Income	RECs, CF, Aggregators	RECs may pay out dividends to their members if profits are achieved in a fiscal year. CF platform provide a return on investment usually in the form of an interest payment on a loan. Aggregators may pay participants based on how much energy they can produce or how much flexibility they make available.
Government Income	RECs, CF, Aggregators	All three pay taxes. This can include land/property taxes, income taxes, corporate tax, and trade tax
Capital Investment in RE Infrastructure	RECs, CF, aggregators	RECs install RE infrastructure via generating units, storage capacity, charging infrastructure or other initiatives. CF platforms raise financing to fund RE projects. Aggregators may not directly invest in RE infrastructure but may motivate participants to invest in further RE generation or storage.

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Avoided GHG Emissions	RECs, CF, Aggregators	RECs and CF provide a RE supply which may previously have stemmed from fossil fuels. Aggregators increase energy efficiency at the household level and can contribute to peak shaving across the entire grid.
Energy Savings	RECs, Aggregators	Some RECs engage in energy efficiency projects for their members and the wider community. Aggregators save energy through optimized energy usage.
Political Mobilization	RECs, CF, Aggregators	In all three expose citizens to RE, and active participation can increase
Energy Literacy	RECs, CF, Aggregators	Owning or investing in an energy asset increases consumer's understanding of the energy market. It can change attitudes towards energy consumption and understanding of meter readings and bills.
Clean Energy Generated	RECs, CF, Aggregators	RECs and CFs build generating units and thus it is important to see how much RE is produced by these units. Aggregators do not directly generate RE but the amount produced by members can be measured.

For each impact the following information is provided:

Indicator: For each impact at least one indicator is given. The indicator gives the user a measurable outcome with which to judge the impact the social innovation has.

Group: Each impact is assigned to a group or multiple groups. The groups refer to the category into which the impact falls. These are economic, social, health, and environmental. This enables users of the taxonomy to focus on the impacted areas they are most interested in for their purposes.

Type: The type describes whether the impacts are direct or indirect.

Spatiality: The geographical scope of the impact is described here. This is important for the user as they may want to present different impacts to different stakeholders.

Beneficiaries/Affected Parties: All beneficiaries of the impact are listed in this section, as well as other affected parties. The distinction is made here between beneficiaries and affected parties as there may also be negatively affected groups.

Assessment Techniques: At least one assessment technique is offered for every impact. The assessment technique specifies whether the impact can be measured

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and assessed qualitatively or quantitatively. The category also indicated whether the assessment can be conducted using primary or secondary data or a combination thereof.

Data Sources: The data sources category lays out the likely data sources for the relevant indicators. The aim is to save the user time and give indications of where to look for the data necessary to run the impact assessment.

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5. Case Studies

To make initial use of the taxonomy, case study partners from the SocialRES project were asked to fill out the taxonomy developed as part of this paper to highlight some of the impacts that the project partners have had and to further present empirical evidence of the impacts of social innovations.

5.1 Crowdfunding Platform Case Study - Go Parity

The crowdfunding platform GoParity was established in 2017 with the purpose to democratize the access to sustainable finance. To that end the online platform brings together individuals, companies and other organizations that share the goal to invest in sustainable projects, among others in the field of sustainable energy (goparity.com, 2021). And the company is growing. Where the volume of funded projects was just above half a million Euros in 2018, it is almost 9 million Euros in November 2021 (ibid.).

Using the developed taxonomy and regarding the economic impact indicators we find that 3.113.681 € were invested in projects of sustainable energy, with a return on investment of 90.149 € until today. In total 4.523 jobs were created until this day. Regarding the environmental indicators, the projects funded through GoParity generated or saved a total of 6.435 MWh clean energy and avoided a total of 22.101 tons of CO_2. In social terms GoParity positively affected 61.333 people in vulnerable situations.

To get a better understanding of the local impacts of GoParity, we examine the case of the "Asbestos-free Solar Nursery" in Ferro (Covilhã), Portugal. This case is a GoParity investment campaign to finance the removal of a 550 m2 asbestos roof of a school in Covilhã and its renewal including an installation of two PV-plants for self-consumption. The promoter is the Associação Centro Social do Sagrado Coração de Maria do Ferro (ACSSCMF) – a local private institution delivering care services for elderly and children that owns the school. What is remarkable about this case is the speed in which it succeeded. On June 1st, 2021 the ACSSCMF launched the campaign on GoParity, and on June 14th, the project was fully funded by 363 investors (GoParity.com **b**, n.d). Since mid of July, the PV-plants are installed and running.

Overall, the project has an economic, environmental and social impact in Ferro. Economically speaking, raised into the renewable energy project. Of the total of 8892,06 €, 579,38 € already paid out Another local impact is that this project was completely implemented by Enforce SA, an energy engineering company located in Covilhã. Regarding the environment, the project avoided 12.3 tCO_2 per year and generates 60.8 MWh solar energy per year. Moreover, the project also has a social

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impact on the community of ACSSCMF. Removing the asbestos decreases health risks of using affected buildings, which due to its toxic fibres, increases the risk of cancer and lung diseases. Additionally, the project gave the impulse to include sustainability topics in the school's education and day-care, increasing the knowledge of climate change and renewable energy (ibid.). That way the project impacts at least the 54 elderly residents and 51 pupils.

Table 4: Case Study Crowdfunding Platform Impact Taxonomy

Measured Impact	Indicators	Group	GoParity	Asbestos-Free Solar Nursery
Investment in RE Infrastructure	Investment in RE projects collected through CF-platform, Value of Capital Infrastructure	Economic	-	-
Job Creation	Number of employed people at crowdfunded project sites	Economic, Social	4.523	-
Investment Flow to RE Projects	Capital flow to RE projects	Economic, Environmental	3.113.681€	51.500 €
Returns to Investors	Return on investment for investors, interest rates paid out	Economic	90.149 € Paid Interests (Oct 8th, 2021)	578 € of 8892 € Interest (Oct 8th, 2021)
Contracting Local Suppliers	CF project expenditures contracted to local firms	Economic	Depends on project location, local suppliers used where possible	Completely implemented by a local company
Community/Municipal Income	Taxes paid by CF funded projects or its employees to the local budget, land rental payments	Economic	Depends on project location	-
Avoided GHG Emissions	Avoided tons of emissions due to RE generation, air quality index	Environmental, Health	22.101t CO_2	12.3t CO_2 per Year
Energy Literacy	Literacy and knowledge of matters such as	Social	-	Sustainability topics are included in

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	climate change and RE			education & day care
People Impacted	Number of people directly or indirectly impacted through a CF project	Social	61.333 People in Vulnerable Situations	>105
Clean Energy Generated	MWh of clean energy generated as a consequence of the CF project	Environment al	6.438,4 MWh	60.8 MWh per Year

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5.2 Energy Cooperative Case Studies - BEG Biederback & Elztal eG and Büger-Energie Bodensee eG

BürgerEnergiegenossenschaft Biederbach & Elztal eG and Bürger-Energie Bodensee eG are energy cooperatives established in 2010 (Biederbach & Elztal eG) and 2011 (Bodensee eG) in Baden-Württemberg, Germany. The cooperatives' aim is to strengthen the local renewable energy generation through solar and wind power (buergerenergiebodensee.de, 2021; buergerenergie-biederbach.de, 2021).

Since its establishment, BEG Biederbach & Elzal eG has installed 20 PV systems, holds shares in five wind parks and runs one local heating network in Biederbach that is fed by a solar thermal system (buergerenergie-biederbach.de). At the end of 2020 it counted 400 members and 21.794 shares and two subsidiary companies that run the wind parks (BürgerWind Biederbach & Elztal GmbH) and the local heating network (Nahwärme Biederbach GmbH) (ibid.). Bürger-Energie Bodensee owns a solar park and holds shares of another solar park and a wind park. At the end of 2020 it counted 135 members and 1217 shares (buergerenergiebodensee.de, 2021).

Applying the developed taxonomy, we start with the cooperatives' economic impacts. Both cooperatives' impact on local energy price development and job creation is rather low. Only BEG Biederbach & Elztal eG created two part-time jobs, one management job (salary: 40.000 €/year) in the cooperative and one employee for the heating network company (salary: 55.000 €/year). The organizations do not employ many people due to their small size and their heavy reliance on volunteer work. Moreover, both cooperatives do not sell electricity to local customers but feed the electricity into the general network to a fixed price, guaranteed by the national state or through power-purchase-agreements. Even though BEG Biederbach & Elztal eG sells renewable heat to local customers in the district heating grid, however there is no price difference between members and non-members. Both organizations generated local value through shareholder income, local capital investments and increases in the municipal income.

BEG Biederbach & Elztal eG raised a shareholder income of 355.000 € and made investments worth 2.564.700 €. BEG Bodensee generated a shareholder income of 100.000 € and invested 1.217.000 € locally, contributing to local energy projects with a total worth of 2.000.000 €. The economic activity of both organizations increased the municipal tax income. BEG Biederbach & Elztal eG stated to have payed 82.825 € in corporate tax and 67.230 € trade tax since its foundation, which makes up roughly one percent of Biederbach's trade tax income in the same time span (Biederbach, 2021). For BEG Bodensee eG paid tax data was not available. However, for the property on which its solar and wind parks are built, it pays a lease of 5.500 € per year to the local municipality. Moreover, the cooperatives contracted local suppliers in their projects, with contracts worth 1.600.000 € in the case of BEG

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Biederbach & Elztal eG. In the case of BEG Bodensee eG, the cooperative indicated that local suppliers were so deeply involved in its projects that the figure roughly matches the sum of all local capital investments made by the cooperative.

Turning to the social impacts, both cooperatives raised the awareness for renewable energies, its importance and benefits, and for energy cooperatives as organizational form to promote the energy transition. Both organizations rely on volunteer work as a form of community engagement. Arguably both cooperatives increased the local energy literacy through these actions. However, these impacts were only estimated and not properly assessed.

Regarding the environmental impacts, the energy cooperatives did not deliver any energy savings but generated renewable energy and thus avoided GHG emissions. This is because both cooperatives are entirely focused on generation and do not run any energy efficiency projects. Since its foundation, BEG Biederbach & Elztal eG generated 6.120 MWh solar electricity – accounting for roughly 40-50 % of generated solar electricity in its municipality (Landesanstalt für Umwelt Baden-Wurttemberg, 2021), 2.300 MWh solar thermal energy, and 10.000 MWh wind energy. It total, this amounts to 6.760t of avoided CO_2 emissions. BEG Bodensee eG generated a total of 12.700 MWh renewable electricity, resulting in 4.661t avoided CO_2 emissions.

Table 5: Case Study Renewable Energy Cooperative Impact Taxonomy

Measured impact	Indicators	Group	BEG Biederbach & Elztal eG	BEG Bodensee
Local Capital Investment	Value of capital infrastructure	Economic	2.564.700 €	1.217.000 € in own shares, total investment: 2.000.000 €
Cheaper energy prices	Energy prices for REC members & customers Total savings on energy since joining	Economic	Electricity is not sold to customers. Renewable heat is sold to customers from the district heating network.	Electricity is not sold to customers
Job Creation	Number of jobs created, gross salaries	Economic, Social	Approx. 1 part-time management staff and one part-time employee for the heating network; average 40.0000 €/year in	None, reliance on volunteer work

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			cooperative, in district heating 55.000 €	
Contracting local suppliers	RE expenditures contracted to local firms	Economic	1.600.000 €	Not assessed
Shareholder income	Dividend pay-out to all shareholders, Average dividend pay-out per 1 share, Multiplier effect of shareholder income to the local economy	Economic	Dividends payed out: 355.000 €	Dividends payed out: 100.000 €
Community/ Municipal income	Taxes paid by REC or its employees to the local budget, Budget allocated to community projects, Land rental payments	Economic	Corporate income tax: 85.825 €; Trade tax: 67.230 €; Donations to associations: 8.000 €	5.500 € for land lease per year, taxes and fees not assessed
Avoided GHG emissions	Avoided tons of emissions due to REC generation, Air Quality Index	Environ-mental, Health	6.760t CO_2	4.661t CO_2
Energy savings	Energy bill savings due to the implementation of energy efficiency measures/ behaviour	Environ-mental, Health	Not assessed	Not assessed
Political mobilization	Support for community activities due to the	Social	Not assessed, but due to the project implementation	Not assessed, but due to the project implementation

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	awareness/experience with REC project		some awareness raising took place	some awareness raising took place
Energy literacy	Literacy and knowledge of matters such as climate change and RE	Social	Increased awareness, but not assessed	Increased awareness, but not assessed
Clean energy generated	MWh of clean energy generated as a consequence of the CF project	Economic	Solar: 6.120 MWh; District heating: 2300 MWh Wind: 10.000 MWh	12.700 MWh

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5.3 P2P Energy trading platform – Tractebel

Tractebel Engie is an engineering firm working in the sustainable energy field and is a SocialRES project partner. As part of the project Tractebel is developing a P2P energy trading platform in Romania. The platform is aimed at household, either consumers or prosumers and small scale RE producers. The platform is currently in its testing phase and does not have impact data yet. However, a brief description of the project is given below and the text will be updated once the platform is finished with its testing phase.

The concept of the platform is to empower households to actively trade, better understand their consumption and production in order to gain better returns or benefit from lower prices than with a standard tariff, either through self-consumption or feed-in tariffs. While consumers can actively trade by themselves, a trading algorithm is also being developed, which learns about the consumption and production patterns of the participants. This allows the participants a more passive role as actively trading energy everyday would be time intensive and the marginal returns would not justify this. Thus, the P2P platform works like a small-scale wholesale market, with day-ahead and intra-day markets, and the algorithms trading to match supply and demand. Each participant is equipped with a smart-meter, which is essential for the algorithm as it needs the real-time consumption and production data to function properly.

This option could be attractive to consumers and prosumers. The exposure to real time price signals can influence their demand decisions or their decision to sell or self-consumer. However, joining the platform carries more risk than feeding produced energy into the grid or relying on a standard consumption tariff. Just like in the wholesale market the participants would be balance responsible parties who must ensure that they can deliver their forecasted consumption or production or face penalties. Thus, participants face both upside and downside risk when participating.

The testing phase will determine if and how much participants can benefit from the platform, including which type of participant is more or less likely to benefit between consumers, prosumers, and small producers. The results will determine the viability and market readiness of such a platform as well as where improvements must still be made. The testing will provide the basis of an ex-ante assessment.

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6. Final remarks

The SocialRES project aims to facilitate the transition from centralised to decentralised energy production and to incorporate greater social participation in Europe's energy system by fostering energy democracy through social innovation in the renewable energy sector. This toolkit will help in this process as it can be used by both policymakers and practitioners to provide a stronger role for social innovations and their impacts in the policy process.

Governments and authorities on different levels across Europe are increasingly using data from impact assessments in various stages of the policy design process. However, systematic assessment frameworks are used only infrequently, especially in the domain of social innovations in renewable energy. The toolkit presented as part of this paper answers the need of policy makers and experts for easy-to-use methods of conducting impact assessments for RES cooperatives, RES aggregators, and RES crowdfunding platforms.

Applying the taxonomy to the cases illustrates how social innovations in the energy sector can be beneficial to the local environment, economy and society - replicating results of earlier studies on the effects of social innovations. Moreover, it shows that not all items of the taxonomy are applicable to all levels and cases but rather that depending on the scope of the analysis, different items can play a role hereby. This highlights the taxonomy's flexibility that allows choosing different foci and conduct IAs with different available data at hand.

While the taxonomy proposed in this paper is not exhaustive in its scope or its detail, it should serve as a tool that provides an overview of the potential impacts of social innovations on a case study basis. The experts and policy makers we interviewed for this toolkit showed that not every municipality has the resources and capacities to conduct an impact assessment. The same applies for organisations that apply the social innovations this paper focuses on. Thus, the toolkit should also represent an opportunity for knowledge exchange and best practice transfer. With the diffusion of this tool and the paper as a whole, municipalities should be made aware of the various opportunities and models that exist to drive the energy transition forward in a socially inclusive fashion. Therefore, the tool can showcase social innovations as new approaches with multiple impacts across three politically dimensions: economic, social, and environmental. Finally, the taxonomy presented here should represent an important step in the policy process, an empirical input to the political and public debate on how to organise and shape the energy transition at the local level.

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Annex: Impact Taxonomies

Table 6: Impact Taxonomy for Renewable Energy Communities and Cooperatives

Measured Impact	Indicators	Group	Type	Spatiality	Temporality	Beneficiaries or affected groups	Assessment techniques	Data Sources
Investment in RE infrastructure	Value of capital infrastructure owned by the REC (Can be local or regional)	Economic	Direct	Local	Immediate-short	Local authorities, citizens	Quantitative, primary and secondary sources	RECs, municipality
Jobs created	Number of jobs created, gross salaries; Can also include jobs created in companies related to the REC	Economic, Social	Indirect	National	Delayed Long term	National authorities, relevant businesses	Quantitative, primary and secondary sources	RECs, business partners, national or local authorities
Lower energy prices	Energy prices for REC members & customers; Total savings on energy since joining (only relevant if REC is also a supplier)	Economic	Direct	Local, regional, national	Immediate-long	Members, shareholders, customers	Quantitative, primary and secondary sources	RECs, customers, utilities
Shareholder income	Dividend pay-out to all shareholders, Average dividend pay-out per 1 share	Economic	Direct	Local	Immediate-long	Shareholders	Quantitative, primary and secondary sources	RECs

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Contracting local suppliers	REC expenditures contracted to local firms	Economic	Direct	Local	Immediate-short/long	Local authorities, local contractors	Quantitative, primary and secondary sources	RECs, local contractors, municipalities
Community/Municipal income	Taxes paid by REC or its employees to the local budget; Budget allocated to community projects, Land rental payments	Economic	Direct, indirect	Local	Delayed Long term	Local authorities, citizens	Quantitative, primary and secondary sources	RECs, municipality
Clean energy generated	MWh of clean energy generated by the REC	Economic, Environmental	Direct	Local, regional, national	Immediate	Citizens	Quantitative, primary and secondary sources	RECs
Avoided GHG emissions	Avoided tons of emissions due to REC generation, Air Quality Index	Environmental, Health	Direct	Local, national, international	Immediate-long	Citizens	Quantitative, primary and secondary sources	RECs, emission factors or energy mix, air quality indexes, local and national authorities
Energy savings	Energy bill savings due to the implementation of energy efficiency measures	Environmental, Health	Indirect	Local	Medium term	Shareholders, local business,	Quantitative, primary and secondary sources	RECs, local contractors, municipalities
Political mobilization	Support for community activities due to the awareness/ experience with REC project	Social	Indirect	Local, regional, national	Delayed Long term	Citizens, local authorities	Qualitative, surveys and interviews	Citizens, shareholders and local authorities
Energy literacy	Literacy and knowledge of matters such as climate change, RE, and energy usage in the home	Social	Direct, Indirect	Local	Delayed Long term	Citizens, local authorities	Qualitative, surveys and interviews	Citizens

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Table 7: Impact Taxonomy for Crowdfunding Platforms

Measured Impact	Indicators	Group	Type	Spatiality	Temporality	Beneficiaries or affected groups	Assessment techniques	Data Sources
Investment in RE infrastructure	Investment in RE projects collected through CF platform; Value of capital infra-structure (Can be measured locally, regionally, or nationally)	Economic	Direct	Local	Immediate - long	Investors, Project developers, local authorities	Quantitative, primary and secondary resources	CF platforms, project developers
Job creation	Number of employed people at crowdfunded RE project sites	Economic, social	Direct	Local, national, international	Immediate - long	Citizens, authorities	Quantitative, primary and secondary resources	Project developers, local authorities
Returns to investors	Return on investment for investors; interest rates paid out	Economic	Direct	Local, national, international	Immediate - long	Investors	Quantitative, primary and secondary resources	CF platforms, Investors
Contracting local suppliers	CF project expenditures contracted to local firms	Economic	Direct	Local	immediate - short/long	Local authorities, local contractors	Quantitative, primary and secondary sources	Project developers, local contractors, municipalities
Community or Municipal income	Taxes paid by CF or its employees to the local budget; budget allocated to community projects; land rental payments	Economic	Direct, indirect	Local	Delayed Long term	Local authorities, citizens	Quantitative, primary and secondary sources	CF platforms, municipality

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Clean energy generated	MWh of clean energy generated by the CF projects	Economic, Environmental	Direct	Local, regional, national	immediate	Society as a whole	Quantitative, primary and secondary sources	CF platforms
Avoided GHG emissions	Avoided tons of emissions due to RE generation; Air Quality Index	Environmental, Health	Direct	Local, national, international	Immediate - long	Citizens	Quantitative, primary and secondary sources	CF platforms, emission factors or energy mix, air quality indexes, local and national authorities
Political mobilization	Support for climate and RE policies due to active exposure and participation to the field	Social	Indirect	Local, regional, national	Delayed Long term	Citizens, local authorities	Qualitative, surveys and interviews	Surveys and interviews with citizens, shareholders and local authorities
Energy literacy	Literacy and knowledge of matters such as climate change and RE	Social	Direct, indirect	Local	Delayed Long term	Citizens, local authorities	Qualitative, surveys and interviews	Survey with local citizens

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Table 8: Impact Taxonomy for Aggregators

Measured Impact	Indicators	Group	Type	Spatiality	Temporality	Beneficiaries or affected groups	Assessment techniques	Data Sources
Investment in RE infrastructure	Investment in RE infrastructure by members of the aggregator	Economic	Direct	Local	Immediate - long	Investors, Project developers, local authorities	Quantitative, primary and secondary resources	Aggregator
Job creation	Number of people employed by the aggregator	Economic, social	Direct	Local, national, international	Immediate - long	Citizens, authorities	Quantitative, primary and secondary resources	Aggregator, local authorities
Lower energy prices	Energy prices for aggregator participants & customers; Total savings on energy since joining	Economic	Direct	Local, regional, national	Immediate - long	Participants, shareholders, customers	Quantitative, primary and secondary sources	Aggregator, customers
Participant income	Dividend pay-out to participants; Price paid per kWh of generation or flexible capacity offered to the aggregator	Economic	Direct	Local	Immediate-long	Participants	Quantitative, primary and secondary sources	Aggregator, participant
Community/ Municipal income	Taxes paid by aggregator or its employees to the local budget; budget allocated to community projects; Land rental payments	Economic	Direct, indirect	Local	Delayed Long term	Local authorities, citizens	Quantitative, primary and secondary sources	Aggregator, municipality

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Clean energy generated	MWh of clean energy generated by the aggregator	Economic, Environmental	Direct	Local, regional, national	Immediate	Aggregator	Quantitative, primary and secondary sources	Aggregator
Avoided GHG emissions	Avoided tons of emissions due to aggregation; Peaking plant usage reduction	Environmental, Health	Direct	Local, national, international	Immediate - long	Citizens	Quantitative, primary and secondary sources	Aggregator, emission factors or energy mix, air quality indexes, local and national authorities. Wholesale market data
Energy savings	Energy bill savings due to demand response and energy management system	Environmental, Health	Indirect	Local	Medium-term	Shareholders, local business,	Quantitative, primary and secondary sources	Aggregator, participants
Political mobilization	Support for climate and RE policies due to active exposure and participation to the field	Social	Indirect	Local, regional, national	Delayed long-term	Citizens, local authorities	Qualitative, surveys and interviews	Surveys and interviews with citizens, shareholders and local authorities

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