Conference Proceedings

ComForEn 2021

11. Symposium Communications for Energy Systems

„ICT for Energy Communities
How can we escape the complexity?“

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Greetings

After 11 years of ***ComForEn*** symposia, the topic of communication technologies for energy systems ("com-for-en") is still developing. In 2021, we put a special focus on energy management in and for energy communities.

This year, the European concept of energy communities has finally been implemented in Austrian legislation. Many players in the field have awaited this moment and are now starting with implementation projects. Flexible loads and storage systems are the screws to turn for optimal self-sufficiency and reduced energy exchange to the public grid. However, these functionalities require monitoring, control and automation systems, often resulting in very complex and expensive solutions. Furthermore, each energy community tends to be unique not only in its available energy sources and demand patterns, but also in terms of ICT architecture.

Therefore, the main topics of ***ComForEn 2021*** are:

1. Reduction of the complexity of ICT systems in energy community as a key for their success
2. Planning, realisation and operation of energy communities
3. ICT reference architectures to achieve straight-forward IT solutions and integration of energy infrastructures such as photovoltaic inverters, charging stations or batteries
4. ICT-enabled optimisation of supply and demand in an energy community

Meeting the climate goals cannot be done alone. Therefore, the AIT Austrian Institute of Technology, TU Wien and the OVE have invited national and international experts from research and industry to discuss the further challenges on the way to a sustainable energy system in a hybrid setting. ***ComForEn*** is aimed at component and system manufacturers, power grid operators, energy suppliers, and research institutions and – of course – future energy community operators.

For the first time, AIT Austrian Institute of Technology hosted a Self-Optimization Challenge to develop, deploy, and validate your own optimization module for energy communities – capable of considering various constraints (e.g., energy trading priorities, prices/tariffs, technical limitations, etc.) and aiming to reach a dedicated optimization objective. We are looking forward to honour the best optimization results with the "Self-Optimization Award".

Many thanks to all contributors, keynote speakers, session speakers, workshop organizers and challenge participants to make the 11th ***ComForEn*** happen again! We hope you enjoy the symposia, whether you stay in Vienna or join from anywhere around the globe.

Friederich Kupzog

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We would like to thank the organization team!

Birgit Sykora, Karl Stanka, OVE

Carina Schöfl, TU Wien

Mark Stefan, Jawad Kazmi, AIT

Symposium Day 1

22.11.2021

Keynote

Ole Langniss

Dr. Langniss has worked in the energy sector for more than 25 years. He holds an MSc in Industrial Engineering from Technical University Berlin and a PhD in Economics from Stuttgart University. In 2014, he founded his own company Dr. Langniss – Energie & Analyse to be able to supply the best value and high-quality consultancy to his customers. In 2016, Dr. Langniss with two co-founders established a blockchain start-up OLI Systems. OLI Systems develops and sells solutions for distributed energy applications both for utilities and other commercial customers in the energy sector. Dr. Langniss has worked in academia, research facilities, and more recently in the private field as a consultant and blockchain developer. Previously he has worked as Senior Consultant at Fichtner Consultant Engineers, as Department Head at the Center for Solar Energy and Hydrogen Research, Germany, Marie Curie Post-Doc at Lund University, Sweden, Guest Researcher at Lawrence Berkeley National Laboratories, USA, and as a Senior Scientist at the German Aerospace Center. His work focuses on strategies and policy instruments for an accelerated deployment of renewable energy technologies, energy efficiency technologies, and more recently on digitization of the energy sector. He has worked in over 50 countries and assisted governments among others in the Caribbean, China, Cuba, European Union, Indonesia, Kenya, Mexico, Pakistan, Senegal, South Africa and Vietnam in establishing favorable framework conditions for renewable energy technologies. His engagement with Chinese government has stretched over almost 15 years. He served as Operating Agent to the International Energy Agency (IEA). He has authored more than 90 publications among them three books, and was Lead Author of IPCC (Intergovernmental Panel on Climate Change). He is founding member of the Smart Grids-Platform Baden-Wuerttemberg where he served as a managing director. He served as the deputy leader to C/sells, a large-scale smart grid project with a budget of € 100 million. He has lectured and presented on a large variety of aspects on renewable energy from an individual university master course on Energy up to large audiences in e.g. the United Nations headquarters.

As part of many assignments on policy drafting, consultations with regional and local stakeholders as well as policy-oriented workshops for decision-makers, representatives of government institutions and other stakeholders were organized and held by Dr. Langniss. He is used to adapt the findings and recommendations to the local context, considering development level and envisaged targets. He commands an extensive network of experts and stakeholders in many world regions, where he has worked.

ComForEn 2021

The future of sustainable energy with cellular structures – Learnings from the large-scale demonstration project C/sells

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Most countries have agreed in the Paris Climate Change Convention to limit a further rise in global mean temperature to a maximum of 1.5°C. Science has shown beyond doubt that if the global temperature rose significantly higher than this value, then both heat and drought would have serious consequences for the earth's habitability. To avoid this an energy transition is gravely needed and the energy industry must be restructured. By 2050 we must be exclusively using energy that is greenhouse gas neutral. Coal, oil, and natural gas cannot be burned for any purpose, regardless of whether it is for transport, heating, or the generation of electricity. This is a huge challenge, however, within the project C/sells a range of approaches have been developed on how we can all meet this challenge together.

What got clear within C/sells is, that nobody holds the solution in their hands alone, only through intensive cooperation can pioneering and practical solutions be generated. in Bavaria, Baden-Württemberg, and Hesse more than fifty partners from industry, science and politics have cooperated in the C/sells project from 2017 till end of 2020 to develop and demonstrate solutions for a successful energy revolution. Over three hundred people spent four years re-searching and implementing solutions for the digital energy revolution.

The necessary innovations involved in revolutionising the energy industry are not an end in themselves, but rather individual steps in the continuous process of radical transformation through constant innovation. This revolution is only possible if the people affected are involved, which is why the transformation of energy systems requires participation from all of us. Renewable energies, and the need to use energy sparingly, are highly distributed. This makes the energy revolution a challenge for each and every individual instead of a few large energy producers and distributors (as has been the case in the past). Millions of private households and smaller companies are now active participants. They are no longer just consumers, but also producers - thus becoming prosumers. In this way, the energy systems of the future will diversify in many different fields: in the actors and their responsibilities, in technologies, and in business models.

Is it possible for a distributed energy system to not only be more environmentally friendly and climate neutral, but also to be just as reliable and affordable as our current system? We believe it can be. C/sells is based on the concept of energy cells - individual or bundled households, as well as companies, that produce and provide energy together. Our project has developed, and successfully demonstrated, the organisation of energy cells. The "Cells" in C/sells stands for the cellular idea. The "sells" stands for economic opportunities.

Cellular organisation complements existing energy markets and networks, plus coordinates millions of actors. Digital technology makes it possible to implement this structure efficiently. C/sells focuses on three core processes:

1. In regionalised marketplaces small consumers, prosumers and producers can buy and sell electricity - virtually from neighbour to neighbour - which provides urgently needed flexibility. In other words, they can switch their generation or consumption facilities on or off based on the capacity utilisation of the electricity grid.
2. Data on current consumption, as well as forecasts of consumption and generation, are essential for an efficient and safe operation. The Infrastructure Information System makes this data available to households, companies, and network operators.
3. The many different operators of the electricity grid will have to coordinate the regulation of the grid more rigorously than before. Currently the coordination is often performed manually. However, when millions of units feed in electricity this must be automatic. The Coordination Cascade provides automated, fast, and secure coordination between the network operators.

Obviously, information and communication technologies are key to implement these processes. Consequently, all use cases are built on the so called iMSys (“Intelligente Messsystem”) which is a combination of a digital power meter and a gateway to securely transmit data and commands. The iMSys is specific to Germany. The roll-out of iMSys has been delayed over several years and ultimately only started in 2020. At the moment, only a minor part of the use cases is fully certified thus is available for commercial use. Looking at the ten-year process of development and certification of the iMSys it gets clear that:

- The very specific German fear of ensuring high individual data integrity has created a particular challenge. Considering the actual rather limited personal data from power metering on the one hand and the personal data openly shared by many in the daily use of the internet on the other hand, these very strict requirement might be regarded as outdated today. Particularly in the light of potential contribution of a highly performing smart meter infrastructure to climate change mitigation one ma assess the costs of high individual data integrity differently.
- Trying to control millions of power generating and power consuming assets of an distributed, cellular energy system in the same secure manner than a few thousand central power plants might be a too ambitious task. Instead of a deterministic command-control paradigm, one may introduce more probabilistic elements for operating the power grid and the entire power system thereby making use of the inherent advantage of millions distributed systems that a single unit is not crucial for ensuring the stability of the entire power supply system.
- Politics, legislation and public administration hinder the pace of digitisation and innovation in the power systems crucially required to shift to a zero CO2 power supply when they got too involved in formulating technical details of standards. Rather, the well-established bodies self-governed by the industry should be in charge to define the technical details.

What also got clear once the first iMSys arrived in the field is, that deployment of iMSys remains challenging in practise.

However, once in place, the iMSys in combination with the three core processes described above creates also very promising use cases for the energy system of the future. For instance, C/sells has demonstrated, that distributed energy generation cannot only ensure energy supply in a case of a black-out (“islanding”) but that distributed generation can actively contribute to ramp-up the power system after the black-out. In this case, the DSO is able to directly control the re-connection of the distributed assets to the central grid.

In the whole, C/sells has been successfully implemented over 30 cells in Baden-Württemberg, Bavaria and Hesse. Such as in Schwäbisch-Hall, where it is now possible, as in other networks, to react quicker and more reliably to changing network conditions. Or in Munich, where several electric heating systems have been added to a virtual power plant. Or in Dillenburg, where citizens trade flexibility.

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Homepage www.csells.net

Session 1

Design

Session Chair: Friederich Kupzog

ComForEn 2021

Energy Communities in Austria - Overview of the Specific Regulations for Joint Utilization of Electricity

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Abstract **-** With the objectives of the European Renewable Energy Directive 2018[1] and the Internal Market in Electricity Directive 2019[2], national implementation acts are necessary. This article deals with the national implementation of the provisions on the Citizen Energy Community and the Renewable Energy Community. The differences as well as the commonalities of the two energy communities are worked out and presented based on the legal regulations. The main similarities are the way of establishment and what purpose a community must pursue. Both communities can use electricity, and this results in common electricity regulations. The main differences refer to the way of energy use. A renewable energy community can use only renewable energy, whereas a citizen energy community can use only electricity,

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[1] Directive (EU) 2018/2001 of the European Parliament and of the Council of 11 December 2018 on the promotion of the use of energy from renewable sources, OJL 2018 L328/82.

[2] Directive (EU) 2019/944 of the European Parliament and of the Council of 5 June 2019 on common rules for the internal market for electricity and amending Directive 2012/27/EU.

but from both renewable and fossil sources. Further differences are the possible range and members of each community.

1. Introduction: The way of energy communities

The "Clean Energy for all Europeans package" laid the foundation for the joint use of energy. Central to this package are RED II and ED 2019, which contain requirements for citizen energy communities (CEC) and renewable energy communities (REC).[3] These two directives strengthen the position of European consumers and enable their participation in the energy transition. European directives still need to be transposed into national law, as directives set the objectives for member states.[4] Each member state is obliged to implement the requirements of the directives into national law. This article deals with the national implementation of energy communities into Austrian law. The Austrian implementation of these two communities took place within the Renewable Expansion Act legislative package[5]. This text provides an analysis of the basic requirements for the joint use of electricity in the context of a CEC and a REC. These legal requirements focus on aspects of electricity law, which is why other forms of energy for joint use are only addressed in appropriate areas. This paper is structured systematically and shows the differences as well as common provisions.

2. Definition, members and scope of CEC and REC

The following remarks focus on the legal framework of CEC and REC.[6] These include the definition, the possible members and shareholders as well as their scope and special require-

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[3] The following explanations in this paper are based on the research results from the European funded project eCREW (Horizon2020, GA 890362) and the national funded project Serve-U (“Community-based Smart Energy Service through flexible OptimizationModels and fully automated Data Exchange”) (project number: 881164).

[4] *Biresselioglu et al,* Legal Provisions and Market Conditions for Energy Communities in Austria, Germany, Greece, Italy, Spain, and Turkey: A Comparative Assessment, sustainability 2021, 2f.

[5] Erneuerbaren-Ausbau-Gesetzespaket – EAG-Paket F.L.G. I No. 150/2021.

[6] Furthermore, the analysis carried out here is also part of the interdisciplinary research project "InduGrid - Industrial Microgrids", which is part of the flagship region "New Energy For Industry" funded by the Climate and Energy Fund under project number 868708. Project partners of Industrial Microgrids are University of Applied Sciences Upper Austria, Austrian Institute of Technology, Energiesparverband OÖ, TU Wien Energy Economics Group, Energieinstitut an der JKU, Amt der OÖ Landesregierung, E-Control Austria, Wels Strom GmbH, STIWA AMS GmbH, ABM automation building messaging GmbH, Ing. Aigner Wasser-Wärme-Umwelt GmbH, Rübig Technologie GmbH & Co KG, Fronius International GmbH, STARLIM Spritzguß GmbH, Format Werk GmbH, Gerstl Bau GmbH & Co KG, PBS Austria

ments. First of all, the common legal provisions of both communities are presented and finally, the common provisions of electricity law are discussed.

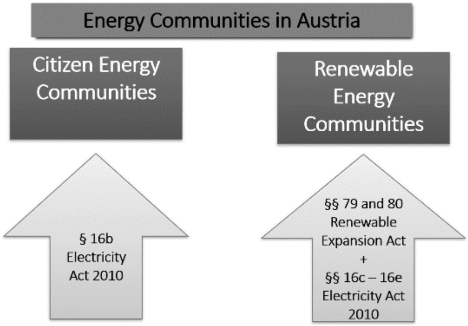

Figure 1: Own illustration of the core provisions on REC and CEC.

2.1 Establishment and purpose of CEC and REC

Basically, the two energy communities are regulated by two acts. The general provision on REC is set out in § 79 Renewable Expansion Act (REA), which regulates the establishment, members as well as the purpose. The basic provision for CEC is in § 16b Electricity Act 2010, which also regulates the above-mentioned topics. These regulations have in common that the establishment and the purpose are identical.

Establishment of REC and CEC: REC and CEC must each consist of two or more members/shareholders. Both communities must be organized as an association, cooperative society, partnership[7], corporation[8] or similar association with legal personality.[9] With this provision, Austria has allowed a wide scope for possible forms of incorporation and draws on existing legal bodies.

Main purpose: For both communities it applies that their main purpose must not be financial gain, this is to be stated in the statutes if it does not already result from the chosen legal form. Furthermore, the communities must primarily bring environmental, economic or social community benefits to their members or to the areas in which they operate.[10] Thus, these aspects are to be applied and specified to the legal form chosen in each case.[11]

Papier Büro und Schreibwaren GmbH, Helios-Sonnenstrom-GmbH, Salesianer Miettex GmbH, Biomontan Produktions und Handels GmbH.

[7] Possible partnerships with legal personality in Austria are: “Offene Gesellschaft (OG)”, “Kommanditgesellschaft (KG)“, „GmbH & Co KG“.

[8] Possible corporation in Austria are: “Aktiengesellschaft (AG)” or “Gesellschaft mit beschränkter Haftung (GmbH)“.

[9] § 16b (2) Electricity Act 2010 und § 79 (2) REA; A civil law partnership (Gesellschaft bürgerlichen Rechts - GesbR) does not have legal personality (cf. *Cejka*, Energiegemeinschaften im Clean Energy Package der EU, ecolex 2020, 338 [339]).

[10] § 79 (2) REA und § 16b (2) Electricity Act 2010.

[11] *Biresselioglu et al*, Legal Provisions and Market Conditions for Energy Communities in Austria, Germany, Greece, Italy, Spain, and Turkey: A Comparative Assessment, sustainability 2021, 12f.

2.2 Citizen Energy Communities

CEC are limited to the joint use of electricity, as already stipulated by the ED 2019. With the introduction of the CEC in § 16b Electricity Act 2010[12], the following points have arisen, which enable the joint use of electricity across the property boundary.

Energy source and activity: CEC operate in the field of electricity, with no restriction to renewable energy. Thus, electricity from all energy sources can be used. Within CEC, electricity can be generated and the generated energy can be consumed, stored and sold. CEC can engage in aggregation and provide energy services to their members. Energy efficiency services or charging services for electric vehicles are shown as examples of energy services in the law.[13]

Possible members and shareholders and the power of decision/control in CEC: According to § 16b (2) Electricity Act 2010, the permitted "members or shareholders" of a CEC consist of a) natural persons, b) legal persons and c) local authorities. Thus, regarding membership, CEC is in principle open to all types of legal persons, but the power of decision is restricted. § 16b (3) Energy Act 2021 limits this power of decision/control within the CEC to the following members: a) natural persons b) local authorities and c) small enterprises, unless they perform the function of an electricity undertaking within the meaning of § 7 (1) no. 11 Electricity Act 2010.[14]

This restriction of control is in any case given if the chosen corporate form includes a statutory majority held by stated members/shareholders. For the purposes of this federal law, "control" means rights, contracts or other means which, either separately or jointly and having regard to all the factual or legal circumstances, confer the possibility of exercising decisive influence over the activities of an undertaking, in particular by; a) rights of ownership or use over all or part of the assets of the undertaking; b) rights or contracts which confer a decisive influence on the composition, deliberations or decisions of the organs of the undertaking.[15] The legal definition and its exemplary enumeration thus show that the decision-making bodies of a CEC (depending on the legal form) may only be occupied by those members/shareholders stipulated by law who may have control in the CEC and thus have influence within the CEC. For this purpose, the further relevant provisions on the possible legal forms are to be consulted.[16] As a result of the almost unrestricted potential circle of members, the essential powers of decision are limited to those members who do not engage in commercial activities on a large scale and

[12] Bundesgesetz, mit dem die Organisation auf dem Gebiet der Elektrizitätswirtschaft neu geregelt wird (Elektrizitätswirtschafts- und –organisationsgesetz 2010 – ElWOG 2010) F.L.G. I No. 110/2010 last amended by F.L.G. I No. 150/2021.

[13] § 16b (1) Electricity Act 2010.

[14] *Biresselioglu et al*, Legal Provisions and Market Conditions for Energy Communities in Austria, Germany, Greece, Italy, Spain, and Turkey: A Comparative Assessment, sustainability 2021, 13f.

[15] § 7 (framework provision) (1) no. 34 Electricity Act 2010.

[16] For further information see: *Cejka/Kitzmüller*, Rechtsfragen zur Gründung und Umsetzung von Energiegemeinschaften, IEWT 2021 (Publ.), 18.

who do not consider the energy industry to be the actual area of their business activity. This means that medium-sized and large companies, as well as companies which are electricity companies within the meaning of § 7 (1) no. 11 Electricity Act 2010, are excluded from control.[17]

Participation in a CEC does not affect the rights and obligations of the respective system users. This applies in particular to the free choice of supplier.

Range and interconnection of the CEC: No local or regional restrictions are imposed on CEC. In addition, the government's explanatory notes mention that a CEC can extend across the whole Austrian market area. The community can use the entire Austrian market and thus concession areas of different distribution system operators may be involved. There are also no special regulations in the form of a beneficial system utilization charge that would be based on a regional restriction. Therefore, the community has to pay the corresponding system utilization charges according to §§ 52 to 58 Electricity Act 2010 and the System Charges Ordinance[18] for the Austria-wide use of the public grid. This also results from the fact that these relevant provisions do not stipulate any reductions as standardized in comparison with CEC on the system utilization charges pursuant to § 52 (2a) Electricity Act 2010.

2.3 Renewable Energy Communities

The general provision and the funding provision on REC are in §§ 79 and 80 REA. In accordance with the directive[19], this does not specify any restriction to a type of energy, but only that the energy must come from renewable sources. It should be noted that this provision is formulated in an energy-neutral manner and refers to renewable energies, which includes among others gas, heat etc. Accordingly, further specific regulations on individual types of energy are to be observed, such as special regulations in the field of electricity that are to be applied to REC that jointly use electricity.

Energy source and activity: According to § 79 (1) REA, a REC may generate energy from renewable sources, consume, store or sell the energy it generates itself. In addition, the community may be active in the field of aggregation and provide other energy services. However, the regulations applicable to each activity must be followed. As mentioned above, the relevant provisions of the Electricity Act 2010 are applicable to REC using renewable electricity.

Possible members and shareholders of REC (regardless of their used renewable energy source) can be a) natural persons, b) municipalities, c) legal entities of public authorities re-

[17] Cf. government explanatory notes, 27 (ErläutRV 733 BlgNR 27. GP 27).

[18] Verordnung der Regulierungskommission der E-Control, mit der die Entgelte für die Systemnutzung bestimmt werden (Systemnutzungsentgelte-Verordnung 2018 – SNE-V 2018) F.L.G. II No. 398/2017 last amended F.L.G. II No. 438/2021.

[19] Cf. Art 22 RED II.

garding local departments and other legal bodies under public law, or d) small and medium enterprises[20].

The specific and exhaustive list of possible participants excludes private companies that are not small and medium-sized enterprises. In addition, there is a further restriction for private companies which states that participation must not be their main commercial or professional activity. In any case, this excludes electricity and natural gas undertakings within the meaning of Electricity Act 2010 and Natural Gas Sector Act 2011[21] (for the special regulation on generators in the electricity sector, see below), as their participation in a REC is always equivalent to their main commercial or professional activity[22] and would therefore not be compatible with the objective of the REC. In the field of electricity, § 16c (1) Electricity Act 2010 includes a lex specialis to the effect that the participating producer may not be controlled[23] by a supplier, provider or electricity retailer within the meaning of Electricity Act 2010. The explanation of the government bill is based on the wording "located in the proximity of the renewable energy projects" according to Art. 2 no. 16 of RED II, which means that wind farm, hydropower or larger PV projects should also be able to participate in a REC, but should not be controlled by energy undertakings. In the internal relationship of the REC for the electricity produced and consumed within the community, no electricity law provisions are applicable, thus no supplier status arises. In the external relationship, the provisions of electricity law are to be applied depending on the assumed role under electricity law.[24] As with CEC, the rights and obligations of the participating system users remain unchanged, such as the free choice of supplier.

2.3.1 Specific provisions of electricity regulation that apply to the use of electricity under REC

REC is not legally defined in the REA, but in § 7 (1) no. 15a Electricity Act 2010. The term "renewable energy community" was established as a basic provision and is defined as a legal entity that enables the energy generated within the community to be used jointly; its members or shareholders must be located in the proximity area as defined in § 16c (2) Electricity Act 2010. The legal definition directly refers to an essential element of the REC, namely the "proximity area" in the context of community use of renewable electricity. Austria has decided to divide the "*located in the proximity of the renewable energy project*"[25] into two areas based

[20] In this regard, the explanation of the government bill refers to "Commission Recommendation of 6 May 2003 concerning the definition of micro, small and medium-sized enterprises, OJ 2003 L124/36.

[21] Bundesgesetz, mit dem Neuregelungen auf dem Gebiet der Erdgaswirtschaft erlassen werden (Gaswirtschaftsgesetz 2011 – GWG 2011) F.L.G I No. 107/2011 last amended F.L.G. I No. 150/2021.

[22] Cf. government explanatory notes, 19 (ErläutRV 733 BlgNR 27. GP 19).

[23] Cf. § 7 (1) no. 34 Electricity Act 2010.

[24] Cf. government explanatory notes, 27 (ErläutRV 733 BlgNR 27. GP 27).

[25] Cf. English version of Art 2 no. 16 lit a RED II.

on the distribution grid structure. This is on the one hand the local area and on the other hand the regional area, which are the following: The consumption facilities of the members/shareholders must be connected to the generation facilities in the concession area of a grid operator

- via a low-voltage distribution network and the low-voltage section of the transformer station (local area) or
- via the medium-voltage network and the medium-voltage busbar in the transformer station (regional area).[26]

The technical approach also complies with the network topology. The regional area connects the consumption and generation facilities through the medium voltage part of the transformer station and this also includes the local area. With these connections, the higher network levels are not used, which has an effect on the network charges (see below). Explicitly, the transit of energy from generation plants or storage facilities to consumption plants using grid levels 1 to 4, up to the medium-voltage busbar in the substation, is not permitted. Transit through the networks of other network operators is also not permitted.[27]

Related to the proximity is the right to information according to § 16c (3) REA. The system users, i.e., the members/shareholders of a REC, have 14 days to obtain information on the part of the distribution network to which their consumption or generation facilities are connected. In the explanatory note, reference is made to the persons who wish to form a REC. On request, they shall be provided with information on the distribution network level to which their installations are connected or whether they are in the regional or local area of a specific community.[28] The distinction if a REC uses the local area or regional area has an impact on the system utilization charge, because with the reduced use of the public grid a reduction of the charge is stipulated for RECs according to § 52 (2a) Electricity Act 2010.

Reduction of system utilization charge: Only for REC are reductions in the system utilization charge, because this energy community operates either over the local or regional area. With this provision, the system utilization charge is taken into account in relation to the consumption that is covered by the allocated energy from a REC generation facility, and thus the charge is reduced in accordance with the system usage. The system utilization charge is reduced for REC according to § 52 (2a) Electricity Act 2010. This specifies how the system

[26] The local area thus extends over grid level 7 to the low-voltage part of the transformer station, i.e. part of grid level 6, but not beyond the medium-voltage part of the transformer. The regional area includes grid level 5 and the medium-voltage busbar of the transformer station, i.e., part of grid level 4, thus not including the part of the transformer station that passes over medium-voltage busbar and the transformation to the high-voltage level. Thus, the close-up range is created by the fact that the connection of the consumption facilities of the members/shareholders with the generation facilities leads via the low-voltage or medium-voltage distribution network of a network operator (cf. government explanatory notes, 27 [ErläutRV 733 BlgNR 27. GP 27]).

[27] Cf. § 16c (2) Electricity Act 2010.

[28] Cf. government explanatory notes, 28 (ErläutRV 733 BlgNR 27. GP 28).

utilization charge is reduced. In this regard, it should be noted that the percentage discount on the energy part has already been defined in the system charges ordinance[29]. In the local area, the discount for grid levels 6 and 7 is 57%, and the discount for the regional area is 28% for grid levels 6 and 7, and 64% for grid levels 4 and 5. Furthermore, the provision also contain an determination of the capacity part from the system utilization charge.

Further exemptions for REC: On the one hand, there is an exemption from the electricity tax for electricity that is generated by photovoltaics of electricity producers (including producer groups such as REC) and is not fed into the grid, but consumed by the producers themselves.[30] On the other hand, there is also an exemption from the renewable support tariff. Under this exemption, electricity generated and consumed within a renewable energy community is not taken into account when determining the renewable support contribution to be paid by the end consumer.[31]

2.4 Electricity regulations applicable to REC and CEC electricity joint use

As a result of the use of electricity within the scope of REC and CEC, corresponding **common regulations** are laid down in the Electricity Act 2010. These regulations affect the members and shareholders, as well as the communities themselves and the grid operators.

These regulations specify which information about the community is to be communicated to the grid operator.[32] They also specify which agreements are to be made in any case[33] and how the measurement[34] and billing[35] of the electricity quantities are to be carried out. Within the framework of the regulations on metering, there is an obligation to make the measured quarter-hourly values of the generation and consumption facilities available to the participating system users, suppliers and the energy community itself by the next day at the latest.[36] Furthermore, these regulations also contain specific requirements for CEC that must be observed.[37]

[29] Verordnung der Regulierungskommission der E-Control, mit der die Entgelte für die Systemnutzung bestimmt werden (Systemnutzungsentgelte-Verordnung 2018 – SNE-V 2018) F.L.G. II No. 398/2017 last amended F.L.G. II No. 438/2021.

[30] § 2 Z 4 Electricity Tax Act (Bundesgesetz, mit dem eine Abgabe auf die Lieferung und den Verbrauch elektrischer Energie eingeführt wird (Elektrizitätsabgabegesetz) F.L.G. I No. 201/1996 last amended F.L.G. I No. 18/2021) in conjunction with § 2 Electricity Tax Implementation Ordinance (Verordnung des Bundesministers für Finanzen zur Umsetzung des Elektrizitätsabgabegesetzes im Bereich mittels Photovoltaik erzeugter elektrischer Energie, F.L.G. II No. 82/2021).

[31] Cf. § 75 (5) REA.

[32] Cf. § 16d (2) Electricity Act 2010.

[33] Cf. § 16d (3) Electricity Act 2010.

[34] Cf. § 16e (1) Electricity Act 2010.

[35] Cf. § 16e (3) Electricity Act 2010.

[36] Cf. § 16e Electricity Act 2010.

[37] Cf. § 16e (2) Electricity Act 2010.

In § 16d (1) Electricity Act 2010, system users as referred to in § 16b (2), § 16c (1) last sentence Electricity Act 2010 as well as § 79 (2) REA, i.e., eligible members/shareholders of the respective energy community, have a legal claim against the grid operators to participate in a REC and CEC (according to §§ 16b as well as 16c Electricity Act 2010).[38] The purpose of this regulation is that a grid operator has to cooperate with the energy communities in order to facilitate the transmission of energy within communities as well as the feed-in of surplus quantities. To this end, the explanatory note points out that the organization of the operation and grid access of energy communities is modelled on the provisions of § 16a Electricity Act 2010. In addition, Energy Communities are to be considered as persons entitled to system access within the meaning of § 7 (1) no. 54 Electricity Act 2010.[39,40]
Support for both energy communities is available under REA because CEC can also use electricity from renewable sources. The opportunity for REC and CEC to receive subsidies are set in the specific provisions under § 80 (1) and (2) of the REA and § 16b (4) and (5) of the Electricity Act. If the requirements of the eligibility provisions are fulfilled, REC and CEC are eligible for either the market premium or the investment subsidy.[41]

2.5 Resume

The illustrations show that the foundation of an energy community results in the same requirements, however, the freely selectable legal entities offer a large scope for individual needs of participants in an energy community. These are also reflected in the respective circle of members. On the one hand, all citizens are welcome in both communities, but this does not apply to companies. In particular, large companies can only participate in CEC. Accordingly, their possibilities are limited. The following table briefly shows the main differences.

Key differences between the energy communities	
Citizen Energy Communities	**Renewable Energy Communities**
Electricity (from fossil and renewable sources)	Energy from renewable sources (**electricity, heat and cold**)
Possible members/shareholders: • natural persons, • local authorites, or	Possible members/shareholders: • natural persons, • municipalities,

[38] Cf. *Autengruber/Tamerl et al*, Erneuerbare-Energie-Gemeinschaften – die Zukunft der kommunalen Energieversorgung? RFG 2021, 110.
[39] Cf. government explanatory notes, 28 (ErläutRV 733 BlgNR 27. GP 28).
[40] The common provisions relating to the use of electricity under REC and CEC are located in §§ 16d-16e Electricity Act, the above is only an excerpt. For further information, please refer to the relevant paragraphs.
[41] Cf. § 55 (9) REA.

• legal persons • **Limited power of decision**	• legal entities of public authorities in regard to local departments and other legal bodies under public law, or • **small and medium enterprises**
No proximity • No reduction of system utilization charge	**Proximity: local** and **regional area** • Reduction of system utilization charge

Table 1: Own presentation of the main differences between the energy communities in Austria.

Each energy community provides opportunities for an individual group of interested parties to develop their own concepts for joint use within a clearly defined legal framework. This can be a group of neighbors or an association of communities with their citizens and local businesses. Time will tell which form of foundation is preferred and how the individual groups will be composed. Furthermore, it is important for interested parties to know how far they want to use energy jointly. With CEC, joint use of electricity is possible across the entire Austrian market area. Electricity from renewable and fossil sources can be used, but there are no exemptions as with REC. While REC enjoys the benefits of its limited operating area as well as the exclusive use of renewable electricity, exemptions are available in this case. These factors also play a role in deciding which community an interested party wants to join.

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Data management in energy communities

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Abstract – Following the introduction of energy communities in European law, they are now transposed into the national laws of the member states. Previous research in this area has focused on various aspects, but not yet on data processing and data protection in the community itself. For the timely allocation of the generated energy to consumers within the community, necessarily energy data needs to be accessed in a high frequency that is shown to be problematic in terms of privacy. Operation systems for energy communities thus need to adhere to the principles of the GDPR. Main responsibilities regarding data acquisition and transfer are among the duties of the distribution system operator. However, for future use cases, the current legal status may not be sufficient.

1. Introduction

Energy communities have been introduced by two directives of European Union's ‘Clean Energy Package for All Europeans’ which need to be transposed by the member states into their national laws. Thus, member states are – on the one hand – in different states of the transpositions processes, where some countries have not yet started with their legislative processes. On the other hand, the implementations in the various member states differ in their details [1] [2] [3]. In Austria, energy communities have recently been introduced by the 'renewables expansion act (*Erneuerbaren-Ausbau-Gesetz*)' in July 2021 [4]. While the Austrian law mainly focuses on the duties of the distribution system operator (DSO), and partly the connection of the DSO with the energy community, collaboration within them is not regulated.

Energy communities aim to jointly produce, consume, store, and share energy to increase the self-consumption of locally generated energy, but they could also offer other energy-related services. They have already been recognized by several national energy and climate plans as important players towards the energy transition [5]. Thus, they may become an essential element of the energy system to contribute to abating the effects of climate change as well as to provide local countermeasures against blackouts. Figure 1Figure shows the abstract structure of an energy community; the dashed lines show the energy flow, the solid lines show the cash flow. Relevant data are generated at all depicted levels; they are processed and stored inside and outside the energy community.

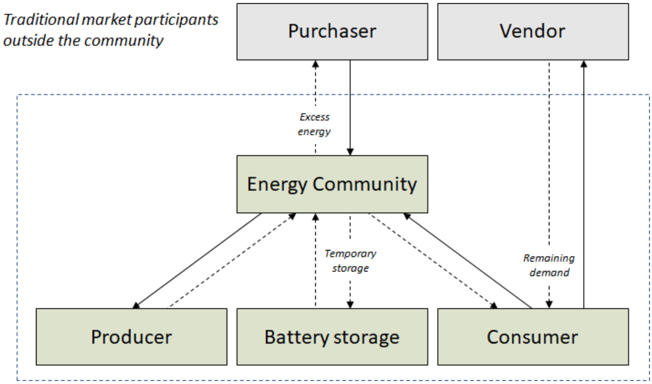

Figure 1: Structure of an energy community [3]

Recent research dealt with various aspects on energy communities (e.g., [1] [2] [3] [4] [6] [7]); for example, the differences between national implementations in the member states, which of the energy communities' variants to choose, restrictions on participation, profitability aspects, legal forms, necessary contractual relations, as well as business models and technical solutions. In this regard, the ongoing international *CLUE* project[42] as well as the national *ECOSINT* project[43] evaluate energy communities from interdisciplinary points of view (technical, legal, economical etc.). No significant focus has yet been laid on data flow and data protection aspects; initial considerations shall be the focus of this article.

[42] https://project-clue.eu/

[43] https://ecosint.at/

2. Energy data are personal data

For a timely allocation of the produced energy and the subsequent billing, it is necessary to determine energy generation and consumption data in near real-time. However, details on the individual energy consumption – especially in a high reading frequency – can provide deep insights into presence and absence, device usage, a household's economic situation, preferences, and lifestyle [8]. Initially, neither European nor Austrian energy laws laid a focus on data protection, while it is now – at least – explicitly mentioned to be an important aspect to consider. The General Data Protection Regulation (GDPR) defines 'personal data' as any information relating to an identified or identifiable natural person ('data subject'). Therefore, energy consumption data are categorized as personal data and the GDPR is thus applicable. There are several articles on data protection issues in intelligent power networks (smart grids), especially when using intelligent power meters (smart meters); various solution approaches were summarized in [8]. Thus, equipping households with smart meters have always been seen sceptically from data protection sides.

European Union's Energy Directive demands a rollout to at least 80 % of the metering points due 2024, while Austria legally specified to eventually reach 95 %. However, so far, the rollout in some regions of Austria has still been slow, at the end of 2020, less than 30 % have been reached [3]. DSOs are now legally required to equip energy communities' participants with smart meters within two months. Generally, despite equipped with a smart meter, the energy consumption of a 'normal' household will be metered only once a day. There is even a legally stipulated opt-out option from smart metering, which is, however, not applicable to members of energy communities. Furthermore, generally, for a quarter-hourly read-out of energy consumption data there must be an explicit opt-in (i.e., either by using a special tariff requiring such data, or by special desire). However, for energy communities' participants this read-out interval is legally explicitly defined and cannot be avoided. For the scope of this article, the relevant nationally defined legal minimum requirements for smart meters are in particular:

- meter readings, average power values, and energy consumption values are measured and saved in an interval of 15 minutes,
- all data recorded by midnight are transmitted to the DSO once a day by noon of the following day at the latest,
- smart meters are equipped to be able to communicate with external devices in the customer's sphere via a communication interface,
- devices and their communication are secured and encrypted according to the state of the art, and
- devices must comply with data protection regulations according to the state of the art.

As an additional aspect in terms of data protection law, the collected data will not only be made available to the DSO and the suppliers, but also to the energy community. The expected small number of participants, as well as the limited geographical operational area needs to be considered as this configuration simplifies to ‘know the face related to the personal data’.

3. Technical implementations

The implementation of energy communities requires suitable (IT) systems, including for allocation of available energy to the consumers as well as the correct billing. In anticipation of the national implementation of the directives, recent research dealt with a prototypical technical implementation using blockchain technology [6]. Indeed, the directives provide a definition for 'peer-to-peer transactions' that leads into the direction of blockchain technology [9]. Its use simplifies the peer-to-peer energy trading among its participants by utilizing smart contracts [9], but it particularly raises privacy concerns and challenges due to their technology-immanent design principles (data once saved on the blockchain is inherently immutable and eternal) [10] [6]. It is neither easy to answer who is the person responsible for data protection in a blockchain system, nor how GDPR's data subjects' rights (information, access, rectification, and erasure rights) can be ensured [10]. Despite those considerable issues, a data protection-friendly prototypical implementation (e.g., use of pseudonyms, user rights management, initiate a new blockchain after each billing cycle etc.) was described in [6].
However, real implementations do not necessarily have to be based on blockchain technology; the *CLUE* and *ECOSINT* projects will also investigate technical implementations of energy communities aside the blockchain. For example, *CLUE* suggests a toolkit consisting of [11]:

- a **planning tool**: to plan the community to integrate renewable energy sources, customers, electric mobility, storage, and power-to-heat applications,
- a **monitoring and information tool**: to provide capabilities for a real-time overview of the community, e.g., the energy flow within the community,
- an **operation tool**: the event-based operation environment with fully automated services for analyses and alarming.

4. Responsibilities of the DSO

The DSO is responsible to

1. **measure** the generated and consumed energy in a quarter-hour interval,
2. **allocate** the generated energy to the participants according to the agreed model, and
3. **provide the data** to the energy community.

4.1 Measure energy data

Each participant is required to be equipped with a smart meter; there is no possibility to opt-out. The quarter-hour measurements are collected at least once a day by the DSO (cf. Sect. 2).

4.2 Allocate energy

Energy generated in the energy community needs to be allocated to the consumers. Surpluses are fed into the public network and assigned to the supplier with whom a purchase agreement has been concluded. Legally there are two options available for the allocation, one of which needs to be chosen at the creation of the energy community and disclosed to the DSO:

- the **static model**: The same share of energy is assigned to each participant at each time (i.e., quarter hour). If the assignment exceeds the current consumption of a participant, the remaining energy is fed in, even if other participants would require more energy than assigned.
- the **dynamic model**: Energy is assigned to each participant according to its consumption at that time (i.e., quarter hour). Only the remaining energy that is not required at that time by any participant is fed in.

	Required energy	**Static model**	**Dynamic model**
Production		4 kWh	4 kWh
Consumer 1	1 kWh	1 kWh	1 kWh
Consumer 2	3 kWh	2 kWh	3 kWh
From supplier		1 kWh (remaining from C2)	-
To supplier		1 kWh (remaining from C1)	-

While the static model is easier to understand, the dynamic model is more economic, and it optimizes the internal consumption of the community. The allocation of energy to the members is among the duties of the DSO; thus, neither the producer nor the energy community can influence which participant gets which amount of the energy.

4.3 Provide data

The recorded quarter-hour values are transmitted to the suppliers and the energy community as soon as possible, but at latest on the next day. They shall be provided in a customer friendly way in a web-portal but/and (also?) in a machine-readable format. While there are specific rules for the data transfer and data protection between DSO and suppliers, detailed rules for energy communities are (currently) missing. Thus, there is a defined communication transfer and format between DSO and suppliers, but not (yet) between DSO and energy communities.

5. Operation of energy communities

According to the law, the community participants are required to agree on "the data management and data processing of energy data of the producing systems and the consuming systems of the participants *by the DSO*". This policy is seen critical: On the one hand, the participants of the energy community cannot decide on how and to what degree the DSO is permitted to operate on energy data. On the other hand, the energy community itself needs to find a consent on how it operates on data.

As described, energy communities shall not only be able to produce, consume, store, and share energy; they could also provide ‘other’ energy-related services. After an initial phase, energy communities are expected to increasingly pursue more advanced use cases beyond the simple allocation and billing of generated energy to its participants. In those use cases, the stipulated limited options of either a static or a dynamic allocation, as well as to receive energy production and consumption data not before the next day might not be sufficient. Furthermore, these use cases could require data in a more frequent interval than quarter-hour values. A higher interval read-out by the DSO is not permitted by law, and a more frequent transfer of the collected data to the energy community is not stipulated.

Energy communities could thus utilize the customer interface of the smart meters, where real-time data is available to the customer. For the usage of such intrinsic data by the energy community, a legal justification is required; applicable would either be:

- the data subject has given **consent** to the processing of his or her personal data for the specific purpose, or
- processing is necessary for the performance of a **contract** to which the data subject is party, such as the energy community’s operational agreement.

In cases, where the energy community pursues advanced use case that require data in a high frequency the processing is necessary. It can, however, also be argued that participants without consent may profit from the basic use cases, but not from the advanced ones, if their operation can be reasonably distinguished.

In any case, operation systems for energy communities must adhere to the principles of the GDPR; among them, and especially to mention in this context are:

- the **data minimisation** principle: data acquisition must be limited to the extent necessary for the purposes; only the minimum personal data required for the specific application must be collected,
- the **storage limitation** principle: data must be stored only for as long as necessary for the purposes, and
- the **integrity and confidentiality** principle: processing of data must adhere to appropriate security using technical and/or organizational measures.

As the GDPR contains sensitive fines, compliance with obligations of the GDPR is important.

The primary subject for the lawful processing of data and compliance with the GDPR is the ‘controller’, who is responsible for adherence to the principles, and to ensure and fulfil the data subject's rights. The controller continuously assesses the risks posed by the processing operations and takes appropriate technical and organizational measures to ensure the adequate protection of privacy. Especially the mentioned principles and the data subject rights may conflict with implementations utilizing blockchain technology (cf. Sect. 3) [10] [6]. The controller is not required to be a natural person, thus the energy community itself – required by law to be incorporated in some legal form [4] – will be the controller.

A further question in regards of the GDPR is whether a data protection officer (DPO) needs to be designated. This is suggested, if 'the core activities of the controller […] consist of processing operations which […] require regular and systematic monitoring of data subjects on a large scale'. The obligation to nominate a DPO within the community would be a burden; however, it shall be mentioned that – like third parties can be appointed for any parts of the community's operation – also the DPO does not need to be a member of the community.
To further foster compliance with data protection obligations, two remarkable concepts are included in the GDPR:

- **Privacy by design**: New inventions shall be designed in a way that privacy is considered from the beginning and not as a subsequent add-on; thus, systems conform to the GDPR at every time. The controller shall, both at the time of the determination of the means for processing and at the time of the processing itself, implement appropriate technical and organizational measures to meet the requirements of the GDPR and protect the rights of data subjects. That obligation applies to the amount of personal data collected, the extent of their processing, the period of their storage and their accessibility.
- **Data protection impact assessment (DPIA)**: An evaluation to reduce the risks of misusing personal data shall be conducted. In particular, the execution of a DPIA is appropriate if new technological solutions are used, if data processing is carried out on large scale or if automated processing leads to decisions that have a legal effect for natural persons, all of which may be applicable to energy community operations. A DPIA provides evidence that appropriate measures have been taken to protect personal data.

6. Conclusion

Data acquisition, usage and privacy have not been in the focus of the beginning research on energy communities. Now, with available national implementations and thus the possibility to start communities, those aspects will come to the fore. The main purpose of this research article was to provide initial considerations on this topic, while it will necessarily need to be further considered throughout the next years.

Acknowledgments

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Integration of sustainable energy solutions in energy communities

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Abstract – A transition of energy systems from a centralized, top-down system dominated by a limited number of corporate actors to a decentralized bottom-up system where individuals and communities can connect and become a stakeholder of the energy system and thereby making it more beneficial to our community and environment in line with anticipated future developments.

The emerging electrification of the consumer sector, resulting from rapidly growing markets such as e-mobility and IoT, further accelerates the demand for energy and the demand for more flexible, distributed power solutions. These growth trends can be used to develop demand orientated decentralized bottom-up energy systems and to integrate them into existing ones.

Distributed energy systems, such as Renewable Energy Communities, developed along this emerging demand with generation from renewable facilities build up and integrated accordingly, ensure a stable integration into existing energy infrastructures. The integration of heat supply and storage technologies provide additional levers and accelerate the development of renewable local energy supplies. Moreover, it will bring new dynamics into the whole system.

In summary, local hubs can be created, contributing to the optimization of the overall system and to the expansion of renewable energies.

Renewable Energy Communities

Renewable Energy Communities (REC) are intended to make a significant contribution to promoting decentralized supply and allowing consumers to participate in the energy transition. A REC is an association of private individuals, companies and communities who jointly generate, consume, store and trade electricity from renewable sources. They contribute to increase public acceptance of renewable energy projects and make it easier to attract private investments in the clean energy transition.

At the same time, a Renewable Energy Community has the potential to provide direct benefits to its members by advancing energy efficiency and lowering their electricity bills resulting from the optimization of the regional energy system in line with its specific energy demand and supply curve depending on its geographic location and economic orientation. Further benefits include a renewable, local, and decentralized production as well as the independence from the electricity market, price stability and reduced fees and charges (reduced network usage fees, exemption of renewable subsidy contributions, exemption of electricity taxes).

To have a chance to reach our environmental goals, there is no alternative than to rapidly expand the share of renewable energies in global electricity generation. Governments and local authorities can initiate processes through legislation and funding, but the key accelerator to success is public participation driven by the growing awareness that change can come through bottom-up initiatives. The individual's interest as a stakeholder of an energy system is to maintain price stability and act in the best interest of its community and its environment. Collective and citizen-driven energy actions will help pave the way for a clean energy transition.

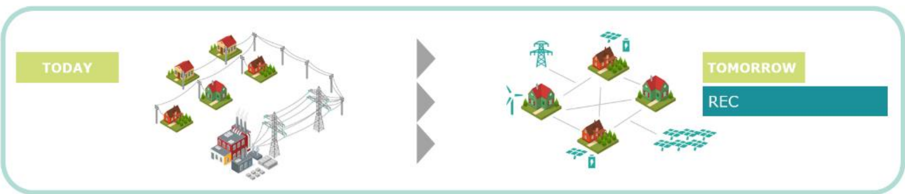

Figure 1. Renewable Energy Community

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ICT Design for Community-empowered Sustainable Multi-Vector Energy Islands

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Abstract – In this paper, a combined approach for creation of urban energy islands is proposed. It consists of technical system for multi-vector energy optimization, as well as social science solution for assembling a renewable energy community. The main challenge of proposed approach is to provide replicability of the solution because of diversity in technical architectures, business models and community engagement levels in different energy islands.

1. Introduction

Slowing down climate change in order to put a halt to climate catastrophe – this is the challenge mankind is facing today. In recent years, a wide range of technical innovations have been suggested to deal with this challenge, mainly striving towards energy efficiency but also aiming to close temporary gaps between energy demand and energy supply in order to maximize the utilization of renewable energies. This applies mainly to electricity, but all energy vectors - electricity, heat and mobility - are affected by these innovations. However, in many cases, the Jevons paradox has counteracted efficiency endeavours, i.e., the paradox situation

that efficiency gains are often more than compensated by over-consumption, stimulated by reduced cost.
In this context, the EU H2020 project "RENergetic" suggests so-called "urban energy islands" striving for local self-sufficiency while, in addition, offering energy services to the external energy grids. The energy island approach has the advantage of having clear and absolute goals, which, if taken seriously, limits the impact of the Jevons paradox, the so-called "rebound effect" because energy efficiency is a relative concept whereas an energy island either is self-sufficient or not. There is no room for rebounds.

How to reach this goal depends heavily on local characteristics of a prospective energy island, not only with regards to its geographical setting, i.e., the abundance of local energy resources, but also with regards to its inhabitants, their usage patterns and complex social ties and contracts. Therefore, an information and communication technology (ICT) based optimization solutions should be on par with needs and preferences of various user groups as well as their responsibility for the energy system that will be seen as system relevant in future active distribution grids. Self-sufficiency and, in particular, self-responsibility will thus be essential features of future energy communities at the age of renewables as an integral part of future *active distribution grids.*

These are the challenges that the RENergetic solution system addresses with a triple approach: it will offer an ICT based optimization solution, a community engagement process and corresponding tools, and it will finally boost the impact of the suggested solution set with a third pillar, a strong replication strategy. This replication strategy determines the requirements as to the modularity of those building blocks. For the RENergetic ICT system this means that it is designed as a hierarchical architecture that consists of subsystems that optimize energy supply and demand within an energy vector which is then successively optimized among energy vectors. For the RENergetic social solution the replication requirement implies that local experiences will be poured into an engagement toolbox containing engagement procedures and milestones as well as RENergetic communication building blocks.

2. Replicability as Guiding Principle

The RENergetic project has three pilot sites, the New Docks in Ghent (Belgium), the Ospidale San Raffeale in Segrate (Italy) and the University Campus in Poznan (Poland). Developing solutions that can be applied to all three sites would require a significant amount of development resources if each of the sites is looked at individually and individual approaches for each site are being made.

Therefore, the RENergetic team decided early in the project that the aspect of replicability of the solutions must be at the center of the design principles. The aim is to design generally applicable solutions that then will be replicated to each of the pilot sites. This stands true for all aspects; technical as well as legal, social and economic dimensions of each implemented solution.

A generalized view on the pilot sites has been envisioned. The human-centric approach of *user stories* [1] allows to communicate the needs of users in clear and simple phrases to get an understanding of all required features. These user stories are structured into overarching user epics to form the basis for the requirements engineering for the RENergetic solutions. These *user epics* [1] cover the electric as well as the heat domain and allow the RENergetic solutions to interact with a variety of infrastructure at the pilot and future replication sites.
With the user epics providing a frame for the requirements engineering, an abstract view on the pilot site's infrastructure, assets and automation systems must be mapped out as well. The Smart Grid Architecture Model (SGAM) [2] has been specifically designed to address interoperability issues in smart grid applications and provides a standardized method of modelling smart grid architectures. However, the SGAM framework was mainly developed with smart grids – and thus the electricity domain – in mind, and efforts to expand models to e-mobility systems [3] or general-purpose multi-energy systems [4] have only recently been published. Adopting the SGAM model and expanding it for the application in the heat domain has been a major task in the RENergetic replicability package and is one of the contributions the RENergetic projects aims to provide to the methodology of building energy islands.

In order to meaningfully utilize the RENergetic solutions, an interface between each of the sites' component layers and the RENergetic software in the function layer are defined, based on a two-layer architecture. The first layer connects to the respective RENergetic software module and is implemented by the RENergetic development team. It provides an API to the software module with a clearly defined data structure for input and output data points. The purpose of this interface layer is to work with a minimal amount of datapoints and still be able to convey the needed functionalities. The second layer acts as a docking module that connects to the pilot sites' infrastructure. In this layer the translation between the condensed datapoints of the API to actual control commands for the site infrastructure takes place. This is shown schematically in Figure 1. As this requires intimate knowledge of infrastructure and automation systems of the sites, it needs to be done within the responsibility of the respective pilot and replication sites in accordance with their technical and administrative framework. This architecture is an exact implementation of the SGAM idea of interoperability taking place on the z-axis of the system cube, while the x- and y-axis are within the sole responsibility of each pilot and future replication sites.

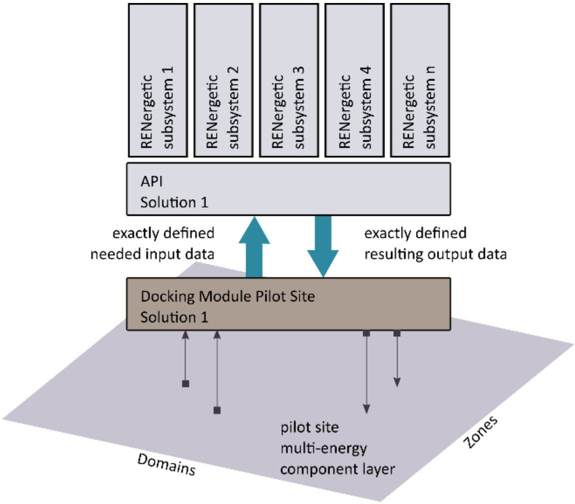

Figure 1. RENergetic interface architecture

3. Technical Solution

To realize described concept of two compatibility layers, it is decided to use OpenEMS platform [5]. OpenEMS is becoming open-source standard for energy management systems (EMS). Sometimes proprietary solutions are closed for the external communications or offer non-standardized interfaces. Utilization of OpenEMS protocols and interfaces, however, does make it possible to create adapters for existing EMS systems that meet requirements of a specific energy island.

Every energy island could have various types of devices in electrical and heating domains. To ensure alignment with most technical architectures, a modular architecture for RENergetic ICT solution is proposed. From the architecture of the RENergetic system depicted in the Figure 2Figure 2, it can be seen that ICT system consists of modules and subsystems. Modules are parts of the system that are shared between all subsystems. The data acquisition module performs data gathering from installed sensors, meters, EMS or other sources. The RENergetic portal is a mobile web application with intuitive user interface for every subsystem. The connectivity module for existing systems serves as a component responsible for pushing decisions and actions recommended by the RENergtic system to the existing hardware.

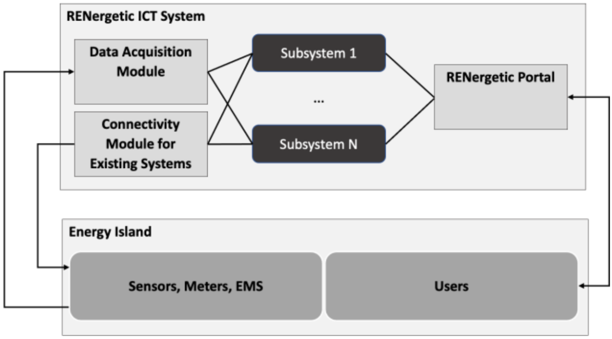

Figure 2. RENergetic ICT system architecture

Subsystems perform an optimization task in specific domain. For instance, the heat demand response subsystem performs a demand response program in central heating system. That means that final heating users (residents, office workers or students at the dormitories) could actively participate in optimization of the heat power utilization. It is done using interactive page in the mobile application with intuitive interface. The heat optimization subsystem is targeted to the heat system operators and managers. It takes into consideration all installed equipment at the energy island such as heat pump, boilers, district heating and waste heat installations. Data from installed sensors and meters, information from demand response program, as well as forecasts of future energy demand and supply are utilized by optimization algorithm. This algorithm proposes the optimal settings for the equipment to achieve desired objective, for example reducing the consumption of fossil fuels.

The electricity optimization subsystem is strongly connected to the heat optimization because many types of heating equipment also consume electricity to operate. The main concept is similar to described in heat optimization. In this domain, additionally the quality of the electricity is considered with the focus on PV installations and battery systems. The electrical vehicle demand response subsystem is a special case of demand response in electrical domain. Users of the charging stations will use interactive page, where they can indicate their preferences on charging time and level of charge. According to this information with combination of the data from forecasting algorithms and electricity optimization module, the system automatically creates a schedule for charging.

Each module could be enabled if there is corresponding equipment in the Energy Island. The overall ICT architecture is created in such a way that these modules could be utilized as separate final systems, since in many existing buildings there are already other smart control systems and user applications, which functionality sometimes intersects with proposed RENergetic system.

From subsystem descriptions, it could be seen that all of them could be considered as optimizers in the specific domain. The objectives could be a reduction of fossil fuel consumption, increase in share of renewable energy or decrease in monetary costs. As it was shown before, in some cases there is a strong connection between heat and electricity domain, so optimization should be performed jointly. RENergetic system utilizes the hierarchical optimization architecture. Figure 3Figure 3 illustrates that there are two levels of the optimization – domain-specific and global. Domain specific optimization is performed within relevant to subsystem domain, for example demand response programs that depend only on energy consumption data in one domain. Global optimizer operates on the higher-level, unifying heat and electricity domain among all optimizers, based on the demand and supply of all energy vectors.

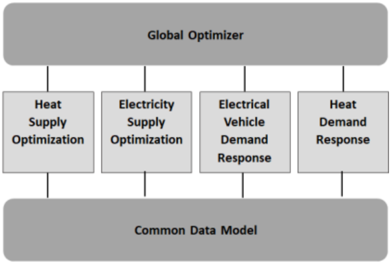

Figure 3. RENergetic optimization process

4. Social Science Solution

Many optimization systems do not need the collaboration with end users. For instance, in the case of a centralized heating system in a local heating network it is up to the energy management to implement rules of activating energy sources according to their efficiency or CO_2 intensity taking, into account capacity or ramp-up/down constraints.

However, for the case of an energy island that aims to be self-sufficient, the energy island inhabitants will have a severe responsibility for the quality of electricity inside their island, but also – due to globally increasing shares of volatile renewable energy sources – towards the external grid. It is merely not possible to strive for a decentralized power grid while taking electricity as a commodity for granted. Therefore, RENergetic not only gives the power back into the hands of the "people" as a right, but this goes with the corresponding duties and responsibility.

There are different levels of involvement, ranging from mere information over acceptance of slightly changed settings controlled by the energy island energy manager to active collaboration on a more or less day-to-day basis. This level of involvement depends on the size of the gap between through mere technical optimization achievable level of self-sufficiency of the energy island: the higher it is, the more active users need to be. Involvement is equally dependent on how the affected end-user group can control their energy usage: parameters are the duration of the stay, the size of induced energy consumption and obviously contractual power. This is why at the beginning of each user involvement there must be a stakeholder analysis. For the energy island setting, the stakeholder analysis carried through by the RENergetic team identified the following structure of generic end-users (see Figure 4): The major differentiators are the invested interest of end-users (mainly long-term vs. short-term and depending on the level of investment) and their level of control regarding the energy. All of them have specific interests, constraints and flexibilities, characteristic of their group.

The results delivered by the RENergetic ICT system need to be targeted at each end user group individually, depending on their status and options of control, but also constraint, flexibilities and interest. The area of overlap between the RENergetic ICT system and its social sciences solution is thus not only limited to the user interfaces, but beyond that the subsystems need to be designed in a way that meets the end-users' needs and control options, whenever collaboration is called for. For instance, a heat demand response system must take into account the nature of control that an end-user has over its heating device. If the heating temperature is determined centrally and the user has no control, they cannot be integrated in a demand response scheme. If, on the other hand, the heating technology was a floor heating steered by the inhabitant of an apartment, delays of several hours would need to be considered, when the end-users' active participation was required.

Currently, in the RENergetic project, a set of in-depth interviews and surveys is being executed in order to extract the main generic flexibility options and constraints of end-user groups. Obviously, the details vary from site to site, which is why the RENergetic replication package will include tools to categorize and elicit the necessary information beyond generic stakeholder characteristics and not build on specifics of the RENergetic pilots.

As shown in Figure 4, end-users may be organized in a community. This may be an informal regular gathering of students or it may be a formal "renewable energy community" (REC) according to the terms of the EU renewable energy directive RED II (2018) [6] where a group of end-users jointly owns and manages renewable energy resources with all induced responsibilities, specifically with regards to internal and external grid quality.

A community organization is a huge lever for the motivation of end-users to collaborate on collective energy actions. Behaviour changes are always viewed in the context of society, and e.g., adapting power demand or heat demand to the supply profile nowadays still is deemed unconventional and not "normal" by a vast share of the population This kind of behaviour does not correspond to current social norms, and for most people this is a major barrier towards adopting a new behaviour that enables the success of the energy island. Apart from social norms, self-efficacy is a further strong motivator for behaviour change, especially in the area of environmentally sound behaviour [6]. In the face of global climate threats, many individuals feel humbled and not able to deliver a strong contribution – which again makes them give up or due to a rising defensiveness not even start changing their behaviour. Building on these research results, the RENergetic project aims at supporting the emergence of new or the expansion of existing communities that deliver strong social identities to their community members [7]. These narratives should include realistic and measurable objectives with regards to absolute values of e.g., self-consumption, self-sufficiency or CO_2 emission to both boost self-efficacy while keeping the rebound effect in check [7]. As with the analysis of energy island stakeholders, also this will happen with replication in mind, resulting in a toolbox with communication and other engagement methods categorized according to user groups, temporal phases of an energy island community and support for building strong narratives.

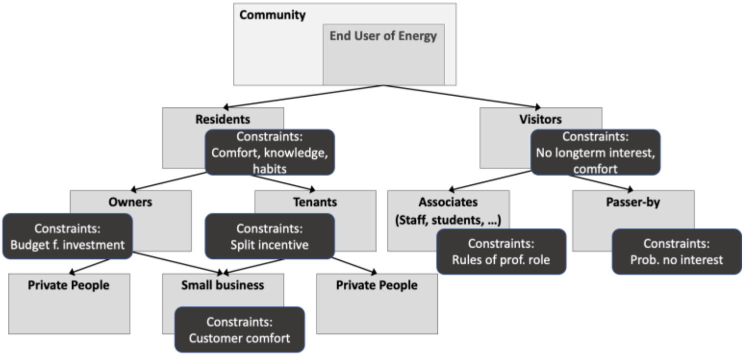

Figure 4. Generic end-user structure of an energy island

5. Conclusions

In this paper, we have outlined the RENergetic approach of energy islanding in heterogeneous environments based on cross-sectoring renewable energies. The approach consists of an amalgam of ICT solutions and far going energy community involvement. The heterogeneity, instantiated by different pilot sites, calls for a strong replicability approach. The connotation of replicability extends within RENergetic from the ICT domain, via legal and regulation frameworks all the way to requirements for end user communities. While various user target groups are investigated concerning their needs and readiness for flexibility in a cross-sector setting, a replicability across heterogeneous environments has been fostered by the concept of *user epics* that generalize the well-known concept of use cases. From an ICT perspective, a layering approach based on an implementation independent energy management system, OpenEMS, in concert with *extended SGAM*, that entails the heating domain as well as the e-mobility domain, has been pursued for *replicability* reasons. A strong point is made to call for *energy* *community responsibility* as becoming a necessary system-relevant part of future *active distribution grids* based on decentralized, renewable energy sources.

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SYSPEQ – Holistic planning concepts for positive energy districts

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Abstract – The aim of the project is to develop comprehensive planning concepts for Positive Energy Districts (PEDs), focusing on the building life cycle and especially on existing buildings and their coupling with new buildings within a neighbourhood. Planning and implementation of a PED as well as its operation as an energy community will be analysed in theory for the complex situation of social housing developers on the one hand and tested in practice with the involvement of residents on the other hand (proof-of-concept).
For full-scale planning, financing options for renewable generation plants, possibilities of marketing the surplus, and the therefrom resulting benefits for different stakeholders will be addressed. Moreover, cross-stakeholder business models shall be developed. Furthermore, a match-making platform is planned to find business partners in the field of PEDs and energy communities, as well as to collect knowledge from the project, already active PEDs and energy communities. This information shall be made available to stakeholders in a structured way and thus promote community intelligence.

1. Background

The first PEDs are being implemented in Austria, although the implementation of PEDs is currently almost exclusively limited to new construction projects. There are only a few initiatives that focus on existing neighbourhoods and thus make existing or historic building structures energetically and participatively 'fit for the future'. These few PED initiatives in the existing building sector mainly focus on unique areas and/or complex interconnectivity of different technologies, which prevents replicability of the results and general findings of the projects. In addition, adequate initiation and operating models are missing to ensure a widespread dissemination of the PED concept.

With the enactment of the renewable energies expansion act (in German: Erneuerbaren-Ausbau-Gesetz), new chances for PED arise. Since legislation that enables the establishment of energy communities beyond building borders is enforced since July 2021, PEDs could benefit from being operated as an energy community with cross-building energy exchange. Such opportunities need to be analysed in a timely manner, with a particular focus on different stakeholders involved.

2. Motivation

Based on the provided background, the motivation of the SYSPEQ project is to provide holistic planning concepts for PEDs, including the financing of generation units, energy contracts, technical and energetic planning and the operation as an energy community. Instead of continue to focus on the novel building stock, this project aims to shift the focus to the existing building stock, and specifically to social housing, in order to include vulnerable customers in the energy transition and guarantee wide applicability an replicability of results. Moreover, planning concepts are intended to be cost-efficient and easy to implement, rather than counting on the application of complex technologies.

3. Detailed description of the project’s goals

The goal of SYSPEQ is to develop fully comprehensive planning concepts for positive energy districts (PEDs) that are not limited to new construction projects but consider the entire building life cycle. A particular focus is on investigating options for implementing PEDs in existing buildings - without renovation, with renovation, or by coupling existing and new construction within a neighbourhood. Legal, technical, financial as well as social aspects are considered in this process. Previous projects are mostly limited to capital-intensive new construction projects. Therefore, this project focuses on the implementation of PEDs in the field of social housing. Legal, organizational as well as financial issues will be addressed.

The possibilities in the field of PEDs are significantly extended by the new legal conditions of the Renewable Energy Expansion Act, which allows energy exchange across buildings. Therefore, in this project, the operation of a PED as an energy community (EC) by different stakeholders is investigated. In particular, the complex situation of social housing developers is examined. Possibilities as well as limitations in the legal and organizational field are analysed.

For the purpose of proof-of-concept, planning and implementation of a PED, and operation as an EC will be carried out in Fuchsenloch, a social housing neighbourhood administrated by Sozialbau, consisting of old buildings and a new building in the planning phase. Residents are optimally involved through targeted surveys and provision of information. A plot of land in the Rothneusiedl urban development area (Wien Süd, Sozialbau) is being planned with regard to the optimal design of renewable generation systems and user structure (residential, commercial, office buildings, etc.). The different characteristics of the two quarters guarantee replicability.
Financing options for renewable generation plants (RES) in PEDs and ECs are evaluated from the perspective of different stakeholders. The goal is to develop a concept for standardizing the technical/financial due diligence. Moreover, energy supply contracts, with special focus on power-purchase agreements (PPAs) between PEDs or ECs and different stakeholders, are investigated. Benefits and risks will be quantified. The intensive collaboration of different stakeholders enables the development of joint business models to maximise benefits for all stakeholders.
Furthermore, a "match-making platform" will be developed, which offers possibilities to initiate business relationships (f.e. financing, leasing, operation, etc.) in the field of PEDs and ECs. Furthermore, collected knowledge will be provided to the users of the platform, as well as information about energy and money flows of active ECs' residents. Data will be collected anonymously to generate best practice examples and promote community intelligence through the sharing of knowledge. The coupling with the platform 7Energy completes the approach of networking and knowledge sharing.

Author

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After completing her master's degree in *Energy and Automation Engineering* at the *Technische Universität Wien* with honours, Bernadette Fina joined the *AIT Austrian Institute of Technology* as a PhD candidate in October 2017. Her PhD thesis focused on the economic evaluation and optimisation of energy communities, within individual buildings and across building borders. After a research visit at UNSW in Sydney, she completed her PhD in *Electrical Engineering* in July 2020 with honours. Bernadette Fina now works as a Scientist at the *AIT Austrian Institute of Technology* in the competence unit *Integrated Energy Systems*. Her field of expertise lies in the simulation and optimisation of energy communities, profitability analysis and the legal and regulatory background of energy communities in Europe.

Session 2

How to Energy Community?

Session Chair: Mark Stefan

Energy Communities in practice: from setup to operation in Austria

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Abstract – In this paper an overview on the current status for setup and operation of energy communities in Austria as well as an outlook on the next needed steps is given. The current Austrian legal and regulatory framework provides the basis for the operation of energy communities, however major additional developments in digitalization, economic and regulatory frame conditions and citizen empowerment are necessary in order for energy communities to play a significant role in the energy transition. The development of digital planning tools and platforms as well as offering education opportunities for interested citizens will be crucial next steps on the way to a decentralized, renewable energy system.

4. Energy Communities as a tool for the energy transition

The Austrian # mission2030 has set itself the goal of reducing greenhouse gas emissions by 36% until 2030 compared to 2005. In order to achieve this goal of a climate-neutral society, new, fossil-free offers must not only be developed and offered in energy supply, transportation, and heating and cooling systems, but also accepted and used by citizens. It is therefore essential that smart, easy-to-use and, above all, financially affordable solutions are developed and integrated into the energy system.

Energy communities are a possible building block for implementing such new solutions in the energy sector. The legal framework for establishing Renewable and Citizen Energy Communities has been codified in the Renewables Development Act (Erneuerbaren Ausbaugesetz, EAG) which was passed by the Austrian parliament in July 2021. However, albeit important, this is only the first step towards striving energy communities that are meaningfully contributing to the energy transition. For energy communities to become a meaningful tool towards achieving carbon emission targets, they need to address the following core aspects:

(i) significantly increase the share of renewables in the energy system
(ii) provide a resilient, reliable decentral energy supply
(iii) allow indiscriminate access to participation for all citizens
(iv) provide system relevant services to the power grid

Designing, establishing, and maintaining energy communities that succeed in addressing these core aspects is a multi-facet challenge that needs to solve technical, legal, regulatory, economic, administrative and social aspects.

5. Setting up of Energy Communities

As the EAG is in effect since July 2021, it is since then possible to legally establish energy communities in Austria. There is much more to it, though, than just forming an association or cooperative.

5.1 Administrative and legal setup

An energy community needs to be established as a legal entity. This could be an association, a cooperative or any corporate form. In most cases the goal is to have an easily to maintain organisation with low annual upkeep cost, which generally favours associations and cooperatives as organizational forms for energy communities. These legal entities also need their respective organizational bodies, which in case of an association are the general assembly, the executive committee and the financial auditors.

These roles need to be filled out and even if done as voluntary work they carry certain responsibilities and liabilities in case of misconduct. It is therefore important to clearly line out all of the duties and responsibilities of the organizational bodies in the association's statutes together with all the other organizational procedures, such as joining and leaving the energy community.

There are no precedents to draw experience from so far in Austria, but efforts are being made to provide template statutes and procedures for energy communities that form a solid starting point. [1]

5.2 Technical setup

The minimum technical requirement to participate in an energy community is to have a smart meter installed by the grid operator. This allows the grid operator to process the consumption

and generation data of all participants and provide them to the energy community for accounting. The DSO is also responsible to communicate these data to all other market participants such as the respective energy providers. For this market communication the ebutilities processes [2] and the Austrian EDA platform [3] are used.
This setup allows for the shared consumption of community produced electric energy, but is not sufficient to support more advanced services such as e.g. a community wide energy management system or any system relevant services. In order to realize these advanced services, additional devices such as real time power meters and advanced ICT infrastructure is needed. A short outlook on concepts for these architectures is discussed in the pilot projects section.

5.3 Economic setup

The main purpose of energy communities is not about generating a financial profit, however the participation in an energy community has to be economically viable in order for people to be interested to take part in it. The Austrian regulatory framework provides financial incentives for energy communities (such as reduced grid tariffs for renewable energy communities) but the main benefit comes for the shared consumption of community produced power at presumably lower cost as energy purchased on the market.
As grid costs and energy tariffs vary quite a bit between different regions and providers, no generally valid price points can be given. Each individual energy community has to find their internal energy price points that will benefit the participating consumers as well as the prosumers equally well.

5.4 Social implications

An energy community is not only a technical but also a social entity. Members of the community are not customers but participants. And being a participant brings more rights but also more duties. Being part of an energy community is not the same as buying eco-friendly electricity from an energy supplier. It's not only about paying the energy bill at the end of each month and receiving a credit entry for feed-in of surplus electricity. Being part of an energy community is about taking responsibility: for the energy supply as well as for a functioning collective of consumers and prosumers.
As social constructs energy communities need social norms and rules and ways to address and solve conflicts that may arise within the group of participants. And it will need people to be willing to take on responsibility for the communities to be able to succeed.

6. Getting into operations

As outlined above the setup and establishing of an energy community, particularly a renewable energy community is not a straight forward process and involves technical, administrative and also social aspects. To plan, setup and operate an energy community a divers set of skills

and expertise is necessary that cannot be expected to be widely available in the general public among lay people. However, for energy communities to be a successful tool towards the energy transition, a significant amount of citizens need to be able to and also want to participate.
In order to achieve these high acceptance and participation rates, at least three enabling factors need to be realized. First, energy communities need to provide tangible benefits to its participants to provide an incentive to participate. Second, participation and administration of energy communities needs to be effortless and must not be time consuming. Third, people willing to take on responsibilities within an energy community need to be empowered and educated to do so effectively.

6.1 Participation incentives

Currently there are small monetary incentives in place for the participation in renewable energy communities in Austria, namely reduced grid fees and the exoneration from the renewable subsidy fee (Erneuerbaren Förderbetrag) and electricity tax for PV-produced power. However, these do not result in significantly lower energy bills for the participants and will likely not be a major pull factor.
Therefore, it will be necessary to create additional, monetary as well as non-monetary incentives for the establishing and participation in energy communities. On the monetary side this includes opening up of business models for energy communities to provide system relevant services such as flexibilities and grid storage capacity. Non-monetary incentives could include increased energy independence and increased resilience in case of black-out events.

6.2 Digital administration

Participation in energy communities needs to be effortless, in order to achieve significant adoption rates among Austrian citizens. The process of joining (or leaving) an energy community must not require more effort than changing the energy supplier.
Digital platforms are needed to provide the tools to establish and administrate energy communities. Managing of membership, accounting and billing, market communication – all these need to be streamlined and automated in online applications to allow carefree participation and time efficient management of energy communities

6.3 Education and empowerment

In order to facilitate the design and setup of plus-energy districts and energy communities appropriate planning tools are required. As pointed out, an interdisciplinary approach that addresses users, participants and other potential stakeholders is needed. An example for such a planning tool is the currently developed project “Plan4.energy” [4]
In addition, education opportunities need to be offered for people that are interested and willing to take on responsibilities in establishing and managing energy communities.

7. Pilot activities

The Innovation lab act4.energy [5] is a living lab initiative in Burgenland (south-east Austria) with the goal of facilitating and demonstrating the development of regional, renewable energy systems. It operates since January 2018 and has a strong focus on the development of renewable energy communities since 2020. Under the umbrella of the innovation lab, several pilot projects for different aspects of energy communities are currently being carried out.

Among these pilot and demonstration activities are the projects "Urbane Speichercluster Südburgenland" [6], "CLUE" [7] and "LocalRES" [8]. All of these projects aim to increase the range of technologies and services that are carried out within the scope of energy communities to provide tangible benefits to the participants as well as system relevant services to the power grid on the other hand. Only with such initiatives it will be possible to tap into the full potential of energy communities.

8. Conclusions

The first step towards the roll out of energy communities in Austria has been done with the passed legislation of the Renewables Development Act. Before energy communities can become a widely accepted form of collective, renewable energy supply additional major steps, in digitalization, economic and regulatory frame conditions and citizen empowerment are necessary. The successful implementation of these additional steps will allow the operation of energy communities as effective tools towards the energy transition and a decentralized, renewable energy system.

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Plan4.Energy – methodological set for the planning support of positive energy districts

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Abstract – The goal of Plan4.Energy is the development of a methodological set for the planning support of positive energy districts. By applying a data-based system integration, this will enable a user-friendly quantitative assessment of the options for the development of a positive energy district. Once performed Plan4.Energy can be used as the basis for future standardisation of the planning process of positive energy districts and support their implementation.

1. Background

Positive energy districts provide a new approach to implement sustainable solutions on a system level that can contribute to achieve goals of local climate protection strategies. This approach combines previous technological developments on a systemic level in order to achieve positive effects on the energy system. Such quarters offer their residents new opportunities and go hand in hand with sustainable business models in the energy system such as energy communities. Their implementation does not burden the local infrastructure and actively contributes to the local, national and also European goals by increasing the generation from local renewable energy sources and the use of energy efficiency measures.

An interdisciplinary approach involving the relevant stakeholders is required for the planning, development and replication of positive energy districts. This concerns city administration, energy supply, investors, citizens and research. [1] Since such processes represent a challenge, especially with regard to the different technical language, depth of content, knowledge base and sometimes different interests, supportive measures are essential for development. A planning process is therefore recommended for the development path of the positive energy districts that involves relevant stakeholders and is supported by technology assessment. [1] Similar to earlier smart city approaches, this enables interaction, coordination and acceptance in the complex planning process. For replication, however, a standardisation process is recommended, which should lead to the mainstreaming of the positive energy district approach. [1]
The implementation of strategies in concrete concepts, which contribute to the achievement of the urban goals but do not burden the infrastructure, pose new challenges for local administrations. As part of the research projects, the planning process is usually accompanied by universities and research institutions. Larger cities have their own offices to support the implementation of novel concepts, also with regard to energy planning. This is however not the case in smaller communities nor for private (citizen or business driven) initiatives.

2. Motivation

So far, no planning support methods for positive energy districts have been provided. Although existing approaches can be used, these need to be adapted. Guidelines and tools are often focused on the urban environment. In addition, these are mostly static, are limited to qualitative recommendations or have to be set up anew for each city (i.e. in the application of an energy system model), which is associated with not inconsiderable effort. There is also a lack of quantitative analysis methods that can be used to support stakeholder processes.

Especially the focus of positive energy districts on the integration of locally available renewable energy sources, the use of flexibility, the inclusion of energy / electricity trading and the stronger focus on the regulatory framework as well as implementation in new business models require adaptation. Positive energy districts are therefore complex to implement, which subsequently affects the planning. A methodological set is therefore required to perform a successful planning process and to support stakeholder involvement.

Positive energy districts are currently being implemented as research projects that are limited to demonstration. For a rollout, the involvement of technology developers / providers and industry is particularly necessary. These are incorporated far too late in the planning process, which is why there is hardly any reference to available products and services. For the implementation of new business models, it is also important to enable providers of services for energy communities to enter the market.

Standardisation is required to facilitate the planning process and to simplify its application. This should build on the results that are already available. A new approach should build on these results, take existing concepts with it and develop them further in order to put profitability in the foreground. However, it is important to pay attention to the heterogeneity in each planning process, which results from the different framework conditions. There should not be a generalisation, as the role of the individual stakeholders, the structures and the local reference vary greatly with each implementation. The questions addressed therefore require the development of an interdisciplinary approach that also includes technology providers.

3. Developed approach

The innovation of this project lies primarily in presenting complex relationships in a simplified manner and clearly depicting them. In this way, it is also possible for stakeholders without a specialist background to understand the planning effort and to realistically estimate the costs. A particular challenge - and thus part of the innovation content - is to minimise the planning effort without reducing the accuracy and precision of the estimate. This is achieved by storing as much data as possible, especially the bundling of publicly available data and data from the partners involved in the project. The advantage is given by the possibility to visualise complex dependencies of tariffs, load and generation profiles, investments in infrastructure such as PV, storage or load flexibility for stakeholders such as mayors, real estate developers, architects, planners and others. This allows stakeholders without a professional background to assess project variants in a realistic way. As a result, the stakeholders involved in the planning process are able to quickly and easily evaluate options for the measures to be taken and see the effects. The methodological set accompanies the planning process from a preliminary analysis identifying the greatest leverage, through stakeholder workshops to the creation of a detailed concept that serves as the basis for possible financing options (see Figure 1).

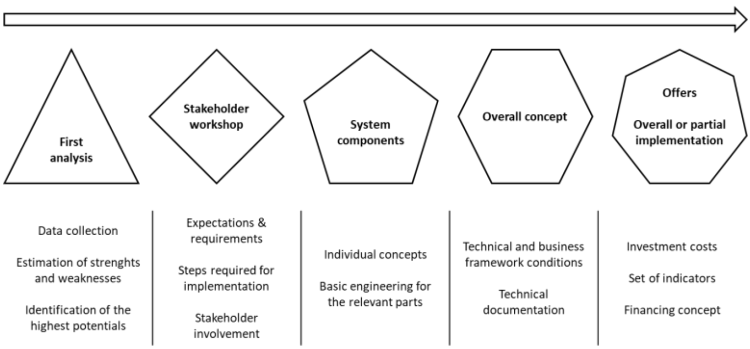

Figure 1: Increasing complexity in the planning process

Another innovation aspect of the project is to develop a method set that is as modular as possible. This means that the application is not limited to a specific settlement pattern or specific applications, but can be applied to a wide variety of regional conditions. Planning support therefore needs to consider different settlement structures: metropolitan areas (large apartment buildings), rural areas (single-family houses), mixed areas (apartment buildings and single-family houses, such as in urban suburbs or outskirts) and small town areas. Of course, this also includes the integration of commercial operations. Thanks to the modularity of the planning tool, positive energy districts can be realistically evaluated in different settlement structures without additional adaptation effort.

Plan4.Energy enables the stakeholders to work together more efficiently and brings new possibilities in the implementation of planning. This leads to time and cost savings and allows the effects to be quantified, with which monitoring concepts can be drawn up. The complexity and novelty of the planning processes for positive energy districts and energy communities make a very specific assessment of the effects difficult. However, it is planned to ask stakeholders in currently implemented demonstration projects. After completion, the planning software is tested on the basis of a specially developed set of indicators and can be used.

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A platform for energy management in communities

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Abstract - The first step in Austria to facilitate collaborative use of energy was taken in 2017 with announcing the so called “kleine Ökostromnovelle”. Legal extensions (for example ELWOG §16a) were the first step to boost using of self produced energy within multiple dwelling units. From financial perspective it was almost equal to single family houses in Austria, but much more complicated in terms of handling these new possibilities. The usage of highly disaggregated data from smart meters or load profile meters (15’ resolution) was the key to net production against consumption. The key role for the energy balancing task was given to the local grid operators.

Since proclaiming the new “Erneuerbaren-Ausbau-Gesetz (short „EAG“), Energy Communities - as indented in various initiatives and packages from the European Union – could be founded and commercialized in Austria since middle of the year 2021.

In the following delineation we investigate our experience from our work with certain pilot customers (like local authorities) and also with the energy intense group of mountain railway operators (research project Clean energy for tourism[44]) with focus on typical questions concerning processes and tools for digitalization and consultancy.

[44] https://www.nefi.at/ce4t-clean-energy-for-tourism, in short CE4T

1. Digital solutions for communities - practical examples and key questions of customers

A typical situation is the first inquiry about this topic from local authorities, like responsible persons for energy in municipalities. Or a first mover within the B2B group of commercial customers for instance wants to erect a big PV-plant and selling energy to the neighbors. Most of these inquiries are directed to local information centers (basically government-financed) or to energy supply companies with typical questions like (customer perspective):

4. Due to the fact, that we have to "manage the community for ourselves":
   a. How can we set up and manage an energy community? And which type of legal entity should we choose (association, co-operative, corporation, …)?
   b. How can we manage members in an efficient way - or can we find a service provider for certain tasks?
5. Due to the fact, that reduced grid costs and disposals/taxes will be the main driver for the communities, we are interested in
   a. the grid levels we belong to (reduced tariffs for energy communities depending on the grid level)
   b. the resulting cost savings in various settings / scenarios
6. Due to the fact, that when we manage to cover production and consumption (incl. storage) in a proper way, further cost savings could be reached
   a. We need either live data from the community to optimize production and consumption (when assets "can do optimization"). In any case we need historical load data (without automatic controls and live optimization) to take the right next steps for onboarding new members or for starting new projects for energy generation.
   b. We need some sort of economic calculation tool to find the right balance of growing or expenditure of assets.

Due to the fact, that energy supply companies are excluded by law from taking part within energy communities, they can only be supplier of services in the field of consulting, erecting & operating assets as well as digital services on behalf of this new communities.

Investigating ideas of communities and during discussions with potential customers we identify many different use cases. For example:

- A mountain railway operator (GmbH) intents to refurbish an old hydro power plant. Question: proper way to feed in 100% of the energy (special feeding in tariff in expectation) or starting an energy community (all stakeholders of the GmbH as members)?
- A municipality in Salzburg identified 17 public buildings with PV potential of 790 kWp scattered to numerous grid sectors (see Figure 1). The question is: How can they start in an economically proper way and expand further onboarding local citizens?

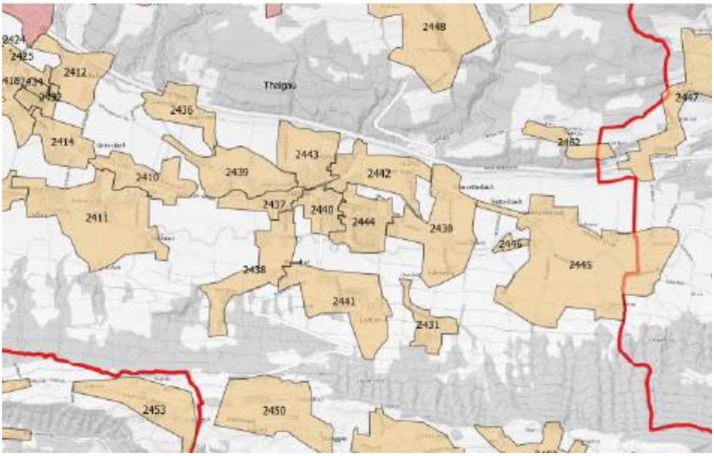


Figure 1: low voltage grid areas Thalgau/Salzburg (Salzburg Netz GmbH, Stand April 2021)

For consulting customers in a proper way and to make first estimations concerning load and production profiles as well as revenue, optimization tools (not to be mixed up with simulations tools) where tested in various projects (see chapter 3). To manage energy flows, Salzburg AG is working on a platform, which is explained now in chapter 2.

2. Platform for Energy Communities

Digital platforms, which are now being erected from various service suppliers, will help to manage questions listed in previous point 1.1 pt. 3 a). GIS integration can solve 1.1 pt. 2 a) or even platform functions for managing or onboarding new customers can solve 1.1 pt. 1 b) – see points mentioned above in the key questions of customers. Salzburg AG is focusing on:

- Scalable cloud based micro services instead of on-premise solutions
- Mobile first & a customer centric approach

To be more precise on the topic of data we can distinguish between two cases:

1. Using a device, which can for example use smart meter data (see Figure Figure 2, smart meter customer interface). This gives operators the possibility of showing real time data. No costs for data measurement occur, but instead costs for the device and cloud-based services (yet most systems are not ready for the mass market, but first pilot projects have started already).

Figure 2: Test version / 1st test bed Druckerei Roser, Salzburg using load profile meter and the optical interface – no scalable version

2. Using data from the standardized "Market communication"45 in Austria. This is for free, but available only with historical, but conditioned and consequently official data from the grid operators.

Finally, for each customer – independently from data collection var 1 or 2, a platform is offered to customers. It can be assumed, the numerous platforms are set up at the moment in Austria – supplying information for each community member and the community itself (see figures Figure 3 & Figure 4Figure as examples)

Figure 3: prosumer status view

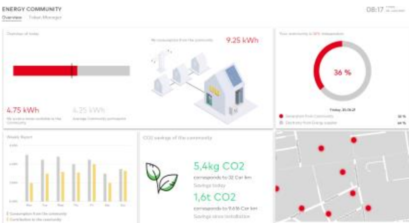


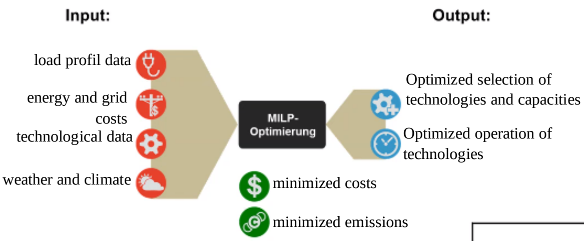
Figure 4: community status view

Nevertheless and independent from all digital possibilities, guidance for interested target groups is crucial and a key factor for success. Leading us to tools supporting consulting:

[45] for more information see https://www.ebutilities.at

3. Optimization tools

BEST Research supported the consortium of the NEFI project Clean Energy for Tourism (CE4T) with an optimization tool for energy communities to investigate most suitable scenarios for skiing areas in terms of self-sufficiency and for creating suitable roadmaps for expanding renewable energy production and storage. With a clear focus on energy communities, based on mixed integer linear programming (MILP, see Figure 5). For each of the participating skiing areas scenarios have been calculated und discussed. One big advantage is, that in contrast to simulation tools (fixed parameters lead to one result) optimization tools can generate results with an optimization logic - based an parameters and restrictions as well as target functions. For example, minimized costs for all (including no one is made worse off) or minimized CO2 emissions:



Minimization of cost function	$f(x) = \sum_k c_k \cdot x_k$ x_k ...Decision variable
Restrictions	$\sum_k a_{ik} \cdot x_k \leq b_i$
Non- negative Variables	$\forall \quad k \quad x_k \geq 0$

Figure 5: Optimization tools (based an OptEnGrid)

4. Conclusion

The new field of energy communities will dynamically boost digital solutions – whether platforms or tools for calculating or managing energy communities. Such digital solutions will become a new field of service on the energy service market. Those, who are able to scale without neglecting regional aspects and customer needs, will set the standard.

Authors

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Session 3

ICT Solutions for Energy Communities across Europe

Session Chair: Stefan Wilker

ComForEn 2021

Using Flexibility Offered by End User Owned Energy Assets

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Abstract – The presented discussion focuses on electric load and production flexibility. Load flexibility could be used to utilise the volatility of distributed renewable sources, increasing the renewable share in the average energy mix. Demand side management can support the balancing, locally within the distribution grid, but also on the energy market across the sources and loads served by an energy supplier or aggregator. We discuss how to identify flexibilities on a per customer level, how to offer flexibilities to potential users, how the quality of offers shall be quantified to achieve a viable fair pricing that a priori covers the inevitable non-fulfilment risk, and sketch how to schedule and possibly aggregate offers. Utilising flexibilities is one piece of the energy transition puzzle, possibly a big one. However, only a plurality and variety of approaches and systems will enable the intended net-zero CO_2 budget, and eventually a truly sustainable renewable (cyclic) energy system.

1. Introduction

Many end-customers voluntarily adopt new technologies that reduce their carbon emissions [1], regulatory and political measures yet to come intend to escalate the adoption rate further. Most prominent are rooftop solar photovoltaic (PV), battery energy storage systems (BESS), electric vehicles (EVs), and electric heat pumps. The path to climate neutral electricity is paved with a plethora of heterogeneous, mostly distributed, still heavily interrelated and cus-

tomised solutions. Local assets that can be managed actively are referred to as Distributed Energy Resources (DERs) because they commonly reside on customer premises, i.e., behind the meter, and enable some control of the local energy demand and/or production.
Control can be direct, e.g., switching an appliance on/off, adjusting the actual power demand, or by adapting set power limits. These control actions cause an immediate change. While on/off is in principle always possible, it shall be a last resort emergency measure because many appliances may be troubled if such harsh interference occurs frequently. Indirect control that manipulates appliance specific set-points, e.g., the intended temperature, also impact the energy demand, although commonly with some time lag. If adjustments are based on prediction, i.e., performed proactively, the response time can be compensated by setting the control action accordingly earlier. The resultant potential power changes state available flexibility.

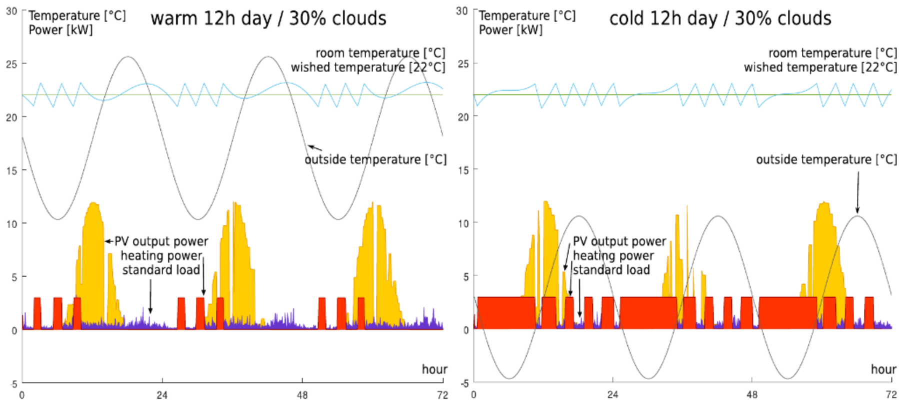

Figure 1: The flexibility offered by customer appliances depends on many factors and varies over time and season. Still, on similar days similar load and production patterns may be identified. These can be used to assess flexibility potentials, the availability and other statistical characteristics of flexibilities [2].

Every appliance has its power flexibility and availability distribution. Both most likely change over the day and across seasons, as shown in Figure 1 for successive days, simulated with equal outside temperature change and randomly distributed cloud cover. The heating intervals slightly move around from day to day, and PV production is interrupted by clouds passing by. Still, we can see recurring patterns, from which we intend to derive timed flexibility offers.
In section 2 we outline the relations of flexibility with the established energy system: How is the energy system organized and how does the energy transition fit in, who may want to buy flexibility, and who can provide flexibility. Section 3 presents an approach to assess the quality of a flexibility offer, addressing both, the providers' and purchasers' aims and needs. In section 4, we sketch how the scheduling of flexibility execution can be pre-planned, and in section 5, how to aggregate flexibilities to achieve high quality offers. Finally, section 6 concludes the discussion and briefly summarises the issues identified.

2. The energy system transition

The transition of the energy system toward a sustainable energy supply is inevitable and has already begun, as indicated in the introduction. The replacement of any fossil fuels is eminent to counteract the manmade climate change. Renewable energy sources (RES) are the most prominent and widely accepted option in contrast to nuclear sources for which neither the waste disposal nor the risk management is yet solved. Photovoltaic electricity generation (PV) and integration of all kinds of DER are essential to achieve the energy transition [1]. However, power from PV is available only when the sun is shining, not comparable to traditional power plants with a rather constant raw power supply or sufficient reservoir to guarantee uninterrupted generation. In addition causes the simultaneity across a region curtailment of PV production around noon. That is neither economic nor ecologically proper, and diminishes the owner's profit causing poor return on investment, a sad example for flexibility usage.
Transition hindrances also result from the energy market, which yet is not designed to handle many volatile not always available RES. Many bulk electricity sources cannot be adjusted sufficiently quickly to compensate the volatility of RES, and legacy power plants may have already sold major shares of the lifetime production to finance their construction. Curtailment or on-demand power provisioning is no option for contractual and economic reasons.

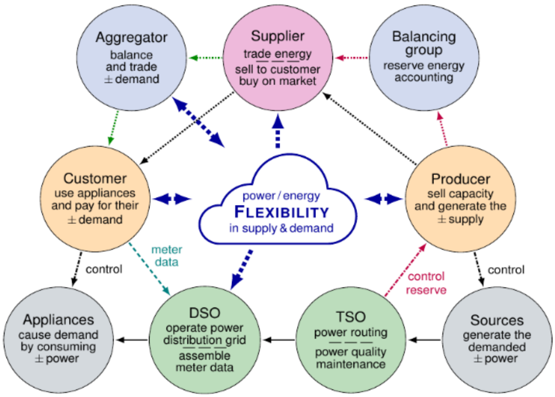

Figure 2: Flexibility in production and consumption could be used by many stakeholders for different purposes with diverging aims (based on [3]).

Figure 2Figure sketches the established energy system. Electric power conduction is positioned on the bottom and trading the electric energy on the top. On the left, the electricity consumers (appliances) and their users, the customers, are shown, and opposite thereto on the right, are the generators that convert some form of raw energy into electricity, and their operators who sell electric energy to the brokers on the energy market. Active Customers (ACs) and Energy Communities (ECs) as specified by the European Clean Energy Package [4-7] are

entitled to trade energy in all markets, similar to the Aggregators shown top left in Figure . Regulatory requirements to participate on the energy market shall be fulfilled likewise [5, 7]. Among peers, ACs and the members of ECs can share RES and DER, and may trade energy on a private basis, possibly even independent of the regulated energy market.
Traded energy needs to be transported over the electricity grid, regionally operated by the local distribution grid operator (DSO). Grid codes, also known as network codes, need to be obeyed. ACs and the members of ECs are in general far from self-sufficient in their energy balance and thus, remain clients of their individual energy supplier [6, Article 4]. However, excess power from private generation and the flexibility of loads they control, they may offer as flexibility. Top right in Figure is the Balancing group, which bills the used reserve energy to the energy suppliers dependent on the deviation between energy purchased and actually consumed by their customers [5, Article 6]. Physical power balancing is commonly managed by the Transmission System Operator (TSO), who controls any electricity generation of size connected directly or indirectly to their transmission grid [6, Article 40].
Flexibility can be offered by customers and producers only. It is provided solely by the energy appliances they control. In case they participate in a virtual power plant (VPP) or have some demand side management (DSM) agreement with an aggregator or supplier, they sell their flexibility and hand over the control. These purchasers buy flexibility to reduce their reserve energy demand or to sell it on the intra-day market in case the current price is good. The other purchaser group interested in flexibilities, in particular in localised flexibilities, are the DSOs. They could use it to stabilise local feeders, to perform peak shaving and thereby possibly postpone grid expansion, and to reduce the peak to average gap to utilise their resources more evenly. However, most DSOs are prohibited from energy trading by unbundling regulations.

3. Assessing the quality of flexibility offers

Flexibility is a feature that may be available at times but is never perfectly assured. The output of a PV-inverter can be controlled only when the sun is shining. Deactivating a heating system is only effective if the heating system is currently consuming power. Consequently, a key quality of flexibility offers is the probability that produced or consumed power can actually be altered. The metric is the availability of a certain power-change. The PV-inverter example shows that the availability and the average amount of the available power alteration depend on the time, the season, the weather characteristics, and only finally on the PV system itself.
In Figure 3, we averaged thirty modelled days with identical temperature change and randomly distributed cloud cover across an equilibrium day (6am sunrise, 6pm sunset), similar to those shown in Figure 1. Shown are the in average available power change and the availability of these changes, being the darker shaded areas close to the zero line, scaled from zero to one. Around noon, curtailing PV production is quite probably available on a rather sunny day with only 30% cloud cover. The availability of flexibility from the heating system is far below because two constraints need to be fulfilled simultaneously: the heating system has to be in a

usable state, and the current room temperature needs to allow the change. In addition thereto wander the heating intervals, such that the on-to-off ratio also affects the availability.

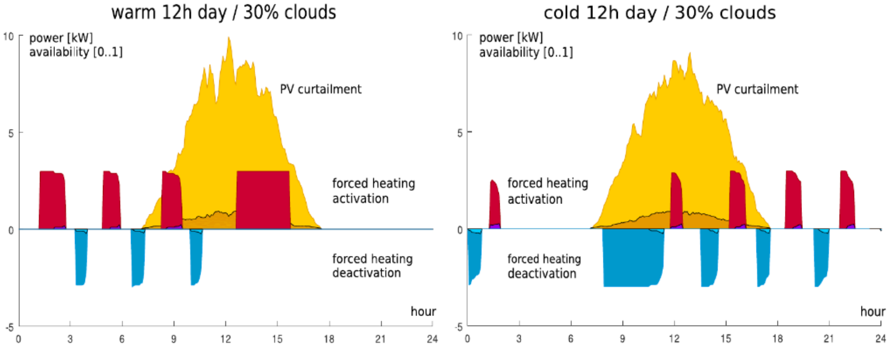

Figure 3: The characteristics of flexibilities result from statistically evaluating sets of days that show a similar pattern [2].

To consider the limited availability, we developed the two dimensional quality rating scheme presented in [2]. The expected availability is covered by one dimension, the other covers the willingness of the asset owner to provide or sell the flexibility. Both are discretised into five bins. The extremes cover special properties and circumstances, and remaining three bins in between cover good, medium, and poor. The more reliable an offer is, the more will a flexibility user pay, and the more compensation a flexibility provider is offered, the more discomfort or control loss will be accepted. Anyhow, the price paid shall a priori cover the possibility not to fulfil an offer. That shall prevent any a posterior reimbursement alike paying for reserve energy and calm any economic fears that could effectively scare off most private customers from offering their individually small but widespread power consumption flexibilities.

4. Optimising the execution of flexibilities

The term Demand Side Management (DSM) refers to managing DERs in general. Diverse approached thereto were proposed and several are readily in operation. First of all, varying energy pricing, either using dynamic price adjustments to trigger on demand load changes or static prices that intend to trigger load shifting away from times at which high load is commonly expected. These schemes belong to the variety where the customers are free to tailor their respond individually. Opposite thereto are switched supply schemes, where the grid operator can cut the supply when needed, typically during high load events. Curtailment of power insertion based on grid codes or some broadcasted signal belongs to the same category, affecting the insertion not the draining of power. Most of these schemes are responsive in that they intend to adjust the load once a critical situation is detected or expected.

In contrast thereto are flexibilities predicted adjustment potentials. Comparable to the stochastic customer response to energy price changes, is the actual availability of a particular flexibility likewise stochastic. Different types of flexibilities that respond more or less reliable can be specified [8]. Assuming the response to different offers is known, we can design pro-active flexibility execution intended to prevent critical states long before these would occur.

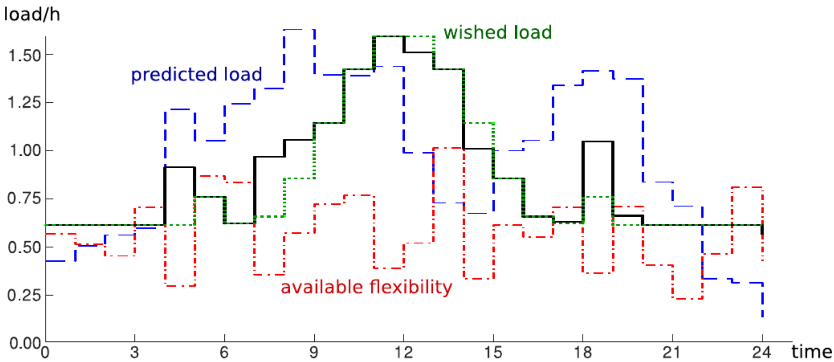

Figure 4: Using local flexibilities (red/dash-dotted) to shift a predicted load schedule (blue/dashed) toward a wished load schedule (green/dotted) resulting in an expected load schedule (black/solid) that benefits both, the flexibility provider and the flexibility user.

Figure 4 shows three load developments over time, which we call schedules. First, we have the planned load schedule on a feeder or transformer (green/solid), which represents the load that the grid operator wishes to achieve by using flexibilities to serve all connected customers best. On the market level that would be the energy a supplier purchased and wishes to sell with minimal deviations. Next, we have the predicted load schedule (blue/dashed) for the feeder/transformer based on the expected customer behavior for a given day considering holidays, events, and the weather. Finally, we have the expected load schedule (black/solid) where flexibilities are used to shift the predicted load toward the planned/wished load. The load changes caused by triggering different flexibilities at different times (red/dash-dotted) are calculated using some multi-dimensional opimisation technique, for example, the SIMPLEX algorithm [https://en.wikipedia.org/wiki/Simplex_algorithm].

5. Aggregation of Flexibilities

Home and Building Energy Management Systems (HEMS and BEMS) provide the means to join different assets into a virtual energy resource, a miniature virtual power plant. Members of Energy Communities can do similar but use the public grid to combine and share their resources. Aggregating different flexibilities can be expected to improve the reliability of a limited power adjustment that can be provided by different subsets of the aggregated sources. For example, if we know that for a certain outside temperature the heating systems of ten similar flexibility provides (households) is in average 30 % on and 70 % off, we can expect that in average three of them could be switched off and seven could be switched on. Assuming a symmetric temperature hysteresis between heating system regular activation and deactivation, we get 50 % probability that the room temperature allows them to provide flexibility. Thus, the probability that three heating systems out of the ten aggregated can be deactivated on demand is 15 %, which equals the individual probability p that a specific heating system may be deactivated to provide its flexibility. The probability that any one of the ten can be deactivated on demand is 80.31 %, using the equation:

$$P(1^+|n) = 1 - (1-p)^n$$

The probability that any one of the ten is activate-able on demand is 98.65 %. Both these probabilities are considerably higher than the individually achievable, i.e., 15 % and 35 % respectively. However, if the flexibility offered shall be 50 % of the total power of all ten heating systems together, we get worse probabilities, i.e., 0.99 % and 24.85 %, based on the binomial probability that exactly k out of n units are available:

$$P(k^+|n) = \sum_{i=k}^{n} \binom{n}{i} [p^i (1-p)^{(n-i)}] = \sum_{i=k}^{n} \frac{n!}{i!\,(n-i)!} p^i (1-p)^{(n-i)}$$

Offering a power adjustment that is in average not available, here 50 % of the total possible where only 15 % or 35 % of the contributing shares are in average executable, is a questionable offer. Even though, some flexibility sources only support switching a fixed amount on/off.

6. Summary and Conclusion

Flexibility is always available where some physical system buffers some form of energy. A room or water tank may store heat energy, compressed air stores pressure, a fly-wheel buffers kinetic energy, and so on. The hysteresis between the maximum and minimum amount stored, the distribution of buffer system states, and the speed at which electric power can be converted constrain the flexibility that is available. To effectively use flexibilities for peak shaving and feeder stabilization, the stochastic nature of flexibilities needs to be considered. Flexibility is not reserve power, but sometimes it can reduce the demand for reserve power. While the optimisation method is only a technical issue, the optimisation target commonly depends on the stakeholder that purchases flexibility. Schemes to calculate the optimal intended load schedule that achieves local balancing and optimised utilisation of local resources still need to be found. For a regionally performed energy transition, the flexibilities offered on a per-feeder or per-transformer level shall rise in parallel to the local RES integration. Thereby shall the impact of inevitable RES volatility be mitigated, the customer awareness for temporary demand and supply mismatches be risen, and private investment in net-zero districts supported.

Acknowledgement & Disclaimer

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Austrian pilot community in Gasen, Styria (ERA-NET Project CLUE)

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1. Description of the Demonstration Site

The so called "Styrian Pilot Case" will be demonstrated in the Municipality of Gasen in the Federal State of Styria in Austria. Its main objective is to demonstrate a year-round self-sufficient local energy community based on different flexibilities such as demand side management and storage technologies. Municipality of Gasen was chosen due to large installed PV capacity in the area (15 PV installations with 350 kWp) and a district heating system in place. The latter is relevant due to the use of a hydrogen storage system that produces heat as a byproduct of converting the electricity to hydrogen and vice-versa. The transformer station, main PV-Installations and the storage sites are depicted in the figure 1.

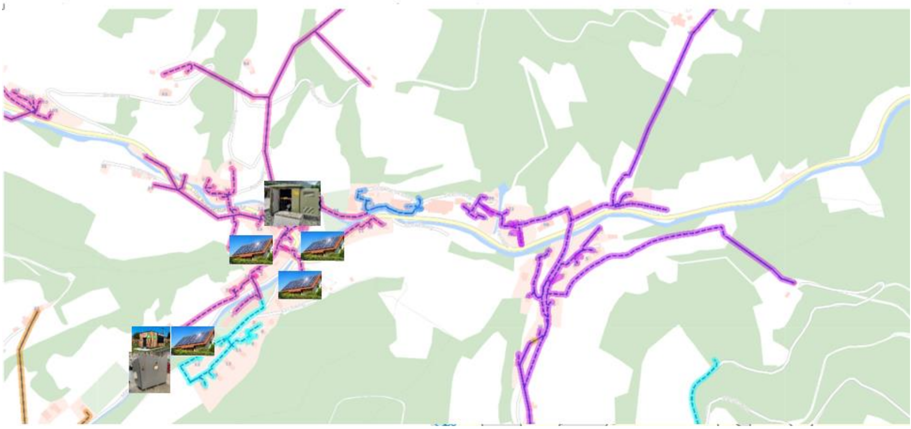

Figure 1: The Low Voltage Grid of Gasen with main components.

The Pilot can be best defined by the following high-level use-cases:

- Grid Support
- Power2Community Trading
- Short-Term Community Storage System (Battery Storage System)
- Long-Term Community Storage System (Hydrogen Storage System)
- Demand side management

All the major components (e.g. BSS) will be used for both grid- and customer use-cases. The grid support use case mainly focuses on the voltage management of a low voltage feeder with a lot of PV-infeed and will be done by intelligent real- and reactive power management of the BSS to obtain additional grid capacity for the connection of renewables (PV). The customer use-cases are focused on increasing the local consumption of the locally stored electricity. In conflicting situations, the grid use-case has a higher priority than the customer ones. It should be noted here, that all components are going to be centrally controlled by a controller that will obtain all the needed system information from customer-based smart home systems and a network of field measurements. One more detail should be highlighted: storage systems (BSS and HSS) will be connected to the grid decentrally at the end of a low voltage feeder to maximize the impact on the local grid.

2. CLUE Concept "Almenland/Gasen"

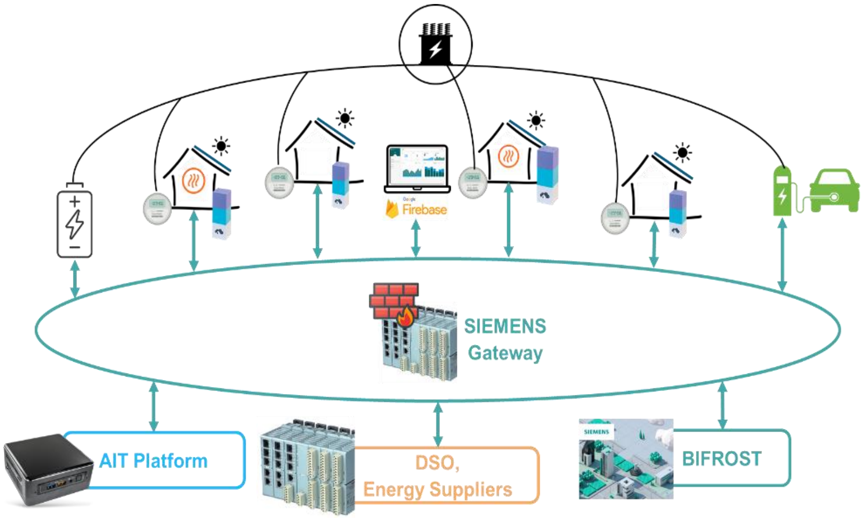

Figure 2. CLUE Concept "Almenland/Gasen.

Local Energy Communities (LECs) will be an important element of the future energy system. These communities cooperate in the production, distribution, storage and supply of energy at local level with the aim to maximize the on-site generation and the self-consumption of renewable energy. New smart energy products and services will be explored, implemented and tested in the Energy Communities.

Information Technology (IT) and Operational Technology (OT) are well-protected networks in energy systems. Communication is only possible with own components or via strict firewalls. Measuring devices (smart meters) and load switching devices must be installed from the distribution system operator, because of secured communication protocols. These devices are normally protected against customer access and limited to some focused features. Money can be saved by using the existing home automation or other cloud systems. Additionally, they can be adapted to customer needs. Therefore, a high secured energy management gateway (SIEMENS Gateway) should connect the energy system and the home automation system.

Within the energy system standard protocols like IEC60870-5-104, IEC61850 and Modbus TCP with standard secure features are used, but this is not possible for standard home devices. The communication between the home automation and the gateway must be based on typical protocols which are already available in these systems, like a RestAPI or Websocket. These Interfaces can also be integrated very fast from tech-savvy customers in existing home automations or any skilled workers.

A user interface is necessary because of some settings like credentials of home automation system. Additional some dynamic changes can be done as well as show some information about private and community data. A user registration and authentication are used for data privacy. The web site is hosted on a siemens server in an internet DMZ, where a customer can access vie browser everywhere.
Some special management platform (AIT platform) is used to control, monitor and optimize the system for the energy community. Grid capacity management and P2P energy trading are possible applications.
Some live data can be supported to the open-source simulation platform BIFROST from SIEMENS, which can be used to demonstrate some use cases for energy communities.

It was important to inform the potential users of the demo local energy community early enough about the CLUE project and its possibilities.
In Case of some local criteria of the Municipality Gasen, the location of the BSS and HSS was fixed together with the network operator “Energie Netze Steiermak GmbH” at the district heating plant in Gasen, because electricity and heat can be distributed centrally from here (including a new cogeneration of heat 110kW therm and power 55kWel). Also a new palace for the (outdoor) places and a new pv plant with 65kWp was built in the first step.
The current approx. 12 users - these are a municipal office, a rectory, a kindergarten, an elementary school, a guesthouse, a museum and some private households - were informed in 2 local information workshops and were convinced of the project ideas.

These participants currently being equipped with smart meters by the network operator, and smart home devices ("homees") have already been installed by the customer. The “homes” communicate with the secure SIEMENS gateway and can give feedback and execute commands.

3. Rapid Deployment Platform

3.1 Motivation

The AIT Rapid Deployment Platform (RDP) is a developer-friendly platform developed specifically for energy communities. One of the major components of an energy community is a community platform which operates the flexibilities and is responsible for the accounting for the exchanged energy. A community platform is a complex system composed of different modules with different functionalities. Based on the requirements of each single project the architecture of such a platform changes and with it the functionalities of the modules that to be implemented. It is often the case that different modules/functionalities of the community platform are developed by different project partners and during the final stage they need to be integrated and deployed together. If the different modules do not follow the same communication protocols or are not compatible, additional work is required to make the community platform work properly. This highlights the importance of defining a standard and a guideline for such a community platform in order to allow the easy integration of multiple functionalities and establish a proper inter-module communication.

3.2 Community platform requirements

The idea behind the RDP is to provide a skeleton for a community platform that defines a standard and guidelines for the inter-module communication, integration of the modules and external information exchange. The RDP fulfils, among others, the following requirements:

- Modular approach
- Parallel execution of the modules
- Inter-module communication
- Access to intermediate results
- Storage (database and cache)
- Support to multiple communication protocols to external systems (Modbus, REST Service, etc.)
- Debugging functionalities
- Cross-platform (the reference implementation for the RPD has been developed in Python)

3.2.1 External data exchange

The RDP supports multiple communication protocols such as Modbus, REST, WebSocket, etc. to exchange information (measurements, setpoints, configurations) with external devices. The core for the exchange of data is based on Redis Streams.

A diagram of the data exchange mechanism is shown in Figure 3.

The measurements from the field can be collected from external devices. Then, they are validated and it is checked if they are in the correct format. Only after a successful validation the received data is inserted in a Redis Stream. After these steps the data is available internally to the modules deployed with the RDP. Multiple modules are allowed to read the data from the streams in parallel.

With the same mechanism the modules can send data (e.g., set points) to external devices. When a module computes new setpoints they are inserted in a Redis Stream and a data pusher module consumes the streams sending the data to the external devices.

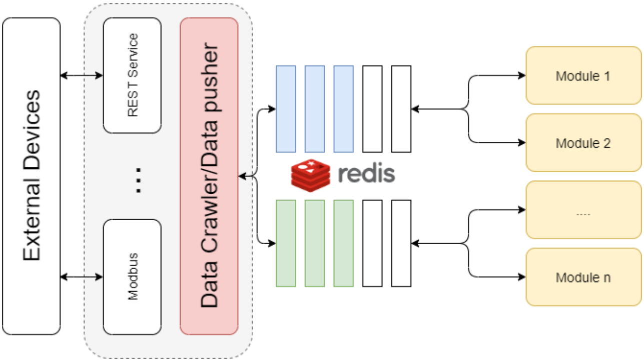

Figure 3 External data exchange diagram

3.2.2 Inter-module communication

The inter-module communication between the modules is implemented in two different ways, using Redis Stream or a publisher/subscriber mechanism. Based on the exchanged data and the requirements one of the two approaches can be selected. If the communication schema between two or more modules is event-based it is convenient to use Redis Streams. In the case a module sets some parameters where the chronology is not important it is better to use a publisher/subscriber mechanism. The parameters can be stored in Redis as key/value pairs and on every change, a module can notify the other modules by publishing a message to a dedicated channel. All the modules subscribed to the same channel receive the notification of the change.

3.3 RDP for CLUE

The RDP is used in the CLUE project and it provides a solid skeleton to interconnect the following base modules:

- Grid Capacity Management (GCM)
- Forecaster
- Accounting

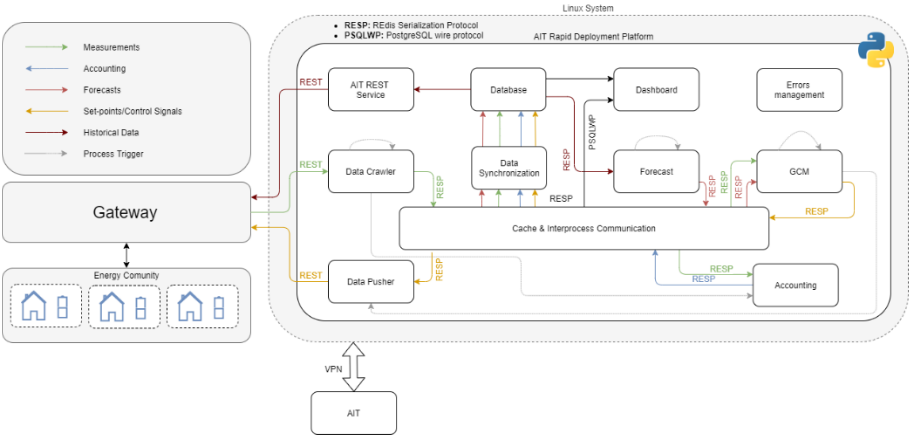

Figure 4 RDP architecture designed for the CLUE project

The RDP is deployed on an industrial PC running Docker. In Figure 4 the architecture of the RDP designed for the CLUE project is shown. The platform communicates via a REST-API with a Siemens gateway which in turn exchanges data with the devices in the field. All the data collected from the field and the intermediated results generated by the modules is synchronized with an internal timeseries database. In a second step the data stored in the database can be used for debugging, computing new forecasts or for visualizing results.

A controlling algorithm based on the measurements and the forecasts computes new setpoints for the devices in the field and sends them to a “Data pusher” module that is in charge to communicate them to the Siemens gateway. An accounting module is also implemented in order to provide billing information about the energy community.

For debugging of the RDP intermediate results and meta data are stored in the internal database. Additionally, Loki and Grafana can be used as debugging tools to automatically collect and store the logs from each module.

Acknowledgement

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Renewable energy communities: Giving the energy transition in the hands of the people

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Abstract – Europe has recognized the importance of engaging citizens in the development of renewable energy sources and smart energy usage to realize the energy transition and achieve the climate targets. Renewable energy communities are an enabler to accelerate this process. The novelty of the renewable energy community concept asks for exploration and innovation to exploit its full potential. The European LocalRES project is a research and innovation project that aims at engaging more citizens in the energy transition through the introduction of renewable energy communities. A key novelty of the project is the development of the first-of-its-kind multi-energy virtual power plant.

1. Introduction

To achieve the European renewable energy targets and to realize an energy transition that is inclusive for everyone, it is crucial to involve all partners of society, i.e., not only the large energy stakeholders, but also the residential customers. Europe has also recognized this need and calls for citizens to help develop renewable energy. So far, residential customers have mainly been concerned by deciding upon their energy tariff and possibly investments in solar photovoltaic panels or energy-saving retrofit measures. However, to optimize their energy

usage and realize the energy transition, residential customers should be engaged even more and integrated solutions are needed supporting them in optimizing their energy usage and in actively participating in the energy transition. Moreover, the security of energy supply and a secure operation of the energy system should be always ensured.
An important role to engage local energy customers can be played by renewable energy communities (RECs). They consist of citizens that collectively carry out a range of activities around renewable energy (notably, production, supply, distribution, sharing and consumption) often in partnerships with small and medium enterprises responsible for the operation and development strategy of the REC, and local public authorities [1]. The European Union has recently enabled RECs and requires all member states to include these concepts in law by the end of 2021, however, substantial room for maneuver is left to the member states [1].
Due to the novelty of this concept and the lack of a formal definition, fully exploiting the potential of RECs still needs research and innovation. One research and innovation project focusing on this concept is the European Horizon 2020 project LocalRES, which has the objective to engage more citizens in the energy transition and to create a level-playing field for RECs (as shown in Fig. 1).

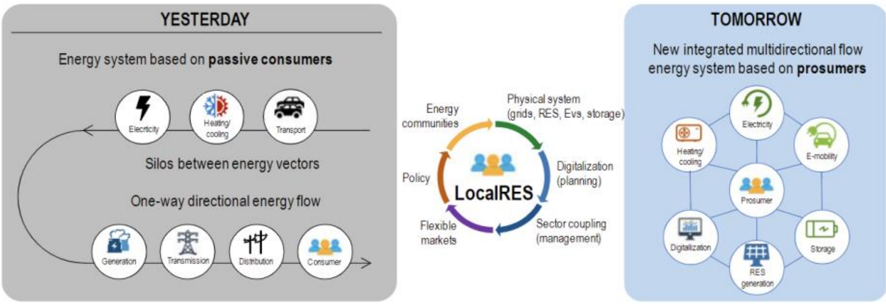

Figure 1. The role of the H2020 LocalRES project in the integration of RECs in the energy system. [LocalRES proposal]

2. European Horizon 2020 LocalRES project

The LocalRES project started in May 2021 and is funded by the European innovation fund Horizon 2020. The project is executed by a consortium of 20 partners, consisting of flexibility providers, universities, and research institutes as well as local energy cooperatives and municipalities of 4 demo sites in Finland, Spain, Italy and Austria. The project aims at supporting RECs in engaging citizens in the energy transition by developing the necessary tools and by demonstrating them in a practical context, as illustrated in Fig. 2.
The output of the LocalRES project will facilitate an effective use of the potential of renewable energy communities with optimal benefits for its participants. First of all, the project is defining new roles of and services to be delivered by RECs. Second, a planning tool is being

developed to determine an optimal development strategy for a given REC. Third, a multi-energy[46] virtual power plant (MEVPP) controls distributed energy resources and flexible demand in the REC to deliver energy and flexibility services for a secure and reliable energy supply. The MEVPP not only operates RECs safely, but also helps communities to maximize the value of their assets and therefore decrease their overall costs.

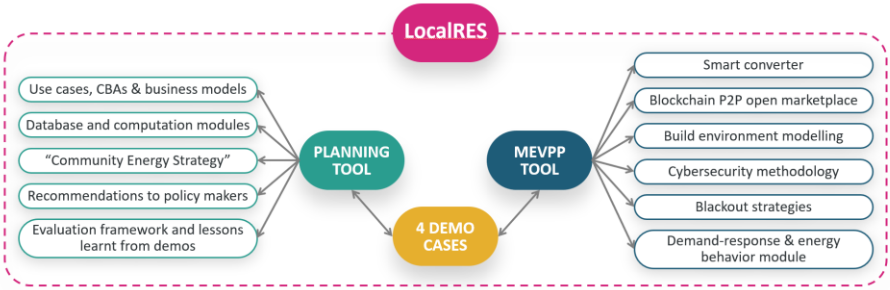

Figure 2. The main expected results of LocalRES.[LocalRES kickoff meeting]

3. Multi-energy virtual power plant

Virtual power plants (VPPs) aim at delivering energy and flexibility services to power systems similar to traditional synchronous generation units. Historically, synchronous generation units provided energy to the end-users and the necessary ancillary services to the system to operate the system securely. However, the secure operation of energy systems is challenged nowadays. First of all, the increasing share of renewable energy sources, which are typically convertor-interfaced, do not provide naturally the necessary ancillary services and their energy production is variable and uncertain. Second, the characteristics of energy demand are changing due to the electrification of society, e.g., mobility and heating. This increases the demand for electricity, but also makes the energy demand more flexible. Third, assets are smaller and more distributed compared to the centralized generator plants. Nevertheless, adequately controlled collections of distributed assets are still able to deliver energy and flexibility services, which is the objective of a VPP.

While historically VPPs mainly focussed on the electrical energy vector, MEVPPs aim at exploiting synergies between energy vectors in a REC, e.g., electrical energy, heating, mobility, etc. The MEVPP optimizes the operation of assets in different energy networks and different energy vectors in a joint optimization. The optimization also considers the constraints that may prevent a secure supply of energy and services, such as network congestion and voltage issues. Assets' models, forecast of demand and renewable generation as well as forecasts of

[46] In a multi-energy system, different energy carriers are coupled together to supply the demand of customers.

users' willingness to participate are the inputs to this optimization, while the control and dispatch signals leading to a minimal operation cost to provide the required energy and flexibility services are the output. Centrica Business Solutions is the main responsible partner in the development of the MEVPP and counts upon its rich experience in and knowledge on the development of VPPs for power systems. The MEVPP is a first-of-its-kind tool that has the potential to facilitate an accelerated integration of RECs.

4. Conclusion

Renewable energy communities will be an important driver to engage citizens in the energy transition. The outcomes of the LocalRES projects will significantly contribute to the accelerated integration of renewable energy communities, as first-of-its-kind tools, such as a multi-energy virtual power plant, are being developed and demonstrated at 4 pilot sites around Europe.

Acknowledgment

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Dr. ir. Evelyn Heylen performs research in the field of future sustainable energy systems. She is currently head of research at Centrica Business Solutions and has an honorary association in the Electrical and Electronic Engineering department of Imperial College London, where she is also a guest lecturer. Evelyn joined Centrica in December 2020, after being a post-doctoral researcher at Imperial College London, UK, and the University of Leuven, Belgium. Prior to this, she obtained the degrees of Master in Energy Engineering and Doctor in Electrical Engineering from the University of Leuven, Belgium, in resp. 2013 and 2018. Her PhD research in the field of power system reliability was funded by a PhD fellowship of the Research Foundation Flanders. She currently coordinates Centrica Business Solutions' research on how virtual power plants, consisting of assets with different characteristics, can help in realizing sustainable energy systems. For this purpose, she investigates novel flexibility products to support the operation of low-inertia power systems and multi-carrier energy systems, as well as control algorithms for virtual power plants to deliver different ancillary services and energy products. The design of flexibility products and control policies is supported by cutting-edge optimization techniques, and hybrid data-driven and physics-informed machine learning models. In her current research activities, she actively participates in research projects together with industry, power grid operators, academic partners and local energy communities.

EV-based flexibility for grid operators

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Abstract - By proposing load shifting, charging Electric Vehicles can provide flexibility to grid operators. However, the prediction of the charging process' time and duration as well as the size of the batteries are challenges to overcome to guarantee the flexibility provision and to have a meaningful impact for system services. One solution is to consider a fleet of EVs deployed in an energy community and to aggregate their flexibility potentials.
In our presentation, this topic will be addressed in two steps:

1. BRIDGE is a European Commission initiative gathering all the Horizon 2020 smart grid projects. In the scope of the Data Management WG, a framework for flexibility use-cases has been defined to enable interoperability.
2. SENDER is a Horizon 2020 project on demand-response. In the Finnish pilot site of SENDER, it is envisaged to use a high number of EVs (approx. 100) for balancing services and participation in the Fingrid FCR-N market. The correspondence with the BRIDGE flexibility framework will be highlighted.

1. EV-based flexibility for grid operators

With controllable devices such as HVAC system or domestic water tank, Smart Home has allowed final consumers to become prosumers. By proposing load shifting or load shedding, consumers have the possibility to change their consumption profile and to take part in Demand Response services. However, the power capacity involved in a single Smart Home is usually limited and not so relevant for system services. Energy communities as the aggregation of multiple Smart Homes can however have a real impact! Same applies for Electric Vehicles.

With a charging time that is usually lower than their plugged time, Electric Vehicles can indeed propose load shifting, while ensuring a satisfying state of charge for their driver at their departure time. EVs can thus provide flexibility to grid operators (TSO, DSO) to contribute to grid stabilization. However, some challenges need to be tackled:

- The difficult prediction of the charging process' time and duration can be a source of deviation between the flexibility requested by the system operator and the effectively provided flexibility,
- The size of the battery does not allow a single Electric Vehicle to have a meaningful impact for system services.

One solution to overcome those challenges is to consider an energy community with multiple Electric Vehicles. The consumption and flexibility forecasting become indeed easier and more accurate on a fleet of EVs and the aggregation of individual EV-based flexibility potentials allows those assets to take part in flexibility markets with entry requirements (e.g., minimum size of the flexibility product).

In SENDER, a Horizon 2020 European project with the objective of developing the next generation of energy service applications for demand-response and home-automation, consortium partners relied on the reference framework developed by the BRIDGE initiative to design and implement Demand Response services.

1.1 BRIDGE: Reference framework for flexibilty

BRIDGE is a EU initiative launched by the European Commission in 2016 to foster collaboration and consolidate results between the research & innovation projects in the area of smart grids, energy storage, islands and digitalisation of the energy system funded under the Horizon 2020 program.

Since its creation, it has gathered 80+ projects involving 700+ organisations from 38 countries for a total EU funding of 750+ M€. BRIDGE is structured around 4 working groups: Business Models, Regulation, Customer & citizen engagement and Data Management.

In the scope of the Data Management Working Group, one of the focus is to analyse and support the interoperability of flexibility assets.

As such, a reference framework has been defined, detailing Generic Business Processes to represent the state-of-the-art of flexibility procurement. So far, five different Generic Business Processes have been defined:

(1) flexibility for grid operator via open market – see Figure 1 below;
(2) flexibility for grid operator via prior bilateral agreement;
(3) BRP portfolio optimization;
(4) energy community optimization;
(5) implicit demand-response (price signal).

Each Generic Business Process is defined by sequential functions and interactions involving the five flexibility roles: Flexibility Consumer, Flexibility Facilitator, Flexibility Market Operator, Flexibility Service Provider and Flexibilitu Provider.

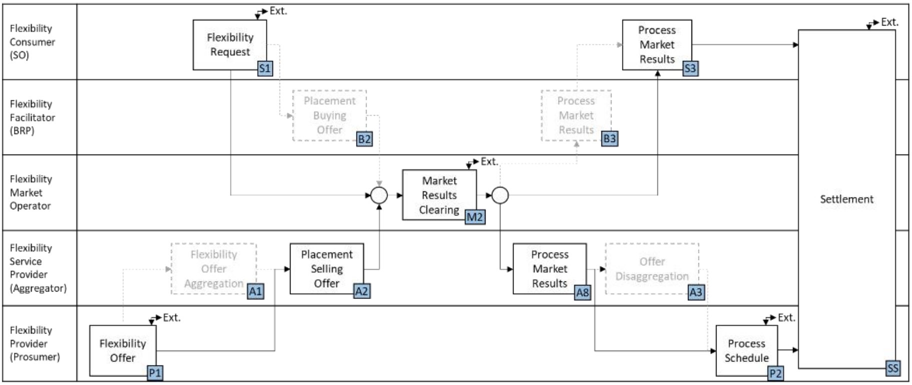

Figure 1. Example of Generic Business Processes covering the provision of flexibility for System Operators through open market

The final purpose of this reference framework is to use the GBPs as common denominators between the use-cases of different projects and therefore allow cross-projects analysis of flexibility use-cases and system implementation. Figure 2 below shows how each project use-case and architecture (based on the Smart Grid Architecture Model – SGAM) can be mapped to one of the five GBPs.

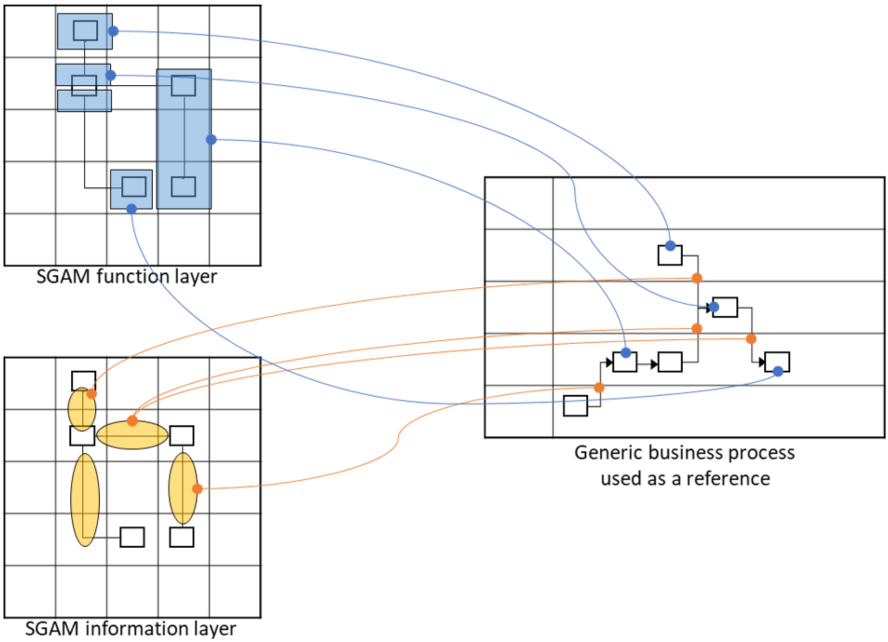

Figure 2. Mapping between a use-case and its architecture with one of the Generic Business Processes to enable cross-projects analysis

When applied to BRIDGE projects, this cross-project analysis allows to build (1) a catalogue of relevant standards per interface; (2) a list of identified gaps; (3) a list of proposed extensions or modifications of existing standards; and (4) insights about how business roles and functions are implemented by projects. Such results enable the design, implementation and demonstration of interoperable flexibility services and support the development and use of relevant EU and worldwide standards.

1.2 Case study of SENDER

In SENDER, the Finnish pilot will analyse and demonstrate how a high number of EVs (approx. 100) can propose balancing services and take part in an open market (e.g., the Finnish Fingrid FCR-N market).

As depicted in Figure 3 below, this use-case can be mapped to the GBP1 "Flexibility for System Operators via open market" of the BRIDGE flexibility framework: EV drivers (flexibility providers) will offer flexibility to an aggregator (flexibility service provider), who will then aggregate all flexibility offers and place a single bid for the whole EV fleet on the market (flexibility market operator). In the case of the Finnish FCR-N market, the flexibility consumer is the Transmission System Operator, Fingrid.

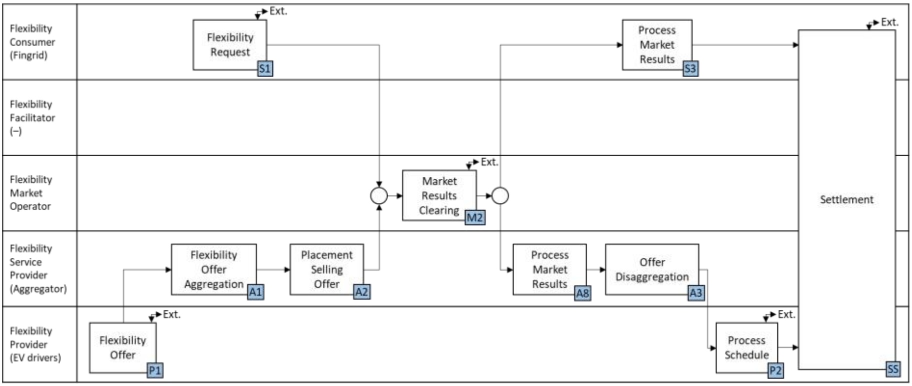

Figure 3. Instantiation of GBP1 for the Finninsh pilot use-cases on EV aggregation for FCR-N market

The Finnish pilot site is located in Espoo, Southern Finland, close to the capital city of Helsinki. More specifically the pilot area is called Otaniemi, which is a cape on the shores of Baltic Sea. Otaniemi forms a campus district with 5,2 km^2 area in total. Around 3500 people live in the area, but more importantly, about 15000 people come here daily for work. The area is composed of university buildings and several companies' offices and as a strong potential for Electric Vehicles.

The Fingrid FCR-N market has high requirements that only an aggregated flexibility from several tens of EVs can meet:

- The minimum capacity of a single bid is 0.1 MW
- The full activation time is set at 3 minutes
- The bids for the next day must be submitted by 6.30 p.m.

In SENDER, the aggregation of EV-based flexibilities will be performed by “T-EMS”, the Smart charging Energy Management System developed by Trialog. It is an innovative EMS that integrates the evaluation of flexibility, its provision to the flexibility market, and also the assurance and traceability of both flexibility offers and activations. It is also designed to support Vehicle-to-Grid (V2G) capabilities.
Figure 4 below depicts how it is interfaced with the Consumer (i.e. EV driver) and Aggregator via a “Building/Home Semantic Interoperability” layer.

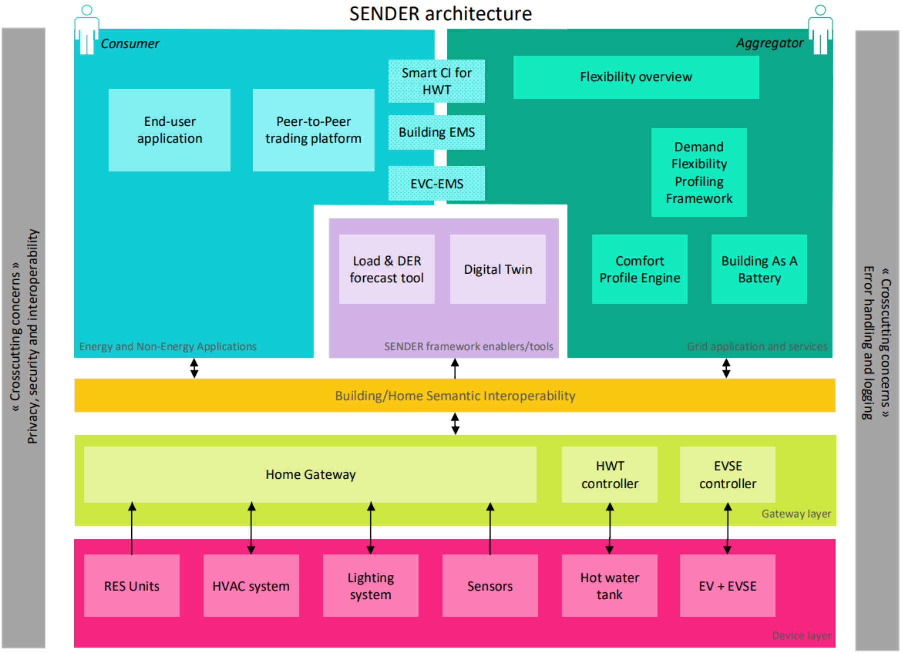

Figure 4. Architecture of SENDER solution

Acknowledgement

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Symposium Day 2

23.11.2021

Session 4

Reduction of the complexity of ICT systems

Session Chair: Friederich Kupzog

ICT interoperability and architectures for energy communities. Smart Grid Interoperability Testing

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Abstract – Smart Homes and communities are central to the energy transition. They set the pace for the connection of renewable energy sources, the promotion of energy efficiency, the smooth management of distributed generation and the charging of electric vehicles, as well as the adoption of new services based on local storage solutions, smart appliances and Internet-of-Things. Smart grid interoperability is an important enabling aspect of electricity technology deployments. Interoperability is the key element to unfold the potential of end users and smart communities to participate actively in flexibility markets but also to facilitate their decision-making on their energy usage. The consumer will be able to use his/her potentialities to offer ancillary services and support the network with high penetration of renewable energy. Achieving near real time communication and agile response of smart devices will enable this but still interoperability testing and certificating remains a big challenge. This paper gives an overview of the Smart Grid Interoperability laboratory testing methodology and presents its online application, the Smart Grid Design of Interoperability tests.

1. Introduction

The Smart Grid exhibits a high complexity regarding organizational and technological issues. A key challenge for the Smart Grid is integration which in turns affects all the components, systems, applications and information involved. Functionalities and interfaces should enable interaction so as to execute all the necessary processes within the system. Thus, interoperability is an essential requirement for the Smart Grid so the different subsystems and components can produce the expected results. Moreover, interoperability is crucial for deploying Smart Grids open to all vendors and integrators, where the operators can concentrate on the top level functions, independent from proprietary solutions. Hence, interoperability is at the same time a technical imperative, and the enabler of an open market where innovation can flourish.

The Green Deal [1] is making Europe climate-neutral and protecting our natural habitat, which will be good for people, planet and economy. The related initiatives are decarbonisation of the energy sector and renovation of building to cut energy bills and use. The New European Bauhaus initiative [2] connects the European Green Deal to our living spaces. It intends to look at our green and digital challenges as opportunities and an approach to finding innovative solutions to complex societal problems. Smart Homes and communities are key players to this change [4]. In addition, the revised Renewable energy directive (2018/2001/EU) [5] aims to strengthen the role of renewables self-consumers and renewable energy communities. Their participation though is highly dependent on the technological development that can give them access to near real time information and access to control and change or shift their energy usage. For this interoperability is a crucial element, otherwise consumers and energy communities may see themselves locked-in proprietary solutions which might jeopardize their participation due to high costs or complexity of usage of these technologies.

This paper presents an overview of the first complete and actionable interoperability testing methodology [3] for digital energy and smart homes. The future use and implementation of the common testing methodology by other laboratories and industry in Europe will secure a homogeneous and consistent reporting and testing of the state-of-the-art of technologies. The vision is that of Interoperable digital energy systems for All Europeans, where each citizen and community can benefit with new products and services. This paper presents the online application of this methodology, the Smart Grid Design of Interoperability tests (SGDOIT) and invites the laboratories to a common approach to testing and reporting, facilitating the openness of information and the development interoperable solutions.

2. The JRC Smart Grid Interoperability Testing Methodology: an overview

The JRC Smart Grid Interoperability Lab (SGILab) methodology [3] could be seen as a set of best practices the developer could follow to complete in a smooth way the interoperability test. The methodology helps the user through a step by step process to create smart grid interoperability testing objects, namely the Use Cases (UC), the Basic Application Profiles (BAP) and the Basic Application Interoperability Profiles (BAIOP). It keeps a track of the testing specifications along the development of the testing process from conception to realization. Moreover, ad-hoc development without the use of any methodology could potentially lead to bad quality, longer development time and higher cost.

The methodology comprises of activities, inputs and outputs. It consists of five stages; use case creation (UC), basic application profile (BAP) creation, basic application interoperability profile (BAIOP) creation, testing and analysis. Each stage allows the developer to select certain features that are used in the subsequent stage.

The block diagram of the JRC Interoperability Methodology (including, inputs, activities, outputs and data storage) is depicted below in Figure 1. The activities of the process are defined as explicit Steps that have to be followed to execute the Methodology:

Step 1: Use Case Elaboration

Step 2: Basic Application Profiles (BAP) creation

Step 3: Basic Application Interoperability Profiles (BAIOP) creation

Step 4: Statistical Design of experiments (DoE)

Step 5: Testing

Step 6: Statistical Analysis of experiments

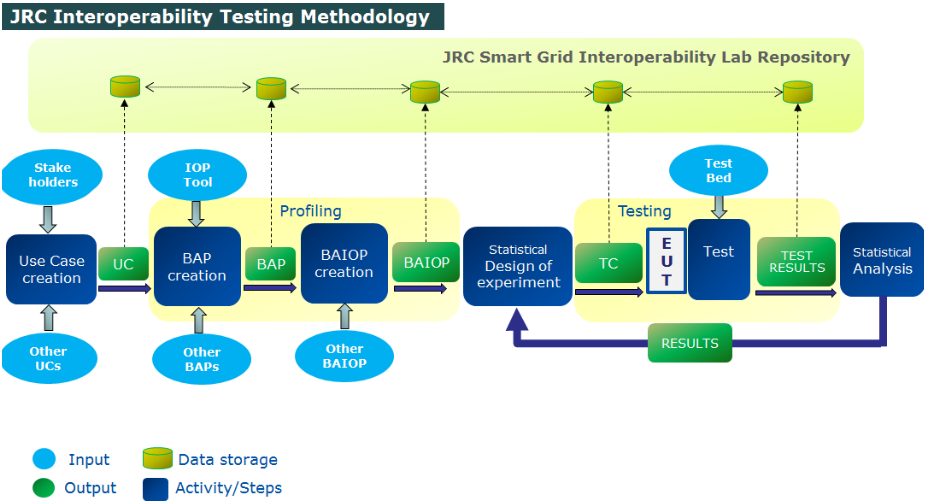

Figure 1 SGILab Interoperability Testing Methodology diagram[3]

3. The JRC Smart Grid Design of Interoperability Tests

The web-based application of the SGIlab Testing Methodology is called Smart Grid Design of Interoperability tests (SGDOIT) and it can be found in the following link: https://smart-interoperability.jrc.ec.europa.eu/

The web-based application guides the user in the creation of the three basic elements of the methodology: the UC, BAP and BAIOP as shown above in Figure 1. These are the fundamentals objects that they are interlinked, thus the application automates some of the procedures, helping in this way the user to create his test specification without inconsistencies between these three objects.

Figure 2 Logo and QR-link of the web based application

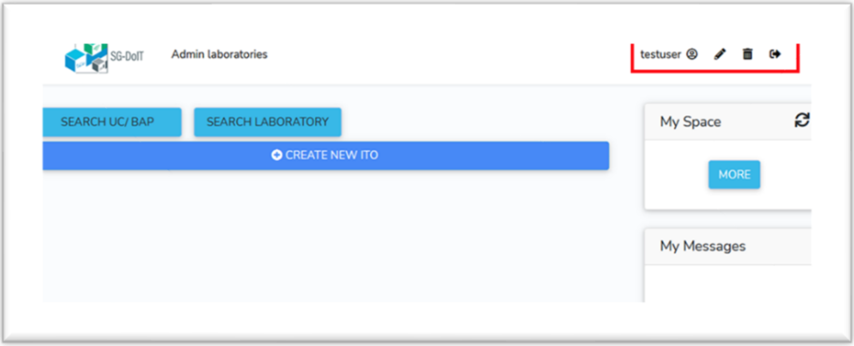

Figure 3 The first page of the SGDOIT

In Figure 3 the introduction page of the SGDOIT is shown. The user can access the system through a registration process. In this page the user can choose to create a new Interoperability object (ITO) which are either the Use Case, the BAP or the BAIOP. After his choice, the application is helping the user in a step by step process and dropdown menus or reuse of information from other objects to create his test specifications.

One of the main features of this application is that it invites the laboratories to create their inventory of smart appliances/ devices or systems by adding them in the “Admin laboratories” button. This is a restricted area Figure 4Figure 4 where only the administrator of the lab and the assigned members can have access.

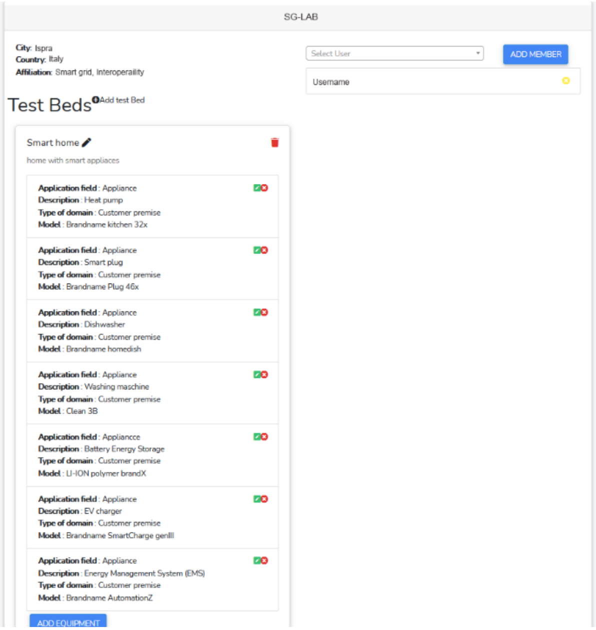

Figure 4 Registered laboratory in the application and a description of its test bed

Finally and after creating the Interoperability objects, the user with access to a laboratory is able to match the actors defined in the UC with the specific devices of the respective laboratory and so to run the test. For example in Figure 5 the Use Case appears to have three actors; the white good, the user and the Energy Management system (EMS) and in this page of the application the user is asked to assign these actors to real devices from his laboratory that he/she is a member or administrator.

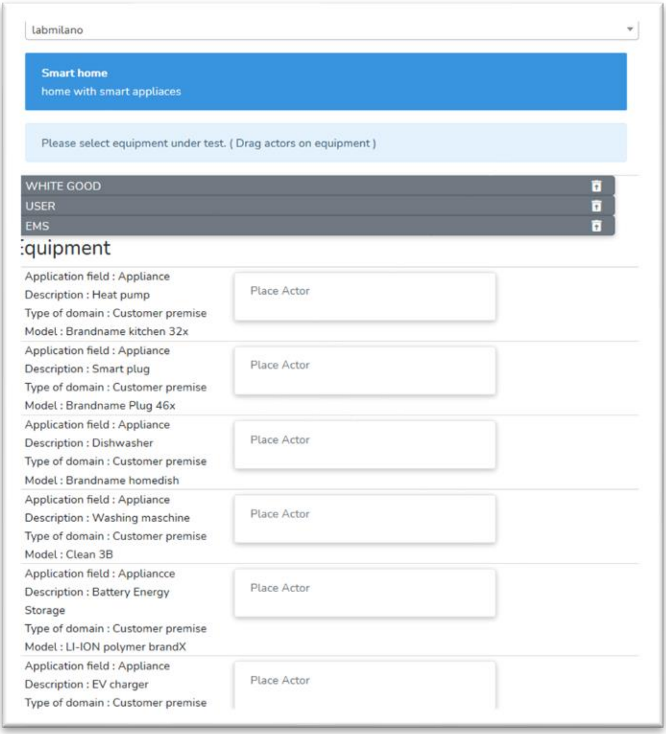

Figure 5 Assigning devices to the actors of the Use Case

4. Conclusions

This paper presents the Smart Grid Design of Interoperability tests application, which is based on the JRC SGILab interoperability testing methodology [3] for digital energy and smart homes. The application automates and facilitates users, mainly laboratories, to create and test specifications. Our vision is that the application will become a knowledge hub where experts test, report and share information pushing thus the development of interoperable solutions which in turns will encourage citizens and energy communities to become active players in the energy markets.

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State of Energy System Digitalisation in Germany - Results of the SINTEG program

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Abstract – Within this contribution, we highlight the most striking as well and consolidated results the authors see from the Digitisation aspect of the German national SINTEG funding schema.

1. Digitisation in the context of the SINTEG Synthesis project – A short overview

Today, (technical) complexity is one of the leading motives in the context of digitization in Smart Grids. In this context, the problem of scaling and complexity of the needed technical interfaces occurs above all at the required TRL - similar to what has already been noted in the context of the national funding schema e-Energy.

However, the projects as of today can rely on artifacts such as experience with domain-specific data models such as the CIM (IEC 61970 respective IEC 61968 series), an overview of national and international standards, and blueprints for the use of new communication technologies in the Smart Grid. The challenges nowadays lay in scaling and implementing the meaningful functional interfaces and data models. In this context, in addition to the operational implementation of technologies in utilities, the problem of scaling and dealing with so called legacy systems at utilities arises.

Architectures play an important role according to all experts in this context - middleware, cloud solutions or even the cellular approach of the labs mainly serve to bring to light complexity in data exchange at runtime, integration of existing systems and the aspect of data volume and processing. Standardization of technical interfaces as well as architecture management serve to manage complexity. It can be seen that further useful methods for complexity assessment and TRL determination / maturity determination used in the labs, seem to be useful. Projects have dedicated a separate studies, which were conducted across laboratories, to standardization and sees the following advantages:

- Early involvement can harness the following benefits, according to the study:
- Creation of uniform, permanent technical regulations
- (International) dissemination of results beyond the project and increase of communication within and between projects
- Creation of interoperability between project results
- Creation of marketability and acceptance among potential users
- Open standardization needs should be pursued further. There is a particular need in the areas of flexibility and digitization, IT and communication, interoperability and networking.
- For reasons of economic benefit and climatic necessity, greater emphasis should be placed on broad, long-term and public availability of the results after the end of the project. For this purpose, norms and standards should be promoted as an exploitation instrument instead of project reports.

In addition to the needed and well recognized technical interoperability, which addresses the issue of complexity, IT security is a particularly important aspect in the context of SINTEG.

The newly created overlay infrastructure and the new interfaces constantly create new points of attacks and possible vulnerabilities. As expected, the smart meter gateway with the associated protection profile sets a high level and, due to the KRITIS regulations and the introduction of ISMS according to ISO 27019 and the amendment of the IT Security Act, the complexity of the operation is increased, but the system in operation is also improved in its security.

The labs have in particular devoted numerous solution elements to dealing with this issue. Valuable experience could be gained through concepts such as a cross-industry risk analysis, as has already been carried out in Austria by E-Control, in Switzerland by BfE or at EU level [1-3]. The existing solutions should be put into context and regularly evaluated in the context of the state of the art in science and technology using an ISO 31000-based approach. IT-

Security by Design is another requirement imposed by the lab projects. New, innovative solutions must take fundamental requirements into account in the design in order to not only initially implement a high level of security, but also to be able to evaluate the effects of IT security on performance and scalability of solutions.

In addition to complexity management and IT security [1], the scalability of solutions plays a major role, for example from the perspective of c/sells. The project has shown that the growth of a solution with increasing quantity scaffolds must be considered in a growth planning with different scenarios. From the project's point of view, telecommunication technologies and interfaces were mentioned in particular. Organisational and IT structures can be realistically tested and evaluated with the help of simulation (e.g., communication simulators such as those used in SINTEG). Simulations based on digital twins should be further developed as a useful tool.

In the context of SINTEG, it can be seen that the topic of smart cities and convergent infrastructures is becoming increasingly important, also from the point of view of a future German federal funding track in the context of hydrogen. Separate infrastructures under different management and development need to interact in order to make climate targets achievable. Multi-utility companies have already gained valuable experience in this area. The share of buildings in the carbon dioxide emissions in Germany is about 30 percent as of 2021, so the trade and its emissions and intelligence will also be the focus of interest of a smart grid in the future. The SMGW can serve as an intelligent gateway into the building with a secure channel for value-added services, which can also be multi-utilities. Ideas like these are emerging from the EU level, such as in the context of the Smart Readiness Indicator (SRI) for Buildings. The term "Smart Readiness Indicator" was mentioned for the first time in the EU Building Efficiency Directive, which was amended in 2018. This is intended to assess the ability of a building to interact with the user and the (utility) grid, as well as to regulate its operation in an energy-efficient manner.

In the context of regulation, the desire of the laboratories to standardize the aspect of speed of new technologies in relation to the aspects of reliability and long-term perspective can be seen. Digitization must always be seen in the context of future scenarios; some labs, for example, have already implemented this as a vision by planning the system cockpit for the target year 2035. Scenario techniques and technology impact assessments are supported by many tools nowadays, but if you look at the BDI Initiativ Internet der Energie roadmap from 2008, for example, you can see that even in a medium-term perspective, even large, broad-based industry associations can miss the reality with their scenarios. Not only technological and political developments come into consideration, but also future developments in the environment. Products such as the flexibilization of consumers and controls such as air conditioning systems have been celebrated as innovative value-added products in Texas in recent years (so-called thermostat tariffs) - due to climate change and heat waves, these products are now completely unsaleable, as the high temperatures mean that shutting down air conditioning systems is no longer accepted as a flexibility. Despite the high TRL and the functioning technology and established value-added services, the context for continued operation is no longer given.

2. Summary

The aforementioned section has outlined preliminary results and challenges which have been identified in the context of national German funding projects. The final report with more details due on March 2022 will elaborate more on the project specific results and thus, be of value to the community.

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ECOSINT - Developing a well-rounded LEC architecture that integrates well into the grid

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Abstract – Numerous studies, including the results of the FFG-funded exploratory study "Future Network Tariffs", clearly show, that the integration of Local Energy Communities (LECs) into the energy grid is associated with challenges as well as with opportunities. It has also become clear, that a holistic view on LECs from all relevant perspectives is necessary to ensure that the goals can be met and that LECs are integrated into the grid in a way that is beneficial to it (e.g., by providing flexibilities, reducing feed-in and consumption peaks or maintaining resilience) rather than detrimental (e.g., by increasing peaks or negatively influencing simultaneities). The research project ECOSINT deals with the intelligent, digital integration of LECs into the overall system. To that end, a system-holistic analysis is performed to identify the goals, opportunities, and requirements regarding the integration of LECs. Based on this analysis, an extensible, modular, and scalable IT system architecture that incorporates security and privacy by design will be conceptualized to serve as a basis for the integration of LECs into the overall system as well as for their operation. Thereby, a consistent foundation that enables system-friendly and safe integration of LECs is created. This document provides a brief overview of the background, the goals, the planned results as well as of the project flow and the current progress of the project.

1. Background

Local Energy Communities (LECs), particularly in the sense of Renewable Energy Communities (RECs), have the potential to facilitate the energy transition and are politically and socially supported on EU and national levels. While the definition of the regulatory and legal frameworks is currently underway, the technical implementation is still largely undefined.
A smart and efficient approach for the integration of LECs into the overall system is necessary, to allow LECs to meet their own goals (e.g., maximizing the consumption of locally generated energy, increasing the degree of self-sufficiency), as well as to make a meaningful contribution to the energy system in general (e.g., reducing consumption and feed-in peaks, providing flexibilities, ensuring resilience). Conversely, an uncoordinated integration of LECs could have a negative impact on the energy system as a whole and be detrimental to its resilience (e.g., by negatively influencing simultaneity in consumption and generation and the associated increase in load peaks).

2. Goals

Currently, there is no common vision regarding the digital integration of LECs. This bears the risk of uncontrolled proliferation of different individualized solutions that are inefficient and complex to set up and maintain, uncoordinated (in the sense of lacking interoperability) and not extensible. Project ECOSINT seeks to remedy this situation by enabling the smart integration of LECs into the overall system. To this end, three main goals have been defined:

- A comprehensive analysis of the goals and possibilities of LECs as well as an investigation of all legal, regulatory, technical, and economic requirements concerning LECs.
- The design of an open, secure, modular, and scalable IT system architecture for the integration and operation of LECs.
- The simulative validation and proof-of-concept evaluation of the designed architecture based on key use cases.

3. Planned Results

The definition of different LECs and their internal requirements, but also the external requirements that should be met will be comprehensively analyzed in ECOSINT. The broad-ranging composition of the consortium (regulators, grid operators, energy suppliers, service providers, industrial corporations, and research institutions) allows an analysis from all relevant perspectives. Further expertise is obtained via stakeholder workshops. One result of the project is the systematic and formal classification of all goals and requirements for the smart integration of LECs.

Another important result is a modular IT system architecture for LECs, which is based on the comprehensive analysis of all framework conditions. This architecture is to provide internal and external interfaces for effective integration into the energy system, consider important requirements such as IT security and privacy protection natively and thus, form an essential basis for future communities, regardless of their characteristics, sizes and external providers of community services. For example, in the case of the maximization of the consumption of self-produced electricity, a LEC should be able to choose from a set of possible approaches and individually decide on the preferred method (e.g., based on machine learning methods).
The IT system architecture will be available as a complete, digital UML model; based on the comprehensive requirements analysis. An instantiation of the system architecture for individual LECs will be exemplarily demonstrated, validated in simulations, and jointly evaluated with stakeholders.
Overall, the project will provide the basis for the efficient and secure integration and operation of LECs by allowing them to meet their internal goals, minimizing complexity and at the same time optimizing the benefit LECs can provide for the overall energy system.

4. Project Flow and Current Progress

The project launched in March 2021 and is scheduled to run for three years. As of November 2021, it is nearing the completion of the analysis phase and beginning the transition to the architecture phase on schedule (planned project flow see Figure 1). One stakeholder workshop with more than 50 participants has already been held, the results of which are currently being analyzed, catalogued, and refined. Key findings from it are requirements such as a unified architecture, interoperability, more versatile tariffs and tariff structures, simple handling, tools to facilitate planning and operation, the availability of fine-grained measurement data for accounting and control, cost transparency, civic participation, fairness, and low entry barriers.

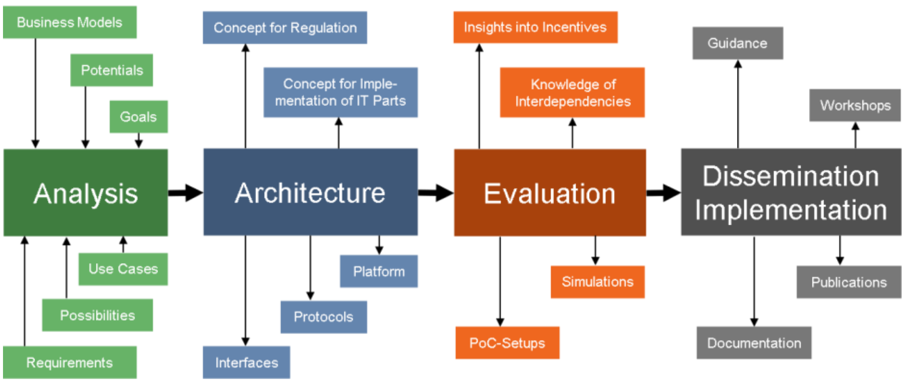

Figure 1. Project flow with in- and outputs

Author

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Solutions for Energy payment and trading in communities

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***Abstract* -** Austria is one of the pioneers within the EU to enable energy communities in line with the official definition of energy communities and the corresponding directives [1]. The Austrian government has a self-proclaimed target of net-zero carbon emissions for the power sector by 2030, which will need about 27 TWh of new renewable energy production capacity.
In line with the EU directives every energy community needs to be a legal entity and to organize the data exchange between all participants, the association of Austria's energy sector "Österreichs Energie" is providing the ebUtilities data exchange platform [2] where the measurements gathered by grid operators through smart meters is forwarded to energy communities as well as energy providers.
In this paper we will show that the current process limitation of only one renewable energy production facility within a Renewable Energy Community (REC) [3] is easily causing higher cost than the savings for participants are. Even when this limitation is lifted, the size of RECs matters a lot regarding possible individual savings. Therefore, we show an alternative – fully blockchain based – approach for RECs to overcome this initial challenge and enter new market opportunities, where the recent progress in blockchain applications is utilized.

1. Austria's Goal of Net-Zero Carbon by 2030

Austria has already a relatively high percentage of renewable electricity production in comparison with many other EU countries. Taking this into consideration, the government has proclaimed a net-zero carbon renewable electricity production goal by 2030. This is 10 years

ahead of the EU and demands approximately 27 TWh of additional renewable energy production capacity [4].
On July 7th, 2021, the parliament approved a new law (the "Erneuerbaren Ausbau Gesetz" or "EAG" in short [5]) to speed up the needed infrastructure investments. Within that mostly funding related package the formation of energy communities was regulated as well. It is beyond the scope of this paper to go into details and therefore we recommend visiting the Austrian Coordination Office for Energy Communities [6] for more in-depth (German) information.

2. Classical Payment in Energy Communities

2.1 Data Exchange

All official energy accounting is based on the calibrated smart meter energy measurements gathered by the grid operator. Measurement data will be provided in 15 min. resolution on the next day for the last 24 hours via the ebUtilities platform to registered energy communities.

2.2 Challenges with Payments via Bank Accounts

New RECs are predominantly formed as associations because it is the organizational form with the lowest cost and administration effort.
It is up to the energy communities how they want to do their accounting and there are likely many ways to do that. Nevertheless, if the administration effort should stay low, it will typically involve the use of regular bank accounts for payments within the energy community. Simply put, producers will get money from the REC and consumers will pay money to the REC's bank account.
A typical bank accounts can cost between 20 and 50€/quarter [7] and if we consider that the savings of an average household for being part of a REC are between 0€ and 100€ [8], it is obvious, that small RECs have a cost problem from the bank account alone. Of course, there are many other additional costs involved, such as the interaction with the ebUtilities platform or administration around the association, especially if the REC also has to take care of overdue payments.

3. Novel Blockchain Approach for Energy Communities

3.1 Building blocks – DAO's and Tokens

Blockchain systems build on the Internet layer and since the introduction of the Ethereum protocol in 2015, they became more easily programable with so called smart contracts. Right from the beginning the ecosystem was fascinated by DAOs (Decentralized Autonomous Or-

ganizations) and despite an early setback with "The DAO" launched in 2016 [9], the community has formed many DAOs and the experimentation with new DAO building platforms is a very hot topic now.
In 2017 the programmability in Ethereum triggered the so called ICO boom (Initial Coin Offerings), where, based on the ERC-20 token standard, many startups raised tens and sometimes even hundreds of millions of dollars. Two more token standards have gained massive popularity by 2021, the so called non-fungible tokens (NFTs), which are based on the ERC-721 and ERC-1155 standard. This standardization led to a global race of new platforms for decentralized financial applications (DeFi) with billions of dollars in monthly turnover and collectibles (NFTs), where artists frequently sell their work for millions of dollars [10].

3.2 REC DAO's and Token Accounting

While DAO's and tokens on blockchains are not yet ripe for the masses, it is still an interesting way to structure RECs to minimize cost and maximize democratization. The legal requirement of RECs to form an organization can still be done as association, but there is no need to have a bank account, if everything is done with blockchain tokens. This can enable even very small RECs to have net-savings, but the huge benefit is the access to all the innovation happening in the blockchain space. Once the users are familiarized with blockchain systems and the management of tokens in a wallet, it opens a whole new universe of applications beyond the simple settlement of energy flows.
Some examples can be:

- Governance tokens with different voting logics, e.g. quadratic voting [11] or conviction voting [12]
- kWh token, that are distributed or consumed based on the current electricity spot market price fed in by blockchain oracle systems [13].
- Streamed token payment (= continuous cash flow) [14] for energy consumption and regular adjustments of said token stream
- Reward token distribution to members supporting beneficial grid behaviour
- NFT badges for various climate friendly activities and as status information within the community
- Trading of tokens via automated market makers, enabled by pool liquidity providers [15]
- Decentralized lending & borrowing of capital, based on on-chain liquidity organized via platforms like Aave [16]
- …

With the current emergence of many scaling solutions (e.g.: zkSync, Arbitrum or Optimism) in the Ethereum ecosystem and the upcoming transition to Proof-of-Stake, with low energy consumption, the danger of high transaction fees can be also mitigated with the choice of the right blockchain system.

At the moment Sidechains like xDai Chain or Polygon are the best systems to get started due to their low transaction fees. Nevertheless, for the future a transition to more distributed systems with high security and low transaction fees will certainly be an interesting option too.

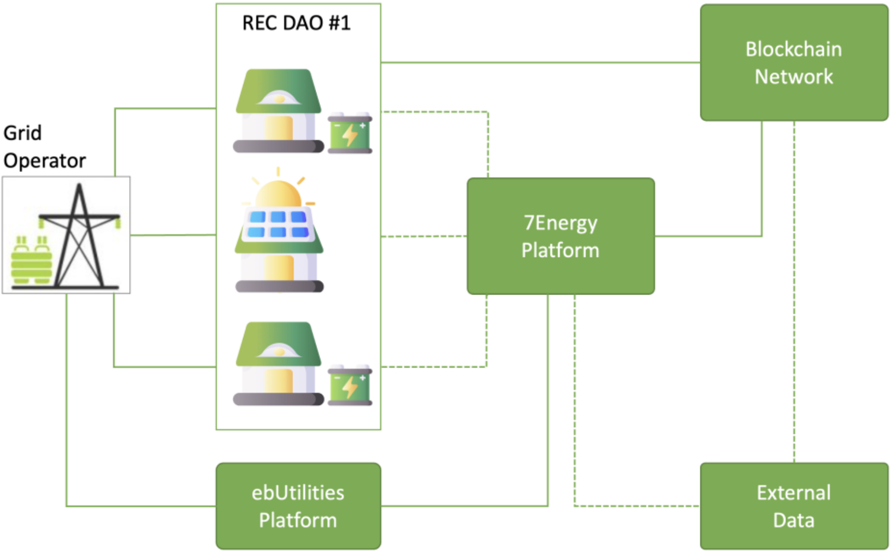

Figure 1. Schematic illustration of blockchain based RECs in line with the current Austrian regulation and the mandatory data exchange via the ebUtilities platform. The 7Energy platform is planned by the lab10 collective to serve as a data exchange platform for energy communities.

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BIFROST - A narrative simulation tool for Smart Energy scenarios - Tutorial and hands-on

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Abstract – BIFROST is a narrative Smart Grid simulation tool for exploring, building, and presenting stories about settlements, communities and quarters pushing to adapt to the climate crisis. It offers simulation orchestration and creative tools to quickly explore variegated scenarios, with the ultimate goals of reducing complexity and presenting technological solutions. It fosters engagement in decision processes, and enables integrative discussions across a range of expertise levels. With this workshop, we want to introduce BIFROST, show some successfully realized projects and applications, and give the participants the chance to build and explore their own virtual community.

1. BIFROST Introduction

BIFROST is a web-based tool for the construction of visually engaging settlements, communities and quarters backed by Smart Energy Infrastructure [1]. External modules can interact with the BIFROST platform to emulate complex smart energy infrastructure-related scenarios and create compelling stories. Conveying hard technical facts in a compelling fashion is challenging. The effects of a warming climate on a city district; higher grid loads through renewable energy installations; benefits of local energy sharing; e-car loading control through unreliable wireless channels – whatever your narrative, BIFROST provides the tools to design and visualize a compelling Smart Infrastructure story, as it can be seen in Figure 1. The Figure shows the UI of BIFROST presenting an exemplary use case about novel energy community concepts, which compares different strategies and visualizes the resulting KPIs.

Figure 1: BIFROST UI: You can see an energy community scenario consisting of multiple different stakeholders (residential buildings, commercial buildings, battery storage), the simulation timeline at the bottom, and some simulation results on the right side.

BIFROST consists of a core simulation engine to drive dynamic data generation and a 3D web UI for the construction of settlements [2]. Its main components can be seen in Figure 2. The BIFROST backend orchestrates the internal data model, which stores all information about available structures and parameters (BIFROST *directory*) as well as the realized settlements and the corresponding simulation data (BIFROST *state*). The BIFROST core itself does not make any assumption about the content of the directory. Both structures, as well as their parameters can be adjusted to the user's needs, who can access the simulation environment through the BIFROST frontend.

The BIFROST core does not generate any simulation data but provides a unified REST API interface to any software component (BIFROST *module*). Modules can introduce any kind of behavior necessary for the current simulation run (e.g., load flow solver, weather generator, energy community controller, etc.). This flexibility allows BIFROST to tackle various use cases from CO2-efficient energy community concepts to intelligent e-car loading controllers or optimized pricing strategies.

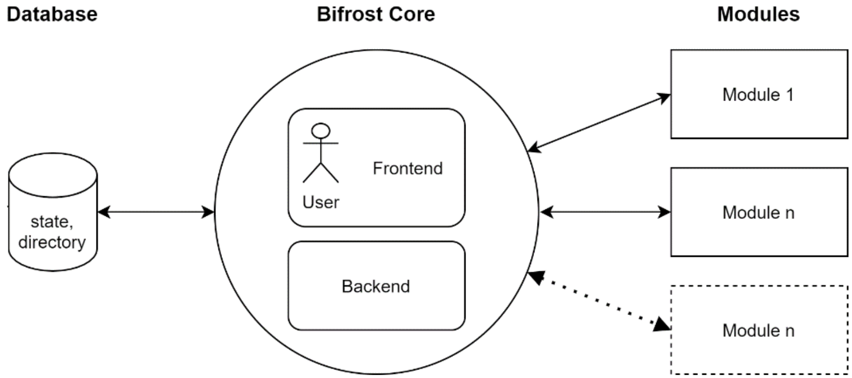

Figure 2: Main BIFROST components: The BIFROST core consists of a frontend for the human interaction and the backend for the orchestration of the internal database. BIFROST modules can interact with the core via a unified REST API interface and can provide any kind of simulation behavior.

Besides the landscape view shown in Figure 1, BIFROST also includes different layers (electrical grid, thermal grid, communication, etc.) for a clear and structured visualization as well as a geo-mode, which allows to include geospatial relations (see Figure 3).

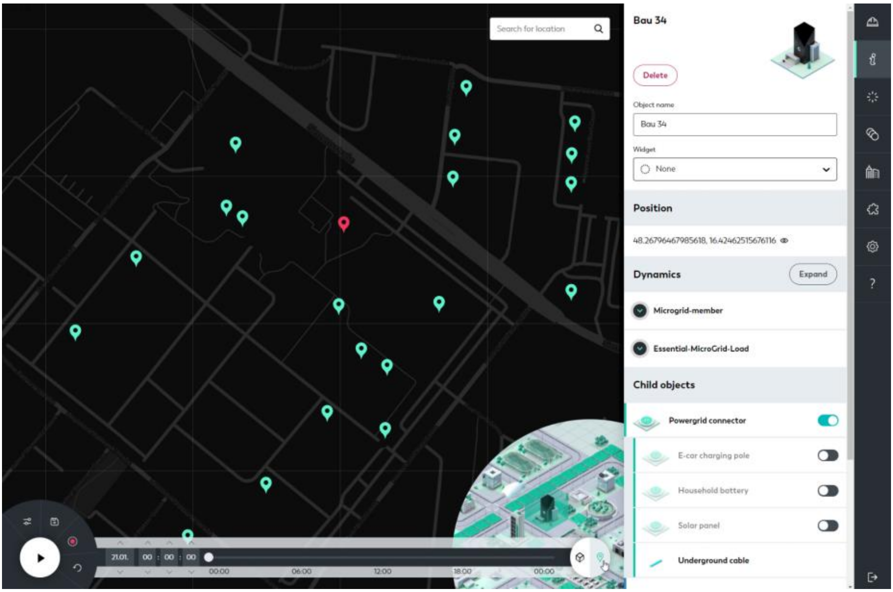

Figure 3: BIFROST UI representation of geospatial relations in BIFROST

2. BIFROST projects and applications

BIFROST is currently used in many national and international research projects, including CLUE [3] and SONDER [4], both focusing on novel concepts for energy communities. In this workshop we want to show some hands-on demonstrations and give anyone the chance to build and explore their own virtual community. Therefore, in this chapter, we introduce some of the exhibited demonstrators you will see at ComForEn 2021.

2.1 External Configuration Tool

The goal of this project is to create different scenarios for an existing BIFROST settlement. This is done by changing the configuration of buildings such as single-family via an external configuration tool – the *BIFROSTExtConfigTool*. Using this tool, users can easily vary different parameters and analyse the results. For example, different battery storage sizes of a community battery influence the price savings and level of self-sufficiency. With the *BIFROSTExtConfigTool* those influences can be simulated and visualized semi-automated. The tool offers a modern user interface and can be used offline and in conjunction with an active BIFROST instance. Figure 4 shows different profiles which have been reconfigured using the *BIFROSTExtConfigTool*.

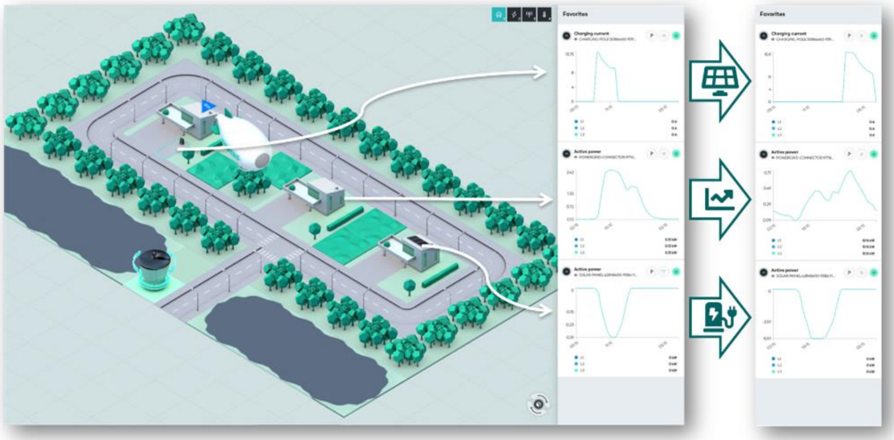

Figure 4: BIFROSTExtConfigTool: Different profiles (basic load, PV, EV) can be configured via the external configuration tool. After a reconfiguration, different profiles can be observed in the right graphs.

2.2 BIFROST Bricks

This project was created with the goal of providing an interactive and illustrative experience of Smart Cities. Anyone can place building bricks on a designated board and watch them be recreated as buildings in their own (see Figure 5). This is made possible due to the combination of object detection, grid auto-routing and the communication with a server for the BIFROST simulation. The project has an educational background, as it was designed for strengthening the awareness of current Smart Grid concepts such as energy communities as well as current and future challenges, such as renewable energy sources.

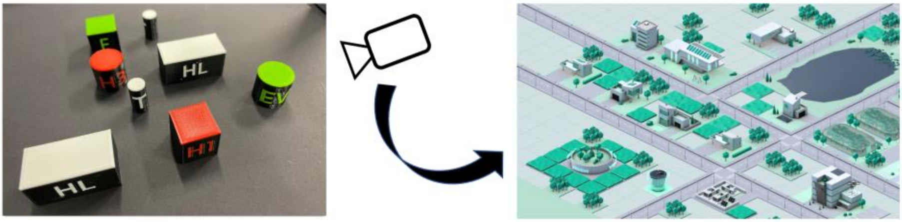

Figure 5: BIFROST Bricks concept: After placing building bricks on a surface, the different types and positions are detected and a BIFROST settlement is automatically created, including the electrical grid.

2.3 BIFROST House

Figure 6: Bifrost House

Bringing simulations into reality has never been more intriguing by combining BIFROST with the popular open-source energy management system called *OpenEMS*. It is used for energy management applications such as controlling electric storages or solar power systems, enabling real-world sensor data to be fed into the simulation. This 3D-printed physical model of a single household (see Figure 6) with integrated environmental sensors and actors allows the interactive demonstration of different household-based energy management strategies within BIFROST.

2.4 Energy Community Evaluation

Energy communities provide the possibility to share energy among their participants with the goals of cost optimization, grid support, and sustainable operation. Community members can share flexibilities (e.g., PV overproduction) or use communal energy storage systems. Depending on the variety of its participants, different strategies can lead to more or less optimal results. With BIFROST, these strategies can be evaluated and compared with each other by building and configuring an energy community and visualizing the results. During the workshop, our visitors will have the chance to build and explore their own virtual energy community.

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Dipl.-Ing. (FH) Dr.-Ing. Ralf Mosshammer joined the "Smart Embedded Systems" group at Siemens Technology Austria in 2011, initially working on simulation coupling for Smart Grid controllers, which eventually evolved to include human-centered monitoring and control concepts. He is the principal developer and maintainer of BIFROST, a Smart Infrastructure modelling and simulation tool with a strong focus on interactivity and narrative design.

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