Good Practice of Integrated Energy Systems

On Integrated Energy Systems in the built environment in Poland and The Netherlands

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Executive Summary

ES.1. Introduction

In Europe, 40% of the energy consumption (and 36% of greenhouse gas emissions) takes place in buildings (Rousselot, 2018). In order to accelerate the retrofitting and energy performance improvements in the built environment, the Commission announced, on 14 October 2020, a *Renovation Wave* with the objective to renovate, by 2030, 35 million buildings in Europe which currently have poor insulation (including residential dwellings) (European Commission, 2020a). An important contribution to the Renovation Wave is expected to be delivered by solutions that combine multiple forms of renewable energy generation in Integrated Energy Systems (IES), for lower emissions and higher energy efficiency. This report contains already gained experiences and good practices with the application of IES in buildings, which may provide a turn-key solution for transforming today's buildings into (near-)zero emission buildings.

Applying IES in the built environment faces a range of technical, financial, and social challenges (or barriers). Essentially, what a fully integrated energy system aims to do is to address these challenges by providing one integrated service to the market. Key elements of an IES include a robust (turn-key) technology concept that includes both energy installation and insulation technologies and practices, as well as complementary financial services and end-user engagement/communication support.

Adequate engagement of and dialogue with relevant stakeholders (particularly end-users) reduces the likelihood of IES triggering any traditional (not-in-my-backyard) protests or social resistance because, if done well, the IES solution chosen meets the demand and preferences of users. Nevertheless, from the literature review in this report and good practice examples from Poland and the Netherlands, it can be concluded that applying IES solutions may not necessarily meet end users' acceptance for reason related to:

1. **Technology**: people are asked to give up an existing situation that they were used to and to do so they demand at least an equivalent energy service in return, if not better,
2. **Finance**: energy needs to be affordable, as also prominently stated in the EU Green Deal, so that the net costs of IES systems, and how these costs are spread over time, needs to be in line with what people were used to pay, and
3. **Social aspects of end users**: since IES combines and balances different energy services in a building, it is important to precisely know what it is that end users want in terms of energy supply. This is even more important in case of multi-purpose buildings with different users, with different needs and perhaps at different moments of the day.

The practical examples discussed in detail in this report have demonstrated how the above aspects in practice go hand in hand, if the planning process is well-designed. Engaging people in the planning process from the very beginning of a building renovation project, where joint existence of multiple energy technologies is replaced with an integrated solution, improves the quality of the technical solution. After all, carefully considering end users' preferences in the technical design leads to a system that is perceived by people to work better. Instead of 'not invented by me', the technology becomes appreciated as a 'co-designed by me' solution. This is reflected by the incorporation of specific end-use preferences in the technology, so that the technology is perceived by end users to be working better.

Part of the acceptance of IES solutions is how the costing and pricing structure is arranged. Ideally, end users would like to see their energy (and building maintenance) costs to remain at the levels they used to pay, but people might be willing to pay more if a solution is perceived as a reliable improvement, also in terms of comfort. Having sufficient choice and flexibility offered to individual end users and different end-user groups in terms of how to finance/pay for the IES is desirable. In that manner financial plans can be offered, either as a one-off full upfront investment or in spread payments as an add-up to the monthly energy bill or owners' association's service cost expenses. Moreover, the examples discussed in this reports suggest that joint actions, such as households sharing a building block or living in one district with comparable dwellings, united by an owners' or housing association, can improve the quality and/or lower the costs of the IES solution applied. In practice, we can observe how people form representative groups (e.g. owners' association) as intermediaries between wider groups of end users and technology providers co-design IES solutions and agree on satisfactory implementation strategies, maintenance solutions and financial plans. A perfect or one-size fits all solution can thus not be recommended based on the examples described, as it is case dependent, but user satisfaction is very likely to increase if end users are engaged in the design of the solution. Engagement can take several forms, such as co-designer of a solution to be purchased or leased individually or co-ownership such as via a co-operation.

From the market analysis in this report, we can also conclude that suppliers have become increasingly aware of how consumers' demand is changing in terms of energy services and maintenance. While traditionally, with multiple independently operational energy services in one building, consumers needed to call a different company per service in case of disruptions or failure, with increasingly integrated (technology, financial and engagement/communication) services, one call to one energy service company, intermediary or IES supplier would ideally suffice. Energy service companies increasingly offer this 'one-stop-shop' service, although the picture of how this is done, and how far companies have progressed into that direction differs. A number of companies analyzed in the Netherlands, for example, offer full-service lease contracts or full-service contracts as after purchase care of the IES system. Also, here we can see that companies tend to shift their services towards the needs and preferences of energy end users.

ES.2. Comparing IES good practices in Poland (Pomerania) and the Netherlands

When comparing IES good practices in Poland and the Netherlands, in terms of market context and IES development status, some similarities as well as key differences can be observed (see Table 1). Overall, the IES good practice assessment results suggest that for IES implementation and upscaling the conditions are more advantageous in the Netherlands, relative to the Polish situation. However, with additional focus of local public bodies (e.g. information campaigns, promoting social innovation and citizen engagement) and a good focus on IES technology developments it should be feasible to have a steeper learning curve in Poland.

Category	Poland	The Netherlands
Context	Coal-based & district heating-based energy system. No official trajectory / national policy for coal phase-out in place.	Natural-gas, household boiler system-based energy system. Official trajectory / national policy for natural gas phase-out in place.
Technology	Generally low level of tech. integration, but first experimental pilot projects are developed.	Generally medium level of tech. integration, but novel and mature IES concepts are already marketed. Scaling up is challenging.
Social innovation	Generally, depends on existing social and institutional structures, and could benefit from additional facilitation by local governments.	Conditions for social innovation (e.g. Facilitated by local governments, energy cooperatives, community initiatives, people's awareness) are fair/good.
Finance	Generally, operational guarantees /warranty and technology specific incentive schemes.	Many experiments ongoing with energy performance contracts, and novel financing instruments for different target groups (e.g. Building-linked finance).

Table 1: Comparing IES market status in Poland (Pomerania region) and the Netherlands

Context

The energy systems and associated infrastructures in both countries are fossil-fuel based. The Polish heating system, especially in more densely populated areas, is strongly centralized by means of coal-fired district heating systems, while in the Netherland provision of heat is more decentralized with a gas boiler-based system in almost all buildings. While both countries are taking steps for a gradual phase-out of coal and natural gas, their actual energy transition processes in the built environment will differ substantially. Whereas in the Netherlands, the option of an accelerated introduction of renewables options in the built environment is now seriously considered, in Poland either limited expansion of gas infrastructure, or wider use of renewables in buildings seems probable in longer term. The other two main transition options, i.e. all-electric (solar energy and heat pump based) and district heating (greening & expansion) are relevant for both regions.

Technology

In Poland, based on the rapid development and dissemination of solar PV technology supported by net-metering and prosumer contracts with electricity distributors, a gradual introduction of all-electric IES is expected. This will primarily replace coal and oil heating in rural areas (i.e. with no or underdeveloped district heating systems and beyond gas grids). Starting from a natural combination of solar PV and heat pumps and adding cooling and energy storage at a later stage, will eventually enable an integrated and efficient energy supply for different buildings. However, current practice in Poland shows that still (too) often PV and heat pump installers operate separately and do not optimise their equipment for working together, despite the efficiency benefits that can be obtained if these technologies are offered as an integrated solution. On top of that, in most cases proper control systems optimising operation of units and the whole systems are still lacking in the market. Similar market practices are also observed within the Netherlands. However, throughout the country relevant market players are gaining more and more experience with IES system development, as this has reached the stage of a high degree of market maturity in most segments of the built environment, from a pure technological perspective. The key technology challenge in the Netherlands relates more to the effective and efficient scaling up of IES practices.

Social

In both countries there are sufficient (and comparable) existing social and institutional structures[1] that provide stakeholders (i.e. building owners, building users) with a legal framework for decision making on renovations/upgrades of e.g. multi-family buildings and shared office space buildings. While in many cases, IES decision-making still takes place through existing social decision-making structures, we observe a higher degree of social innovation taking place in the Netherlands, where novel social structures are being introduced. This social innovation is facilitated through or partly triggered by dedicated communication and information campaign efforts by public bodies (e.g. such as the Expedition Energy Neutral Living in the Province of Drenthe). To illustrate, the number of local energy communities or energy cooperatives in the Netherlands more than doubled between 2015 and 2019 to almost 600 in 2019 (RVO Netherlands Enterprise Agency, 2019). While most of these energy cooperatives mainly focus on developing solar PV and wind power projects, they gradually shift towards, energy savings, and alternative heating systems.

Financial

In both countries a range of traditional financial mechanisms, such as (soft) loan schemes and grants/subsidies, are in place that can either be accessed by individual entities or specific groups. Within Poland, IES investments usually only take place if there are public funds or soft loans available. It also happens frequently that – due to insufficient technology integration – certain energy system components are oversized which increases overall investment costs. In addition, there are several cases where the costs of maintenance and other services are not considered at the stage of the decision-making process. In the Netherlands, a growth in IES concepts and financing schemes can be observed that capture the full cost-of-ownership, so that IES solutions can be marketed as 'cost-neutral' in terms of CAPEX and OPEX expenses versus the (expected) lower expenses on energy use and building maintenance. The increasing use of energy performance contracting, and ongoing development and standardization of novel financing schemes, such as building-linked finance (e.g. the *Asser Servicekostenmodel*), leasing, and renting, in addition to the traditional mortgage or (soft/green) loan based financing, provide (groups of) end-users with a broader spectrum of financial solutions.

ES.3. Recommendations for IES development and implementation

In this report it has been argued that a robust and fully integrated IES addresses identified *technical*, *financial*, and *social* barriers (or challenges) of individually implemented energy solutions. This integrated service ideally includes three main components (see Figure 1):

1) Technology concept improvement
   i. Compatible set technologies and practices (integrated turn-key solution)
   ii. Good quality energy monitoring and -performance guarantees (software, legal)

[1] Such as home-owner associations, and housing associations.

iii. Robust information and communication structures

2) Financial service innovation
    i. Financial guidance and solutions
3) Social innovation
    i. Stakeholder engagement procedures and structures

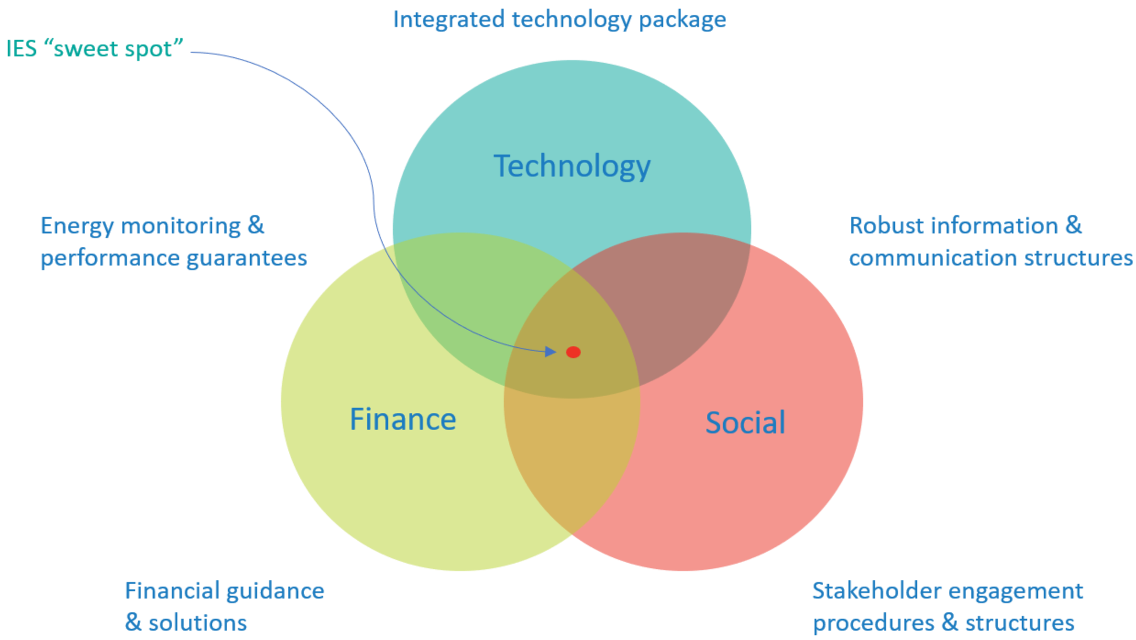

Figure 1: Key elements of an Integrated Energy System

The comparison between the Netherlands and Poland shows, that the Dutch IES market is relatively advanced and gradually progressing from the experimental and pilot phase to deployment of IES solutions in the market, towards further commercial diffusion. While in Poland IES development requires continued public funding support for progressing along the technology development journey, the challenge for the Dutch market is to ensure public-private collaborative actions for further upscaling and standardization of IES solutions to all segments of the built environment. Depending on the IES market stage of technology demand (i.e. research, development and experiment/pilot phase, grow/expansion phase, maturity phase, etc.) within a given country there are different policy strategies to pursue.

R&D, experimental / pilot phase

During this phase, the role of the public bodies is more prominent as a driving and enabling/facilitating actor in the IES market. With respect to the technology concept, research, development, pilot, and demonstration projects throughout the country and within different segments of the built environment are needed to show proof of (technology) concept. Parallel to that, national and local governments can also launch targeted information campaigns and host information sessions or marketplace events. In addition, some first experiments with novel financing schemes are needed, as well as facilitation, support, and experimentation of novel social structures (e.g. energy communities, local energy cooperatives). The direct public support (in-kind or with some subsidies) for improving the conditions for development of new financial instruments and promoting social innovation will eventually be needed to grow and expand the IES market.

Market deployment: growth / expansion phase towards mature, commercially viable solutions

Within this phase, the IES technology concepts become increasingly more standardized, and larger segments of the built environment could be serviced. However, in this phase more support is needed for further standardization and institutionalization of the various new social and financial structures. Here, both public and private bodies can collaborate to further develop and support local (energy) communities/cooperatives (i.e. professionalization) in their ambitions. In addition, market actors need to be encouraged to develop robust solutions, with proper energy monitoring, for which they are willing to provide performance guarantees. Public bodies could aid in the co-development or development of new financing schemes (i.e. a Province could provide a financial guarantee, such as the *Asser Servicekostenmodel,* discussed in Chapter 3 of this report), by providing either funding for hiring financial experts, or financial security (i.e. public guarantee fund) for at least a first generation of IES projects that are funded through novel financing schemes.

1. Introduction

Over the next decades, Europe will face a range of important challenges. Limiting global average temperature increase to 1.5 degree Celsius, as agreed in the Paris Agreement under the UN Framework Convention on Climate Change (UNFCCC), will require emissions of greenhouse gases to become zero or even negative around halfway this century. Global population will continue to increase in the course of this century and within a decade around two-third of the people will live in urban areas (Ritchie & Roser, 2019). This requires cities to meet growing demand for energy, as well as to become more resilient to climate change impacts such as flooding of streets or heat stress. To reduce pressure on transportation systems employees will agree more flexible working hours with their employers and increasingly work from home. These and other challenges have been recognised by policy makers and have resulted in a range of policy packages, including the European Green Deal (European Commission, 2019), which recognises that the climate challenge cannot be addresses as a stand-alone issue, but requires integrated policy packages, including infrastructure investments, retrofitting of buildings and streamlining transportation systems.

In this report, the focus is on the built environment as one of the core elements of the European Green Deal. Currently, 40% of the European energy consumption (and 36% of greenhouse gas emissions) takes place in buildings (Rousselot, 2018). In order to accelerate the retrofitting and energy performance improvements in the built environment, the Commission announced, on 14 October 2020, a Renovation Wave with the objective to renovate, by 2030, 35 million buildings in Europe which currently have poor insulation (including residential dwellings) (European Commission, 2020a).

In order to deliver on these goals and strategies, buildings in Europe will need to fulfil a range of requirements. According to Arcadis (2019), first, it will be essential for buildings to be climate resilient, e.g. enable people to cope with heat stress. Second, buildings need to be deconstructable so that materials can be re-used in new buildings. Third, future buildings should be climate and energy neutral or even deliver net energy to the surrounding energy grids. Fourth, supported by digital technology, such as the Internet of Things, buildings must be smart, i.e. cognitive, so that energy management can be optimised on the basis of collected data on energy use. Fifth, buildings will be flexible in use, so that functionality can change over time. Sixth, given the increased focus on health, especially with an aging population, indoor environment quality will be an important parameter for building design and maintenance. Seventh, the above requirements also support the multifunctionality of buildings as places to live, work and recreate, which requires a range of services and facilities to enable this. Finally, ensuring that these requirements are successfully met, buildings require performance measurement, not only to comply with standards and policies, but also to enhance the (economic) value of the building.

While these requirements imply a huge challenge for the built environment sector in Europe, knowledge of these building and retrofitting activities is quickly being built. This strengthens the technical potential for making buildings energy positive, healthier, climate resilient and multifunctional. In RES4Build, the aim is to integrate multiple, low-emissions and renewable energy-based technologies to, at least, meet the requirements of energy-neutral (or even positive), circular and multifunctional buildings, supported by smart, cognitive technologies. This will be done by developing new or improving existing technologies and optimising their integrated use in buildings, such that solutions are financially feasible and socially acceptable.

To obtain an idea of the required speed of improvements in the built environment, a recent progress report by a taskforce on a sustainable, climate resilient and circular built environment in the Netherlands (De Bouwagenda, 2018) is illustrative. Given the approximately 8 million buildings in the country (of which 7.5 million residential dwellings and 0.5 million utility buildings), the task force estimates that for achieving the goal of climate resilient buildings in the Netherlands in 2050, between now and mid-century about 1000 buildings need to be made sustainable per working day. This sharply contrasts with the present ‘productivity rate’ of only a few dozen buildings being upgraded per day. This gap shows that not only a higher degree of standardization in renovation approaches is required, but also increasing levels of industrialisation of this process to allow for scaling up and cost reductions.

In this report, we will focus on already gained experiences and good practices with the application of integrated energy systems (IES) in buildings, which may provide a turn-key solution for transforming today’s buildings into (near-)zero emission buildings. This will be done by desk study of literature and by identifying and analysing case studies in Poland and the Netherlands. By focussing on case studies in two different Member States, differences and commonalities that are present across the EU may be revealed. The studied examples of the application of IES in buildings are considered as good practices in this report. Apart from technical solutions, the focus in this assessment of good practices will be on the wider system for technology application, including the policy enabling environment, habits of consumers, the value chain with collaborating and competing stakeholders and existing facilitating services in the countries (or lack thereof). This systemic focus facilitates the identification of possible technological, social, policy and financial enabling factors for the energy transition in the built environment and barriers that need to be overcome.

2. Integrated Energy Systems in the Built Environment

2.1. What it is

Integrated Energy Systems (IES) in the built environment enable a combined and integrated application of multiple technologies, including auxiliary equipment that generate, distribute, and store energy on site, to jointly and efficiently meet the energy demand in the building. The integration thus aims at an optimisation of technology operations, given the status and capacity of the other technologies in the system. The design of IES mostly concerns both the 'passive' building envelope and the 'active' energy generation equipment used in the building as both are, in practice, related. For instance, improving the thermal insulation performance of the building envelope with materials with a high insulation values [2] mostly reduces the energy demand in terms of heating/cooling or lighting. The extent to which the building envelope is integrated with the operational energy systems is design specific. There are examples of integrated zero-emission technology options [3] without specific requirements for the insulation quality of the building envelope, but in most (deep) renovation [4] cases the identification and operation of energy technologies also consider the status of the building envelope (Tisov, 2017).

2.1.1. Building specific and collective solutions

IES can be designed for one specific building or a group of buildings (e.g. specific building type/vintage, or buildings in proximity). Several combinations of IES approaches are possible here. For instance, while the (passive) insulating element designs are largely building specific, the energy systems can either be fully dedicated to a single building (e.g. ground source heat-pump, with solar photovoltaic-thermal and borehole thermal energy storage, BTES) or part of a collective system that serves an entire street, block or suburb (e.g. like a district/block heating system). In the latter case, an IES can also be designed for multiple buildings of a similar type, with comparable building envelope conditions, as a way to scale up a single IES solution. For example, the feasibility study for a district heating system in Groningen (NL), combining BTES, aquathermy and individual heat pumps, targeted 450 largely identical dwellings for scaling up one IES solution (050 Buurtwarmte, 2019).

2.1.2. Retrofit versus new builds

IES solutions are applicable in both refurbished existing buildings and in new buildings. In new buildings, IES solutions can be fully integrated in the design and construction phases, while in existing buildings, IES applications often require modifications, retrofits to the buildings. In terms of scope, retrofit plans are likely to offer the largest scope for IES as it is expected that by 2050 about 80% of the current European building stock will still be in use. (European Commission, 2020b). Hence, a substantial effort towards a sustainable built environment in Europe must be

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[2] E.g. through use of double/triple glazing, roof (in- or outside), wall (in-, outside or cavity) or floor insulation.

[3] E.g. via heat pumps (air, water, ground), boilers (gas, electric), biomass energy (pellets, wood chips), solar energy (PV, thermal, PV-thermal), etc.

[4] According to the European Commission (European Commission, 2019a), *"Deep renovations are those leading to refurbishment that reduces both the delivered and final energy consumption of a building by a significant percentage compared with pre-renovation levels, leading to very high energy performance. According to the staff working document accompanying the Commission's 2013 report on Financial support for energy efficiency in buildings, 'deep renovation' can be considered as renovation that leads to significant (typically more than 60 %) efficiency improvements."*

made through refurbishing existing buildings. Applying IES solutions, which can be used in similar buildings in comparable circumstances may accelerate the renovation rate of current buildings. Nowadays, this rate varies from 0.4% to 1.2% in the EU (renovation as % of total building stock) (European Commission, 2019).

2.1.3. Sudden versus gradual transformation

IES solutions can be installed in existing buildings at once, but it is also possible that individual IES components are installed over time, one after the other. The advantage of an immediate upgrade is that energy services and savings can be realised at full potential, although this requires relatively high initial investment costs. The gradual approach has the advantage of spreading costs over time, albeit often with lower immediate energy saving gains. An example of a gradual approach is the mandatory (by law) accumulation of funding for maintenance of buildings by associations of building owners in the Netherlands. According to this law, an owners association annually reserves funding for maintenance, based on a multi-year maintenance plan (Rijksoverheid, 2020b). For specific buildings, a viable strategy could be to implement some cost-effective and more shallow renovations to extend the lifetime of the building up to the point where it is demolished and completely replaced in line with the latest building codes and standards on energy performance, including consideration of IES.

2.2. IES success factors

Over the past decades, a range of technological and operational advancements have been made in designing and implementing optimised packages of energy technology options for different building types. A series of (EU) research projects[5] and further developments in the industrialization and standardization of building methods contribute to these advancements. From this experience, lessons can be distilled in terms of:

- What are viable approaches to address barriers to IES implementation, such as technical and financial obstacles?
- How to organise IES design and planning so that the eventual IES solution meets the energy demand and preferences of the end-users?
- How to mitigate risks and uncertainties regarding IES implementation, such as development of energy prices and policies?

Below, these lessons are further elaborated. In the next chapter, the analysis of these factors will be extended with evidence from the Polish and Dutch case studies.

2.2.1. Identification of barriers to IES and viable approaches to clear these

Based on the research projects mentioned above, barriers to IES implementation can be both technical and non-technical of nature. Technical barriers relate to building design and energy infrastructure characteristics, spatial constraints, practical limitations in relation to installation of a technology, technology compatibility/interoperability, energy balancing, etc. Examples of non-technical barriers are stakeholders' objections to potential IES solutions (e.g. when people are used

[5] Annex I provides an overview of the technology scope of a range of EU funded research projects.

to natural gas and feel reluctant to change), regulatory issues (e.g. existing regulations do not allow a certain IES solution or policies/regulations incentivise a single technology option rather than the integrated combination of technologies), financial/economic issues (e.g. inability to finance initial IES investment, cost-effectiveness of identified technically optimal solutions), and environmental issues.

Sanner (2018), for example, lists a range of technical and non-technical barriers for shallow geothermal in deep renovation and concludes that "technical barriers are deemed to be overcome more easily" but that "dealing with non-technical barriers is less straightforward and needs to address a large number of different aspects." Ebrahimigharehbaghi, Qian, Meijer & Visscher (2020) focus on the importance of 'hidden' or non-financial costs which often stem from "market behaviour that is mainly due to imperfect and asymmetric information" and "consists of search for information, negotiating, and monitoring costs". In an extensive review of barriers to implementation of novel technologies and practices in the built environment, based on a review of 31 EU funded projects covering a wide range of technologies, D'oca, et al. (2018) categorise technical and non-technical barriers as follows:

- **Technical barriers**:
  - A lack of consistent and standardized solutions or integrated solutions to comply with the new and different building standards requirements on energy saving,
  - Lack of skilled workers to carry out the work,
  - Shortcomings in technical solutions and long processes discouraging owners,
  - Safety / seismic risk connected with the deep renovation processes,
  - End users' and owners' lack of technical expertise and trust in effective renovation savings.
- **Financial barriers**:
  - High up-front costs and owners reluctant to borrow funds for energy renovation purposes,
  - Long pay-back times of retrofitting interventions,
  - Lack of confidence of the potential investors,
  - Insufficient and instable available funding,
  - Lack of attractive financing for homeowners with low to medium incomes,
  - Existing financial tools are insufficient and unattractive.
- **Social barriers**:
  - Decision-making processes that are long and complex, especially in cases of multi-owner houses,
  - Lack of consensus, understanding, and support from inhabitants,
  - Disturbance during site works and /or relocation,
  - Low awareness about energy efficiency and non-energy benefits of renovation,
  - Lack of dialogue between different stakeholders.

D'oca, et al. (2018) conclude that "Until now, deep renovation has often been approached as a technological challenge" while "social and financial barriers have been overlooked". They suggest that "new approaches will probably need to integrate technical, financial, and social aspects from the beginning […]."

2.2.2. Clearing social barriers with social innovation

Insights on solving social barriers can be obtained from research on social innovation, which, in the domain of energy transition, generally try to better understand human (i.e. attitudes, values), institutional (i.e. organizational structures and processes) and governance aspects (i.e. strategies and policies) that determine individual and collective decision making. Building on these insights, Hoppe (2018) argues that social innovation helps to find "new ways of collaboration, decision-making, and of mobilizing society", which can involve the development of completely new organisational structures, such as local energy cooperatives, communities or energy service companies in their role of intermediaries, and the reform or repurposing of existing social/institutional structures such as home owner associations (Warbroek, Hoppe, Coenen, & Bressers, 2018).

Voorberg, Bekkers and Tummers (2015) describe social innovation in terms of *"the creation of long-lasting outcomes that aim to address societal needs by fundamentally changing the relationships, positions and rules between the involved stakeholders, through an open process of participation, exchange and collaboration with relevant stakeholders, including end-users, thereby crossing organizational boundaries and jurisdictions."* By placing stakeholders, such as the traditional supply chain stakeholders, but also, and increasingly, the end-users of the building(s), at the heart of the analysis, social barriers can be identified based on feed back from stakeholders, i.e. what are their demands, preferences and what problems do they see with implementing new energy technologies and systems? For IES implementation, these insights are highly valuable as IES systems usually imply a significant change in the way energy is produced, stored and used, with accompanying costs and benefits which need to be valued and balanced.

There are clear indications (Breukers, Van Summeren, & Mourik, 2014) that participation of stakeholders in decision-making on energy systems in a building, such as IES, improves the quality of the system design and enhances the acceptance of users of the system. Essential preconditions for such engagement with end-users are the establishment of clear lines of communication, a structured construction and communications planning and preferably fixed contact points for end-users. Breuker, Van Summeren en Mourik (2014) analysed the communication and engagement processes between suppliers of energy neutral renovation concepts and end-users and found that the main challenge for IES suppliers is to adequately embed these lessons in their day to day operational processes (e.g. an internal 'early warning system' of any (un)expected delays in construction could avoid frustration of end users).

A resident satisfaction survey in the Netherlands (Borsboom, Leidelmeijer, Van Vliet, De Jong, & Kerkhof, 2016) generated the following lessons:

- Promise less and deliver more, in order to avoid underestimation of the construction time for energy measures and, thus, disappointment and frustration with end-users,
- Consider people's financial concerns, especially when end users spend a relatively large share of their income on energy (e.g. energy poverty),
- Consider offering an alternative temporary residence for (some of) the residents, during the construction stage,
- Include executive staff in the project with different backgrounds and disciplines, including technicians, communications experts, etc., for handling technical issues and addressing people's financial and social concerns,

- Support end-users to take an additional step beyond the energy measures that they already take. This step towards the implementation of other energy saving measures (e.g. LED lighting, standby killers, energy efficient fridges and other appliances) could, for example, be stimulated through vouchers,
- Make sure that characteristics and preferences of specific end users are considered in the planning and implementation of measures, as the group of end users may be composed various groups, such as elderly people, single-parent families, young couples with full time day jobs.

In order to capture the above insights into a working model, the Hanze University of Applied Sciences (HUAS), together with TNO, developed a cooperative business model for promoting clean energy solutions in buildings through participatory engagement of citizens (HUAS & TNO, 2019). The model distinguishes different roles and responsibilities, such as producers and distributors of energy, including heat, grid operator and investors. For each role potential stakeholders are identified and attributed in terms of their capacity to provide:

- Funding,
- Technical support,
- Legal expertise, and
- Business operational capacity.

This attribution is dynamic in the sense that, for example, households may have limited capacity in terms of legal expertise or funding, but when united in a citizens cooperative, this capacity can become substantial. Based on the attributed roles and responsibilities of stakeholders the model foresees a range of scenarios with different roles for stakeholders, which then forms a basis for discussion and participatory decision making with stakeholders. This social innovation model is being further developed under the MVI-e project at the Hanze University and is being tested on a participatory district heating project in Groningen (HUAS, 2020). When completed, the model can facilitate participatory decision making with stakeholders in building (retrofit) investment projects.

2.2.3. Handling financial barriers by managing uncertainties in decision-making

The discussion above has illustrated how non-technical issues can determine the success of IES investments in buildings. We discussed potential social barriers and identified viable ways to clear these, thereby tapping into insights on social inclusiveness via social innovation. Another key obstacle to energy renovation or IES implementation success is related to funding, and in particular the uncertainty about costs and returns on investments. For example, Matschoss, Heiskanen, Atansiu & Kranzl (2013) refer to “genuine uncertainties regarding cost-effectiveness” of energy efficiency investments in the built environment as a potential barrier to taking energy investment decisions. They indicate that “there is often conflicting information on the costs and benefits of energy efficient or renewable energy solutions in buildings” and that “there may be uncertainties concerning measurement and verification of energy savings, which can be a concern particularly for external financiers of energy efficiency investments.” The issue of cost-effectiveness relates not only to the expected/deemed or real energy savings, but also to the financial savings on future energy and building maintenance costs resulting from the investment. This issue is particularly challenging in a building setting with multiple and/or heterogeneous end-user groups. Based on this and other publications, this issue could be resolved by a minimum level of energy saving performance to be guaranteed by technology providers. Not only would that address end-user’s uncertainty, it would also provide extra guarantees to potential external financers.

However, while there is widespread use of contracts and warranties on the technical functioning of specific IES components and appliances (e.g. on durability of parts), the use of energy service or energy performance contracts is still a relatively new phenomenon within the building and construction sector in Europe. The concept of 'energy performance contracting' was first defined in the 2012 Energy Efficiency Directive (2012/27/EU) as "a contractual arrangement between the beneficiary and the provider of an energy efficiency improvement measure, verified and monitored during the whole term of the contract, where investments (work, supply or service) in that measure are paid for in relation to a contractually agreed level of energy efficiency improvement or other agreed energy performance criterion, such as financial savings" (European Parliamant and the Council, 2012).

The Directive refers to a set of minimum items to be included in energy performance contracts (European Parliamant and the Council, 2012, p. Annex VIII).[6] Since the publication of the Directive a range of EU-funded (research) projects have focussed on enhancing the EU markets for energy service companies, further uptake of energy service contracting and mechanisms for de-risking investments in energy efficiency measures in buildings.[7] Key terms and conditions of such contracts include aspects such as price/costs ratios, duration of the contract and warranties, guarantees about the financial and/or energy savings as well as the monitoring and enforcement of the contract.

An assessment on the first experiences with energy performance contracts for Dutch 'zero-on-the-meter' renovation projects (i.e.. net zero energy consumption) (Borsboom, Leidelmeijer, Jacobs, Van Vliet, & De Jong, 2015) highlights a range of key success factors for no-net energy consumption performance, including:

- The quality of the renovated building and energy system must be optimal,
- Good and clear arrangements over performances, terms and conditions and responsibilities are needed,

[6] Minimum items to be included in energy performance contracts with the public sector or in the associated tender specifications

- Clear and transparent list of the efficiency measures to be implemented or the efficiency results to be obtained.
- Guaranteed savings to be achieved by implementing the measures of the contract.
- Duration and milestones of the contract, terms, and period of notice.
- Clear and transparent list of the obligations of each contracting party.
- Reference date(s) to establish achieved savings.
- Clear and transparent list of steps to be performed to implement a measure or package of measures and, where relevant, associated costs.
- Obligation to fully implement the measures in the contract and documentation of all changes made during the project.
- Regulations specifying the inclusion of equivalent requirements in any subcontracting with third parties.
- Clear and transparent display of financial implications of the project and distribution of the share of both parties in the monetary savings achieved (i.e. remuneration of the service provider).
- Clear and transparent provisions on measurement and verification of the guaranteed savings achieved, quality checks and guarantees.
- Provisions clarifying the procedure to deal with changing framework conditions that affect the content and the outcome of the contract (i.e. changing energy prices, use intensity of an installation).
- Detailed information on the obligations of each of the contracting party and of the penalties for their breach.

[7] A range of EU funded projects, like Transparense on Increasing the transparency of energy service markets (2013-15), EPC Plus on Energy Performance Contracting Plus (2015-18), guarantEE on Building energy services in Europe (2016-19), AmBIENCe on active managed buildings with energy performance contracting (2019-21) and EEnvest on Risk reduction for building energy efficiency investments (2019-22).

- Monitoring of the performance of the building, installations and overall energy performance is important,
- Take note of the heterogeneity of energy use in energy efficient buildings,
- Guidance and instructions regarding use and maintenance must be very clear,
- Promoting energy efficient behaviour and providing feedback on the (quantitative) effect of such behaviour is highly recommended,
- Quick intervention when start-up phase issues arise is needed, to avoid (too) high energy use and end-user disappointment/discomfort,
- Ensure continuity for long-term service and warranty arrangements.

An important condition for an IES provider to offer energy performance guarantees to end-users is that a robust energy management system (EMS) is installed that can be remotely monitored and controlled. Without that, proper aftersales troubleshooting, maintenance, and servicing is difficult to perform; but it also contributes to solving issues in case of future disputes about system performance. This is especially relevant in relation to behavioural aspects of the end-user. Placement of additional (movement) sensors (e.g. window/door use) or 'sub- or intermediate meters' or data loggers to explain any differences between expected (contracted) energy performance and the real monitored performance can avoid such problems (Borsboom, Leidelmeijer, Jacobs, Van Vliet, & De Jong, 2015). Moreover, a good and accurate integration of the (remote) control, and data logging systems of each individual system component (e.g. controllers of solar pv, heat pump, BTES, heat buffer, and other appliances) are required. In addition to these conditions, IES systems that feed unused electricity into the grid must comply with European and national technical requirements, such as the Dutch grid code electricity up to 0.8 KW (Netherlands Government, 2020) or the EU regulation for larger scale delivery (European Commission, 2016).

2.3. Key elements of IES good practice

In this chapter, we have discussed a range of potential barriers to IES implementation, as well as enabling actions to clear these. Barriers have been categorised in technical, social, and financial barriers to clearly characterise and analyse these and suggest, based on literature sources, enabling actions. Referring to social innovation literature, we have identified viable ways to include people as end users in IES design and implementation in the buildings that they use and/or live in. Regarding finance barriers we have considered ways to reduce financial uncertainties both for the providers of IES solutions and users (including their financers). It has become clear that for a successful implementation, any IES concept has to be technologically sound, but at the same time must be accompanied with other services and agreements that reduce/mitigate the non-technical social and financial barriers to a minimum.

Following the above reasoning, successful IES concepts or IES business models contain the following key elements:

- **Technical**:
    - It offers an integrated technology package (meeting specific needs and preferences of users) that can be tailored to specific building types,
    - It has robust building and energy system performance monitoring and performance contracting.

- **Social**:
    - It includes active and structured stakeholder engagement procedures, also targeting end-users, whereby end-users are not used as 'sound boards' but invited to actively partake in design and decision making,
    - It provides robust and targeted information and pays attention to communication management, thereby avoiding overstating the expected IES performance,
- **Financial**:
    - It gives independent financial guidance, advise, and/or solutions,

Translating these lessons into a decision-making process, the following steps can be identified Figure 2:

- Identify the energy needs and other preferences of the building users,
- Co-design IES solutions with engagement of technical experts, financial experts and users/consumers,
- Consider business and operational models for financially feasible and socially acceptable IES investments,
- Establish robust building energy performance monitoring, and
- Prepare for implementation and evaluation.

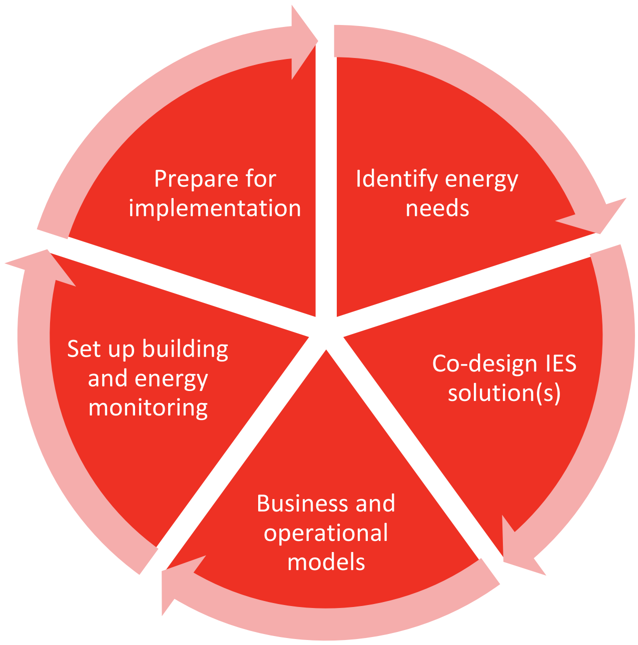

Figure 2. Decision model for co-design of IES solutions for buildings

3. IES Good practices in Poland and the Netherlands

Further to the discussion in Chapter 2 on aspects of implementing IES in buildings, based on a literature review, in this chapter we will focus on practical cases of applying IES solutions. The cases are situated in Poland and the Netherlands (two case studies each) and are analysed in terms of whether and to what extent in these cases technical, economic and social aspects of IES projects have been considered in conjunction. For both countries, we briefly describe the country/regional contexts, followed by a detailed description of real-life projects, and concluded with lessons learned.

3.1. Poland

3.1.1. Regional context: Pomerania region, Poland

The Pomeranian Voivodeship is in northern Poland and covers an area of 18,310 km², of which forests cover over one third and arable land over 50%. The region's population amounts to 2.3 million persons (2019).

Energy for heating buildings

Heating of buildings is mainly based on coal, although there are striking differences in coal use between urban and rural municipalities. In urban communities, about two thirds of heating energy originates from coal, including coal used as the dominant fuel in district heating systems; in rural communities the share of coal is about half. In these communities, biomass (wood) contributes to about one third of heating energy. The share of natural gas in heating energy amounts to about 20% in urban communities and 10% in rural communities. The share of coal in the figure below takes into account coal used both in district heating systems and as end-use fuel.

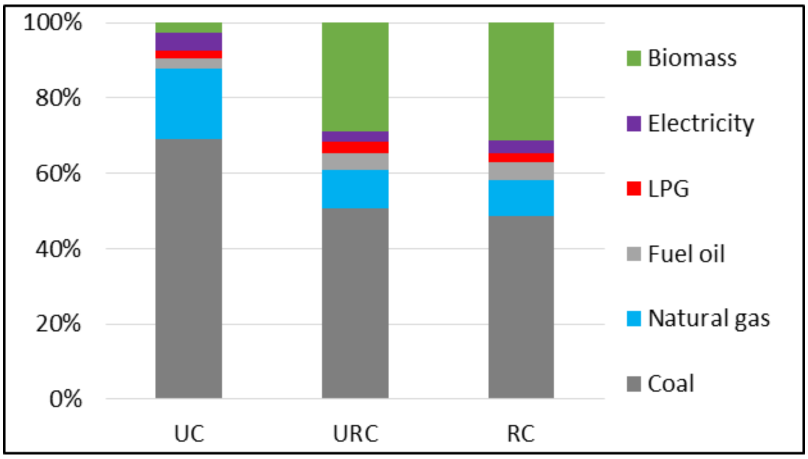

Figure 3: Energy carriers and fuels used for heating of buildings in different types of municipalities (% of total)

*UC – urban commune; RC – rural commune; URC – urban-rural commune.

Source: Main Statistical Office and BAPE's own analysis (2019 data).

Overall, most solid fuel (coal- and wood-fired) boilers and stoves are characterized by low efficiency and high emissions, especially during ignition. This results in smog formation (including PM_{10} and $PM_{2.5}$, soot, and benzo(a)pyrene). The average seasonal efficiency of coal stoves can be estimated at 50% and of individual old-type coal boilers at 55% (Hlawiczka, S. at. al., 2011). Modern solid fuel boilers have a much higher seasonal efficiency of over 75%. Network heat, supplied from heating plants and CHPs, has an efficiency of over 80%. This means that replacing old, inefficient heat sources could result in over 30% savings in heating energy demand.

The demand for heat power in the Pomeranian voivodeship is about 7,800 MWt (BAPE, 2018). The largest demand is in the main cities, like the Tri-City area (Gdańsk, Gdynia, Sopot). Residential buildings have a major share in the heat demand of buildings (over 75%) (Figure 4). The share of public buildings, whose energy efficiency is affected by municipalities, is over 9%. Communes are active in the thermo modernization of communal buildings, financed by external funds.

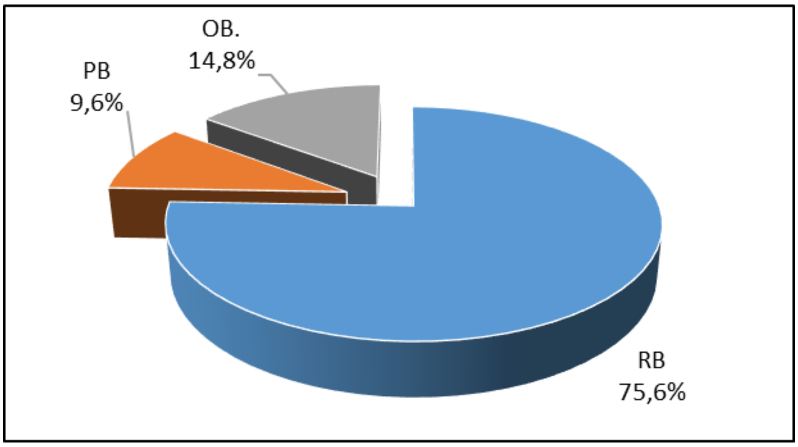

*Figure 4: Share of different types of buildings in heat demand (%) in Pomerania**

*RB: residential buildings; PB: public buildings; OB: other buildings.

Source: Main Statistical Office and BAPE’s own analysis (2019).

Renewable energy

Pomerania has very favorable natural conditions to produce renewable energy with a high potential of biomass and favorable wind and solar conditions. Investments in renewable energy sources are mainly carried out with support of subsidies from EU funds and special loans. According to the applicable Renewable Energy Sources (RES) law, consumers that generate electricity by using micro installations might deliver surplus energy to the grid for future own needs. As such, the Act can be considered as an incentive for homeowners to generate renewable energy for own needs. In 2019, in Poland approx. 149,000 consumers delivered surplus energy to the grid, three times more than in 2018 (Urząd Regulacji Energetyki, 2020). The RES Act also enables the creation of energy cooperatives. These prosumers can ‘store’ surpluses in the power grid and reclaim 70-80% later depending on the size of the generator.

Experience with RES financing in Pomerania region

Most investments in renewable energy sources have been and are carried out with the support of dedicated financing sources such as subsidies and special loans, such as:

- Regional Operational Programmes for Pomerania Voivodeship 2007-2013 and 2014-2020,
- Infrastructure and Environment Operational Programme 2007-2013 and 2014-2020,
- EEA and Norway Grants,
- Swiss Contribution,
- Programmes implemented by the National Fund for Environmental Protection and Water Management,
- Programmes implemented by the Voivodeship Fund for Environmental Protection and Water Management in Gdańsk, and
- Pomeranian Loan Fund (ESIF and state funds).

A total of 349 RES installations were identified under 138 projects (some projects cover several installations, sometimes of various types). Collective data of the identified renewable sources are summarized in Table 2. The results (renewable energy production) of RES projects financed by the Regional Operational Programme in the period 2007-2020 are given in Table 3.

RES type	parameter	unit	
Solar collectors	surface	m^2	1 418
Heat pumps	capacity	kW	4 392
PV	capacity	kW	1 952
Wind turbines	capacity	kW	12
Biomass boilers	capacity	kW	2 253

Table 2: RES installations supported between 2007-2016 in Pomerania

Source: BAPE (2018).

RES technology	Energy production MWh/year
Solar collectors	14 093
Heat pumps	13 884
Biogas CHPs	12 803
PVs	13 757
Wind turbines	10
Biomass boilers	20 832
Small hydro	0
Total	**75 379**

Table 3: Results of RES projects financed between 2007-2018 in Pomerania by the ROP
Source: BAPE *(2018)*.

At the end of 2019, the capacity of PV power plants in Poland was almost 1.3 GW, of which as much as 950 MW were micro-installations. Simultaneously, a decrease in RES installation costs could be observed resulting in average cost of relevant RES installations by the end of 2019 of:

a) 3 kW installation – 5 400 PLN/kW (tax incl.) – approx. 1250 EUR/kW,

b) 10 kW installation – 4 200 PLN/kW (tax incl.) – approx. 975 EUR/kW,
c) air-to-air heat pump 1500 PLN/kWt (tax incl.) – approx. 350 EUR/kW,
d) air-to-water heat pump 2500 PLN/kWt (tax incl.) – approx. 580 EUR/kW,
e) solar collectors 2500 PLN/m^2 (tax incl.) – approx. 580 EUR/m^2.

Financial support for residential building owners

The call for applications from the National Fund for Environmental Protection and Water Management Programme 'My Electricity' is open from 13 January 2020 through 31 December 2020, with a total budget of PLN 1 billion. Under the programme grants can requested up to 50% of eligible costs, with a maximum amount of PLN 5,000 for the purchase and installation. Natural persons who generate electricity for their own needs are eligible to apply for the funding. Under the programme, it is allowed to build 2-10 kW PV installations for the needs of existing residential buildings. Subsidies granted under this programme can be used for income tax exemption, i.e. taxpayers are not required to include the funds received in their annual tax report.

The Clean Air Programme has been implemented since September 2018. It includes subsidies and loans granted to owners of single-family houses with a maximum of PLN 53,000 and a minimum of PLN 7,000. Support may be granted for the following projects: heat exchangers, heat pumps, condensing gas boilers, oil boilers, electric heating, solid fuel boilers meeting the requirements, thermo-modernization works and RES installations. The amount of subsidy granted depends on the household income. It can be expected that subsidy levels will be linked to the environmental effect and the Clean Air programme will take into account the low-carbon and renewable bonus, promoting investments that are zero-emission solutions while enabling CO_2 reduction. The highest possible levels of co-financing concern investments that are optimal from the point of view of air-climate goals, such as installation of heat pumps and PV. In addition, changes are planned to simplify the procedures in the programme regulations as the number of successful applications is much lower than expected.

Financial support for entrepreneurs

A loan from the Regional Operational Programme for the Pomerania Voivodeship 2014-2020 is available for entrepreneurs, local government units and organizations conducting economic activities, with preferential terms covering 100% of investment expenditures. The loans budget is approximately Euro 13 million (PLN 57 million). Preferential interest rates (from 0,25%) are available to investors who meet the preference criteria with de minimis aid[8] or aid provided for in Articles 40, 41 and 49 of GBER (General Block Exemption Regulation). The maximum renewable energy loan amount is approximately Euro 3.5 million (PLN 15 million) with a repayment period of up to 15 years (PFP, 2020).

RES legal framework

The most important legal acts regulating investment activities in RES area include: 1) the Energy Law, 2) the Construction Law, and 3) the Act on renewable energy sources.

[8] De minimis aid refers to small amounts of state aid to undertakings (essentially companies) that EU countries do not have to notify the European Commission about. The maximum amount is EUR 200 000 for each undertaking over a 3-year period.

The *Energy Law* sets out the principles for shaping the State's energy policy, principles and conditions for supply and use of fuels and energy (including heat) as well as activities of energy enterprises. It also defines authorities competent in matters of fuel and energy management. As a rule, the head of the commune (mayor, city president) is responsible for the preparation of a document called *Assumptions for the plan for the supply of heat, electricity and gas fuels* (hereafter: Energy Plan). After this is approved by the voivodship self-government and public consultations, the commune council adopts the Energy Plan, which includes an assessment of the current state and anticipated changes in the commune's demand for energy and fuel carriers, energy efficiency issues and the use of local energy resources, including renewable ones. The Energy Plan complies with the provisions of local law in the field of spatial development planning, taking into account local development as well as environmental requirements.

The *Construction Law* regulates activities concerning design, construction, maintenance, and demolition of building structures and it defines the principles of operation of public administration bodies in these areas. It sets out conditions of thermal insultation that newly constructed buildings must meet and recommends the use of renewable energy sources in new buildings. In case of the public sector, it is also required to investigate feasibility of using RES in buildings undergoing reconstruction.

Changes in the Construction law (that entered into force in 2017) significantly tightened technical conditions for obtaining a building permit. The key update involved limiting the maximum rate of the building's demand for non-renewable primary energy. Thus, in order to fulfil the required criteria, investors will have to take into consideration implementation of RES and/or IES.

The *Act on renewable energy sources* regulates:

1) rules and conditions for carrying out activities in the field of manufacturing:
    a. electricity from RES,
    b. agricultural biogas in renewable energy installations,
    c. bioliquids,
2) mechanisms and instruments supporting production:
    a. electricity from RES,
    b. agricultural biogas,
    c. heat in renewable energy installations,
3) rules for issuing guarantees of origin for electricity generated from RES in renewable energy installations,
4) rules for implementing the national action plan on energy from renewable sources,
5) conditions and procedures for certifying installers of micro-installations, small installations and installations of RES with a total installed thermal power up to 600 kW as well as accreditation of training organizers, and
6) rules of international cooperation in the field of renewable energy sources and joint investment projects.

3.1.2. Analysis of IES good practice examples: Pomerania region

Identifying already implemented IES concepts or solutions has not been an easy task. The vast majority of buildings is heated with conventional sources. In rural areas, beyond the reach of district heating and natural gas grids, biomass heating is well established. Other renewables like solar thermal collectors, PV panels or heat pumps are used randomly and treated as supplementary to the other main heat sources. Where applied, renewable energy solutions are mostly used in individual stand-alone settings. Nevertheless, more and more attention is being paid to the possibility of integrating solutions for heat and electricity generation in single-family buildings, the so-call ‘hybrid’ solutions.

In small towns and rural areas, in addition to the natural gas and district heating networks, it is mostly recommended to install heat pumps in combination with solar PV (for the electricity needs of the heat pumps). It is also typically proposed to use RES-based electricity to feed the electric heater in a domestic hot water heating installation. Surplus electricity can also be ‘stored’ in the power grid and restored in 70% (in case of RES of up to 10 kW) or 80% (RES with installed capacity between 10 and 50 kW). Micro-installations (up to 50 kW) are connected to low voltage distribution grids and have an impact on the balancing of the network by a given distributor. An increase in dispersed generation has a positive impact on grid performance during periods of Summer peak demand and no restrictions on new connections are expected in the nearest future. However, in the longer run the introduction of generation control, like demand side response (DSR) and grid monitoring and controlling will be necessary. This will change the landscape of which solutions are feasible, as free grid storage will no longer be available.

These types of solutions are most often used in new single-family buildings. In case of existing buildings, a change in the heating system supplied from a traditional boiler room is often associated with the reconstruction of central heating installation, which results in higher modernization costs and is also more troublesome for residents.

New multi-family, public and commercial buildings shall, by law, primarily be heated from district heating or renewable sources. In practice, when natural gas is not available, biomass heating or heat pumps are installed. In light of the widespread anti-smog regulations, use of coal shall not be considered. In existing multi-family buildings, basic solutions to reduce heat losses are used, such as improving a building's thermal parameters, its internal installation efficiency and utilising solar collectors or PV installations on the roofs (Zaborowski, 2018). In the Pomeranian region there are examples of investments for improving the energy efficiency of public buildings with the use of heat pumps combined with PV, as well as the use of CHP, solar collectors, and PV installations. Another solution is integration of a ground heat pump with a ventilation system and a PV installation. However, implementation of these solutions is still rare and usually takes place in modern office buildings that require mechanical ventilation.

Either in the Pomerania region or in the rest of the country there are only a few examples of truly IES solutions in the modernization of existing multi-family buildings. This is an indication that the IES market in Poland is still rather underdeveloped. IES investments thus far have been mainly supported by the National Fund for Environmental Protection and Water Management. The implementation of the programme in the Pomeranian Voivodeship was carried out by the Voivod Fund for Environmental Protection and Water Management in Gdańsk, as part of the prosumer programme.

Below some IES examples identified in Pomerania region and other parts of Poland are discussed in further detail.

Case 1: Pomerania voivodeship, Sztum poviat, Stary Targ commune, Zielonki

Figure 5: Sztum poviat, Stary Targ commune, Zielonki

Source: http://www.rynekinstalacyjny.pl/aktualnosc/id8795,panele-fotowoltaiczne-i-pompy-ciepla-realizacje-w-budynkach-wielorodzinnych

In Table 4, basic information about the IES good practice Sztum poviat building is provided.

Type of the building	Residential (housing association)
Total building area (m^2)	850
Modernization year	2015
Modernization purpose	reduction of energy costs
Before modernization	originally a coal boiler, then biomass boiler (straw)
After modernization	ground-source heat pump with capacity of 60 kW (16 wells with depth of approx. 100 m each, located next to the building) + 10 kW PV installation (37 PV modules with 270W unit power)
Utilization of electricity produced	as prosumer (for own needs and a periodic excess is fed into the power grid)
Investment costs	410.000 PLN (approx. 95.000 EUR)
Financing	Voivod Fund for Environmental Protection and Water Management in Gdańsk and own sources

Table 4: Basic information on IES in Case 1

In this case, the investment decision was made due to high energy prices imposed by its suppliers and with the goal to protect the environment. The change in the heat supply system was made together with the thermal modernization of the building. The PV installation works in the on-grid system. The decision-making process by the involved stakeholders strongly depends on the form of ownership and administration of residential buildings. In this case, it is a condominium (housing association), which is created by virtue of the law and which consists of all owners of dwellings. A housing association supervises common elements of real estate, which applies to land (under the building, green areas, playgrounds, parking lots), common parts of the buildings (in this case staircase, storage chute, attic), external elements (roof, facade, trash) and installations and equipment (central heating, plumbing, chimneys). The association bears responsibility for the repair, use and renovation of these common areas, and its members are charged with the associations' costs in proportion to their premises.

Each resident of the association has the right to vote and each vote is 'weighted' depending on the share of the floor area of a given flat. Decisions exceeding the scope of ordinary management are taken by adopting an appropriate resolution by the association members, by a majority of votes counted by shares. In this case, the residents had to undertake the decision on disconnecting from the heat source and installation of heat pump and photovoltaic panels for the building. The building had undergone thermo-renovation before the project was initiated.

The project financing structure was as follows:

- A loan from the Voivod Fund for Environmental Protection and Water Management (WFOŚiGW) in Gdańsk,
- Non-returnable subsidy from WFOŚiGW - 22.3% granted under the programme "Installation of a heat pump with a photovoltaic installation - Prosumer for Pomerania",
- Own sources – 2,5%.

Investment decisions have consequences in increasing the renovation fund monthly rates to cover the repayment of the loan instalments incurred for the investment. However, savings in heat and domestic hot water costs cover loan costs.

Case 2: Pomerania voivodeship, Gdańsk poviat, Cedry Wielkie commune, Cedry Wielkie

Figure 6: Gdańsk poviat, Cedry Wielkie commune

Source: http://arch.wfos.gdansk.pl/wfosigw.gda.pl

Figure 7: Gdańsk poviat, Cedry Wielkie commune; view from the air

Source: https://nowiny24.pl/pompy-ciepla-w-budynkach-wielorodzinnych-czy-to-sie-oplaca-przykladowe-realizacje

In Table 5, basic information about the IES good practice Gdansk poviat building is provided.

Type of the building(s)	12 residential building (the same technology) ("Żuławy" Housing Cooperative, multi-family, three-story, basement)
Total building area (m^2)	6.700 m^2 (550 m^2/building)
Modernization year	2015-2016
Modernization purpose	reduction of energy costs
Before modernization	local coal boiler house with capacity of 1,05 MW
After modernization	40 kW ground source heat pump (10 ground source heat pumps in total) + 19 kW PV installation (79 PV modules with 240W unit power)
Utilization of electricity produced	as prosumer (for own needs and a periodic excess is fed into the power grid)
Investment costs	Not available
Financing	Voivod Fund for Environmental Protection and Water Management in Gdańsk

Table 5: Basic information on IES in Case 2

In this case, there is a housing cooperative, established in 1981, which consists of all residents of the building/settlement with decisions on investments and financial consequences being made by the cooperative's board, on behalf of the residents. The is controlled by the supervisory board of the cooperative. Once a year, a general meeting of members of the cooperative is held, which grants absolution to the management board and may introduce changes to the cooperative's statute.

The Żuławy settlement was heated by its own boiler house. Due to necessity of retrofitting the aging heat source and coping with the high heat price, a possible solution was to switch from coal to renewables. This investment towards this IES was supported by the Voivod Fund for Environmental Protection and Water Management in Gdańsk (WFOŚiGW). Further to advice from the Fund's experts, it was decided to choose individual heating for each house by heat pumps supported by roof PV panels. The decision on launching the project and acquiring financing for the whole project had to be undertaken by the Cooperative members. The investment was finalised in October, 2016. The financing structure offered by the WFOŚiGW included both a soft loan (74%) and a grant (26%). The loan agreement was signed by the Cooperative Board for all buildings of the settlement and it has been guaranteed by the Cooperative assets.

These IES investment decisions imply that the renovation fund rates which tenants pay each month have increased, as they now have to contribute to the Cooperative fund to cover the repayment of the loan instalments incurred for the investment. Energy cost savings achieved allow for covering loan costs.

Case 3: Warmia-Masuria voivodeship, Szczytno poviat, Szczytno City commune, Śląska 12 street

Figure 8: Szczytno poviat, Szczytno City commune, Śląska 12 street

Source: http://www.chronmyklimat.pl/projekty

Similar to case 1 above, this example considers also a housing association, with a comparable decision-making process. It is one of the first buildings in Poland that belong to a housing association undertaking such an investment. The example proves that modern technologies integrated into IES can significantly reduce thermal energy bills. In Table 6, basic information about the IES good practice Szczytno poviat building is provided.

In order to convince the inhabitants to invest in renewable energy sources, the board members of the housing association went for a site visit to another housing association that had installed heat pumps. During the visit, after talks with residents, they became convinced that such pro-ecological activities were the right way forward. Afterwards, the management board representatives talked individually with residents of their housing association and later on they organized two meetings with inhabitants where specialists from heat pump and photovoltaic industry were invited. During these meetings a decision was made to start activities aimed at implementing investments in renewable energy.

Type of the building(s)	residential building, multi-family, five-storey (housing association)
Total building area (m^2)	2.150 m^2, including 1.907 m^2 living area
Modernization year	2014
Modernization purpose	reduction of energy costs
Before modernization	gas boiler house
After modernization	ground heat pumps with a capacity of 120 kW (24 wells with depth of 99m each, located under the playground) + PV installation with a capacity of 39.7 kW (153 pcs of panels with a unit power of 260W)
Utilization of electricity produced	as prosumer (for own needs and a periodic excess is fed into the power grid)
Investment costs	625.000 PLN (approx. 145.000 EUR)
Financing	Voivod Fund for Environmental Protection and Water Management in Gdańsk, bank and own sources
Modernization year	2017 – extension of the previous project
Modernization purpose	reduction of energy costs and improvement of flats safety (elimination of individual gas boilers for hot tap water)
Before modernization	individual gas boilers for hot tap water preparation
After modernization	8 solar collectors, 2 air/water heat pumps of 20 kW each
Investment costs	284 000 PLN (approx. 70 000 EURO)
Financing	Regional Operational Programme and own sources

Table 6: Basic information on IES in Case 3

In 2014, in order to reduce costs of a multi-family building heating, the housing association decided to replace their heating system with ground heat pumps with a total heating capacity of 120 kW cooperating with photovoltaic panels with a capacity of 39.7 kW. Previously, the building was heated with gas (and coal beforehand). The main task of photovoltaic panels is to provide electricity to power heat pumps, while the surplus is transferred to the power grid outside the heating season. The association functions as a prosumer - it not only consumes electricity but also produces it.

The photovoltaic panels and heat pumps are automatically and remotely controlled by the energy management centre. Operation of the installation can be monitored on-line thanks to the appropriate application.

Due to the installation of heat pumps and photovoltaic panels the board of the housing association in Szczytno has already achieved substantial reduction of energy bills for the residents of the building.

Also, in this case the decision on the IES investment was possible thanks to financial support (donation) from the funds of regional Voivod Fund for Environmental Protection and Water Management, in this case in Olsztyn. This action is a part of the *Prosumer programme*.

80% of the investment costs (approx. EUR 125,000) was financed with a loan from the Voivod Fund for Environmental Protection and Water Management (WFOŚiGW) in Olsztyn. 10% of this amount was remitted. The investment brought annual savings in heating costs of approximately EUR 15,000. After the payment of the liability to Voivod Fund, the residents of this building will be able to use the heat for a small fee per m^2 of the apartment area.

Good experiences with implementation of the heat pump system in conjunction with PV installation prompted residents to reach for additional European funds in 2017 to modernize their hot water system.

Figure 9: Szczytno poviat, Szczytno City commune, Śląska 12 street; air view

Source: Thermomodernization of multifamily buildings; Energy Agency of Warmia and Mazuria

Eight sets of solar collectors (cooperating with air-water heat pumps) were installed on the roof. The investment also increased safety of the residents as the much worn out gas hot water heaters were removed. 83% of the investment costs (almost EUR 60,000) was financed with a grant from the Regional Operational Programme.

3.1.3. Discussion on Polish IES good practice examples

Technology

In the three IES cases described above, heat pump technologies replaced heating from gas and coal-fired boiler houses. In all these three cases there was no district heating system (nearby) to which the buildings could be connected. This would suggest that within Poland an IES system including a district heating system is often seen as a competing or default solution to increase the share of renewable energy in the built environment. The better prospects for implementing heat-pump and PV-based IES systems is then in the more remote / rural areas where no district heating system is available. In all the three IES systems discussed also solar panels were used for both heat generation and domestic hot water production (supported by hot water buffer tanks) as well as for lighting of common usable part of buildings, such as staircases and corridors. Seasonal thermal storage has been only introduced in a few experimental buildings, well before implementation stage. The costs of renovation of the exploited heat sources were avoided. The implemented IES system contributes to the reduction of CO_2 emissions from energy systems. It must be noted that all three good practice cases had a good / fair starting position with respect to the quality of thermal performance of the building envelope.

Financial

The decision-making that involves housing communities is a more complicated process than in housing cooperatives. In each case, there are other non-technical aspects like energy poverty and the financial consequences of investment decisions that should be considered. This means that a robust assessment of the costs and benefits must be made by weighing the reduction in operating costs and increasing repair costs in favour of paying off the investment costs.

In none of the three cases described, the investment would not have been implemented without the financial support from financial tools like soft loans and funds.

Social

The form of ownership and administration of residential buildings are a complicating factor in the multi-stakeholder decision-making processes. In housing associations residents have a higher impact on the decision-making process than in the case of cooperatives.

The main factors that stimulate decision making on investments in IES include:

- reduction of energy costs for end-users, including operation and maintenance costs,
- improvement of internal comfort,
- the possibility of obtaining attractive investments financing, and
- financial consequences for residents in relation to the renovation fund paid monthly.

3.1.4. Lessons learnt from Polish case studies

From the above case studies, the follow set of lessons can be distilled:

1 The main factor for increasing interest in the modernization of heating systems, such as with IES solutions, is the possibility to reduce high heating costs.

2 Financial support for investments in IES is a key incentive in the decision making process. Additional factors encouraging such projects are improvement of thermal comfort and dealing with environmental issues.

3 The decision-making process depends on the ownership structure of the buildings and is different for condominiums, housing cooperatives or communal housing. Usually, this is a complex and time-consuming process. There are concerns among residents about the choice of the technology, whether new solutions function properly, means of acquiring funding and repayment of financial obligations. The widespread promotion of good practice examples can help to alleviate these concerns.

4 Regardless of the building's ownership structure, additional burdens resulting from additional financial obligations are borne by end users, i.e. residents. Thus, it is advisable that the energy cost savings resulting from the implementation of the investment should not be lower than the new financial obligations. Only in case of communal buildings, the municipality may decide to cover some or all investment costs without any additional consequences for residents.

5 The foremost promoter of new technological solutions should be the state equipped with resources for broad educational campaigns, followed by municipal officials, energy advisors, designers and technology suppliers.

6 There is usually no debate on options/variants of innovative technical solutions in the public forum, e.g. among residents of a housing association. Discussion and decision making (e.g. voting) concerns specific technologies and proposed solutions. It is advisable to establish cooperation with stakeholders at an early stage of the investment design in order to present different solutions and discuss consequences related to each option.

7 Building relationships with stakeholders in the current COVID-19 era is much more challenging. So far, the meetings of residents have been held in traditional ways and it will take time to adapt and change some regulations and procedures. Inhabitants avoid contacts in the form of personal meetings and while remote contacts will become increasingly important, not

everyone is prepared for such changes. There is a lack of worked out patterns of action, incentives for the use of Internet tools for purposes other than personal communication or remote learning. This factor has to be taken into account in future developments.

8 Investments in IES without external co-financing were not identified in the case studies. Decisions on co-financing projects - to improve energy efficiency and implement renewable energy sources - from public funds are made on the basis of call for proposals. Financial support is rewarded to projects with the best energy, ecological and economic parameters resulting from energy audits and/or feasibility studies.

3.2. The Netherlands

3.2.1. Country context

In 2019, the number of residential buildings in the Netherlands amounted to 7.9 million, of which 58% were owner-occupied homes and 42% rental properties (CBS, 2020). The number of non-residential buildings (for offices, industries, etc.) amounted to 1.1 million. During the past decades, the share of houses with different types of insulation has gradually increased (Figure 10). This increase was mainly due to the construction of new houses, but insulation facilities have also been installed in many existing homes, especially in the social rental sector. In 2018, about 85% of the houses had double glass and rooftop insulation, over 70% floor insulation and over 60% floor insulation. Overall, owner-occupied homes tend to be more often insulated than rental properties: 80% versus 73% (CBS, PBL, RIVM, & WUR, 2020).

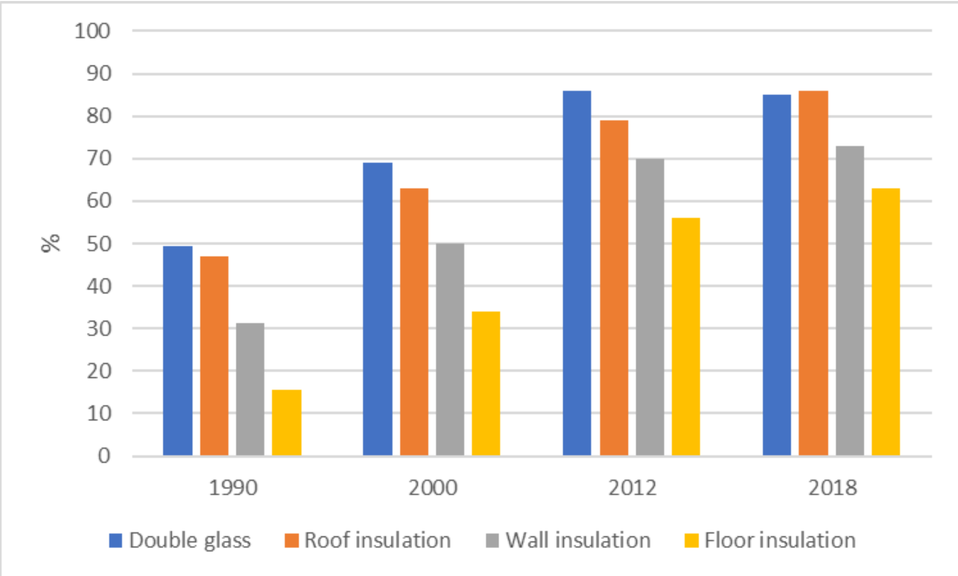

Figure 10: Insulation of houses in the Netherlands, 1990-2018 (% of total)*

*) In these data, no distinction is made between the thickness or quality of the insulation.

Source: (CBS, PBL, RIVM, & WUR, 2020).

Energy consumption by households

Energy consumption by households in the Netherlands refers mainly to natural gas (Table 7). Since the 1990s gas consumption gradually decreased due to the insulation of homes and the transition to high efficiency gas boilers. The use of renewable energy by households is still rather low but increasing because of the use or heat pumps and solar water heaters. After an increase in the years 1990-2010, the electricity consumption by households slightly declined in recent years.

	'1991' *	**'2000'**	**'2010'**	**'2017'**
Total energy consumption (PJ)	462.9	461.2	471.7	408.8
1990=100	100	100	102	88
	As % of total consumption			
Natural gas	81.2	78.9	75.8	71.1
Electricity	12.6	15.6	17.5	18.8
Renewable energy	2.9	3.2	4.0	6.8
Heat	1.1	1.6	2.3	3.0
Coal and coal products	0.1	0.0	0.0	0.0
Petroleum raw materials and products	2.1	0.7	0.4	0.4

*Table 7: Energy consumption by households in the Netherlands, "1991"-"2017" **

* 1991' data = three yearly average of 1990,1991 and 1992, etc.

Source: CBS-Staline (2019); adapted for the table by JIN.

Greenhouse gas emissions in the Netherlands in 2018 amounted to 188 MtCO_2-eq., which were 15% lower than in 1990 (Rijksoverheid, Emissieregistratie, 2020a). Buildings account for about 15% of total emissions. The decrease in GHG emissions from buildings in the period 1990-2018 of almost 20% is slightly above the decrease in total Dutch emissions.

Key policy developments affecting the built environment

The Netherlands government aims to reduce the country's CO_2 emissions in 2030 by 49% relative to 1990 level. In the National Climate Agreement (Klimaatakkoord, 2019) business, societal stakeholders and governments agreed upon measures to achieve this goal. The measures are structured around different sectors, including the built environment.[9] Besides emission reduction, the agreement also refers to the planned cessation of gas production from the massive onshore Groningen gas field in the northern part of the Netherlands. This cessation is related to the frequent earthquakes in the Groningen area, due to natural gas exploitation. To maintain a balance between energy security of supply, the costs of energy and energy import dependence on natural gas, some sectors, including the residential sector, are scheduled to be disconnected from the supply of low-calorific natural gas.

Key ongoing policy processes for the built environment induced by the National Climate Agreement are the design of Regional Energy Strategies (RES) and Transition Visions Heat (TVH). The RES have to result in an annual production of 35 TWh solar and wind energy on land from 2030, while the TVH have to indicate plans for the insulation of buildings and phasing out the use of natural gas at the local level. The RES divide the Netherlands in 30 sub-regions where relevant stakeholder groups (including local governments, energy network companies, societal partners, local citizens, and

[9] The sector built environment includes measures targeting, I) the rental sector, II) private homeowners, III) utilities, IV a support programme for homeowners, V) programmes aiding neighbourhood oriented transition approaches, VI), regulatory programme on sustainable heat and market reform, VII) a programme targeting cost reductions in the building & construction sector, and VIII) a nationwide financing and fiscal support programme.

private companies) are asked to decide on its regional solar and wind energy production aim and to co-develop a strategy for achieving that aim that is fitting and acceptable for the regional stakeholders[10]. The process of developing local TVH plans is governed at the municipal level. The TVH contribute to the Climate Agreements' goal of at least 1.5 million sustainable buildings in 2030. All Dutch municipalities must submit a TVH plan by the end of 2021, in which they indicate how many residential and other buildings are planned to be insulated and made natural gas free until 2030. In the TVH, it is also indicated which districts and neighbourhoods are dealt with first and which future energy alternative is considered. TVHs are based on a dialogue with a broad range of local stakeholders, including real estate owners, residents, and energy network companies. After the TVHs have been accepted, more detailed 'district implementation plans' ('wijkuitvoeringsplannen') for each district, street or area within the municipality will be determined.

Moreover, as per January 2021, all newly built buildings in the Netherlands must comply with the standards set by BENG, which aims at 'nearly energy neutral buildings' (BENG is the acronym for this phrase in Dutch), both dwellings and utility buildings. The BENG standards are the results of incorporating the EU Energy Performance of Buildings Directive (EPBD) (RVO Netherlands Enterprise Agency, 2020). Criteria for assessing the energy performance of buildings under BENG are: a maximised energy consumption (in KWh/m^2/jr); a maximised use of fossil fuels (in KWh/m^2/jr); and a minimum share of renewable energy sources in the building (in %). As examples for inspiration, the Netherlands Enterprise Agency RVO has published possible solutions for both residential dwellings and utility buildings, which are different types and use different (renewable) energy sources. When combined, these solutions can form IES applications in order to comply with BENG indicators.

Subsidies for homeowners

Over the past years, subsidies and other incentives were used to reduce the GHG emissions from residential buildings. Among these were subsidies for insulation of houses and energy systems (such as the Home Energy Savings Subsidy (SEEH) and Sustainable Energy Investment Subsidy (ISDE)) at national level and specific subsidies at municipal level. Similar subsidies will remain in force in the future as per the Dutch National Climate Agreement.

In addition, a heat fund is also being created with financing options for making houses more sustainable. Lately, a netting scheme for energy generation has been applied. This means that the power supplied to the electricity grid may be offset (netting) against the electricity taken from the grid. For every kilowatt-hour of electricity that is supplied by a household to the grid without being netted, the energy company pays a compensation which is lower that electricity consumption price. However, the government intends to gradually phase out the netting scheme between 2023 and 2031. The reason for this is that solar panels have become increasingly more efficient and cheaper over time, which means that the payback period has become much shorter. Moreover, with more solar PV systems installed on rooftops, it becomes increasingly expensive for utilities to absorb the costs of netting. Another aspect of this consideration relates to behaviour, as netting does not stimulate consumers to optimise their electricity consumption based on power supply from the sun. After all, without netting, a household would use its electric appliances, such as a dish washer,

[10] For an overview of the (draft) RES strategies that are already published see: https://www.regionale-energiestrategie.nl/bibliotheek/res++media/1571136.aspx?t=Concept%2DRES%2Dper%2Dregio

during peak solar radiation hours, and minimise electricity consumptions elsewhere during the day. The netting enables people to continue with their conventional behaviour as electricity surpluses and deficits will be balanced (netted) via the grid connection.

The perspective of homeowners

Home owners have broadly three strategies in the transition to energy neutral buildings: they can act pro-actively, they can wait until the municipality starts activities in their district, or they can wait and do nothing until they are legally obliged to act. If homeowners decide to pro-actively undertake insulation of their homes and install IES, they have broadly three options (Figure 11): all-electric, collective heating systems and renewable gas-based options.

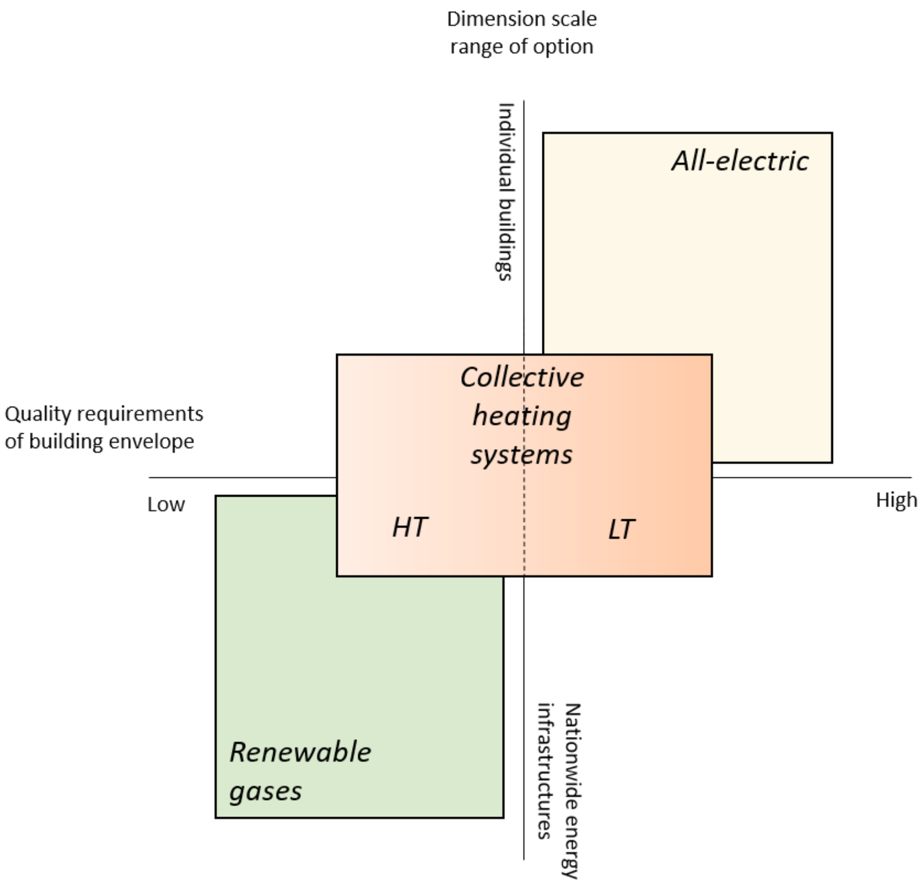

Figure 11: Primary alternative heat supply options within the Netherlands
Source: own illustration JIN.

The first ‘all-electric’ IES option generally involves a high level of thermal insulation combined with heat pumps and solar energy. These systems are generally more flexible in terms of application scale and are often implemented as building-specific systems. The second option revolves around collective heat supply systems, that target an entire housing block, street, or district. These systems can also be fuelled by heat pumps and can either be operated as a high- (HT), mid- (MT), or low-temperature (LT) system. HT collective heating systems places lower requirements to the (insulation) quality of the building envelope, in comparison to a LT system which requires a high-level of insulation. The third option involves the introduction and usage of renewable gases, such as biogas, green gas, or hydrogen that can be supplied through the existing (possible refurbished) gas grids.[11] While this latter solution would require some changes to be made to the gas distribution and gas use infrastructure (e.g. piping, burners, and appliances), it would allow to keep relying on an HT heating system with a lower need for a high level of thermal insulation.

Housing cost neutrality

As explained above (the case of BENG), newly built buildings must be nearly energy neutral and gas free. Therefore, the main challenge in the transition towards sustainable buildings relates to the refurbishment and upgrading of the existing building stock. As a condition for that, the National Climate Agreement states that a transition towards sustainable residential buildings should be 'cost neutral' for homeowners or tenants. This could be realized if the savings on the monthly energy bill compensate the costs of the investment in insulation and an energy system for homeowners or the increase in rent for the tenant. However, recent estimates by (Schilder, 2020) show that housing cost neutrality is hardly feasible for homeowners of terraced houses. It appears that the monthly repayment on a 30-year loan for the sustainability investments exceeds the savings on the monthly energy costs for most of these owners. For realizing housing cost neutrality, Schilder (2020) argues that the current insulation subsidies have to be considerably increased till at least 70% of the investment costs or that households can sell excess self-generated energy to the energy grid at the consumer price. In addition, a substantial reduction of costs for insulation and energy systems, for example due to scaling up and standardizing, would also be needed and could considerably contribute to achieving housing cost neutrality.

Leading role for governments

The above-mentioned policy processes initiated by the National Climate Agreement are massive not only in organisational terms, but also in terms of potential societal, spatial, economic, and environmental impacts. As such this energy transition is not without any hurdles. There already are questions about the quality of the level of citizens engagement, social acceptance, and spatial implications of specific proposals on new energy production and distribution infrastructures in a relatively small country, like the Netherlands. The uncertainties amongst different stakeholder groups (i.e. homeowners, tenants, private companies, housing associations, etc.) are aggravated by the notion that the policy documents up until this point do not imply that a final choice or decision has been made. RLI (2018) argues that the current energy transition differs from technological transitions due to, for example, the steam engine or ICT and Internet, which were driven by market forces. The energy transition is induced by governments for collective interests. As advisor of the Dutch government, RLI (2018) recommends that the government:

- use a clear planning,
- clearly indicate what the public and private responsibility is in the energy transition,
- make connections between the energy transition and other issues that need to be tackled at the neighbourhood level,
- set a good example by making all government buildings sustainable by 2040, and

[11] It is noted that we do not include biomass here as its renewable energy nature has been subject to discussion in the Netherlands Parliament. Initially, biomass was considered a climate-friendly alternative to coal combustion in power plants, but on 12 December 2019, Parliament adopted a resolution that biomass is not to be considered a purely renewable energy option and that subsidy programmes supporting this should be stopped.

- use long-term subsidies and develops financial instruments that make it for everyone affordable to make homes more sustainable.

3.2.2. Good practice example: homeowners association "De Ellen" in Assen

In 2018, the renovation of the multi-family apartment building 'De Ellen' in Assen was completed after an intensive process of three years with engagement of stakeholders (Table 8). The project consists of a four-storey flat with 28 single-family apartments. Originally built in 1965, the building needed considerable maintenance and (energy) renovation. Now, the renovated building has a zero-on-the energy meter performance,[12] with a 30-year energy performance warranty. This renovation - aimed to serve as a pilot or flagship project - was facilitated and supported by the municipality (Assen) and the province (Drenthe) in order to ensure that the monthly repayments of the loan for the renovation will not exceed the monthly savings on the energy bill.

Stakeholder	Role
'VVE de Ellen'	Homeowner association aiming to become energy neutral
Municipality of Assen	Facilitation and support of this pilot IES project
Province of Drenthe	Provides (financial) guarantee as security for "VVE de Ellen" to obtain bank loan
BouwNext	Technical design (BIM), process planning and guidance
A3 Architecten	Architect, designers
Renolution B.V.	Delivery and installation of façade panels and HVAC systems; a limited liability company
Segon	Process guidance and financial advisor
Triodos Bank	Provides loan to homeowner association

Table 8: Key stakeholders involved in VVE de Ellen renovation process

Applied technology

The renovation process was supported by BouwNext, A3 Architecten and Renolution B.V. It included the installation of prefab modular outer wall façade elements with high thermal insulation property (light-weight steel frame based). In addition, a HVAC system that was integrated (hidden) in the ceilings and the placement of solar PV panels on the rooftop were also included. By making use of light-weight steel frame prefab façade elements the construction (or assembly) process on site could be minimised. Before placing the façade panels, the old window frames were removed. Although construction and installation workers had to have access to the individual apartments on specific times, the residents did not have to move out of their home during the renovation process. With these prefab elements Renolution indicates that remaining primary fossil energy requirements will be at 25 kWh/m^2 per year.

The construction work inside the apartments included the placement of a heating, ventilation, and air-conditioning (HVAC) system under the ceilings. For that, new (lower) ceilings were placed to cover the installation. Also, new prefab window frame connections were placed. All remaining

[12] https://renolution.nl/project/renovatie-appartementen-vve-ellen-te-assen/. To view the renovation process click here.

energy required for heating and hot water is generated with the help of electric heaters, and electric boilers. As such, this concept can be classified as an all-electric IES.

Financing

One of the main challenges for the homeowners in this pilot project was to secure the financing for the renovation. In the process, SEGON facilitated the development of a completely new financial scheme called the *Asser Servicekostenmodel* (which took about two years to develop). This model was needed because in the conventional way of financing renovations each individual apartment owners would need to secure their own green loan/mortgage. This route would most likely have failed because some homeowners might not have been able to secure such extra funding from banks themselves, for reasons such as (temporary) unemployment or existing mortgages that are already higher than the current market price of an apartment. This in turn would have frustrated the renovation process.

The *Asser Servicekostenmodel* enables the homeowners association, being a legal entity (and not the individual homeowners), to sign a loan to finance the renovation. The costs of this loan are included in the monthly service costs that all apartment owners pay to the association. The financial model is based on the principle 'cost of ownership neutrality', i.e. the cost of the renovation loan (repayment + interest) is equivalent to (or lower than) the cost savings on energy consumption and (future) building maintenance.

Developing this new financial model required clearing of a number of obstacle though. First of all, the homeowners association themselves needed to secure mortgage-like loans with a long (app. 30 year) duration.[13] Second, the bank wanted to have additional guarantees / securities regarding the repayment of the loan, since now the loan would be signed by a homeowners association instead of individual homeowners. These additional guarantees are secured through a public guarantee fund, which implies that in this case the Province of Drenthe now has full legal liability in case of loan repayment default.

Both the local municipality and the province provided additional targeted support and subsidies for Renolution, A3 Architecten, Bouwnext and SEGON, so that their costs would not have to be born by the home owners. Follow-up actions are being taken to further develop and standardize the *Asser Servicekostenmodel* so that its use can be scaled up.

Social aspects

Before being listed as pilot project, the homeowners association (VVE de Ellen) was triggered by the 'Expeditie Energie Neutraal Wonen' (Expedition Energy Neutral Living). This expedition is a communication campaign set up by the local governments in the Province of Drenthe to inform and support homeowners to improve the energy performance of their houses. With support from the municipality of Assen the initial steps were taken to discuss the energy renovation during the regular meetings of the homeowners association VVV De Ellen. Where needed, additional external expertise was hired to better inform the homeowners about the possible technologies, financial options, and implications for them. Specifically, trying to convince most residents (which all have a vote in the homeowners association) to agree with such a renovation process has been a challenge as a range of general and specific concerns needed to be addressed before residents would agree

[13] Aside from this the Asser Servicekostenmodel had to be checked and cleared to ensure it satisfied all existing regulatory and legal requirements.

with the renovation. This not only requires dedicated and active board members of the homeowners association, but also sufficient and high quality (external) expertise. Here the municipality and province were important partners in facilitating this process for frontrunner initiatives.

After selecting the (technology/service) suppliers, the construction company (Renolution B.V.) developed a detailed work planning and had to experiment with a communications procedure to be able to timely inform residents on the various activities (e.g. to announce when construction workers needed to access the apartments). The experience gained in this pilot process shows that a carefully managed stakeholder engagement process, work planning and good communications is important to avoid frustration and discomfort amongst residents.

The fact that this full renovation process took about three years in total (while the actual renovation activities took ‘only’ several months), is a clear illustration that process planning, as well as timely addressing any social and financial barriers are key aspects within (energy) renovations in multi-family buildings.

3.2.3. Discussion on IES good practice example

Technology

From a technology perspective, the implemented IES solution is easily *scalable*, both to smaller and larger and ground-based and taller buildings. The modular façade panels can be prefabricated in many different design specifications to fit most building types. Renolution B.V. has a project portfolio[14] ranging from single family homes, to ground-based adjacent houses, as well as tall buildings with 10 storeys or higher. The solution offered by Renolution is a renovation that occurs in one step. With this intervention the energy performance of the building goes well beyond A+ energy label performance and will last for at least 30 more years. However, given the duration of the loan, and repayment scheme of 30 years the solutions might not be the most cost-competitive on the medium to long-term. For example, it could be more cost-effective to have a phased approach during, e.g., a decade where first the rooftop is insulated and rooftop solar PV installed, followed later by installing the façade panels and HVAC system (i.e. generally rooftop PV projects have shorter pay-back periods relative to outer wall insulation measures). Which trajectory to take, and renovation ambition to have, thus strongly depends on the financial capacity and capabilities of the homeowner association.

Financial

Given that each multi-family building with shared components or spaces must, as per law, must establish a homeowners association, the *Asser Servicekostenmodel* has a great replication potential. However, the current scheme fits best to homeowner associations where all residents own their property. In multi-family buildings where there is a more mixed *ownership status* (for example with a social housing association that rents out apartments) the financing can become more complex as the housing association is bound to / governed by a different set of rules and regulations under the Housing Law (Woningwet). Part of the Housing Law ensures that all corporations fall under the (financial) supervision of the Housing Corporation Authority. Also, the

[14] https://renolution.nl/projecten/

Housing Law depicts the conditions under which a housing corporation can co-invest in building renovations.

An interesting feature of the new financing model explained in this case study is that the responsibilities for paying off the loan (and thus the investment) can be fully transferred to any new owner, in case an apartment is sold (i.e. the debt is thus fully transferable). With a 30-year loan the payback period of the implemented IES is typically considerably longer than the average timespan that a typical homeowner moves into a new house. Although this timespan varies per age category (Ministry of Economic Affaires, 2013)[15], such long payback periods have important consequences for the willingness of homeowners to invest.

The *transferability* of any debt (loan or mortgage) will be relevant for younger people/families to avoid any residual debt resulting from the energy renovation. In addition, also elderly people will factor in the duration of the loan and debt considering that they are unlikely to remain living longer than 30 years in the same building. Without such a financing model, the elderly building owners might not be willing to try to secure a personal loan or mortgage to finance the renovation. The transferability of debt with such investment in energy renovations is important for any homeowners since under normal market circumstances probably only a smaller part of the initial investment would have been repaid with the increased property price (i.e. asset value price increase generally is around 50-60% of total renovation investment).[16]

The *Asser Servicekostenmodel* is also scalable because it reduces the need for every individual homeowner in the homeowner association to secure the investment upfront. This removes a key barrier to the energy transition in the built environment. Despite that several other provinces and municipalities are taking steps to also adopt the *Asser Servicekostenmodel*, local governments cannot indefinitely remain providing full financial guarantees to banks to support homeowners in the energy transition. To resolve this issue, there are plans to develop a national guarantee fund. However, although such a guarantee fund is an attractive solution to trigger building renovations on the short term, it is expected that at some point the private sector will have to absorb the risks in their financial products and services. As such, novel financing schemes for building renovations that are now still predominantly publicly funded or backed need to gradually transition towards more *market conformity*.[17]

[15] According to EZ, 2013 the following averages timespans before moving to a new home per age category apply:

- Age <25y – timespan <5y
- Age 25-34y – timespan <5y
- Age 35-44y – timespan 5-10y
- Age 45-54y – timespan 10-15y
- Age 55-64y – timespan 15-20y
- Age 65-74y – timespan 20-25y
- Age >75 – timespan 20-25y

[16] One drawback from using such a collective financing scheme is that the interest paid over the loan (through the monthly service payments) is not income tax deductible. This contrasts with a normal (second) mortgage where the interest paid would be tax deductible.

[17] The current Dutch National Energy Saving Fund (Nationaal Energiebespaarfonds) applies a series of terms and conditions that are not considered market conform. This means that the Fund does not offer loans that meet the current checks and balances of renovation financing under real market conditions. While this is understandable from the Funds core objective (to trigger the scaling up of building renovation activities), the result is that limited experience (to date) is gained by the private sector to test, develop, offer and evaluate this new area of building-linked loans without necessarily having the real estate (object) itself as underlying collateral.

Social

Besides the achievement that the overall renovation was done in a cost-neutral way for the home owners (i.e. the money saved on energy and upcoming maintenance, was equivalent to costs of the investments in renovation), the increased comfort levels (less air draft, less indoor temperature extremes, less outside noise, etc.) experienced by the residents after the renovation are a major (non-financial) *co-benefit*.

One important *trade-off* or hurdle for end-users is the potential inconvenience or discomfort that can be experienced during the renovation phase. During this phase, the constructions activities, both outdoors and indoors, will be implemented. One basic condition for IES solutions would be that the residents should be able to stay in their homes. In addition to that, a robust end-user targeted communications procedure needs to be in place to ensure a proper work planning, while minimizing the (e.g. noise) disturbance for the residents.

3.2.4. Good practice examples in non-residential buildings

The main function of residential dwellings is living. Other, non-residential buildings have different functions depending on how they are used. In addition, the size of other buildings varies enormously. When making other buildings more sustainable, both their function and size must be taken into account, which means that making them more sustainable requires a tailor-made approach for each building. Moreover, social and financial aspects of making other buildings more sustainable might differ from residential buildings as users and available financial funds diverge. In this section, we highlight the construction of a sustainable sports accommodation and a parking garage in the Netherlands.

Sports accommodation 'De Roodloop'

'De Roodloop' in Hilvarenbeek is a complex with a swimming pool, a sports hall and a restaurant. In 2015, the municipality of Hilvarenbeek issued a tender for the construction of the sports accommodation 'De Roodloop' on the basis of an integrated Design, Build & Maintain (DBM) contract. A consortium consisting of a project manager, an architectural firm, a building contractor specialized in health accommodations and a technical installation company completed the building in 2017 and 2018. This resulted in an all-electric, energy and CO_2 neutral complex, built with sustainable materials. Solar PV panels are installed on the roof, which are connected to heat pumps to heat the building and swimming water. The swimming pool is covered airtightly from roof to floor with damp-proof foil to prevent condensation in the structures. The building's insulation complies with the EPC 0 standard and LED lighting has been installed (Bureau Franken, 2020).

The municipality and the technical installer have agreed on a performance contract with a term of 25 years for the maintenance of the building and its energy use. It contains a bonus-malus scheme whereby the installer guarantees a maximum energy use per year. Should the accommodation nevertheless have a higher energy use than that, then the installer will receive a lower payment from the municipality for the energy use. In case of lower energy use than the agreed maximum, the benefits from energy saving are shared between the installer and the user (i.e. the municipality).

With regard to financial aspects, the municipality had a municipal budget available and the building's exploration requirements were required to fall within the municipal operating budget. Considering social aspects, a sports complex has no residents who must be taken into account in the construction process. However, the building had to meet legal requirements for the sports functions that take place in the building.

The Oostenburg parking garage

Oostenburg is a parking garage in Amsterdam, opened in 2020, constructed as an energy-neutral garage. It has 704 parking spaces in 17 layers, three of which are underground. There are 719 solar panels on the roof, which provide the building with energy and 15 electric charging points. The latter can charge 30 cars at the same time. The remainder of the roof is covered with the plant sedum for sustainable water storage. The lift system in the garage is energy efficient and LED lighting is used (Q-Park, 2020).

The financial aspects of the construction of the parking garage were tackled by using an investment fund whereas the social aspects refer to adapting the parking garage to its surrounding. The Oostenburg parking garage is located in the Oostenburgereiland district of the city, which will be redesigned in the coming years with 1,800 houses, a hotel with 300 rooms, restaurants and meeting facilities, and there is space for some 2,100 m2 of catering and 39,000 m2 of business and office functions. Traditionally, this district has been a working island, which was used by, a.o., the Dutch East India Company in the second half of the seventeenth century. This historical function is taken into account in the redesign of the urban district by giving the buildings an industrial look and feel and making the public space a low-traffic residential area. During the construction of the parking garage, the construction consortium responded to the redesign by talking to the housing corporation about the residents' wishes and giving the parking garage an industrial look. The talks with the housing corporation resulted in a great deal of attention being paid to social safety in and around the parking garage, such as adequate lighting in and around the parking garage and a fire alarm and evacuation system in the garage. The parking garage also contributes to making the neighbourhood car-free by offering parking for residents.

4. Discussion and results from IES stakeholder interviews/market survey

Following the assessment of practical examples of applications of Integrated energy solutions in Poland and the Netherlands in chapter above, in this chapter we report on meetings and consultations with stakeholders in the built environment sector in both countries. The main focus in the chapter is on practitioners and how they manage that the chosen technical IES solution is financially affordable for end-users and meets their preferences. We also explore how and when engagement of end users in the project is to be considered for an improved and socially realistic energy service through IES. We first discuss stakeholder consultation in Poland, to be followed by reports from stakeholder meetings in the Netherlands.

4.1. Poland

4.1.1. Selection of stakeholders

Given the development status of the Polish IES market, the IES stakeholder interviews/surveys focussed on interviewing a number of selected stakeholders on the key barriers to IES implementation and upscaling in Poland. The survey focussed on the following issues:

1. Stakeholder: type of company/organization.
2. Technology: overview of technologies / combinations implemented in building (multi-family residential, commercial, public, or industrial).
3. State-of-the-art: technology uncertainties (new, innovative, state-of-the-art)/ frontrunners.
4. Motives: motives of initiator for implementation of new energy technologies/ applicability of initiator's motives to other stakeholders.
5. Process: co-design/ stakeholder engagement / building users / residents/ challenges/risks/ success factors.
6. Expertise: in-house knowledge and skills/ need for external consultants / experts.
7. Management: managing the integrated energy system managed (hardware, software, human resources).
8. Diffusion: template for wider deployment/potential for copying the technology and process to other buildings.

The stakeholders were carefully selected so that their responses illustrate the regional IES market. It should be mentioned that the IES market in Pomerania is currently at the stage of development and the solutions involve installation of heat pumps integrated with PV installations. There are still hardly any more advanced solutions, and the number of those that have been implemented so far is small.

All in all, five stakeholders were interviewed about their experience with IES applications. The stakeholders represent the following types:

- Regional administration,
- Design office,
- Industrial park,
- Regional energy agency,
- Public agricultural advisory centre.

4.1.2. Main outcomes of stakeholder interviews

Below the main findings of the survey for each stakeholder are discussed.

The ***regional administration*** plays an important role in establishing criteria for RES and energy efficiency financing within Regional Operational Programmes. In their opinion, heat pumps are a well-developed technology and they are installed without special financial support, while solar PV and solar collectors – on the verge of success – require marginal special funding. Generally, the regional administration supports basic solutions in multifamily buildings, such as rooftop solar PV. In public buildings, where financing with grants is acquired for implementation of integrated energy systems, solar PV and heat pumps were installed. In some larger public projects like hospitals, even more ambitious projects were financed, such as combined heat and power, with solar thermal collectors and PV. Only in a few bigger, state-of-art projects, tri-generation (heating, cooling and electricity) and heat pumps were supported. Energy cost reduction was referred to as the main incentive for IES implementation.

New renewable energy sources and their integration with building energy systems require trained staff for operation and maintenance of equipment and new systems. Public buildings usually are maintained by their own staff that is involved in project development and supervises the investment progress. They acquire initial training for that so that can become responsible for operational issues. Because of limited financial resources of public institutions, outsourcing of maintenance services is rare. In industry, there are internal energy specialists who take part in project preparation, design and development and are able to ensure proper operation of modernised systems. The preparation and decision process in a multi-family housing is a complex and time-consuming process due to the involvement of housing cooperatives and housing associations, often with a mix of private and municipal flat owners. During the lengthy preparation and implementation of the project, external consultants may be faced with distrust and the project may be stopped at any stage.

Usually the management of the RES installation is transferred to maintenance staff after the guarantee period. Engagement of a professional company would be more adequate however this solution is typically considered as too costly to be implemented. Control and measurement equipment of RES systems is typically minimal and therefore metering of gained renewable energy and savings hardly exists. Mandatory energy monitoring is typically limited to one to five years, according to the period of obligatory project reporting period for public financial support.

The ***design office*** is a private design company established in 1990, that is active at the building market (sanitary, electrical installations, IT) and experienced in both large public, commercial and residential projects. In the opinion of the designers, external, special funding is often a driving force to install renewable energy systems. Often, end-users are not ready to discuss proposed technologies and solutions by the design office. They rather decide on the estimation of investment expenditures and future costs, given by the design office. This means that there is room for either a designer, energy adviser or consultant to present and explain the proposed IES solution to the end-user(s).

Usually, larger facilities are equipped with building management systems (BMS). Energy, though, is often only a minor part of a BMS and is not taken into daily consideration and the necessity of energy monitoring is generally not understood by end-users. This is partly due to changes in energy carriers prices and complexity of invoices from suppliers so that energy savings achieved are not easy to identify and quantify. Promoting energy monitoring by designers and energy auditors as well as by the state and municipalities could be a viable approach to increase end-users interest in energy management and thus saving.

The ***industrial park***, established by four municipalities, is a public innovation centre on green energy covering research, production and service sectors as well as energy management technologies. Playing a role as promoter of RES, there were some innovative solutions implemented in this park at the stage of design and construction, just to collect its own experiences. Therefore, a gravel ground heat exchanger, a ground heat pump system, a gas fuel cell, a 100 kW PV, a 2 kW vertical axis wind turbine and a mechanical ventilation system with heat recovery were installed in the park. In addition, due to large glazed areas, movable external blinds were installed as well. This innovative project gives an opportunity to test new technologies. The functioning of the devices is controlled by a BMS with the possibility of continuous monitoring.

The project has been supported by EU funding for development of entrepreneurship in the Pomeranian region and financed under the Regional Operational Programme for the Pomerania Voivodeship and municipalities (investment loans).

For the implementation of the project a general contractor was selected, among others based on the criterion that applicants had to demonstrate experience with RES implementation. Implementation was based on a 'design and build' formula[18] with an equipment warranty for a period of five years. Nowadays, the daily management of devices and system operation is funded from the park's own resources.

The ***Regional Energy Advice Agency*** is an energy consulting, training and international cooperation company in the field of energy efficiency and RES implementation, especially with experience in small RES implementation in the region. In 2016 they started one of the largest projects in their portfolio i.e. small RES installations at single-family houses. The project has been implemented by the energy agency in partnership with the four municipalities where these households are situated. However, it is the agency that manages and supervises the project. Both the agency and communes were responsible for information and promotion of this project among inhabitants. The municipalities have collected the applications, while the agency carried out site visits allowing to assess technical installation possibilities such as RES type, capacity, combined types of installations, etc. This has resulted in 437 end-users (owners of single-family houses) that are willing to install RES at their premises.

The project successfully applied for EU funding from the Regional Operational Programme and it received a grant of approximately 84% of the total investment value. It was the agency's responsibility to sign contracts with all household owners of lending for use in order to be able to perform all the RES installation works. The end-users had to pay only 16% of the total cost of the installation and they are going to be released from the loan for use contract after 5 years from project's successful implementation. The works were carried out in 2019 and in total 562 RES were installed including 189 PV installations, 73 biomass boilers, 212 flat solar collectors and 86 heat pumps. In some cases IES consisting of two or three RES technologies were installed. Generally, market-tested and high-quality solutions were chosen in order to avoid equipment failures and related costs that could have negative impact on the RES image among local communities. Heat pumps of 2-3 kW capacity and hot water storage tanks were designed to meet the needs of

[18] The model, equivalent to a turn-key contract, includes both design and construction works by the same contractor.

domestic hot water preparation. PV panels with a capacity of 2-10 kW were installed as well as solar collectors combined with hot water storage tanks.

Again, the motive behind the project was the availability of EU funds in the Pomeranian region for the development of renewable energy sources. Local governments took advantage to obtain a high level of co-funding and promoted RES among local communities. Co-financing of RES investments certainly contributed to the great interest in the project. End customers wished to improve the comfort level of their households and to reduce operating costs but without such a high grant many of them would not take a decision to implement RES on their own. Another strong incentive was that the energy agency was the only stakeholder the end-users had to cooperate with. The agency was responsible for the formal application for financing, organizing the tenders and obtaining competitive prices due to large scope of the project, coordinating design and installation processes as well as coordinating maintenance within the guarantee period of five years after the installation. After this period all the responsibilities, mainly maintenance, will be transferred to the household owners.

The agency had most of the technical expertise necessary to implement the project, however, the Managing Authority of the EU funds in Pomerania region was consulted on administrative procedures. One of the hurdles was also lack of practical experience concerning interactions with such a large number of final recipients. Therefore, assistance from municipal offices cannot be underestimated.

The project has been successfully implemented. In general recipients are satisfied with their new energy sources.

The ***Agriculture Advisory Centre*** is a public agency in Pomerania Region that supports the development and competitiveness of agriculture by means of training and information, agriculture fairs and other supporting activities aiming at farmers and businesses in rural areas. To promote innovative technologies, they installed RES in two buildings at the Advisory Centre site at their own premises. Heat pumps with boreholes as the lower source support heat and DHW (capacity 80 kW), PV panels 8 kW roof-mounted and 40 kW ground-mounted, with two sun-tracking systems with monitoring available on-line. The RES installations are operated by own trained staff. External specialized companies are involved in necessary servicing. PV systems are monitored. However, RES systems are not integrated together in a joint management system.

Besides the RES, also a prototype micro-biogas plant was constructed at the Advisory Centre site. Biogas plants considered by some communes shall be primarily used to utilize waste from agricultural production, including manure and chicken droppings.

As development and mechanization of agriculture require more electricity, there is a growing interest in PV generating electricity for own needs. Farmers are interested in most recent technologies, lately in PV micro-installations, as long as they are economically feasible. They primarily look at financial aspects of RES implementation. Their incomes from agricultural activities are volatile, so they look for special incentives. Farmers often rely on already verified contacts in the rural neighbourhood, including local installers and technology providers. They are usually offered turn-key solutions, with delivery and installation of new systems.

4.1.3. General conclusions based on stakeholder interviews

Based on the interviews, the following conclusions can be drawn:

1. Technology suppliers often tend to deliver and install RES installations (PV) oversized, exceeding actual needs.
2. Some end-users are also approached by third parties offering financing schemes with RES installation; this typically also leads to excessive capacities and investments.
3. There is lack of experience as to monitoring and maintenance of RES installations.
4. Often costs of maintenance and other services are not considered at the stage of decision making process. For example, an industrial park, where in fact it turned out that the operating costs of the equipment are high.
5. Technical expertise was available at some places. However, if external funding is involved often consultations in the field of state aid and EU funding were necessary.
6. Experience of regional administration, based on implemented projects, showed that public buildings staff is often ready to undertake and implement RES projects. Especially larger entities, like hospitals, have own specialists to successfully complete and later maintain RES installations. In case of other buildings, like schools, support from communal staff is required. Nevertheless, all projects require external experts, like auditors, consultants, designers and supervisors. External experts are needed when analyzing options for RES solutions, including the analysis of investment costs and installation and maintenance costs, selection of devices, supervision of the installation, etc.
7. Residential buildings owners and administration do not have required knowledge on RES technologies and their operation. This can result in operation of units beyond their optimal work point and with reduced efficiency.
8. Usually only reliable technologies are used by design offices.
9. Promotion of more advanced IES technologies is highly required at every level of the project starting from energy advisors, designers, installers , but most of all by the state, who should develop wide-ranging popularization campaigns on RES, including IES solutions.
10. Recently, there have been initiatives and planned changes in incentive schemes to co-finance joint use of heat pumps and PV panels. However, till now they are lacking optimization and integration mechanisms, funds are allocated based on the applying household income and supportive analyses based on energy balance are not requested. Introduction of IES could change this approach.

A summary of the interviews conducted by BAPE with stakeholders can be found in Annex IV.

4.2. The Netherlands

As IES applications have not yet been widely diffused in the Dutch built environment, due to the decades long availability of fossil fuels (in particular natural gas), good practice examples need to be collected from a group of front runners. The latter stakeholders are generally people or organisations that, for different reasons, decide to refurbish their homes or buildings towards energy efficient or even energy neutral status. One key driver, as explained in Chapter 3, has been the governmental announcement in the Netherlands to reduce natural gas production from the Groningen fields. This has triggered several regional governments to pilot energy neutral districts in their municipalities so that dependency on natural gas will decrease. It is these initiatives that we have tapped into and selected for detailed, targeted interviews with stakeholders. In addition, we have performed a small survey among key stakeholders.

Supported by a review of online and literature sources, we have interpreted the results of the survey and interviews for a comparative analysis of different IES providers that are active in the Dutch market. This analysis has been carried out by comparing suppliers against technological, financial, and social aspects.

4.2.1. Comparing IES providers in the Netherlands

A key finding from the analysis in this chapter is that the Dutch building and construction sector has made considerable progress with improving and standardizing stand-alone applications of individual technologies and practices (e.g. energy modules, modular/prefab facades). However, progress with combined, integrated applications of these options has been less widespread, with only a relatively small number of front runners. IES solutions offered by the latter also differ widely. In Table 9 below, we present an overview of thirteen identified and reviewed IES suppliers in the Netherlands (identification was done, first, through a Google search with Dutch terms equivalent to 'IES', 'suppliers', 'services', followed by a review of relevance of the companies found for this analysis).[19] Factsheets with basic information and characteristics of each of the thirteen selected IES providers are included in Annex III.

In the sections below, the results of a comparative analysis of the companies in Table 9 are presented, with a focus on their:

- Technology scope or focus,
- Market focus and organisation structure,
- Contract forms and warranty conditions, and
- End-user engagement and after care.

[19] JIN attended a workshop on 24-09-2019 on large-scale energy renovations targeting homeowner associations (link). The workshop was hosted by the Province of Gelderland. The session speakers included IES providers, BENG Nederland, Renolution, VolkerWessels, Dura Vermeer, Hegeman Bouwgroep. During and after the plenary session JIN spoke with several of the invited speakers about their IES products and services. JIN has also liaised with SEGON on several occasions on financial aspects related to IES.

Company	Description of IES solution	Founded
Klimaatgarant	Provides all-electric ('e-home') solution for homeowners and/or project developers	2012
The FCTR E (the factory)	Provides all-electric ('e-home') solution for homeowners and/or project developers	2016
Eteck	Private company designing, owning, operating, exploiting heat/cold energy supply projects	1895
ThuisBaas	Social enterprise helping homeowners to become energy neutral	2016
Grunneger Power	Local Energy Cooperative, based in Groningen, supporting members in greening homes, and developing local green energy projects	2011
Het Woningabonnement ('WOAB')	Provides green energy and energy saving concepts for homeowners without need for upfront investment by homeowner	2017
RENOLUTION	Provides modular façade/roof insulation panels with integrated HVAC systems to refurbish building blocks	2008
Dura Vermeer	Large building and construction company providing broad spectrum of IES concepts and solutions	1855
Koninklijke VolkerWessels	Large building and construction company providing broad spectrum of IES concepts and solutions	1854
BAMwonen	Large building and construction company providing broad spectrum of IES concepts and solutions	1869
BENG Nederland	Provides guidance to associations of homeowners and housing corporations in making residential complexes (almost) energy neutral	2017
WoonlastenNeutraal Renoveren (WNR)	Renovation of residential complexes of homeowners' associations using a broad spectrum of IES concepts and solutions at neutral costs	2020
Voor de VVE	Rooftop insulation, solar panels, and a collective battery for homeowners' associations at neutral costs	2016

Table 9: List of selected IES system providers in the Netherlands

4.2.2. Technology focus of IES Suppliers

Aside from Klimaatgarant, The FCTR E, Eteck and Thuisbaas, all other providers offer IES concepts with full coverage of passive and active technologies and measures. Retrofit IES concepts such as those offered by The FCTR E and ThuisBaas require the building to meet certain minimum requirements of thermal performance of the building envelope (i.e. Energy label C at least). Although ThuisBaas also indicates that they can offer passive solutions, they generally consider these measures as being too costly (with too long pay-back times).

The large, traditional building and construction companies that were established around mid-nineteenth century (e.g. Dura Vermeer, VolkerWessels, BAMwonen) offer a wide range of passive and active IES services, but also often work with full package service providers (like Klimaatgarant and The FCTR E or Eteck) for installing the energy installation and adjacent systems (either as partner, subcontractor or in a joint venture). While these large building and construction companies generally target larger multi-building developments, they also increasingly offer industrialised, prefab building solutions (like the MorgenWonen concept from VolkerWessels).

Most IES system providers offer all-electric solutions for electricity, heating and/or cooling, thereby exclusively using proven, market-ready technologies. Generally, these IES solutions include a (ground-based air-source) heat pump, a heat buffer, solar PV, HVAC systems and, depending on the heating solution chosen, either electric heating (e.g. infrared panels) or low temperature radiators. Eteck provides a full-service heating/cooling and hot water supply solutions for larger-scale investments (e.g. multiple dwellings, buildings blocks), without offering solar PV supply, installation, and maintenance services. ThuisBaas is one of the few enterprises that actively (and explicitly) promotes and uses PVThermal panels in their proposed IES system designs.

4.2.3. Market focus and organisation structure

As shown in Table 10, about half of the analysed organisations are not-for-profit based. These are mostly some new entrants that structure and/or brand themselves differently, either as social enterprise, non-profit, foundation or as cooperative (e.g. Grunneger Power, ThuisBaas, WOAB, WNR or BENG Nederland). Enterprises such as Dura Vermeer, VolkerWessels, BAM, and Renolution generally have a long track record in the traditional building and construction sector or have been established as spin-offs of these. Klimaatgarant, The FCTR E, and Eteck have their roots and core business focussed in the market for energy installations/systems. After a merger in 2016, Klimaatgarant strongly relies on the specific HVAC technology solutions from Itho Daalderop, while Renolution relies strongly on its patented prefab steel frame construction elements to improve the building envelope. The FCTR E relies mainly on NIBE for supplying their heat-pump and boiler solutions, while Voor de VVE relies on Rhepanol® rooftop insulation.

Company	New or existing buildings	Main building types	Dominant project scale – type	Geographic scope	Organisation structure
Klimaatgarant	New	Residential	>20 dwellings projects	Netherlands	Independent private company, part of CFL holding
The FCTR E (the factory)	Both	Residential	Single-family and larger grouped developments, minimum label C building.	Netherlands	Independent private company
Eteck	New	Residential + utility	Medium- large-scale heating/cooling projects	Netherlands	Independent private company
ThuisBaas	Existing	Residential	Mainly single-family houses	Western end middle parts of the Netherlands	Private non-profit (social enterprise)
Grunneger Power	Existing	Residential + utility	From single family houses to urban district or regional level developments	Province of Groningen	Energy cooperative
Het Woning abonnement ('WOAB')	Existing	Residential	Mainly single-family houses	Provinces of Overijssel, Friesland,	Independent private company (social enterprise)

				Gelderland, and City of Almere	
RENOLUTION	Both	Residential	Single-family and larger grouped developments	Netherlands	Independent private company, part of Renolution Group
Dura Vermeer	Both	Residential + utility	Medium- large scale developments	Netherlands and abroad	Independent private company
Koninklijke VolkerWessels	Both	Residential + utility	Medium- large scale developments	Netherlands and abroad	Independent private company
BAMwonen	Both	Residential + utility	Medium- large scale developments	Netherlands and abroad	Independent private company
BENG Nederland	Existing	Residential	Larger grouped developments	Netherlands	Cooperative
Woonlasten Neutraal Renoveren (WNR)	Existing	Residential	Larger grouped developments	Netherlands	Foundation
Voor de VVE	Existing	Residential	Larger grouped developments	Netherlands	Independent private company

Table 10: Overview of market focus and organisation structure of IES suppliers

Thuisbaas, Grunneger Power, and WOAB have more socially driven origins and ambitions (see Table 10). Thuisbaas was established in 2016 by Urgenda, which is a non-profit organisation to promote sustainability and innovation in the Netherlands.[20] With Thuisbaas, Urgenda aims at speeding up the energy transition in the built environment. Grunneger Power is a local energy cooperative that positions itself as a local civil movement for scaling up low-emission energy solutions in the Groningen area. It is one of the co-founder energy cooperatives of *Energie Van Ons* that was created in 2013 as a cooperative energy supply organisation to buy and sell locally produced green energy to local customers. WOAB also aims to enable lower income households to participate in the energy transition by avoiding the need to make up front investments.

For some IES system providers specific conditions or limitations apply with respect to application of solutions. For example, The FCTR E all-electric solution is considered only viable in buildings with minimum energy label C; Thuisbaas, WOAB[21], and Grunneger Power[22] only operate in specific geographic areas.

4.2.4. Contract forms and warranty

The traditional business model for IES suppliers is to sell and transfer full ownership of the IES package to the end-user(s). In such a model, the end-user(s) buy the IES system from the supplier(s). This typically requires individual homeowners to increase their mortgage, obtain a green loan or

[20] In 2015 Urgenda won a climate lawsuit against the Dutch state spurring the Dutch government to comply with climate targets of the Netherlands set for the year 2020.
[21] WOAB is liaising with local governments to expand their services to more Dutch provinces and municipalities.
[22] Via the co-founded cooperative energy company (EnergieVanOns), energy can be supplied also in the rest of the country.

pay out-of-pocket. For groups of end-users that are looking for a collective IES solution, such as in a multi-family building, securing funding is often more complex. Ideally, a collective financing solution is implemented. This typically involves the home-owner association to take on a green loan or mortgage and charge the individual homeowner an additional monthly payment on top of their service costs so that the association can pay the instalments. In case individual finance solutions are preferred in such circumstances, the IES supplier ideally has the flexibility to provide both a buy and lease solution to end-users. This is because not all end-users might have the financial means to pre-finance the total sum of the investment upfront. One of the key differences between the collective and individual finance solution is that the collective financing set-up is linked to the property, while the individual finance solution still predominantly is linked to the end-user (i.e. homeowner). However, in the Netherlands research and experiments with 'building-linked' financing are increasingly being conducted, such as the *Asser servicekostenmodel* (as discussed in Chapter 3).

The 2019 National Climate Agreement (Klimaatakkoord, 2019) announced building-linked financing (*Gebouw Gebonden Financiering*) as a new way of funding the energy transition in the built environment. While such financial products are still in the early stages of development, one of the key conditions for such financial products to be considered acceptable is that the financial scheme is at least cost of ownership neutral. This means that the monthly costs (instalment + interest) do not exceed the energy cost savings made by the end-user. As a result, the IES service provider can offer a package of energy measures of which the monthly costs are at least equal to or lower than the energy cost savings. WOAB already provides this service to also enable low-income households to take part in the energy transition. With the '*WOAB Abonnement™'* the end-users choose which energy measures they want to implement. Additional energy measures can be included as long as the monthly costs (repayment + interest[23]) do not exceed the monthly energy cost savings. The monthly fee of the *WOAB Abonnement* includes an Energy Performance Guarantee, all repairment and maintenance and warranty during the duration of the subscription (a*bonnement*). Subscriptions of 10, 15, 20 year are offered. WNR and *Voor de VVE* apply the *Asser servicekostenmodel*, in which the homeowners association takes a loan and charges individual homeowners a monthly payment.

Another financial solution for end users who do not have the financial means to pre-finance the upfront investment costs themselves (e.g. via a green loan or mortgage) is offered by the FCTR E via a membership (lease) solution, where the end-user pays a monthly fee. This enables property developers to replace part of the financial reservation that project developers make in their investment plan for the energy systems, and thus lower the direct CAPEX for the buildings' energy system. This type of 'business model' allows new apartments/buildings to be marketed at lower/dampened prices to end-users, who pay a monthly membership fee.[24]

Within the traditional IES supply model, end-users usually have to turn to different companies or service providers (e.g. the building and construction company, the installation company, the technology suppliers, the electrician, the subcontractor(s)) in case of issues with system

[23] WOAB currently offers the WOAB Abonnement™ at a 3% interest rate. The interest paid is not income tax deductible (note: the interest paid on mortgages in the Netherlands is income tax deductible).

[24] For a typical residential building this comprises on average around EUR 25.000, which could be replaced by a membership fee of around EUR 225 per month.

performance and/or maintenance. This easily gives rise to frustration as customers basically have to identify where in the IES there is a problem and who they should call to solve it. As an alternative, lease options for IES solutions, or individual IES components, are increasingly offered by most IES system providers. Thuisbaas, however, does not provide any other financial solutions other than the end-user to buy the IES package (i.e. this is generally done through a mortgage or green loan).[25] Due to a different position in the IES supply, Grunneger Power and Eteck do not provide a lease option. Instead, they operate their energy systems more as a 'traditional' energy supplier (i.e. Grunneger Power in involved in developing a cooperative district heating network, and Eteck builds, owns, operates, and exploits local heating/cooling systems). In such systems, the end-user pays a fixed monthly fee, including maintenance, and a variable payment in line with energy use.

Aggregator entities or intermediaries, like Klimaatgarant, Thuisbaas, WOAB, The FCTR E, RENOLUTION, WNR and *Voor de VVE* generally offer a full system performance warranty for the duration of the servicing contract. Occasionally, this full warranty is also given for all individual system components or added to the standard warranties applying to each individual system component. There is a crucial distinction between energy system performance warranty and component/appliance warranty. In some cases, the energy performance warranty is optional or conditional, which implies that without such performance warranty the warranties of the individual system components apply (see Table 11). These energy system performance warranties are generally conditional upon agreeing a lease, servicing, or maintenance contract with the IES system provider (e.g. with annual or monthly payments).

While the FCTR E offers a maximum 15 years IES system performance warranty, *Klimaatgarant* offers an optional 25 years energy system performance warranty, conditional upon having a maintenance contract (at fixed price per month). Renolution and WNR, for example, offer an energy performance warranty of 30 years[26]. *Voor de VVE* offers a warranty of 25 years.

Energy system component	Lease – service membership*	Buy
Nibe heat pump	For duration of service membership	2 years
Solar panels		10 years
Solax inverter		10 years
Solaredge inverter		12 years

**maximum service membership warranty of 15 years*

Table 11: The FCTR E warranty duration of system components under lease or buy

Source: https://www.thefctre.com/nl/faq/

[25] Thuisbaas offers assistance / guidance to help people secure regional, national green subsidies or green loans.

[26] Given that the IES technology solutions differ from supplier to supplier it is difficult to adequately compare the quality of the different warranty durations and conditions.

4.2.5. End-user engagement and after care

Engagement with end-users before and during renovation

RENOLUTION has dedicated staff for end-user engagement and communication to communicate with the end users clearly and regularly on what actions are about to be taken, such as maintenance and renovation. RENOLUTION applies a 6-stage end-user communication and engagement process that includes the preparation, implementation, and completion/delivery phases. Before the renovation activities start, RENOLUTION initiates a series of engagement sessions, ranging from group sessions to 'kitchen-table' conversations. During the renovation phase a weekly planning is send to the end-users (either online or hardcopy). While such engagement systems are not waterproof, they can prevent a lot of inconveniences in terms of work planning (e.g. handing over of keys in workers need to work inside dwellings). *Voor de VVE* also intensively involves homeowners in the preparation stage before renovation.

Engagement after the renovation and after care

Within the traditional IES supply model the end-user has direct contacts and contracts with several entities, e.g. per IES component, which is generally quite complex for the (individual) end-user who must figure out who to contact and which organisation (e.g. technology supplier, installer, building and construction company, subcontractor, energy supplier) is responsible for what aftercare service. One of the main advantages of aggregator entities or intermediaries that provide a full-service package is that maintenance or trouble shooting is much easier for the end-user. The aggregator or intermediary serves as a 'one-stop shop' for any technical, contractual, or financial issue.

Adequate customer aftercare can be provided in different manners. For example, Eteck has its own customer affairs department and web care team, while other organisations have their own call-centre that provides customer relations support. BAM, as another example, offers house buyers/owners an online portal (www.ditismijnthuis.nl) to inform and engage with dedicated groups of end-users for specific (new) developments.

The lease, membership, or subscription-based IES providers (e.g. The FCTR E, WOAB, VolkerWessels) have robust energy management systems as their warranties generally apply as long as the ownership of the IES installation is not (fully) transferred to the end user. By means of a user-friendly end-user interface (e.g. website, app) the customer can observe the energy performance of his/her own building and of individual components. RENOLUTION works with an energy monitoring app called IUNGO, while Thuisbaas works with infrared panels from ThermIQ that run through a WebIQ controller.

It appears that almost every individual appliance or system components comes with its own controller system. While the controller requires to be fully functional, it also needs to be able to be compatible with aggregator applications, that do full system monitoring and control.

5. Recommendations for IES development and implementation

In this report it has been argued that a robust and fully integrated IES addresses identified *technical*, *financial*, and *social* barriers (or challenges) of individually implemented energy solutions. This integrated service ideally includes three main components (see Figure 12):

1) Technology concept improvement
    i. Compatible set technologies and practices (integrated turn-key solution)
    ii. Good quality energy monitoring and -performance guarantees (software, legal)
    iii. Robust information and communication structures
2) Financial service innovation
    i. Financial guidance and solutions
3) Social innovation
    i. Stakeholder engagement procedures and structures

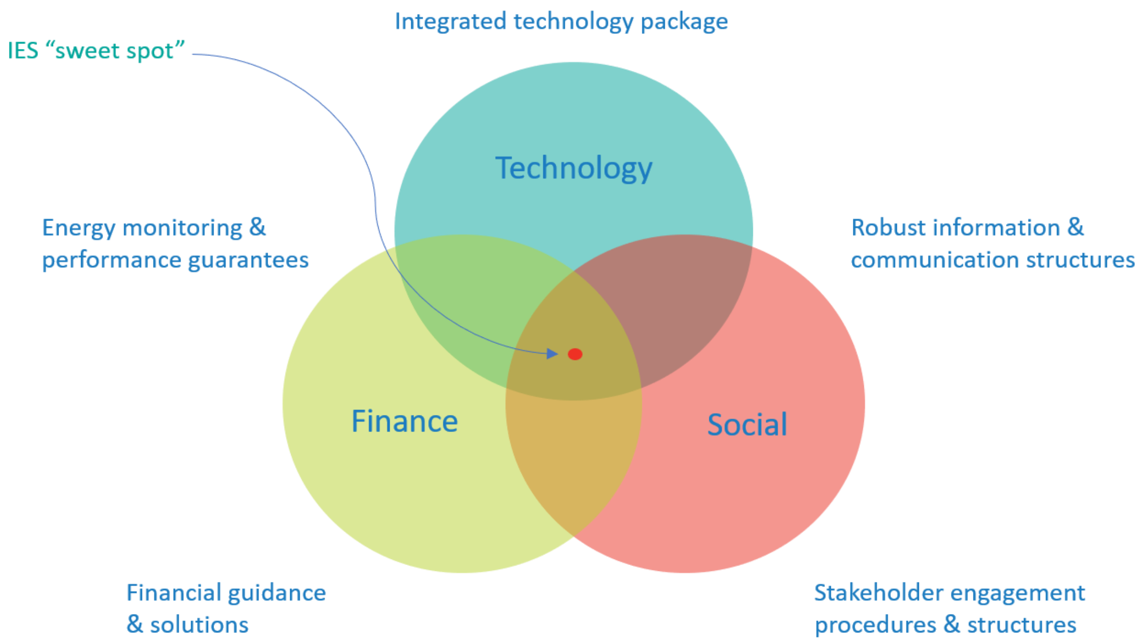

Figure 12: Key elements of an Integrated Energy System

The comparison between the Netherlands and Poland shows, that the Dutch IES market is relatively advanced and gradually progressing from the experimental and pilot phase to deployment of IES solutions in the market, towards further commercial diffusion. While in Poland IES development requires continued public funding support for progressing along the technology development journey, the challenge for the Dutch market is to ensure public-private collaborative actions for further upscaling and standardization of IES solutions to all segments of the built environment. Depending on the IES market stage of technology demand (i.e. research, development and experiment/pilot phase, grow/expansion phase, maturity phase, etc.) within a given country there are different policy strategies to pursue.

5.1. R&D, experimental / pilot phase

During this phase, the role of the public bodies is more prominent as a driving and enabling/facilitating actor in the IES market. With respect to the technology concept, research, development, pilot, and demonstration projects throughout the country and within different segments of the built environment are needed to show proof of (technology) concept. Parallel to that, national and local governments can also launch targeted information campaigns and host information sessions or marketplace events. In addition, some first experiments with novel financing schemes are needed, as well as facilitation, support, and experimentation of novel social structures (e.g. energy communities, local energy cooperatives). The direct public support (in-kind or with some subsidies) for improving the conditions for development of new financial instruments and promoting social innovation will eventually be needed to grow and expand the IES market.

5.2. Market deployment towards mature, commercial solutions

Within this phase, the IES technology concepts become increasingly more standardized, and larger segments of the built environment could be serviced. However, in this phase more support is needed for further standardization and institutionalization of the various new social and financial structures. Here, both public and private bodies can collaborate to further develop and support local (energy) communities/cooperatives (i.e. professionalization) in their ambitions. In addition, market actors need to be encouraged to develop robust solutions, with proper energy monitoring, for which they are willing to provide performance guarantees. Public bodies could aid in the co-development or development of new financing schemes (i.e. a Province could provide a financial guarantee, just as seen with the *Asser Servicekostenmodel* in Chapter 3), by providing either funding for hiring financial experts, or financial security (i.e. public guarantee fund) for at least a first generation of IES projects that are funded through novel financing schemes.

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Annex 1: The technology scope of IES in EU funded projects

Throughout the years several EU (e.g. FP7, H2020) funded projects have been executed to develop novel technologies and concepts to improve the energy and sustainability performance of buildings. Several projects targeted the research and development on single technologies, components, tools, or materials used in the building sector, while other focussed on several technologies that would fit in an integrated energy solution. On top of that there is a split in focus of projects targeting the 'passive' elements of an IES (e.g. insulation materials, façade concepts), while other projects target innovations in the active element: the energy installations (e.g. heat pump, solar pv improvements).

Figure 13 below provides an overview of a technological scope of a (non-exhaustive) subset of 18 EU funded projects.

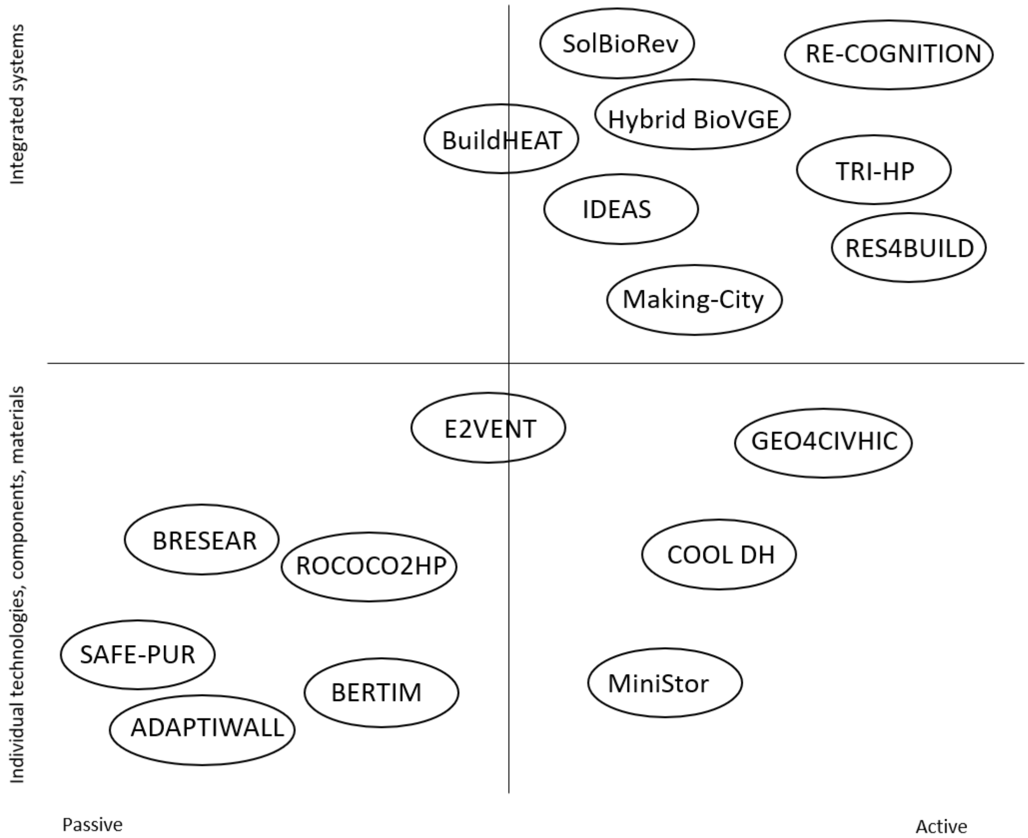

Figure 13: Main technology focus of EU funded projects

Projects like BRESEAR, ADAPTIWALL, SAFE-PUR, and BERTIM target individual materials and components with insulative properties, like modular façade panels or insulating materials. MiniStor, COOL DH and GEO4CIVHIC target individual energy technology solutions (resp. small scale seasonal energy storage, low temperature district heating and ground-source heat exchangers). There is also a range of EU funded projects (i.e. RES4BUILD, IDEAS, SolBioRev, RE-COGNITION, TRI-HP, Making-City, Hybrid BioVGE) that primary focus on further developing the 'active' components of integrated energy concepts by combining different renewable energy, and energy storage technologies (e.g. heat pumps, PV, solar thermal, bio-energy). The BuildHEAT project has focussed both on active and passive elements of an integrated energy system, while the E2VENT project aimed to develop a modular insulating construction component combined with a Smart Modular

Heat Recovery Unit (SMHRU) and the Latent Heat Thermal Energy Storage (LHTES). Most of the projects that target 'active' elements of an IES system also generally work on a monitoring / data management tool and/or (remote) controller system.

What is clear from this project analysis is that there has been less emphasis on developing and designing robust ways of selling, branding, and marketing these innovations. While developing robust marketing strategies or business models for a specific technology or service might not make immediate sense when the technology is in a low TRL stage, there can be great value in exploring early on in what market environment and under what conditions the specific technology, service or integrated concept is most likely to be delivered to the market of today and tomorrow.

While most barriers are often (to a certain degree) context-specific, they are generally well understood by local market experts and practitioners in the field. Within this report we have a special interest in barriers that arise within the social domain in multi-stakeholder settings (e.g. multi-family buildings, community centres, health care organisations) as solving these barriers is key to advance and speed up the uptake of IES solutions in the built environment.

	H2020 projects	**Technology focus**
	Acronym	About
1	RES4BUILD	RES4BUILD develops renewable energy-based solutions for decarbonising the energy used in buildings. The approach of the project is flexible, so that the solutions are applicable to a wide variety of buildings, new or renovated, tailored to their size, their type, and the climatic zones of their location. In the heart of the solution lies an innovative multi-source heat pump with a cascading configuration, including a magnetocaloric (bottom cycle) and a vapour compression heat pump (top cycle). The heat pump will be combined with other technologies in tailored made solutions that suit the specific needs of each building. These technologies will be selected on a case by case basis from a mix of standard equipment available in the market and from innovative components that will be specifically explored within the project. The innovative technologies include innovative collectors that integrate in one panel photovoltaic cells and solar thermal energy collectors (PV/T) and borehole thermal energy storage (BTES). For all solutions, advanced modelling and control approaches will be developed and will be integrated in a Building Energy Management System, allowing the users to select their objectives and to optimise the use of the system accordingly, allowing the activation of demand response and the exploitation of the full value of smart appliances and smart charging of electric vehicles.
2	TRI-HP Project	Development and demonstration of TRI-generation systems based on electrically driven natural refrigerant Heat Pumps coupled with photovoltaics, using cold (ice slurry), heat and electricity storages to provide heating, cooling and electricity to multi-family residential buildings with an on-site renewable share of 80% reducing the installation cost by 10-15%.
3	Hybrid BioVGE	Designing and demonstrating a highly integrated solar/biomass hybrid air conditioning system for space cooling and heating of residential and commercial buildings with improved efficiency and strong market potential.
4	IDEAS	Novel building Integration Designs for increased Efficiencies in Advanced climatically tuneable renewable energy Systems. IDEAS will create an innovative building-integrated renewable energy system using state-of-the-art demand-side management software combining the power of solar technology, phase change materials and heat pump configurations for a zero-carbon footprint.

5	Making City	A lighthouse project where innovative solutions of RES production, energy storage or smart control implemented on high performance buildings, are implemented at real scale to demonstrate that the Positive Energy District (PED) concept is a real solutions for transforming our cities into more sustainable places. The PED, as a district that produces more energy than consumes, generating a surplus that could be shared with other parts of the cities. Other aspects as energy flexibility and new business models for enhancing the energy sharing between different stakeholders are key aspects to optimize the PED and maximize the surplus produced.
6	SWSHeating	Development and Validation of an Innovative Solar Compact Selective-Water-Sorbent-Based Heating System. The SWS-HEATING project concept is to develop an innovative Seasonal Thermal Energy Storage (STES) unit with a novel sorbent storage material embedded in a compact multinodular sorption STES unit.
7	SolBioRev	Solar-Biomass Reversible energy system for covering a large share of energy needs in building. The core objective of the SolBio-Rev project is to combine promising renewable energy technologies based on solar, ambient and bioenergy, having at the core an innovative heat pump-based configuration and to allow the efficient application of this solution, without any geographical restriction at least in the EU.
8	GEO4CIVHIC	project is aimed to develop and demonstrate easier to install and more efficient Ground Source Heat Exchangers, using innovative compact drilling machines tailored for the built environment and developing or adapting Heat Pumps and other hybrid solutions in combination with Renewable Energy Sources for retrofits through a holistic engineering and controls approach improving the return of investments. GEO4CIVHIC target is to accelerate the deployment of shallow geothermal systems for heating and cooling in retrofitting existing and historical buildings.
9	RE-COGNITION	Combined applications of different Renewable Energy Technologies resulting in carbon-neutral buildings. The RE-COGNITION solution stands as an ICT integration framework, on-top of established and newly developed innovative Renewable Energy-based technologies, representing a highly inter-disciplinary concept for empowering the transition towards a renewable building landscape. This goes even a step further by setting the ambition towards zero-energy or even energy positive buildings, with emphasis on the small and medium-sized building stock in Europe.
10	COOL DH	"The COOL DH project will innovate, demonstrate, evaluate and disseminate technological solutions needed to exploit and utilise sources of very low-grade ""waste"" heat for heating of energy efficient buildings via Low Temperature District Heating (LTDH) and show how the District Heating (DH) systems can be more resource efficient and more energy efficient. The demonstration covers both new developments and stepwise transition of existing areas with district heating and energy retrofitting of buildings.
11	ADAPTIWALL	ADAPTIWALL (Multi-functional light-weight WALL panel based on ADAPTive Insulation and nanomaterials for energy efficient buildings)
12	BERTIM	BERTIM aims at the development of a standardized product for the wood industry for building energy efficient renovation.
13	BRESEAR	BRESAER will design, develop, and demonstrate an innovative, cost-effective, adaptable and industrialized envelope system for building refurbishment. This system will include combined active and passive prefabricated solutions integrated into a versatile lightweight structural mesh.
14	BuildHeat	A set of reliable, energy efficient and affordable retrofit solutions will be made available, which execution is facilitated by industrialised, modular and flexible HVAC, façade and ICT systems developed.

15	E2VENT	The E2VENT module embeds two distinct active systems. The Smart Modular Heat Recovery Unit (SMHRU) and the Latent Heat Thermal Energy Storage (LHTES). The LHTES is not designed for the air renewal but only to store the external potential energy to use it for heating or cooling. Therefore, it can a complementary system with high performance for heating and cooling especially aiming at reducing the peak loads.
16	EENSULATE	Development of innovative lightweight and highly insulating energy efficient components and associated enabling materials for cost-effective retrofitting and new construction of curtain wall facades.
17	MiniSTOR	The overall objective of the MiniStor project is to design and develop a novel compact, integrated thermal storage system for achieving sustainable heating, cooling and electricity storage that can be adapted to new and existing residential buildings. The system includes an innovative HEMS (Home Energy Management System).
18	ROCOCO2HP	The aim of this project is to develop efficient real-time optimal control (RTOC) for the carbon dioxide (CO_2) heat pump as a part of a building energy supply system and validate its reliability experimentally.

Table 12. Overview of Horizon 2020 projects considered

Annex II: Complementary contextual information on Pomerania

Energy production and consumption

Pomerania is a region dependent on external electricity supplies. Electricity production in 2018 in the voivodship amounted to 4,105 GWh versus a consumption of 8,464 GWh. This results in an electricity production to electricity consumption ratio of 48.5% (Table 13).

Electricity production	unit	2006	2010	2016	2017	2018
total, including:	GWh	2 970	3 081	4 465	4 534	**4 105**
from fossil fuels	GWh	2 577	2 310	2 240	2 125	**2 001**
from RES	GWh	393	770	2 226	2 409	**2 104**
RES share in electricity production	%	13.2%	25.0%	49.8%	53.1%	**51.3%**
ratio of electricity production to electricity consumption	%	41.5%	39.4%	53.0%	53.6%	**48.5%**

Table 13: Electricity production in Pomerania voivodeship

Source: Head Statistical Office, Local data bank, www.stat.gov.pl (2020).

Gas network connections

The gas network in Pomerania is small but increasing by over 3% per year since 2005 (Table 14). Although the number of gas consumers in cities is virtually unchanged, it has increased significantly in the countryside where gas consumption since 2010 grew significantly by about 42%. In areas without a gas network, LPG is used for communal and domestic purposes.

	unit	2005	2010	2015	2017
Gas network including:	km	3 853	5 308	6 605	7 056
cities	km	2 648	3 219	3 514	3 697
countryside	km	1 206	2 090	3 091	3 359
Gas connections	1 000	87,8	101,3	114,9	118,3
Network gas consumers, including:	1 000	405,5	403,3	402,5	415,6
cities	1 000	396,6	387,5	376,8	387,7
countryside	1 000	8,9	15,8	25,7	27,9
network gas consumption, including:	GWh	1 972	2 326	2 207	2 489
cities	GWh	1 856	2 095	1 895	2 139
countryside	GWh	117	230	312	350
per capita:	kWh	897	1 025	957	1 077
cities	kWh	1 252	1 398	1274	1 439
countryside	kWh	163	298	381	424

Table 14: Gas network, consumers, and consumption of network gas in households

Source: Main Statistical Office, Local data bank, www.stat.gov.pl (2018).

Renewable energy

There are different types of RES installations:

- Micro installation – is a RES installation with a total installed electrical capacity of no more than 50 kW, connected to the power grid with a rated voltage lower than 110 kV or with a maximum thermal capacity in combination of not more than 150 kW, in which the total installed electrical capacity is not higher than 50 kW;
- Small installation – is an installation of a renewable energy source with a total installed electrical capacity greater than 50 kW and less than 500 kW, connected to the power grid with a rated voltage lower than 110 kV or with a combined thermal capacity greater than 150 kW and lower than 900 kW, in which total installed electrical capacity is higher than 50 kW and lower than 500 kW.
- Other installations - are larger than small installations.

Operating data for micro- and small-scale RES installations are difficult to access. The list of producers of electricity from renewable energy sources in small installations includes the following number of installations in the region (see Table 15).

RES type installation	Number of small installations
Biogas	3
PV	5
Wind	5
Hydro	41
Other RES	4

Table 15: Number of small-scale RES installations in Pomerania
Source: Energy Regulatory Office report, 17.02.2020.

Information about the capacity of installations and the volume of energy produced is unavailable, even though installation operators submit this data to the Energy Regulatory Office.

Household energy consumption

In recent years, the voivodship (similarly to the whole country) has seen a decreasing consumption of electricity by households (Table 16). Approx. 65% of energy consumed by households is intended for space heating.

	unit	2010	2015	2017		2018
consumption	GWh	1 891	1 656	1 712		n/a
per capita consumption in cities	kWh	840	731	715		n/a

Table 16: Consumers and electricity consumption in households, 2010-2018
Source: Main Statistical Office, Consumers and electricity consumption in households, 2010-2018, www.stat.gov.pl (2019).

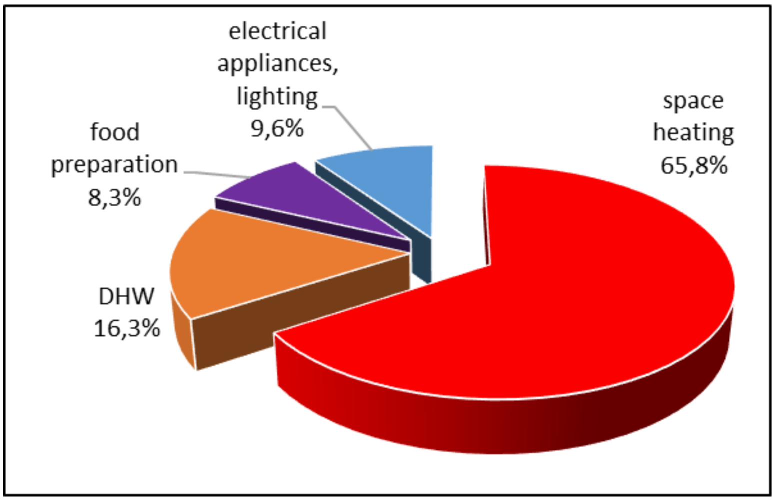

Figure 14: Energy consumption by households (2017)
Source: Main Statistical Office, Consumption of energy in households, www.stat.gov.pl (2018)

Annex III: Factsheets of Dutch IES system providers

Organization	Klimaatgarant
Founded	2012
Focus	
Passive components	No
Active components	Yes
Organization structure	After merger with Itho Daalderop part of the 'Climate For Life' (CFL) Holding since 2016. CFL is a group of cooperating companies, including Itho Daalderop, Klimaatgarant, Klimaatgarant Solar, and flow. Itho Daalderop develops, manufactures, and sells HVAC solutions. A key investor in CFL Holding is Gimv private equity investors.
Market focus	New builds; residential (single houses, apartments, flats)
IES concept	Deliver a full package including (balance) ventilation, shower heat water recovery, thermostats, floor heating/cooling, PV, triple glazing, LED lighting, short- and long-term heat storage, heat pumps.
Works with preferred technology / service suppliers?	Yes, with Itho Daalderop for HVAC technology supply. No exclusive links to service suppliers (installers), works through Joint Ventures, or local partnerships.
Mode of operating	Generally contracted as partner in new developments by project developers, building & construction companies, housing corporations and investors. Increasingly working as partner in joint ventures (e.g. with Roosdom Tijhuis construction company). Also subcontracts work to TES & PV installers, well drillers, and maintenance partners.
Can deliver	EPC 0 (energy neutral) buildings.
Contract forms	Buy
	Lease
Warranty	Optional with 25 years energy performance guarantee, incl. maintenance contract at fixed monthly rate. Guarantee is granted on claimed performance, not on functionality of individual devices.
Minimum requirements building	New builds that meet building code minimum requirements. Prefer projects with >20 dwellings or more.
Strategy to help/engage end-users	No dedicated end-user engagement strategy in place. With focus on new builds the end-users only come in during the exploitation phase, for example with maintenance and/or within the leasing concept. Online reviews from end-users show that there are some issues with customer satisfaction and after sales servicing.

Organization	The FCTR E
Founded	2016
Focus	
Passive components	No
Active components	Yes
Organization structure	Independent private company (energy start-up).
Market focus	New and existing residential houses; (single houses, apartments, flats).
IES concept	Energy system for transforming a house into an e-home with solar panels, an air/water heat pump and an integrated boiler tank.
Works with preferred technology / service suppliers?	Yes, for heat pumps they have a collaboration with Nibe.
Mode of operating	Generally contacted by a homeowner, who wants to transform his house into an e-home.
Can deliver	All-electric energy system for houses, includes heat-pump, buffer and possible extra option of solar pv panels.
Contract forms	Lease, in form of membership / subscription (fixed fee per month)
	Buy also possible, after 1 year
Warranty	With Lease option, full system warranty as long as you have membership. When system is bought product warranties apply (24 months on Nibe heat pump, max. 10 years with solar pv panels, 10 year solax reformer and 12 years solaredge reformer). https://www.thefctre.com/en/wp-content/themes/the-fctre/static/the-fctr-e-algemene-voorwaarden.pdf
Minimum requirements building	Minimum energy label C fore existing houses is required (building envelope should be suitable)
Strategy to help/engage end-users	The FCTRE team inspects the house and makes an adaption plan in order to make the house suitable for the installation of the electronic energy system. The homeowner takes care of the adaptation of the house. If desired, the FCTRE team can contact a contractor and supervise the reconstruction. When the adaption is completed, the FCTRE team installs the energy system. The FCTRE offers a membership to users. The membership includes monitoring, maintenance, service and guarantees. The membership is obliged for leasers and optional for buyers. The members are considered as a community.

Organization	ETECK
Founded	1895
Focus	
Passive components	No
Active components	Yes
Organization structure	Private company, funded by several banks.
Market focus	Mainly new and in some cases existing residential (predominantly through take-overs) complexes and business buildings owned by project developers and housing corporations.
IES concept	ETECK is an energy providing company, which can develop, build, exploit and operates sustainable, collective, decentralised installations that supply heat and cooling
Works with preferred technology / service suppliers?	No.
Mode of operating	Essentially operates as an energy company that supplies heating and cooling services, mainly to larger developments (areas, building blocks).
Can deliver	Heating and cooling services.
Contract forms	Payment for services through monthly energy bill (fixed share + variable share)
Warranty	25-year warranty on the energy performance provided to end-users (at monthly payment).
Minimum requirements building	Seems to mainly target new developments that come with block-heating/cooling systems.
Strategy to help/engage end-users	For users of ETECK an app is provided in which they can monitor their energy consumption, report meter readings and malfunctions. At ETECKs website, users can make their own account for controlling their registered data. Online (google) reviews suggest that customer aftercare can be improved.

Organization	ThuisBaas
Founded	2016
Focus	
Passive components	No
Active components	Yes
Organization structure	Private non-profit organisation (social enterprise, founded by Urgenda)
Market focus	Mainly existing buildings from individual private house owners in the western and middle part of The Netherlands.
IES concept	Mainly all-electric systems, combining heat-pump, infrared panels, instant heater, PV and/or PVT panels, with heat buffer, but also insulation measures.
Works with preferred technology / service suppliers?	No.
Mode of operating	Thuisbaas advises / supports house owners (and also housing associations) and as an independent intermediary, composes together with them a tailor-made energy installation system and installs the system at estimated average cost of 35.000 EUR per house.
Can deliver	Energy neutral systems for individual houses.
Contract forms	Buy. The client buys a full-service package (without financing)
Warranty	Provides standard warranty on individual appliances and components but offers a 'zero-on-the-meter' optional warranty.
Minimum requirements building	Individual households are mainly targeted, with mainly stand-alone houses but also adjacent houses in the current portfolio. With the primary focus on the energy installation, any additional insulation measures are not omitted, but a minimum quality building envelope needs to be present to remain within the 35k EUR budget target.
Strategy to help/engage end-users	On its website, Thuisbaas presents itself as a social enterprise, attracting people with the slogan 'do you also want to get rid of the gas?', a hot issue in The Netherlands due to the earthquakes in Groningen as a result of the gas extraction. If house owners choose to do business with Thuisbaas, the firm guides them from the beginning by making a tailor-made plan to the installation of system in their home.

Organization	Grunneger Power Energy cooperative
Founded	2011
Focus	
Passive components	Yes
Active components	Yes
Organization structure	Local energy cooperative
Market focus	Mainly existing buildings and local energy projects in the Province of Groningen.
IES concept	Offer local support and advise to neighbourhood associations, private households on solar energy, electric fuel stations, development of collective solar park/rooftop projects, both for home owners and people who rent. Also develops collective energy supply projects, such as a district hearing system.
Works with preferred technology / service suppliers?	No.
Mode of operating	Membership: anyone can become a member of Grunneger Power (for free or for a small fee). The members of the cooperative undertake many activities themselves: they give each other advice on how to make houses or businesses more sustainable (via the district energy coach) or form small groups to realize an initiative. That is always tailor made work. Stimulating and facilitating the use of energy from solar panels on a private roof, a communal roof nearby, a roof on a rental house or a panel from a solar park. Offering a pass for a Grunneger Power charging point for electric cars. Organizing purchasing actions (for example of induction hobs) and information evenings and district energy plans. Grunneger Power thereby provides professional independent support and financial benefit.
Can deliver	Green local electricity. Develop local energy projects. Advice on making homes, businesses and neighbourhoods more sustainable and to provide professional support in its realization.
Contract forms	Membership of cooperation, customer from energy supplies, take part as 'investor' in projects developed by the cooperative.
Warranty	Not specifically indicated. So, likely that manufacturers, suppliers warranties apply.
Minimum requirements building	Most initiatives to date, target placement of solar pv on rooftops, which has to meet very minimal requirements.
Strategy to help/engage end-users	Grunneger Power is a local sustainable energy initiative, for and by citizens. Each citizen can become a member of the cooperation and benefit from its activities. GP employs community mentors, and hosts/takes part in regular social/impact events.

Organization	Het Woningabbonement 'WOAB'
Founded	2017
Focus	
Passive components	Yes
Active components	Yes
Organization structure	Private company. Brands itself as social enterprise. Originated as start-up and received start-up support from public bodies.
Market focus	Targets mainly existing buildings (individual private homeowners), and serves clients in Provinces Overijssel, Gelderland, Friesland and City of Almere. Specific ambition to also target lower-income households, who cannot generate investment funding.
IES concept	Individual measures are accumulated up to the point where the monthly costs for the packages reaches the level of the expected energy bill savings. No specific IES concept is promoted.
Works with preferred technology / service suppliers?	Yes, WOAB works with a subset of 'trusted' suppliers.
Mode of operating	Operates as a total service intermediary, that ensures that technologies, contractors, installers, finance, subsidy applications are in order.
Can deliver	Integrated Energy Solution for buildings with both passive and active measures.
Contract forms	Provides a subscription for 10, 15 or 20 years. Participants pay a monthly subscription fee similar to the cost savings on their energy bill as a result of measures implemented. 3% interest is charged.
	Also allows for homeowners not to lend, but (partially) fund the measures themselves. Once per year free of admin charge early redemption payments can be made.
Warranty	Warranty applies to energy performance and all individual appliances as long as subscription runs.
Minimum requirements building	No specific minimum requirements seem to be in place, but most likely the building needs to be privately owned (by household).
Strategy to help/engage end-users	The nature of the subscription contracts, requires a good aftercare, and after sales procedure. Given that WOAB still is a small enterprise (7 FTE staff), this still seems manageable. WOAB also provides regular presentations in local social/neighbourhood events.

Organization	RENOLUTION B.V.
Founded	2008
Focus	
Passive components	Yes
Active components	Yes
Organization structure	Renolution Group comprises Renolution B.V. And subsidiaries Renolution Bouw B.V., Renolution Beheer en Onderhoud B.V. And Fit4TheFuture B.V.
Market focus	Larger scale dwellings/buildings (blocks), both new builds and retrofits.
IES concept	Puts great emphasis on improving the building envelope with prefab modular facade solutions. An industrialized construction system consisting of a prefab insulated steel frame construction. A CO2-controlled ventilation system with heat recovery has been installed in the facade to control the ventilation of the house. A sensor measures the CO2 value and, if necessary, will blow in extra clean fresh air. The shell also contains an air-to-water heat pump with a hydrobox. Linked to this is the delivery system to radiators and/or underfloor heating and hot tap water. The installation is standard equipped with a very extensive intuitive operating unit with monitoring options. Solution fits passive house, zero-on-meter and energy neutral concepts
Works with preferred technology / service suppliers?	Develops their Renolution prefab system in-house.
Mode of operating	Renolution applies a four-stage process. First, an inventory of wishes and requirements is made, and a preliminary design of the system is presented. Second, a realistic construction and assembly plan is drawn up on the basis of constructive, structural and installation-technical calculations. Third, after approval of that plan, an insulated steel frame construction is made in the Renolution factory. Finally, the steel frame construction is mounted on the construction site by certified construction partners. Because the facade is produced prefab in the factory and mounted on the construction site, the construction takes only a few days. Does not offer financing services.
Can deliver	An integrated energy solution, with HVAC systems integrated in the prefab facade panels for larger grouped buildings/building blocks.
Contract forms	Buy.
Warranty	Minimum of 30 year performance warranty.
Minimum requirements building	No specific requirements seem to be in place, but the Renolution solution is very suitable for building blocks with relatively simple geometric forms.
Strategy to help/engage end-users	There is a dedicated 6-phase process in place to communicate with end-users. Each end-user gets a personal file. Monitoring occurs through IUNGO application.

Organization	Dura Vermeer
Founded	1855
Focus	
Passive components	Yes
Active components	Yes
Organization structure	Limited company Dura Vermeer is a large construction company with over 2500 employees. It wants to be a leader in energy neutral construction in both new buildings and renovations.
Market focus	Residential construction (new and renovation), buildings and infrastructure.
IES concept	No fixed concept but in general energy neutral buildings by applying smart technological and innovative applications such as solar panels, heat and cold storage systems, ready-made facades, new roofs, triple glazing and installations, these houses/buildings deliver as much energy to the energy grid as they extract from it. In some cases, they generate even more energy than they use.
Works with preferred technology / service suppliers?	No.
Mode of operating	As a major market player, Dura Vermeer builds and manages real estate. Also develops, designs, build, manage and exploit energy systems.
Can deliver	Integrated Energy Solution for buildings with both passive and active measures.
Contract forms	Different service, performance and contract forms are offered to the market, including energy system exploitation service agreements.
Warranty	Dura Vermeer gives a 40-year warranty on the established standard for energy performance.
Minimum requirements building	No. As IES solutions are tailored to fit specific circumstances.
Strategy to help/engage end-users	In renovation projects, Dura Vermeer strives to be involved from design to operation. Great importance is attached to good communication with residents, such as information evenings, visits of residents at home to discuss the personal situation, visible presence in the neighbourhood during the renovation, consultation hours and the deployment of a resident counsellor.

Organization	Koninklijke VolkerWessels B.V.
Founded	1854; Volker and Wessels merger took place in 1997.
Focus	
Passive components	Yes
Active components	Yes
Organization structure	Private company with over 120 firms and 17,000 employees.
Market focus	VolkerWessels focuses on the new construction/refurbishment of residential complexes and buildings, telecom, installation technology, supply, road construction, energy networks, civil engineering, railway construction and mobility & engineering.
IES concept	No fixed concept but in general energy neutral buildings by applying smart technological and innovative applications such as solar panels, heat and cold storage systems, ready-made facades, new roofs, triple glazing and installations, these houses/buildings deliver as much energy to the energy grid as they extract from it. In some cases, they generate even more energy than they use. The 'MorgenWonen' concept develops pre-fab houses with full energy installation concepts that reduces building time.
Works with preferred technology / service suppliers?	No.
Mode of operating	As a major market player, VolkerWessels builds and manages real estate. Also develops, designs, build, manage and exploit energy systems.
Can deliver	Integrated Energy Solution for buildings with both passive and active measures.
Contract forms	Different service, performance and contract forms are offered to the market, including energy system exploitation service agreements.
	Buy, lease (whole building)
Warranty	Depending on type of contract agreed upon with VolkerWessels.
Minimum requirements building	No. As IES solutions are tailored to fit specific circumstances.
Strategy to help/engage end-users	VolkerWessels supplies real estate and negotiates with companies, cooperatives and governments. They do not concern themselves with future individual residents in homes.

Organization	BAMwonen
Founded	1869
Focus	
Passive components	Yes
Active components	Yes
Organization structure	Limited company The BAMgroep has about 21,500 employees and realizes construction projects in the Netherlands and abroad.
Market focus	The operating company BAMwonen is focussed on new construction and renovation of residential complexes (typically larger developments).
IES concept	No fixed concept but in general energy neutral buildings by applying smart technological and innovative applications such as solar panels, heat and cold storage systems, ready-made facades, new roofs, triple glazing and installations, these houses/buildings deliver as much energy to the energy grid as they extract from it. In some cases, they generate even more energy than they use.
Works with preferred technology / service suppliers?	No.
Mode of operating	As a major market player, BAM FM builds and manages real estate. Also develops, designs, build, manage and exploit energy systems.
Can deliver	Integrated Energy Solution for buildings with both passive and active measures.
Contract forms	Different service, performance and contract forms are offered to the market, including energy system exploitation service agreements.
Warranty	Depending on type of contract agreed upon with BAM.
Minimum requirements building	No. As IES solutions are tailored to fit specific circumstances.
Strategy to help/engage end-users	Every buyer of a new house or tenant of a renovation home gets access to his own personal environment on the BAM portal (ditismijnthuis.nl). There the news and the latest relevant developments about the house and the project can be found. A housing advisor can also be contacted at that portal and it is possible to contact fellow residents as well.

Organization	BENG Nederland
Founded	2017
Focus	
Passive components	Yes
Active components	Yes
Organization structure	Cooperative (between different private companies that provide different components of the IES)
Market focus	Retrofit of bigger grouped (block) buildings. Targeting mainly, Associations of home owners and housing corporations.
IES concept	(Almost) Energy Neutral Building (NOM-ready). Depending on the building, a selection of innovative products is used in the field of facades, balcony systems, roofing, insulation, ventilation and power generation systems.
Works with preferred technology / service suppliers?	Claims to be an independent cooperative, but works with a set of preferred suppliers, and affiliated/founding partners do fulfil roles and/or supply technologies and services in the BENG Nederland projects.
Mode of operating	Guiding associations of home owners and housing corporations to turn residential complexes into (almost) energy neutral buildings. The guidance is given throughout the entire process: from the first feasibility studies up to and including the final realization. BENG makes an inventory of the sustainability options for the project, thinks about various financing and subsidy options and takes care of the communication with all parties involved, such as boards, residents, municipalities, provinces and 'society'. BENG does not operate like a regular contractor, but joins forces with independent consultants, producers and suppliers as partners to achieve the best result for the client. Because clients and partners have the freedom to decide for themselves which implementing party they work with, BENG is not bound by permanent implementing parties.
Can deliver	Nearly energy neutral buildings (NOM-ready)
Contract forms	Buy. BENG Nederland provides also a financial advisor who will aid in searching for and arranging suitable finance solutions (e.g. Building related/linked finance).
Warranty	Not clearly specified.
Minimum requirements building	No. Seems to be able to tailor the solution to building specifics.
Strategy to help/engage end-users	No clear dedicated strategy communicated in public documentation.

Organization	WoonlastenNeutraal Renoveren (WNR)
Founded	2020 (https://wnr.nu/)
Focus	
Passive components	Yes
Active components	Yes
Organization structure	Foundation WNR is an initiative of SME construction entrepreneurs who have been working together for many years in the knowledge network 'DNA in Construction'. This collective has developed the approach to renovate homes 100% affordably sustainably, with permanently low housing costs. Affiliated companies are certified by WNR.
Market focus	Homeowners Associations (only retrofit)
IES concept	Integrated approach to roof, facade and floor insulation, balance ventilation, triple glass and the highest possible air tightness.
Works with preferred technology / service suppliers?	WNR works with construction teams of certified SMEs.
Mode of operating	Renovations are carried out by certified WNR construction teams. The façade is made prefab in factory. The rest is assembled on site.
Can deliver	
Contract forms	Buy
Warranty	The WNR construction teams guarantee energy performance during the term of the loan taken out by the Homeowners Association, up to 30 years.
Minimum requirements building	Each residential complex can be transformed by WNR.
Strategy to help/engage end-users	WNR attracts people by stating that the transition is housing costs neutral: the cost savings on maintenance and energy are sufficient to finance the renovation. The Homeowners Association (HA) takes out a loan, guaranteed by a guarantee fund. The homeowners pay a monthly amount to the HA. When a house is sold, the monthly payment obligation to the HA is transferred to the new owner. WNR offers a total package for the renovation of buildings: communication with residents, financing, legal support, design and implementation of the renovation by expert companies, a performance guarantee, aftercare and maintenance.

Organization	Voor de VVE (For Homeowners Associations)
Founded	2016 (https://www.ae-duurzaam.nl/ https://www.voordevve.nl/)
Focus	
Passive components	Yes
Active components	Yes
Organization structure	Private company; the company started in 2016 as AE Duurzaam; it changed its name in 2019 into Voor de VVE.
Market focus	Homeowners Associations (only retrofit)
IES concept	Roof insulation, solar panels, collective battery, and individual meters in each apartment. Voor de VVE works with Rhepanol® roofing. Modularly built solar panels are mounted on the roof, which after 25 years still have a performance guarantee of at least 84 percent. All solar panels go with their cables to one central technical room. All inverters, optimizers, batteries and central control are in this room. From this room, all individual apartments are wired via the meter cupboards. Thus, all apartments can be individually connected and supply to a collective battery. Also, a special energy meter is placed, which ensures that only the power that is consumed in the apartment is converted and that the rest is stored in the battery.
Works with preferred technology / service suppliers?	Yes, Voor de VVE works with own regular suppliers.
Mode of operating	Voor de VVE supplies the energy system and has it installed by our own technicians.
Can deliver	Roof insulation, solar panels, collective battery, and individual meters in each apartment.
Contract forms	Buy
Warranty	20 years warranty and maintenance on the solar panels and roofing. After this period, the solar panels are in possession of the HA. The energy performance of the solar panels is guaranteed for 25 years.
Minimum requirements building	Each residential complex can be transformed.
Strategy to help/engage end-users	Voor de VVE, the costs for the roof, the solar panels and the individual meters are financed by means of various banks and funds. The HA enters into an agreement with Voor de VVE for 20 years. In addition, the HA pays a monthly amount to Voor de VVE. During this period, Voor de VVE ensures that the entire installation continues to work and to be maintained. The monthly amount that homeowners pay to the VVE for the renovation does not exceed the savings on energy costs per month. Voor de VVE guides the HA in the search to find the most desirable, logical and most affordable way to sustainability. This depends, among other things, on the lifespan of current installations, the personal wishes of the HA, the environment, the composition of the family situations and the financial position of the HA. If a choice is made, Voor de VVE takes care of the implementation and financing.

Annex IV: Summary of stakeholder interviews in Pomerania

Stakeholder	**Administration of Pomerania Province, Section of Energy Planning, Department of Economic Development**
Type of stakeholder	Regional administration
Key characteristics and potential role	- coordination of municipal energy plans from Pomerania region - establishing criteria of RES and EE financing within Regional Operational Programmes
Technology	- heat pumps – well developed, installed even without special financial support - PV and solar collectors – at the edge of success, require marginal special funding
State-of-the-art (innovation)	In general projects were financed from different special funds; already known technologies, typically less expensive, were applied. In multifamily buildings – basic solutions, like PV, located at roof-tops. Public buildings – financing with grants acquired for implementation of integrated energy systems, e.g. PV and heat pumps; in larger projects, like hospitals, more ambitious projects: CHP with solar collectors and PV were installed. Only few bigger, state-of-art projects with tri-generation and heat pumps were implemented.
Motives	Energy cost reduction was the main motive. RES projects supported by special funds and grants aimed at public buildings play important demonstration role for local communities. Employed technologies: primarily - solar collectors and heat pumps; secondary - PV systems. Also biomass heating expanded in the countryside (mainly wood, straw to a lesser extent). Unfortunately agriculture biogas plants have not reached expected widespread application.
Process	Public buildings - typically maintenance staff is involved in construction, supervision of progress, training and operational issues. Industry - internal energy specialists take part in project preparation and development and have impact on the design process. Multi-family housing - it is the most difficult process at housing cooperatives and housing associations as these are a combination of private and public flat owners. Preparation and implementation of the project can be very lengthy, external consultants may meet with distrust and the project may be stopped at any stage.
Expertise	Public buildings staff is often ready to undertake and implement RES projects. Especially larger entities, like hospitals, have own specialists to successfully complete and later maintain RES installations. In case of other buildings, like schools, support from communal staff is required. Nevertheless, all projects require external experts, like auditors, consultants, designers and supervisors. Residential buildings owners and administration do not have required knowledge. There is also uncertainty about the outcome of the investment.
Management	Typically management of the RES installation after the guarantee period is transferred to maintenance staff. In some cases engagement of professional company would be more adequate. Energy monitoring is typically run and limited to the period of obligatory project reporting - 1 to 5 years.
Diffusion	In a longer run RES projects, especially implemented in public buildings, have impact on end-users, other sectors and buildings. Advanced technologies and IES concept developed within RES4BUILD project could be later adapted to local conditions, using special financing from regional funds for innovations and development.

Stakeholder	Record Ltd., Gdańsk
Type of stakeholder	Design office
Key characteristics and potential role	Design company established in 1990, active at building market: sanitary, electrical installations, IT. Experience in large public, commercial and residential projects
Technology	Technologies employed in larger projects include cogeneration, tri-generation, heat pumps, energy recovery. For buildings close to water - front sea water used as lower source for heat pumps.
State-of-the-art (innovation)	Typically well known, reliable technologies are used. However, in more prestigious buildings equipment of high quality and efficiency is installed. Still, all RES solutions are treated as innovative.
Motives	External, special funding is often a driving force to install renewable energy. Sometimes end-users are prepared to use advanced technologies after initial studies and consulting advice. Future operation costs are important to clients.
Process	Typically end-users are not ready to discuss proposed technologies and solutions. Estimation of investment expenditures and future costs is necessary and sometimes it is the determining factor.
Expertise	Investments are prepared and run by experts. There is general understanding of smaller PV systems and heat pumps.
Management	Typically larger facilities are equipped in BMS systems, however energy is often only a minor part of it. The necessity of energy monitoring is generally not understood.
Diffusion	RES projects are attractive when pay-back period is rather short, well below 10 years. Price of traditional energy sources is low and often not stimulating use of innovative RES.

Stakeholder	Kwidzyn Industrial and Technology Park
Type of stakeholder	Technology Park (TP)
Key characteristics and potential role	Center for innovation development in the field of green energy covering research, production and service sectors as well as energy management technologies.
Technology	Gravel ground heat exchanger, ground heat pump system, gas fuel cell, 100 kW PV, 2 kW vertical axis wind turbine and mechanical ventilation system with heat recovery were installed. In addition, due to large glazed areas, movable external blinds were installed.
State-of-the-art (innovation)	Innovative project gives an opportunity to test new technologies. Functioning of the devices is controlled by a Building Management System with possibility of continuous monitoring.
Motives	An important element of the project was to provide advanced infrastructure for the development of innovative companies (those operating in RES sector in particular). The stimulus of the project was the availability of EU funds in the Pomeranian region for the development of entrepreneurship.
Process	The project was financed from the Regional Operational Programme for the Pomerania Voivodeship and self-governments' own funds (investment loans). General contractor was selected. The project was implemented in "design and build" formula. Equipment warranty was provided for the period of 5 years. In the process of contractor selection it is important to include not only lowest price criterion as the deciding factor but also experience in RES implementation.
Expertise	Technical expertise was available at KPPT. Consultations in the field of state aid and EU funding were necessary.
Management	Management of devices and system operation is based on Kwidzyn Industrial and Technology Park's own resources. KPPT technical support has access to the BMS system and it concerns management of heat, cold and electricity use.
Diffusion	Implementation and operation of the project can be transferred to similar projects. It is important to consider not only investment costs, but also operational and maintenance costs and staff dedicated. It is also important to have the device manuals well prepared and to run professional trainings on the operation of devices.

Stakeholder	Regional Energy Agency (PRAZE)
Type of stakeholder	Energy Advice Agency
Key characteristics and potential role	Energy consulting, training and international cooperation in the field of energy efficiency and implementation of renewable energy sources.
Technology	Installation of RES at 437 end-users - owners of single-family houses. In total 562 RES were installed, including 189 PV installations, 73 biomass boilers, 212 flat solar collectors and 86 heat pumps. In some cases EIS of two or three RES technologies were installed.
State-of-the-art (innovation)	Market-tested and high-quality solutions were chosen in order to avoid equipment failures and related costs that could have negative impact on RES image among local community. Heat pumps of 2-3 kW capacity and hot water storage tanks were designed to meet the needs of domestic hot water preparation. PV panels with capacity of 2-10 kW and solar collectors were installed inside or outside combined with hot water storage tanks.
Motives	The motive behind the project was the availability of EU funds in the Pomeranian region for the development of renewable energy sources. Local governments took advantage to obtain high level of co-funding (approx. 84%) and promote RES among local communities. Co-financing of RES investments certainly contributed to great interest in the project. End customers wished to improve standard of their flats and reduce operating costs.
Process	The project is managed and supervised by the local energy agency. There are also four municipalities involved as project partners. They collected applications from interested household owners. Administrative procedures were consulted with the Managing Authority of the EU funds in Pomerania region. The agency also participated in consultations during the design, implementation and investment settlement stages. The agency owns all the installations for a period of 5 years. Cost-effective roof rental agreements were concluded to enable PV installation.
Expertise	The agency had technical expertise, but there was lack of practical experience concerning interactions with final recipients, public procurement, etc. Consultations with EU funds experts were also necessary.
Management	Installations are equipped with automation and control systems. Contractor is obliged to provide 5-year warranties. Users were instructed on the use of devices installed as well as rules of correct, safe operation and maintenance.
Diffusion	The project attracted a lot of interest among local communities. The project organization model can also be used by other recipient groups. One of the key success factors is a proper selection of experienced project leader.

Stakeholder	Pomeranian Agriculture Advisory Centre (Pomorski Ośrodek Doradztwa Rolniczego), Lubań
Type of stakeholder	Public agency in Pomerania Region
Key characteristics and potential role	Agriculture Advisory Centers operate in each province, they support the development and competitiveness of agriculture by the means of training and information, agriculture fairs and other supporting activities aiming at farmers and businesses in rural areas.
Technology	- heat pumps with boreholes as the lower source to support two buildings with heat and DHW (capacity 80 kW) - PV panels: 8 kW roof-mounted and 40 kW ground-mounted, with two sun-tracking systems - monitoring available on-line - prototype micro-biogas plant
State-of-the-art (innovation)	Installed RES systems at PODR premises have employed recent, state-of-the-art technologies available on the market. Farmers are interested in most recent technologies, lately in PV micro-installations, as long as they are economically feasible. Biogas plants considered by some communes shall be primarily used to utilize waste from agriculture production, including manure and chicken droppings.
Motives	Farmers primarily look at financial aspects of RES implementation. Their incomes from agricultural activities are not fixed, profits are low so they look for special incentives. However, there are special funds available for farmers and agriculture businesses. Development and mechanization of agriculture require more electricity, therefore there is growing interest in PV generating electricity for own needs.
Process	Farmers use typically already verified contacts in rural neighborhood, including local installers and technology providers. They are usually offered turn-key solutions with delivery and installation of new systems.
Expertise	Technology suppliers often tend to deliver and install RES installations (PV) oversized, exceeding actual needs. Farmers are not ready to verify these offers, this can make investments not feasible. Farmers are also approached by third parties offering financing schemes with RES installation; this typically also leads to excessive capacities and investments.
Management	RES installations at PODR site are operated by own trained staff. External specialized companies are involved in necessary servicing. PV systems are monitored. However RES systems are not integrated in joint management system.
Diffusion	PODR use installed RES systems in their everyday activities, also as demonstration objects. However, farmers decision depend mainly on the energy market situation and prices of electricity. Offers to install PV micro-installations are widely available and present prosumer system stimulates PV growth.