Integrated Energy Systems (IES) co-design

Results and lessons in the built environment in Poland and in the Netherlands

Deliverable 4.2

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2. Executive Summary

Stakeholder driven co-design process for IES in Poland and the Netherlands

One of the objectives of the project RES4Build to engage relevant stakeholders in co-designing low-emission Integrated Energy Systems (IES) for meeting current needs and future expectations in buildings. For that, co-creation processes have been conducted in seven buildings, four in Poland and three in the Netherlands. The case study buildings have been selected for their different functions to learn about commonalities and differences across building types, such as multi-family buildings, a commercial industrial plant, a school building, community centres, health care real estate and a multifunctional event building complex.

For each building, a technical assessment has been carried out to analyse the status and technical and economic shape of its existing energy system, with a focus on the system for heating, ventilation and air-conditioning as these aspects are most applicable for replacement by the RES4Build IES technology solutions. Based on this assessment, for each building opportunities could be identified for replacing the current energy system with improved systems, including IES. Examples of such opportunities are the existence of problems with ventilations leading to insufficient indoor comfort or almost economically written off technology systems.

Starting from this technical assessment co-creation activities have been organised for each case study so that building stakeholders could be consulted about their needs and priorities for future energy systems in their building. With that the report builds further on the concept developed by Spijker, et al. (2020) which stipulates that IES' market potential (and that of other potential clean energy technology options) can only be optimally utilised if the technology fits in the building (technical feasibility), a solid financial model for its implementation in the building can be developed (financial viability) and stakeholders accept the technology as being in line with their needs and preferences (social acceptability). The better these three conditions are met, the stronger the potential for IES in existing buildings.

With stakeholders, the seven case studies elaborated on these three conditions to conclude whether IES will be feasible, and if so, within what timeframe and under which financial model it could be implemented. Technically, IES opportunities have been identified in nearly all case study buildings, especially as IES can be efficiently combined with existing rooftop solar PV and heating systems or could be integrated in already planned energy efficiency improvements. Technical obstacles or barriers often relate to, e.g., insufficient (metering) equipment, lack of space for deep boreholes for energy storage, or need to strengthen rooftops for additional PV panels.

From a financial perspective, particularly the Polish case studies identified some financial obstacles for IES, such as the change in the legal environment for solar PV exploitation which has made the existing prosumer system less attractive for building owners. Also, the relatively long payback times (often more than 10 years) for relatively expensive IES options, together with necessary thermo-renovation measures, has been considered a financial obstacle. Both the Polish and Dutch case studies have illustrated how the energy price increases during the first half of 2022 have triggered interest of building owners and users in investing in energy efficiency measures.

The case studies also have provided a wide range of organisational and stakeholder-related aspects that could stand in the way of successful IES implementation. For example, for the Dutch case studies it can be concluded that while the technical and financial obstacles are solvable and rather easily outweighed by technical and financial opportunities, organisational bottlenecks could hamper implementation of IES solutions. For example, when a building faces a short-term urgency to invest in energy efficiency measures, but a building renovation is planned within ten years, including dismantling and reconstructing (parts of) the building, only solutions can be considered with a relatively short payback time. This could exclude IES as these options often have a longer payback time. Also, case studies have demonstrated how limitations within the organisation of sustainability improvements of building can paralyse investment decisions. The cases have described situations in which for a building is subject to a policy or owner's decision on sustainable energy improvement, but the stakeholders individually do not have the capacity nor have a clear incentive to undertake investment actions, such as on IES. In case of the multifamily buildings, it has been highlighted that IES would require a common decision making, e.g., via energy cooperatives, instead of each homeowner associations having to take individual solutions

Generally, the case studies have shown that, while substantial in several case studies, finance and technology-related challenges are often solvable, but require early-on involvement/inclusion of relevant (external) expertise for coherent, integrated planning. Moreover, building specific IES solutions in multi-stakeholder contexts are relatively easy to implement as the building context and preferred solutions are generally homogenous. Instead, when considering IES solutions for a more heterogenous real-estate building portfolio, such as in the Dutch case study for multiple health care buildings, more heterogenous technology packages and finance solutions are required, which can easily lead to a quickly growing information and data intensity and emerging micro-management, rather than overarching guidance and decision-making.

In terms of participatory opportunities, both Polish and Dutch case studies have explored, with stakeholders, the benefits of collaboration between buildings and their owners. In the Polish multifamily buildings and the primary school and kindergarten cases, the option of establishing energy cooperatives has been highlighted as a solution to supply renovated settlements of buildings with RES from PV farms and use of building-level heat pumps. In the Dutch case studies, it has been explored how reaching out to neighbours or adjacent parks and districts could strengthen the potential for IES, as it could help collectively produce, store, and distribute energy produced via IES, and strengthen the business model for that. Finally, both in the Polish and Dutch case studies, it has been found that stakeholders in general are (increasingly) aware of the benefits of energy system improvement and several case studies also experienced that building management has been receptive to suggested improvements, to be even carried out in the short term, albeit not all directly related to IES.

3. Introduction

3.1 Background and case study choices

RES4Build's aim is to integrate multiple, low-emission and renewable energy technologies (IES) for energy-neutral, or even -positive buildings. Technically, these integrated solutions would contribute to meeting the EU's ambitions for the built environment, such as in the *European Green Deal* (European Council, 2022a) and the programme *Fit for 55* (European Council, 2022b). The project develops technical solutions to enlarge the technical potential for IES in European buildings, including residential dwellings. In this report, the focus is on the extent to which this potential can be realised by improving the financial viability of IES options and strengthening their embedding in (existing or modified) societal structures, including how existing policy instruments help to accelerate or may hamper implementation of IES.

Based on an analysis of good practice examples in Poland and the Netherlands and substantiated by a literature review (Spijker, et al., 2020), it was concluded that successful IES initiatives are those that enable an 'overlap' between technological, financial, and social conditions that together determine the realisable potential of IES (see Figure 3-1). For example, the literature review describes a case of an apartment block where households had jointly prioritised solutions for sustainable energy in their dwellings which were also technically feasible. By designing, with help of financial partners, a long-term financial model the financial burden for individual households of the required investment could be kept acceptably low.

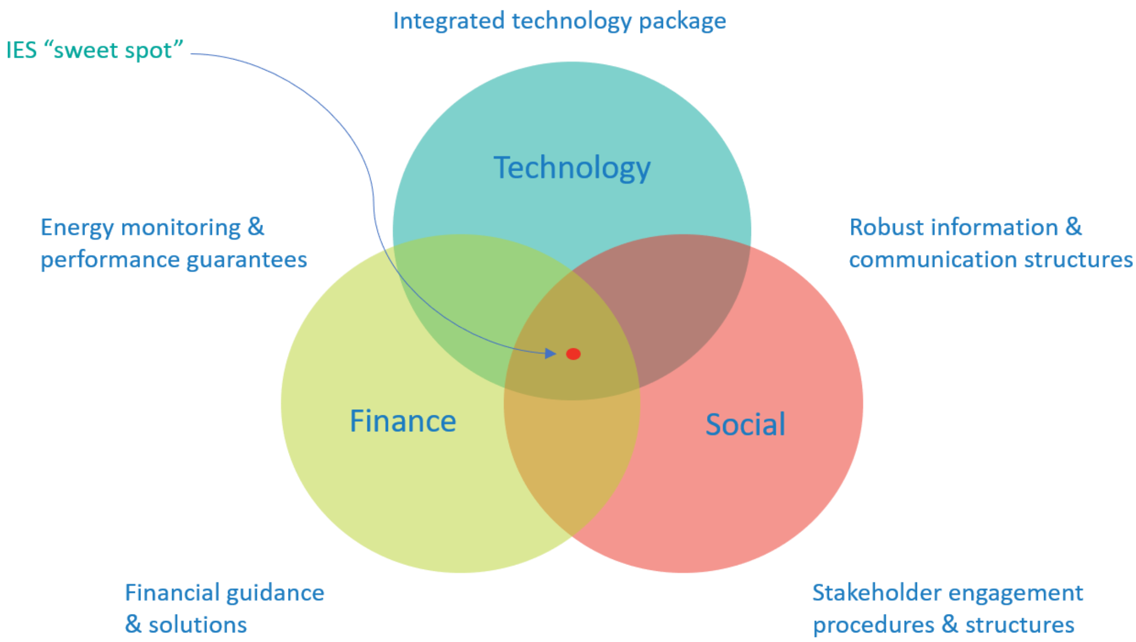


Figure 3-1: Key elements of an Integrated Energy System

This report extends the analysis of good practice examples with a set of detailed case studies in Poland and the Netherlands (at least three in each country). These case studies have followed the logic of Figure 3-1 by reviewing, first, for each case study building its technical status and potential for sustainable energy improvement, including IES, and second, analysing with stakeholders whether the suggested improvements are financially feasible and acceptable from a societal and organizational perspective. As such, it could be explored what could be potential (technical, financial, and social) obstacles to be cleared for success in both countries. Together, the case studies cover a wide range of building types (with different user groups), as follows:

- Health care building
- Multiple events building
- Community centre
- School building
- Residential dwellings apartment block
- Small and medium-sized enterprise plant

Box 1 shows an overview of the case studies.

Box 1

- **Housing settlement Pucka:** four multi-family buildings in Choczewo (Poland) – scope: thermal renovation of houses with replacement of internal heating and domestic hot water installation; decentralisation of heat supply system by IES consisting of heat pumps with deep boreholes in each building supported with PV systems on building roofs and building energy management system (BEMS).
- **Primary school**: EU primary school and kindergarten in Choczewo (Poland) – scope: installation of IES with heat pumps with deep boreholes supported with PV systems on building roofs with BEMS; possible extension and connection with nearby old "palace" communal building.
- **Industrial plant**, in Tczew (Poland) – scope: PV and installation of heat pumps with deep boreholes or small-scale rooftop solar PV panels, covering electricity demand of heating, ventilation and air-conditioning; an own wind turbine installation of up to 1 MW capacity is also analysed.
- **Communal multifamily building** in Mały Klincz (Poland) – scope (limited case study): analyse installation of 10 kW rooftop solar PV panels for energy use in the building.
- **Cultural Centre Zuidhorn**, a multi-purpose community centre in Zuidhorn (the Netherlands) – scope: replace existing boiler and chiller with an innovative heat pump and link this to a heat source, such as a closed loop thermal storage system in the nearby park nearby; equip system with a borehole thermal energy storage controller to optimise performance on PV yield.
- **MartiniPlaza**, a semi-commercial building for hosting multiple events in Groningen, the Netherlands) – scope: elaborate on implementation of smart building control strategies (within the MartiniPlaza complex) and on a sustainable energy strategy for the adjacent district for generation and distribution of electricity, heat, and cooling.
- **Royal Visio**, a health-care building complex in Vries (the Netherlands) – scope: assess building-specific IES versus collective IES design, as well as explore robust sustainability strategy housing (technology, social & finance).

3.2 Methodology for analysis

All case studies have been analysed through a similar stepwise approach. First, case studies have been selected by BAPE (for Poland) and JIN (for the Netherlands) with the goal to analyse a diverse set of cases and to focus on buildings where owners, management or users have been interested in considering changes in the building's energy system. Reasons for being interested could be that building users have complaints about indoor comfort and see sustainable energy improvement as a solution for that, or the management is concerned about increasing energy costs, or a municipality has a long-term vision fitting IES, but it is yet unclear what this will imply for individual buildings, *etc*.

Second, buildings have been technically reviewed by the RES4Build partners ARUP (for the Dutch case studies) and BAPE (for the Polish cases), in terms of the current energy system for heating, ventilation and air-conditioning and scope for improvement in the short and longer run, including scope of IES. This step resulted in a technical potential assessment of IES options in the case study buildings.

However, it should be emphasised that the possibilities of implementing technical solutions strictly depend on the applicable law. The law may support, hinder, or even prohibit the implementation of good sustainable energy solutions. For example, in Poland, it is practically impossible to build wind farms. Moreover, during the case study analysis, there have been legislative changes that forced the revision of the already developed IES solutions for the buildings analysed. For example, in Poland there has been a shift from the net-metering system, which support the development of micro-PV installations, towards the much less attractive net-billing system.

Third, BAPE (for Poland) and JIN (for the Netherlands) organised a co-creation process by identifying all the stakeholders for each building (users, owner, management, maintenance, etc.), characterising their roles and responsibilities in the building use, operation and ownership, and setting up participatory discussions with them about potential options for building improvements, with a main focus on the energy system, their preferences for that and how to incorporate these in suggested packages based on IES. Stakeholder consultations have been supported by questionnaires about building performance and preferred improvements, the results of which have been discussed with them either in physical meetings or, in case of COVID-19 restrictions, online gatherings. Outcomes of these meetings are included in the case study reports elsewhere in this document.

Fourth, based on the above inputs, a provisional timeline has been suggested to stakeholders for realistic implementation of IES options in each case study. Moreover, from the data collected, BAPE and JIN have been able to identify potential obstacles to successful IES implementation, such as financial constraints, lack of incentives to invest among stakeholders, political obstacles (see above), legal limitations, or organisational barriers in terms of stakeholder collaboration or lack thereof.

In this report, all case studies have been systematically analysed and reported along the above stepwise methodology. An overarching assessment across the seven case studies is done in Chapter 13.

4. Policy background for case studies - Poland

4.1 Country level policy developments

Poland's "Long Term Renovation Strategy" covers long-term measures up to 2050 towards a climate-neutral economy and replacement of the most polluting heat sources ensuring cost-effectiveness of renovations and fair distribution of investment costs in building refurbishment (Council of Ministers, 2022). The recommended scenario envisages that by 2027, 2035 and 2045 all buildings with a primary energy index higher than, respectively, 330, 230 and 150 kWh/(m^2/year) will be modernised.

In terms of energy transformation, the Council of Ministers (2022) assume phasing out of the use of fossil fuels (including natural gas) as basic energy carriers in thermal modernisation of residential and non-residential buildings until 2030. At the same time, using hybrid solutions remains possible as well as techniques that can be adapted to utilization of zero-emission alternatives. Until 2050, phasing out fossil fuel use by replacing heat sources or using zero-emission alternatives (e.g., biomethane, synthetic fuels, hydrogen) in other buildings with a parallel deep renovation will continue.

The implementation of the variant recommended for investments in building renovation in 2021-2050 (in terms of thermal modernisation and replacement of heat sources) requires approximately 1.54 trillion PLN (0.33 trillion euro) (Council of Ministers, 2022). Organizational and legal solutions for investment support are recommended, including one-stop-shops and wider implementation of energy service companies (ESCOs).

4.2 Regional level policy developments

The Regional Strategic Program for environmental and energy security (for Pomerania Region) (Pomorskie Voivodeship Board, 2022) supports, i.a., energy efficiency improvement and renewable energy sources (RES) for clean energy production and air quality improvement. Actions indicated for realising both priorities concern the development of RES, including support for distributed energy generation, the development of energy islands, energy clusters, energy cooperatives and energy communities, the development of energy-efficient and smart systems of transmission, distribution, fuel and energy storage, as well as external lighting systems. Concerning heat, the reconstruction of individual and local heat sources is prioritised through the construction, expansion and modernisation of heating systems, improvement of thermal comfort and energy efficiency in buildings. Finally, maintenance and development of air quality monitoring system are highlighted in the program.

Among the activities planned, the support for potential new and regional clusters as well as for the development of modern cluster services has been emphasised by BAPE in the case study analysis elsewhere in this report, for potentially promoting IES.

4.3 Structural solutions

In Poland, the prosumer system for micro (mostly PV) installations of up to 50 kW (based on net-metering) has dominated the domestic market and contributed to the rapid increase in installed capacity during recent years (Table 4-1 and Figure 4-1).

Table 4-1. Overview of installed micro-PV systems in Poland

	No. of micro-installations connected by DSO	Total capacity of micro-installations connected by DSO [GW]	Increase of micro-installations capacity [%]	Increase of micro-installations number [%]
31.01.2016	4,080	0.03	-	-
31.01.2017	16,173	0.102	294.40	240.65
31.01.2018	28,778	0.183	77.94	78.78
31.01.2019	54,214	0.343	88.39	87.34
31.01.2020	154,426	0.992	184.85	189.30
31.01.2021	457,443	3.007	196.22	203.09
31.01.2022	853,958	6.071	86.62	101.68
Source: PTPiREE (2022)				

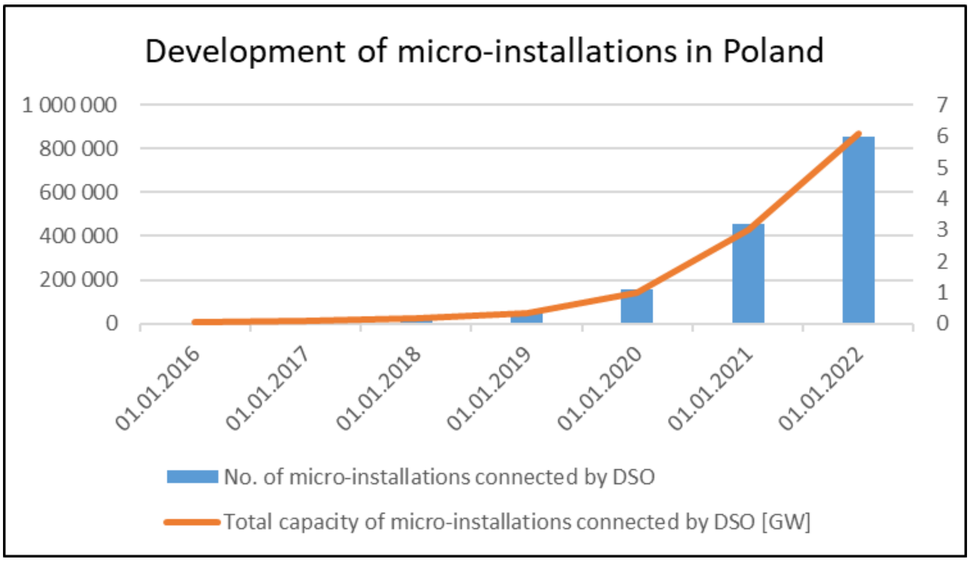


Figure 4-1. Development of micro-installations in Poland (PTPiREE, 2022)

From early 2019 through the end of 2021, the number of micro-installations increased strongly, which has resulted in almost 854,000 micro-PV installations connected to the networks of the distribution system operator (DSO). Total micro-PV capacity amounted to over 6.35 GW. However, due to a modification (Government of Poland, 2021a) (as of 1 April 2022) of prosumers' billing principles (based on net-billing), the profitability of such investments will decrease, which is likely to raise interest in other forms of organization of local communities involved in energy transformation. This is discussed below.

Energy clusters and cooperatives

Energy clusters aim at the development of distributed energy to improve local energy security while maximizing economic efficiency. They do so by creating optimal organizational, legal, and financial conditions which enable the implementation of the latest technologies, and to consider local resources and the potential of the national energy industry. Energy clusters are most suitable in areas where access of the following energy sources already exist or are planned to be provided:

- Electricity: PV conversion, wind energy, water energy, biogas, and conventional sources,
- cogeneration / trigeneration: biogas, biomass, waste, geothermal, and conventional sources,
- heat: photovoltaic conversion, aerothermal energy, biomass, biogas, waste, geothermal energy, and conventional sources, as well as
- other technologies such as fuel cells, and bio-liquids.

Establishment of an energy cooperative is an appropriate solution in case a group of recipients would like to commonly use energy from RES. The *Act on Renewable Energy Sources* (Government of Poland, 2021a) defines energy cooperative within the meaning of the Act of 16 September 1982 on the Cooperative Law (Government of Poland, 2021b) or the Act of 4 October 2018 on farmers' cooperatives (Government of Poland, 2018).

The main activity of an energy cooperative is the production of electricity/biogas/heat via RES installations and to distribute this in a balanced way among its members to meet their energy demand. Cooperative members can be connected via an area-defined power distribution network with a rated voltage lower than 110 kV, a gas distribution network, and a heat network. To obtain the status of an energy cooperative, certain criteria must be met, including the definition of the area of activity in rural or urban-rural municipalities, the minimal number of members, installed power and the degree of covering cooperative's (and its members') own needs.

The settlement of the electricity surplus supplied to the power grid in relation to the amount of electricity taken from the grid for consumption by the cooperative and its members is corrected with a quantitative factor of 1 to 0.6. The billing scheme is similar to the prosumer scheme.

In the light of current regulations, it is possible to plan the establishment of an energy cooperative based on several or even one renewable source, such as a PV farm. Regarding analysed possibilities of implementing integrated energy systems (IES), BAPE’s own analysis, included in the next chapters in this report, show that it is feasible to fully cover electricity demand of energy cooperative members (including heat pumps in buildings).

Conclusions

For now, and the near future it seems that an energy cooperative can be a realistic and feasible organizational form for small, local energy groups. Furthermore, once they evolve it can be considered to transform them into clusters, i.e., a form of an energy island. Transformation of an energy system requires not only examining and analysing technical condition of buildings and heat sources as well as available technical solutions, but also considering the needs and expectations of its users. This would result in a functional system which provides thermal comfort to users (at an acceptable level of costs). Currently, however, the legal environment for such projects is not stable and support mechanisms are insufficient.

The main challenge while planning a new local energy structure (apart from using local energy resources) is to determine the required level for balancing energy needs within this new structure. Balancing can be understood as:

- the extent to which local sources can cover the demand of local recipients and thus limit energy exchange with the environment (power system), and
- the ability of the new structure to control and maintain the exchange of power and energy with the system at a given level.

The above context will be considered when analysing, in the next chapters, four case studies of specific building situations in Poland’s Pomerania region.

5. Case study: Pucka settlement

5.1 General introduction of case study

The Pucka settlement is in Choczewo village, in the Pomeranian Province, along Pucka Street. The settlement has its own boiler house, serving four multifamily buildings, as well as outbuildings with garages and a recreational area. The buildings are administrated by housing associations of flat owners. Built in the 1970s, partly with prefabricated technology, the buildings have not had thermal insulation and had poor thermal properties. Over the past ten years, the buildings have been thermo-renovated with walls and roof insulation and window replacement.

Heat and domestic hot water (DHW) are supplied to the buildings from the coal-fired local boiler house (see Figure 5-1), which is attached to gable wall of the building Pucka 16 (see Figure 5-2). Both the boiler house and heating network have been retrofitted over the years.

Considering local conditions of the Pucka settlement the following retrofit options can be considered: 1) conversion of the coal-fired boiler house into biomass-firing, and 2) decentralisation of the heat supply system by installation of heat pumps in each building, supported with rooftop PV systems. As the price of heat generated in the aging coal-fired boiler house, belonging to a third party, is expected to increase, the second option with integrated heat pumps and PV is preferred. This option will require combining control systems into one integrated system to ensure efficient use of solar energy, to be used as a primary energy source.

Buildings are administrated by housing associations of flat owners, and it is essential to engage them in the potential changes. Other enabling stakeholders include the Choczewo municipality, the power distributor, technology providers, financing institutions, and consultants. All these key stakeholders have been contacted for the case study analysis. Following meetings with tenants of the settlement, all four associations have decided to join the project. Also, the mayor of Choczewo municipality supports the initiative.

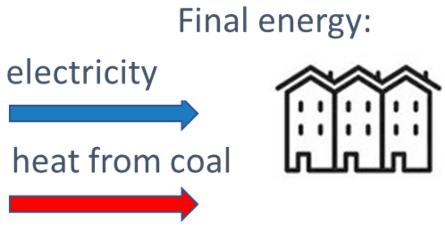


Figure 5-1. Final energy delivered to buildings

5.2 Current situation - status of building and present energy technology

As explained above, buildings of the Pucka settlement were built in the 1970s with partly prefabricated technology, which was widely used in the countryside in Poland in that time. Nowadays, when considering clean energy technologies, this uniformity enables scalability of, e.g., an IES project to similar houses and settlements in the Polish countryside. A thermal imaging inspection carried out for this case study by BAPE has not revealed big faults in the buildings' insulation, which implies that IES solutions are potentially applicable within the current building envelopes.

Low-voltage aerial lines deliver electricity to the buildings from the aerial line along Pucka Street.

The buildings' switchboards are in bad technical conditions though. The apartments in the buildings are equipped with electricity meters and electricity bills are paid directly to the distribution company. Internal heating and DHW installations in the buildings are in a bad technical shape.

While the buildings originally belonged to the state forest administration, the apartments have been privatised. The tenants established housing associations for each building to take decisions on building management, modernisation, and expenses. The associations typically hire a professional real estate administrator to manage building-related expenses. Since 1990, building tenants have improved their living comfort, including gradually replacing windows with plastic-frame double-glazed and air-tight windows. Since 2000, walls and roofs have been insulated.

Based on the technical documentation of buildings of the same construction, thermal parameters of building envelopes are shown in Table 5-1 for the buildings, before and after the thermo-renovation for each building.

Table 5-1. U-values of the four buildings in the case study*

	U-values	Walls	Roofs	Windows
Original values	W/m2 K	0.95-1.43	0.66	2.6-3.0
After thermo-renovation	W/m2 K	0.213-0.30	0.270	average 1.5

* U-values represent thermal transmittance of a material, such as insulation or concrete (Wikipedia, 2022)

Heat supply

Heat from the boiler house is delivered to buildings by a relatively new, pre-insulated network, which consists of two, flexible double pipes for heating and DHW. The network is laid partly between buildings and partly through cellars. The heating system of Pucka settlement is shown in Figure 5-2.

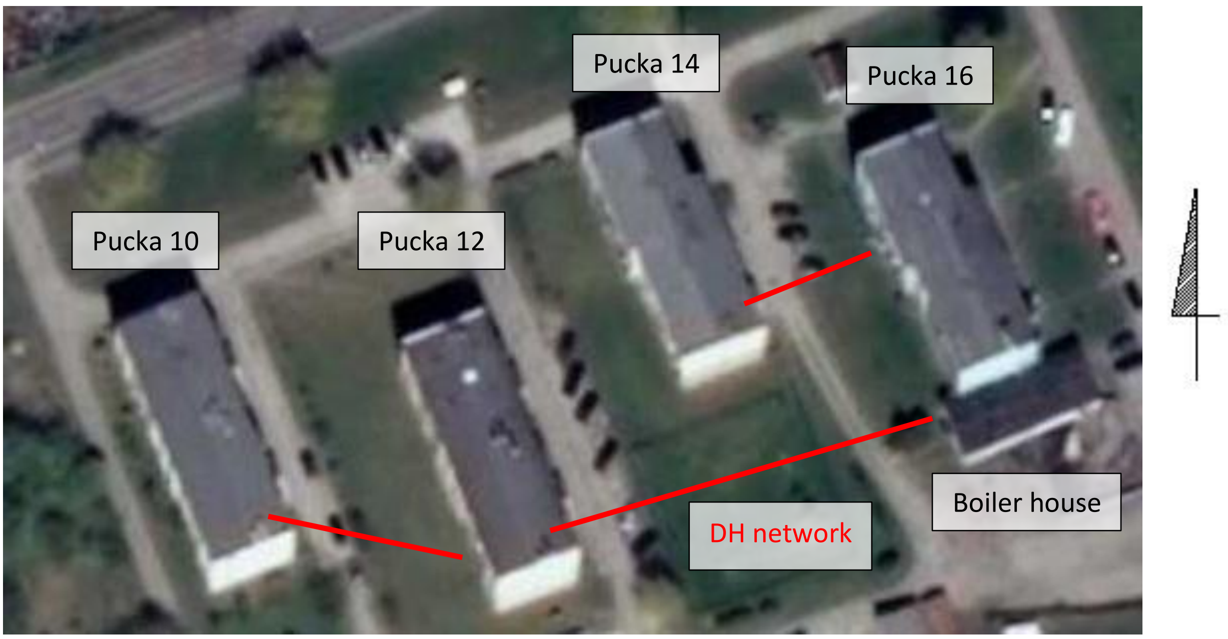


Figure 5-2. Pucka settlement

Heat consumption is metered for each building and is paid for by tenants every month based on their floor area. The DHW use is metered in each flat. There are differences in heat consumption in buildings, with the highest heat consumption for Pucka 10 and 14. Based on buildings' energy profiles it can be estimated that peak demand for heat is from 43 to 54 kW (see Figure 5-3).

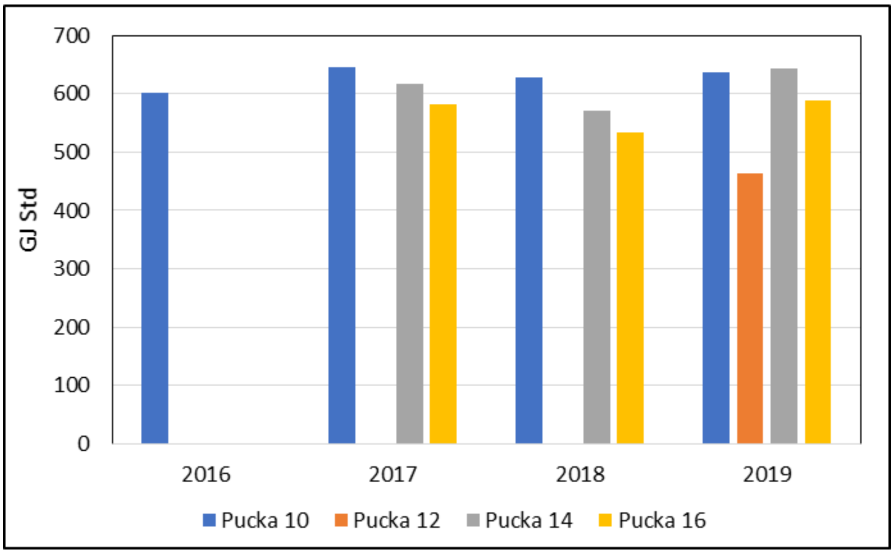


Figure 5-3. Comparison of heat consumption in the following years (converted to standard year)

The boiler house and heating network are owned and operated by third parties, who deliver heat through contracts with the Pucka housing associations. The price of heat includes fuel, labour, operation, and maintenance cost, as well as taxes, depreciation, and other costs. However, a precise breakdown of the price structure of the heat delivered to buildings is not known, as for a boiler house of this size an operator is not obliged to have a licence and the price of heat is not controlled by the Regulator. What is known are the fixed and variable cost components at the time of the technical review in 2021:

- fixed $price_{heat}$: 1,514 PLN/month (352 EUR/month) per building,
- variable $cost_{heat}$: 64.73 PLN/GJ (15.05 EUR/GJ).

As per June 2022, these price components have increased by over 20%.

Power supply

Low-voltage aerial lines deliver electricity to the buildings from the aerial line along Pucka street. Main fuses for each building are 32A for each phase, allowing for connecting 21 kW. Electricity use for common areas (staircases, cellars, garages) is metered and these costs are split between flats.

Power to individual flats is distributed by aluminium low voltage wiring. As said, the buildings' switchboards are in bad technical shape. Flats are equipped with electricity meters (located at the staircases) and residents settle electricity bills directly with the distribution company. The electricity tariff used for housing is G11[1] and is controlled by the state Energy Regulator Office (URE).

[1] G11 is the most popular energy tariff in Poland, indicating a similar at any time of the day throughout the week (EinP, 2022), special group of tariffs for households, controlled by the Regulator (URE).

5.3 Current situation - roles and organisation of stakeholders

Key stakeholders

The key stakeholders in the housing settlement Pucka projects are the flat owners. In each of the four buildings there are 12 flat owners, which are households of different sizes (see Table 5-2; Table 5-3 describes their roles). Their flats were bought over the years from the state entity, the original builder and owner of buildings.

Table 5-2. Key stakeholders – Pucka settlement

Name of stakeholder	Stakeholder description Affiliation / organisation	Contact details / Address
Housing Associations Pucka 10, 12, 14 & 16	4 multifamily houses	Pucka, Choczewo

Table 5-3. Characterisation of stakeholders – Pucka settlement

Case study supporting stakeholder	Main characteristics / activities
Financial service providers (banks, venture capital / special funds, as well as equity providers)	One of the banks supporting investments. Special environmental funds, which were available in previous rounds of EU funding, expected in the 3rd round (after 2020). Choczewo Commune can offer special grants for the conversion from coal boilers to renewables. SMEs can get special financial support from the Polish Agency for Enterprise Development.
Key technology suppliers	Developers and suppliers of relevant technology in the areas of PV, heat pumps and control systems. Key technologies are: - PV installations - heat pump systems with deep boreholes - heating and domestic hot water systems
Key industry or other relevant association	PV and heat pump producers and installers Coal boiler house and DH network owner Drilling companies
Key public agencies	Mining Authority, District Mining Office in Gdansk Regional Director for Environmental Protection in Gdansk (only when EU funds are applied for) District Headquarter of State Fire Service Energy Regulatory Office DSO (ENERGA)
Provincial governments, municipalities and/or delegated permitting organizations	Commune of Choczewo, Mayor District Authority in Wejherowo, District Head Spatial plans, building conditions and permit, environmental reports
Consulting and legal service providers	Consulting agencies, regional energy conservation agencies (Association "Energy and environment conservation" SAPE-Poland), energy auditor (if thermo-modernisation is included), construction designer, housing association administrator

Management and supervision of the buildings

There are four active housing associations – one for each building. Pursuant to *Polish Act on Housing Associations* (Government of Poland, 2021b) (more precisely, the Act of 24 June 1994 on the ownership of premises), a housing association is a union of owners of premises in each property. It has no legal personality, nor is it an economic entity; it mainly represents the owners of the property who are members of the association. A housing association is created by law to supervise common elements of real estate. This applies to land (on which the building stands, green areas, playgrounds, parking lots), common parts of the buildings (in this case staircases, storage chute, attic), external elements (roof, facade, trash) and installations and equipment (central heating, plumbing, chimneys). The association pays for the repair, use and renovation of these common areas, for which association members pay a contribution in proportion to size of their premises.

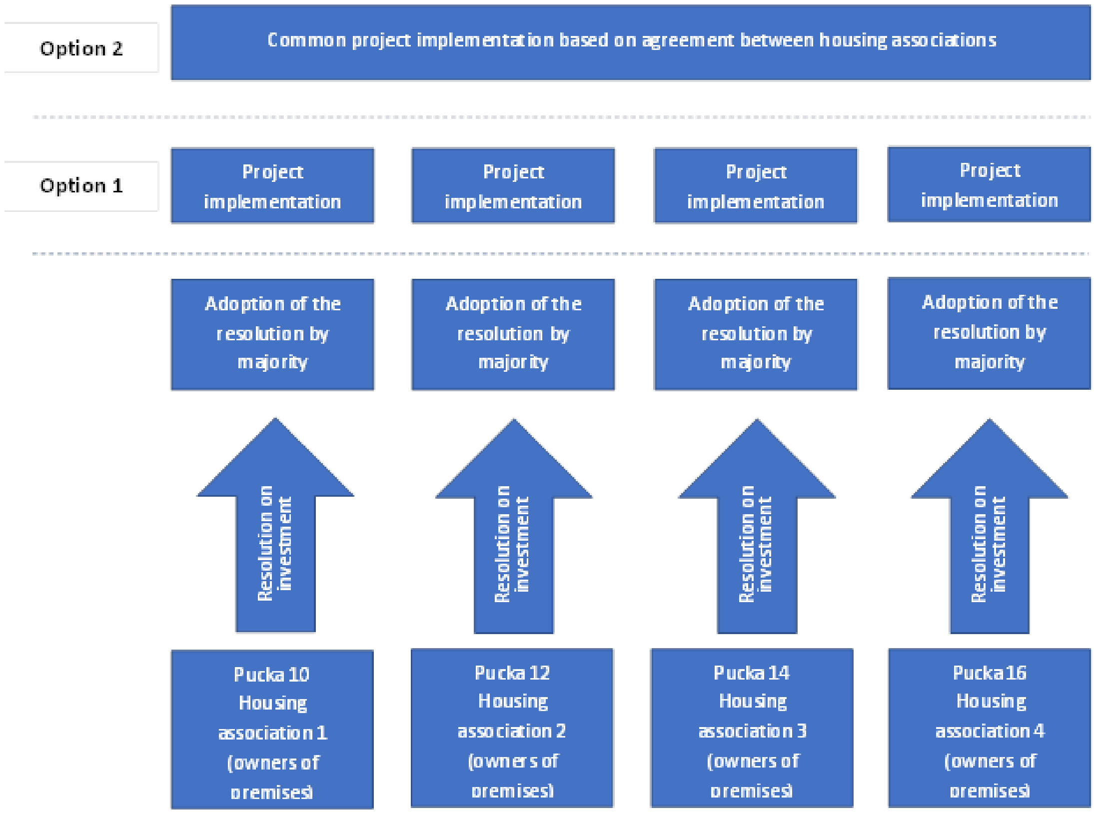


Figure 5-4. Decision making process by housing associations

Each resident of the association has a vote, the 'weight' of which depends 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, which is adopted by a majority of votes, counted by shares.

As the Pucka settlement housing associations each represent more than seven flats, they are considered as large, which implies that they each have their own management board with members elected from residents. The management board is responsible for the state of the common parts of the property, including taking care of cleaning, snow removal and other matters related to the care of the building. For Pucka 10, 14 and 16 these tasks are entrusted to the external, professional administrators. The decision-making process for the project implementation is presented in Figure 5-4. At this stage of project development, it is difficult to foresee which option will be implemented considering housing associations' independent decisions.

5.4 IES options for case study building(s)

Choczewo is not connected to the natural gas network. The most recent Heat supply plan, adopted by the Commune of Choczewo (Pomorska Grupa Konsultingowa, 2020), assumes reduction of coal-based heating and conversion of coal boilers to RES, including biomass, heat pumps and PV. Considering local conditions of Pucka settlement, the following retrofitting options are considered in the plan:

A. Conversion of the coal-fired boiler house to biomass firing, using pellets, and distributing heat and DHW using present heating networks; and
B. Decentralisation of the heat supply system by installing heat pumps in each building, supported by PV systems on building roofs (this option is based on IES).

Option A would require involvement of the boiler plant operator and his contribution during project preparation and implementation. It is not known if this involvement is possible. Additionally, housing associations would not have a real impact on the investment and future costs of heat. In Option B project implementation and future operation of the system would be in hands of each housing association. Below, the analysis of the options is split in two, as, due to changes in the regulatory system and sharp increase of energy prices since spring 2022, the initial case study analysis done in 2020-2021 had to be updated.

Original analysis 2020/21

Comparison of present and future heat costs for end users has been based on the following assumptions for each building:

- The installation of a 20 kWp PV system will generate 20 MWh/year. Operating as prosumer, surplus electricity will be sent to the operator network and recovered for 80% during the heating season. 17 MWh/year of the own energy will supply the heat pump system.
- Heat pumps with deep boreholes will have energy effectiveness measures by the Coefficient of Performance (COP) of 4.0.
- Taxes apply only to the centralised system with the boiler house and networks.
- The actual heat price (2020/2021) serves as reference for cost calculations.
- Other costs are typical for local conditions in Choczewo.

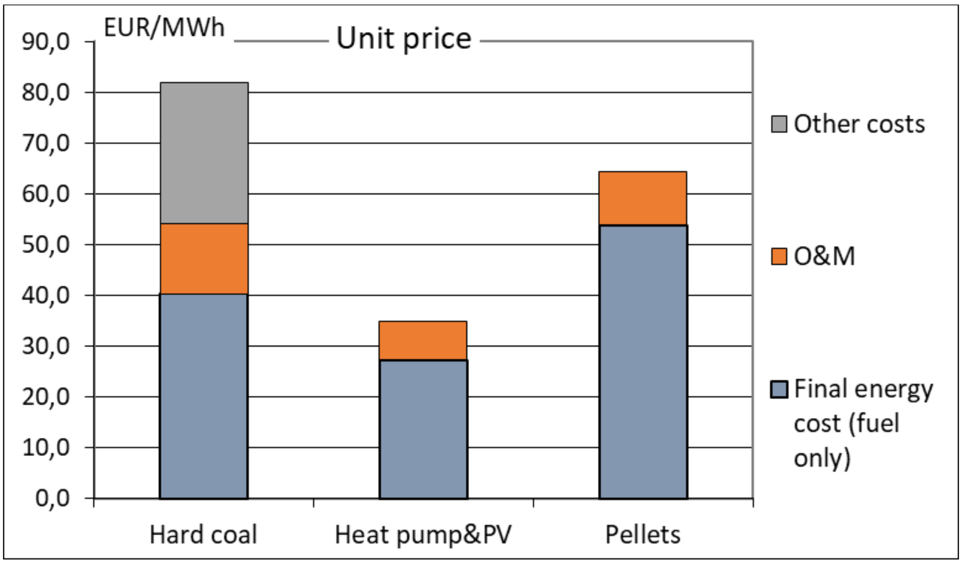


Figure 5-5. Heating costs for present coal-based system and alternatives in case study buildings

In terms heat costs, it can be concluded, from Figure 5-5, that installation of individual heat pumps for each building supported with roof PV systems (the IES solution) is the preferred option (B) over conversion of the coal boiler house to pellet boiler house (option A) for retrofitting the Pucka settlement heating system. However, for the case study, no successful examples were available of IES heating systems based on heat pumps supplied partly from PV panels. Total costs of the system for one building of Pucka settlement are summarised in Table 5-4.

Table 5-4. Project expenditures (for one building)

CAPEX	PLN	EUR
Heat pump	300,000	69,767
PV system	95,760	22,270
Total	**395,760**	**92,037**

Both installations will require combining control systems into one integrated system to ensure efficient use of solar energy, to be used as a primary energy source. Comparison of present and proposed heating systems shows future expenditures, costs, and savings for investments.

Table 5-5. Expenditures, costs, and savings – 2020/2021 (for one building)

	PLN	EUR
Expenditures	395,760	92,037
Present costs	53,771	12,505
Costs of energy after retrofit	18,416	4,283
O&M costs	3,958	920
Savings	31,397	7,302
payback time (years)	**12.6**	

Based on the comparison of necessary expenditures and future savings in Table 5-5, a pay-back period of 12.6 years is found for investments in conversion of coal heating systems to renewables, whereby coal is used without imposed charges for causing environmental and human health damages. Presently, special funding is available from the Pomeranian Loan Fund, which is a segment of the Regional EU fund (special soft loan 100%, interest rate 0,25%, 15 years repayment period).

The results of these calculations are presented in Table 5-6, whereby the interest rate and instalments during the payback period are assumed to remain constant. The crediting period is set for 15 years, and calculations are expressed in real terms, without considering inflation. It can be assumed that all costs and prices related to the residential sector are regulated and will not change considerably in comparison to inflation.

Tenants pay rent monthly according to the floor area of their flats. Monthly instalments for the special loan for 100% of expenditures are summarised in Table 5-6. Utilising special funds, such as a special EU loan, allows for keeping the heat price for tenants below the present price and enables paying back the loan.

Table 5-6. Monthly instalments for the special loan for investment in IES in Pucka Street buildings

Loan	PLN/m^2/month	EUR/m^2/month
Capital instalment	2.72	0.756
Interest instalment	0.05	0.014
Total instalment	**2.77**	**0.770**

Situation in 2022

Following important changes in the regulatory system in Poland and the sharp increase in energy prices since Spring 2022, new calculations of the IES project feasibility have been made. The biggest change has resulted from introduction of a net-billing system for an energy prosumer. Only 20% of the prosumer deposit accumulated during each month from PV systems in form of stored cash (energy times selling costs) in the DSO network can be used during winter period. For Pucka residential buildings this would result in a reduction of available energy accumulated during the Summer by 20% and a reduction of possible supply of heat pump demand from PV systems.

The comparison of previous net-metering system and the new net-billing system is summarised in Table 5-7. Calculations are made for an analysed multifamily building with PV rooftop installation of 20 kW. Present energy prices have been employed for both cases.

Table 5-7. Comparison of old net-metering and new net-billing system

Parameter	net-metering	net-billing	Unit
PV capacity	20	20	kW
AEP*	20	20	MWh/a
Direct use of PV gen.	20%	20%	
Useful PV energy	15.2	12.4	MWh/a
Share of demand	**48%**	**39%**	
Total savings	16,720	12,641	PLN/a
	3,635	2,748	EUR/a

**AEP – annual energy production by PV*

It can be concluded that for the base case, a possible PV system would cover less than 40% of the energy required for the heat pump. Additionally, when considering technical conditions of internal heating and DHW installations in the building, it is necessary to replace these which will increase capital expenditures for each building.

Table 5-8. Heat demand for a multifamily building

		Insulation		
Parameter	*Unit*	*Weak*	*Medium insulated*	*Well insulated*
Heating	kWh/m^2	120	65	35
DHW	kWh/m^2	40	40	40
Total	kWh/m^2	**160**	**105**	**75**
Annual heat demand	kWh/a	**128,000**	**84,000**	**60,000**
	GJ/a	**461**	**302**	**216**
Electricity demand for heat pumps	kWh/a	32,000	21,000	15,000
Supply from PV system	kWh/a	12,360	12,360	12,360
Share of PV system	%	**39**	**59**	**82**

Higher electricity prices make PV systems more attractive but the reduced possibility of electricity storage in the grid reduce effectiveness of the investment. The possible solution is to thermo-renovate buildings to reduce heat demand, such as insulation of the building envelope and replacing internal heating and DHW installations with automatic control of heating parameters.

Calculations have been made for two renovation goals: from current specific heat consumption of 160 kWh/(m^2/year) to 105 and 75 kWh/(m^2/year). Both specific energy consumption parameters could be achieved for these types of low-efficient buildings. Table 5-8 shows specific and annual heat demand for a multifamily building, as well as energy demand for the heat pumps.

The table shows that after introducing energy efficiency measures, reduction of heat demand allows to cover over 80% of electricity demand for heat pumps from the building's rooftop PV system. However, reaching low energy demand for a building requires expenditures for energy efficiency measures. Table 5-9 summarises the costs of these measures and implemented IES with solar PV and heat pumps.

Table 5-9. Expenditures and savings for complex renovation and introduction of IES

		Insulation		
Parameter	*Unit*	*Weak*	*Medium insulated*	*Well insulated*
CAPEX				
HP	EUR	65,217	41,739	26,087
PV	EUR	16,043	16,043	16,043
Thermo-renovation	EUR	43,478	108,696	152,174
Total	EUR	**124,739**	**166,478**	**194,304**
Savings	EUR/a	6,512	9,377	10,968
payback time	years	**19.2**	**17.8**	**17.7**

The calculated necessary capital expenditures are high for flat owners and housing associations of each building. In addition, there is no financing available for jointly implemented energy efficiency measures and RES. The other possibility to employ renewable energy to power heat pumps in renovated buildings is to join an energy cooperative, which would be established by the commune to cover own energy needs and those of other, private members of the cooperative. The cooperative would apply for funds for renovations and share energy from its own RES source, such as a PV farm. This would require certain organisational steps and commitment by the commune authorities.

The successful implementation of the IES to several multifamily buildings in the Polish countryside and semi-urban areas requires a combination of energy efficiency measures and introduction of IES systems. This will allow for phasing-out of coal and oil used for heating, typically in low-quality boilers. According to the recently adopted National Long-Term Renovation Strategy (NLTRS) (Council of Ministers, 2022), there are 550 000 multifamily buildings in the country, about half of which were built before 1994. About 40% of multifamily buildings in Poland require termomodernisation.

Environmental impact

Conversion of a coal-based heating system to separate renewable energy systems will reduce emission of CO_2 and other pollutants. CO_2 emission from the local coal-fired boiler house will be replaced with CO_2 emission from power plants supplying the national power grid. Use or electricity from the grid will be reduced though by using primarily electricity from PV systems in the case study buildings.

A list of different technical, legal, social, environmental, and other barriers and their characterisation is shown Table 5-10.

Table 5-10. Overview and characterisation of barriers to IES in Pucka buildings

Technical barriers	Legal barriers	Social barriers	Environmental barriers	Other barriers
Lack of experience in IES design, construction, maintenance	Lack of novel financial tools for IES implementation	Lack of trust among stakeholders	Not an issue	
	Long and complicated decision-making process	Long and complicated decision-making process		
	Continuously changing legal environment	Lack of knowledge of IES among end-users		
Worn-out internal heating and DHW piping		Joint action of building occupants needed		Additional expenses, not resulting in measurable savings but in efficiency and safety of operation
	Incomplete regulations regarding establishment and operation of energy cooperatives			
				Lack of financial support addressed to housing communities for IES implementation

5.5 Co-creation for energy system and IES planning

As explained above, the transformation of the local heat and power supply system towards IES should take place with participation and involvement of building owners and users. For increasing the likelihood of socially acceptable improvements, investment decisions are to be preceded by the analysis of local communities' awareness and readiness to take up such (IES) projects. Therefore, questionnaires to study the awareness of the local community have been developed to carry out a survey among residents (conducted in November 2020). It was sent by post to flat owners due to the Covid-19 pandemic.

The questionnaires were distributed by representatives of the four housing associations. Responses were collected and sent back to BAPE. In total 23 opinions were collected from 48 dwellings, which constitutes 47.9% of the dwellings.

The questions in the survey covered five aspects, as shown below.

I. Thermal comfort of apartments and heat and electricity costs for the residents of the estate.

	Question	Answer: YES
1.	Does indoor climate of your flat meet your requirements?	69.6%
2.	Do you regulate temperature in your flat (is the installation equipped with thermostatic valves)?	56.5%
3.	What would you like to improve?	
	to raise temperature in your flat during wintertime	21.7%
	to lower temperature during wintertime	21.7%
	Other	4.3%
4.	Is the share of heat cost significant for your budget?	87.0%
5.	Is the share of electricity cost significant for your budget?	56.5%

The results show that more than 2/3 of the respondents are satisfied with thermal comfort of their apartments and more than half of them have the option of temperature control thanks to thermostatic valves. At the same time, residents of the building at 10 Pucka Street believe that thermal comfort in their apartments is insufficient and the temperature in their apartments should be higher. On the other hand, the inhabitants of Pucka 12, 14 and 16 believe that it is too warm in their apartments; they would prefer the temperature in the apartments to be lower. 87% of the respondents think that the share of heating costs in family budgets is significant. More than half of inhabitants also consider the costs of electricity to be significant - 56.5%.

II. Air quality

	Question	Answer: YES
6.	How is the quality of air around your building during wintertime?	
7.	Is the boiler room operation (during the heating season) noticeable in the air quality?	78.3%
8.	Would you like to have air quality improved during heating season?	91.3%

Answering the question about the outside air quality in the winter, 76% of respondents assessed the condition as average and 19% as bad. The operation of the boiler room during the heating season has an impact on air quality. Over 90% of respondents would like the air quality to improve.

III. Energy saving

	Question	Answer: YES
9.	Do you have any energy saving appliances in your flat like refrigerator/dishwasher/washing machine/other)?	100%
10.	Are you planning to replace household appliances with energy saving equipment?	21.7%
11.	Do you have energy saving lighting (LED) in your flat?	87.0%
12.	Are you planning to replace lighting with energy saving one?	30.4%

Ecological awareness of the local community is high. Residents use equipment with low electricity consumption and almost all of them have energy-saving light sources and plan further improvements.

IV. Energy system modernisation

	Question	Answer: YES
13.	Are you interested in modernizing the building supply system with heat and electricity by reducing the use of coal to more environmentally friendly sources, such as heat pumps or photovoltaics?	100%
14.	Are you aware of the fact that in the coming years it will be necessary to modernise the boiler room and resign from burning coal?	100%
15.	Do you consider the possibility of cutting off from the external heat supplier (as you have no influence on the heat price) and looking to supply the building from your own heat source?	73.9%
16.	Are you aware that in the light of the current Polish policy, following the decisions of the European Union, it is possible to obtain a subsidy or a preferential loan only for modernisation of a heat source consisting of RES installation?	91.3%
17.	In your opinion, will the market value of the building (apartment) increase after installing a modern, ecological heat source?	82.6%

Respondents representing all four housing associations are interested in modernising the heat and electricity supply system. At the same time, they are aware that it will be necessary to move away from coal as heat energy carrier in favour of more ecological sources. In most cases, they are aware that such modernisation may involve a change resulting in a cut-off from the current heat supplier. In the current situation, residents have no influence on the price of heat. Modernisation of the system will require a capital expenditure and respondents are aware that it is possible to obtain sources for financing RES on more favourable terms than commercial loans. The responders are also aware that the market value of the building (apartment) increase after installing a modern, ecological heat source.

V. "Green image"

	Question	Answer: YES
18.	Do you care about the "green image" of the building?	95.7%
19.	Are you going to disseminate solutions leading to a "green image" among relatives and friends?	87%

Residents of the estate are aware that transformation of their energy system into environmentally friendly one will contribute to their buildings' 'green image' and they intend to promote the implemented solution.

Design a proposed IES system

The process of designing an IES system for residential buildings is a time-consuming, multi-phase and participatory process, as it requires cooperation with many stakeholders, as described above. Below, the organisational steps to be taken for IES in the case study buildings are elaborated on.

Step 1 - The first step was a **meeting with representatives** of the relevant housing associations in December 2019 and a presentation of an outline of cooperation in the process of modernisation of the heating system.

Step 2 - In November 2020, **concise information was prepared for residents** of the Pucka estate in Choczewo, presenting the current state of heat source and heat and electricity supply to residential buildings at 10, 12, 14 and 16 Pucka Street. The information - in the form of a leaflet brochure - also included a description of selected solutions regarding the possibilities of using RES, as well as an initial modernisation proposal. The solution included a proposal to have an IES as an optimal solution, which included decentralization of the heat supply system, resigning from the local coal boiler, and installing heat pumps in each building supported by rooftop PV systems.

Step 3 - **Survey conclusions** based on the residents' responses. The results of the survey can be summarised as follows:

- Not all residents believe that conditions of sufficient/desired thermal comfort are met in their apartments.
- The costs of heat constitute a significant share in the budgets of families living in Pucka estate. Therefore, they are interested in modernisation activities that, on one hand, will ensure failure-free heat supply and, on the other hand, will not contribute to increased heat costs. Of course, the ultimate preference is to cut these costs.
- Residents are prepared for changes in the estate's heat and electricity supply system and
- Successively replace household appliances and lighting with energy-saving, which proves their awareness of the impact of devices on the environment and household budgets.
- It is important for inhabitants of the commune that energy transformation takes place with the use of modern, clean technologies. Elimination of coal in the town with a strong touristic character, and thus also giving many inhabitants income from tourism, is an important consideration in decision making.
- A 'green image' of the commune is important for the inhabitants.

Step 4 - A **brochure** addressed to stakeholders was developed, introducing the RES4BUILD project and describing EU's energy policy (the brochure is available on BAPE's website: www.bape.com.pl/res4build). In particular, the brochure explains what energy efficiency improvement in buildings is and presents the idea of IES and selected solutions in RES, i.e., PV installations and heat pumps.

The brochure also contains information on the applicable legal provisions related to the implementation of such projects, as well as the possibilities of obtaining financial support for investments. However, constantly changing legal environment results in volatility of the profitability of investments, as well as underdeveloped legal regulations regarding organizational and legal forms that could be harnessed in the projects, make it necessary to periodically update the brochure. So far (January 2022), two editions of the brochure have been developed, with updates to follow.

Step 5 - Indication of the possibilities of **obtaining financial support**. Financial instruments are currently under development for the next budgeting period 2021-2027 and new opportunities will appear (see paragraph on Financial and other incentives). This step is required for implementation.

Step 6 - Defining **forms of stakeholder cooperation** for investment implementation. Currently, there are no complete legal regulations for establishment of energy cooperatives which would be the preferable organizational solution in this case. This step is required for implementation.

Step 7 - Project **implementation**.

To sum up, the process of project preparation is well advanced. Further actions depend on the introduction of proper legal regulations allowing to choose an adequate organisational form and new financing rules to obtain funds for the investment. Also, in case of housing communities, the establishment of an energy cooperative is an organisational challenge, as there are no detailed legal solutions and thus no good practice examples available yet.

6. Case study: Primary School and Kindergarten

6.1 General introduction of the case study

The school *European Union Primary School and Kindergarten* was built in the 1990s and opened in 1997. In 2004, a building retrofit took place with thermo-renovation.[2] The building shape is special as it consists of 2-3 story classrooms with interconnected structures plus a big gym (see Figure 6-1). The school building has spacious corridors and stairways.

Figure 6-1. Top view of the building

Figure 6-2. The school building's front facade

[2] After the retrofit, the insulation parameters are as follows: walls 10 cm styrofoam and plaster, windows have a U-value of 1.1 and the roof are insulated with blown loose fill insulation of 15 - 30 cm, U-values of the building envelope are close to present demands and acceptable)

Other characteristics of the building are:

- The floor area of the building is 8,300 m^2.
- Number of attendees: kindergarten 50 children and 4 staff members; primary school 450 pupils + 70 staff members.
- The building is operated during 08:00-15:00 o'clock on weekdays; the gym is often used after 15.00.
- The school has its own kitchen and canteen serving 400 meals/day.

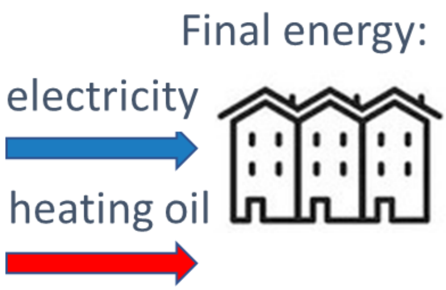


Figure 6-3. Final energy delivered to the building

6.2 Current situation - status of building and present energy technology

The school is heated by its own boiler room, which is in the cellar of the east side of the gym wing. The following data of the boiler room is available:

- Two oil boilers are installed with a capacity of 500 and 330 kW; manufactured in 1997 by a Polish manufacturer. The control system allows for lowering temperatures at nights and weekends.
- Light fuel oil (LFO) costed 70 EUR per MWh in 2020/21 and over 100 EUR/MWh in June 2022.
- Heat is supplied to the school and the 'palace', which is a public building (including a library among others) located 35 meters south from the boiler room. The palace building is not insulated.
- Heat use by the palace is not metered. The estimated shares of heat use, including specific heat demand for both buildings are shown in Table 6-1.

Table 6-1. heat consumption by the school and the palace, taken from the school's boiler room

	Floor area m^2	Share in heat demand
School	8,300	83%
Palace	920	17%
Total	**9,220**	100%

Energy delivered in LFO, and heat used by the school in the last two heating seasons, including conversion to standard year conditions (Degree Days) are shown in Table 6-2.

Table 6-2. LFO and heat used by the school during 2017-2019

	Energy in LFO, converted to standard year				School		
Heating season	kWh	GJ	Degree Days	GJ Std	GJ	kWh	kWh/m^2
2017/18	685,891	2,469	95.0%	2,599	2,167	601,901	72.5
2018/19	596,983	2,149	96.3%	2,232	1,861	516,808	62.3

The specific heat consumption by the school, 62-70 kWh/(m^2/year), can be considered low. The domestic hot water (DHW) system in the boiler room has four tanks with a total capacity of 2 000 litres, which is supplied to sanitary rooms and the kitchen. Considering a typical load factor of 7 GJ/kW (seasonal heat production from 1 kW in Polish conditions), estimated peak demand for heat is 400 kW, plus 30% for the period of heating premises after the night or weekend (when the temperature has been lower). Hence, estimated peak heat demand is about 520 kW.

Measurement of flue gas losses has shown good combustion quality during steady boiler operation with chimney losses of about 11%. However, considering the periodic operation of boilers and other losses, seasonal efficiency of the heat production is estimated at 85%.

The boilers' primary and secondary loops are:

- heating (school, palace, DHW): loops with 3-way controlled valves; and
- School loop – further distribution: North and South sides of the building and gym.

The temperatures of hot water supply have been monitored by data loggers at the main loops of the school's heating system during January and February of 2020, when the outdoor temperature was between 0 and +5°C. The monitoring results show that for these outdoor conditions the supply temperature to the school is 45°C and to the palace 55°C. It can be estimated that for coping with winter conditions of -16°C, a supply temperature of about 75°C will be necessary. The school heating system is suitable to be supplied by heat pumps. During the same period, the indoor temperature has been monitored in selected classrooms; in the school premises the temperature was reduced at night and during the weekend. As to BAPE's inspection, the boilers are old and boilers control system is not reliable requiring both to be replaced, while the controls of the heating loops need to be retrofitted. Currently, the school suffers from high heating costs, which is a burden for the commune.

Concerning the status and retrofit potential of the **heating, ventilation, and air-conditioning** (HVAC) the following can be stated:

- The heating system is in good technical shape and does not require intervention.
- The building in general has a natural ventilation (windows in classrooms); the school has spacious corridors and installing mechanical ventilation with heat recovery would be very costly.
- The sanitary rooms have exhaust ventilation working periodically.
- The canteen is equipped with a mechanical ventilation with heat recovery, which requires repair and maintenance.
- The gym has natural ventilation and is often used much longer than the school premises. There are big energy losses with uncontrolled air exchange. Potentially, a mechanical ventilation with heat recovery could be installed. The location of the central ventilation unit could be close to the boiler room, which makes it easy to supply heat to the HV unit (inside or roof location).

Electricity is provided to the school through a low-voltage (LV) ground cable line; the main fuses are 3 x 315 A (240 kW) with the school fuses being on the receiving end of 3x80 A (50 kW). The electricity is delivered within tariff C21 (uniform fare) resulting in an average price of 200 EUR/MWh. The annual use of electricity is 120 MWh/year.

Concerning **lighting**, typically originally installed linear fluorescent lamps (2x36W) are used, which have different shapes. Gradually the lamps are replaced with light-emitted diodes (LED) tubes or lamps (over 10%). In the gym, LED lamps have recently been installed, which has resulted in a reduction of power demand by 40%.

Potential extension of the case study (school + "palace")

Recently, the Commune of Chorzewo has expressed an interest in extending the school modernisation project and to include the 'palace' building (for the locations, see Figure 6-4). For the palace building, funding was obtained from the National Fund for Environmental Protection and Water Management for thermal modernisation including windows replacement, modernisation of sanitary installation, insulation of the ceiling, implementation of energy management system and other renovation works necessary for the continued operation of this historic building. The heat supply to the building from the school oil boiler will be replaced with air heat pumps.

As of June 2022, the extension of this case study is at the stage of analysing the building's heat demand and examining the possibility of implementing IES by also installing a PV installation on the rooftop of the school building and supplying the palace building with a cable connecting both facilities. Depending on the regulations for generation of electricity from PV installations, there could be two separate micro-installations on the school's rooftop or both entities could form an energy cooperative and install bigger PV installation on the ground.

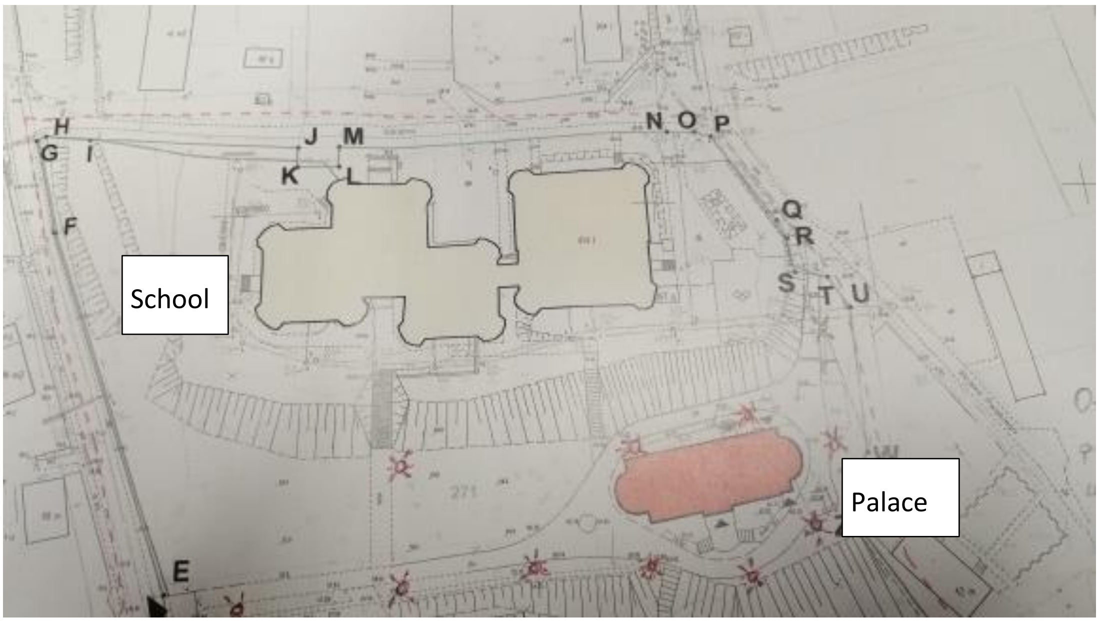


Figure 6-4. Location of the school and the palace building

6.3 Current situation - roles and organisation of stakeholders

The following stakeholders are of key importance for considering IES in the case study's buildings:

- Choczewo Commune:
  - Mayor (supervision)

  - the Council (funds)
  - administrative staff (technical, bookkeeping)
- School Headmaster
- The school's maintenance staff.

Other stakeholders, potentially offering financial, technical, and legal support to an IES investment are listed and characterised in Table 6-3; Figure 6-7 shows how these stakeholders are connected.

Table 6-3. Overview of supporting stakeholders to IES in the school with kindergarten

Case study supporting stakeholder	Main characteristics / activities
Financial service providers (Banks, venture capital / special funds, equity providers)	One of banks supporting investments. Special environmental funds. Support was available in previous rounds of EU funding, expected in the 3rd round (after 2020). The Commune can cover some expenditures.
Key technology suppliers	Developers and suppliers of relevant technology in the areas of PV, heat pumps and control systems. Key technologies: - PV installations - heat pump systems with deep boreholes - control system
Key industry or other relevant association	PV and heat pump producers and installers Drilling companies
Key public agencies	Mining Authority, District Mining Office in Gdansk Regional Director for Environmental Protection in Gdansk (only when EU funds are applied for) District Headquarter of State Fire Service Energy Regulatory Office DSO (ENERGA)
Provincial governments, municipalities and/or delegated permitting organizations	Commune of Choczewo, Mayor District Authority in Wejherowo, District Head Spatial plans, building conditions and permit, environmental reports
Consulting and legal service providers	Consulting agencies, regional energy conservation agencies (Association "Energy and environment conservation" SAPE-Poland), energy auditor (if thermo-modernisation is included), (construction designer, housing association administrator

The school's heating and electricity installations are maintained by the school's own staff. Temperatures in the classrooms were monitored against outdoor temperatures (Figure 6-5 shows an example of temperature profiles for one winter week).

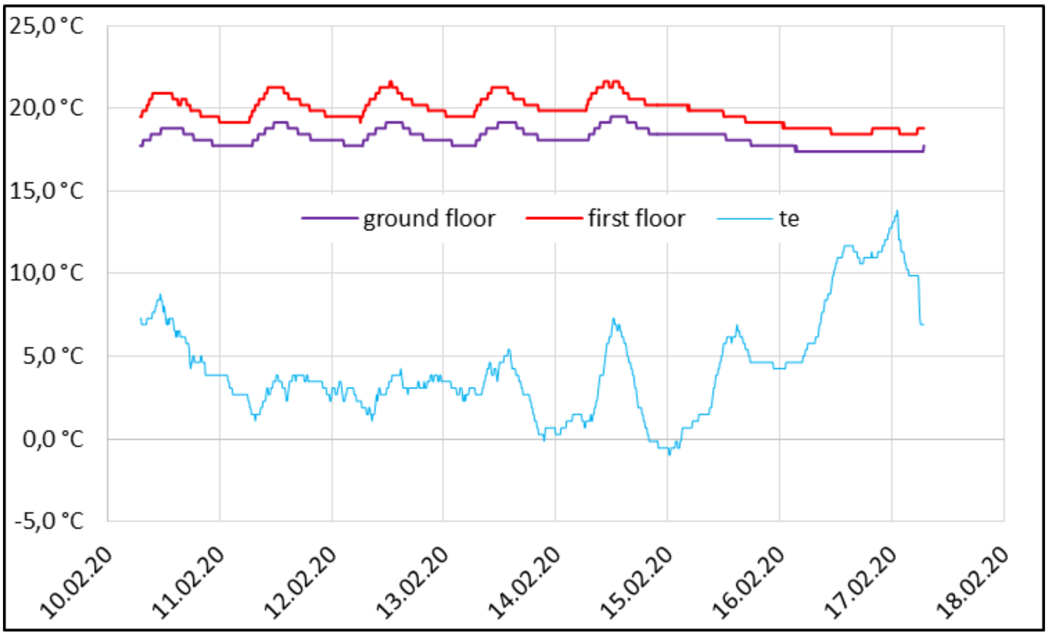


Figure 6-5. Internal temperature in selected rooms and external temperature (te)

Thermography tests of the school's walls did not reveal thermal bridges and excessive losses through the building envelope (walls, windows). Examples for the N/E walls are shown in Figure 6-6. Necessary repairs and services are outsourced to professional service providers.

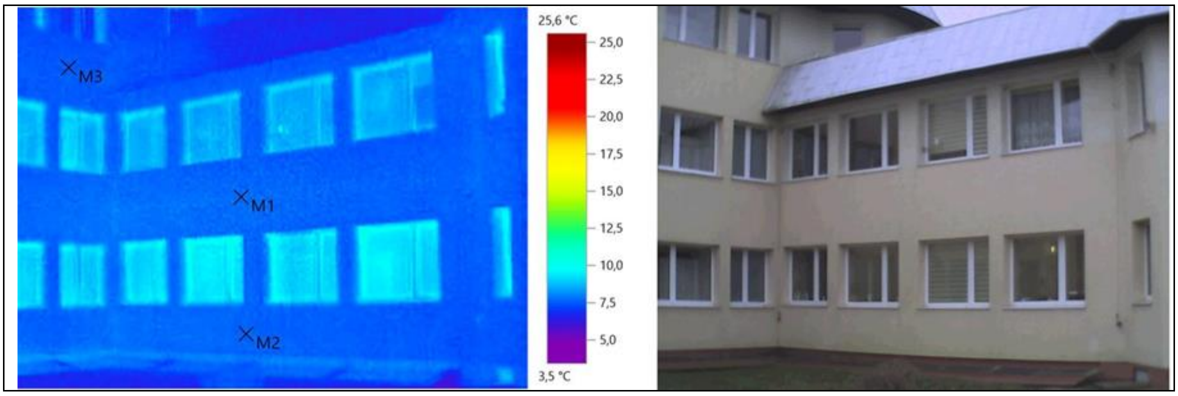


Figure 6-6. Results of thermography tests

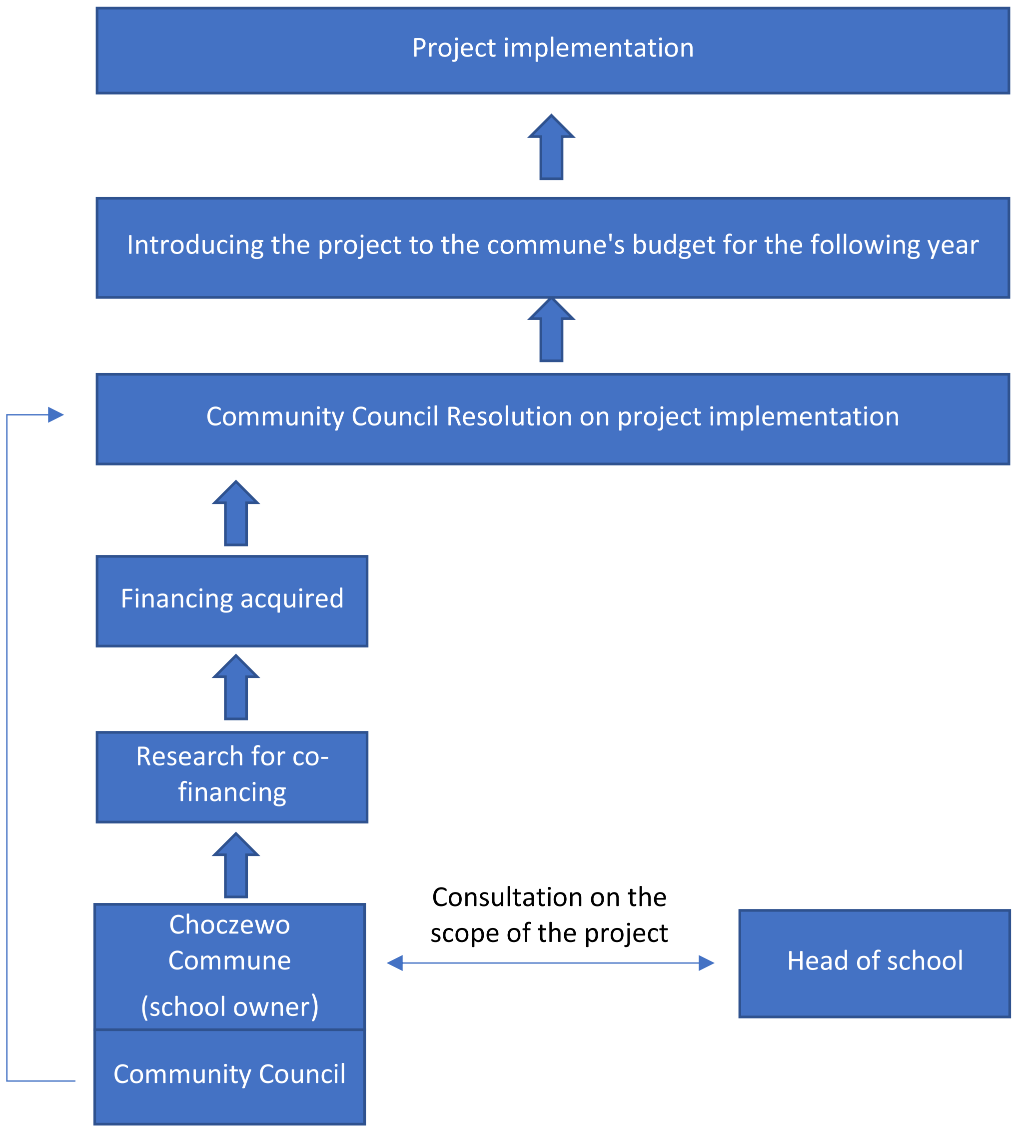


Figure 6-7. Organisation structure of relevant stakeholders for the case study buildings

6.4 IES options for case study building

The Choczewo Commune is not connected to the natural gas grid and there is no district heating network in the village. Considering local conditions of the school, the following retrofit options are considered:

A. **Possible conversion of oil boiler to biomass**, using wood pellets. With the price of fuel being 45 EUR/MWh and necessary new staff and operating costs amounting to approximately 10 EUR/MWh, the price of heat would be about 22% lower than with the present heat based on LFO. However, there would be problems with pellets storage, for which a silo outside the school would be needed. Moreover, the delivery of pellets would require access for big trucks near the school.

B. **A heat pump system with rooftop PV** can cover base load (for example 100 kWt heat pump can cover about 60% of annual heat demand); one of the existing boilers or a new oil boiler should serve as a reserve and peak load boiler. Over 1,000 m^2 (net) of flat roof can host up to 50 kWp of PV panels. This is the limit of “micro-installation” in Polish RES Law – simplified procedures and a prosumer (net metering) system with the possibility to reclaim 70% of the surplus electricity sent to the DSO network during the summer.

The success of the heat pump relies on own electricity stored for the winter, which implies that there must be a maximum production from the roof within the 50 kW capacity levels. However, as the school is not operated during the summer, installing solar (thermal) collectors for DHW is not feasible. The existing oil boiler could serve for the transition period as the reserve and peak capacity. Figure 6-8 shows an overview of how heat demand is met by an oil boiler and heat pumps.

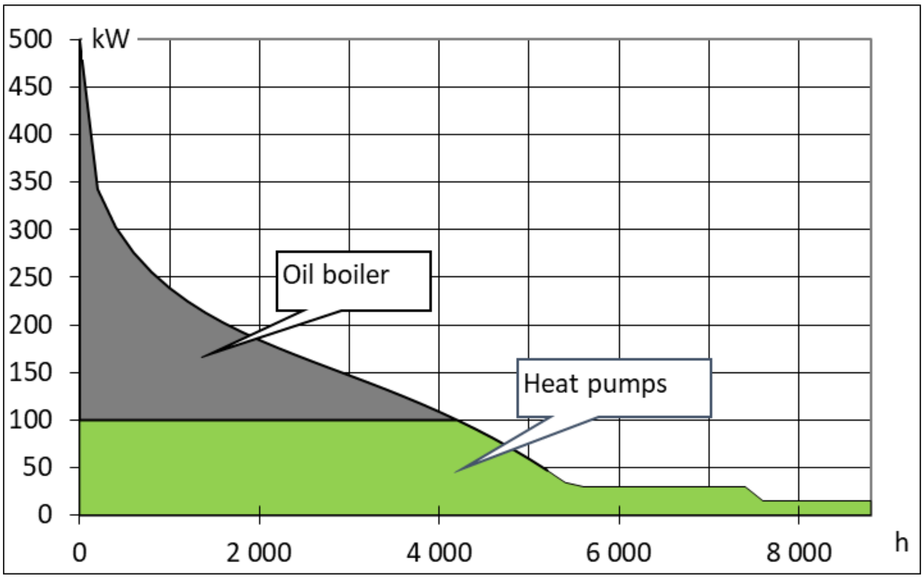


Figure 6-8. Ordered diagram – base load covered by heat pump

Below, the analysis of the options is split in two, as, due to changes in the regulatory system and the sharp increase of energy prices since spring 2022, the initial case study analysis done in 2020-2021 had to be updated.

Original analysis 2020/21

The comparison of present and future heat costs for end users is based on the following assumptions:

- the installation of a 50 kWp PV system will generate 50 MWh/year; operating as prosumer, surplus electricity will be sent to the operator network and recovered for 70% during heating season. 38 MWh/year of the own energy will supply the heat pump system.
- heat pumps with deep boreholes will have a Coefficient of Performance (CoP) of 4.0.
- the oil boiler will be used as reserve and peak heat source.

From the analysis for this case study, it can be concluded that the IES option B, based on a heat pump and PV installation, is the best solution for retrofitting the school’s heating system. The total costs of the system for the school are summarised in Table 6-4. Both installations will require combining control systems into one integrated system to ensure efficient use of solar energy, to be used as a primary energy source.

Table 6-4. Project expenditures

CAPEX	PLN	EUR
Heat pump	700,000	162,791
PV system	225,000	52,326
Total	**925,000**	**215,116**

Comparison of present and proposed heating systems shows future savings and potential for investment (see Table 6-5), leading to a payback time of 11.7 years. The latter could be shortened in case special funds, such as the special EU loan (available during present financing period and expected to be functioning during the coming years) (see Annex I, description of RES Loan), were utilised.

Table 6-5. Expenditures, costs, and savings – 2020/2021

	PLN	EUR
Expenditures	925,000	215,116
Present costs	178,112	41,421
Costs of energy after retrofit	99,171	23,063
Savings	78,941	18,358
Payback time (years)	**11.7**	

Situation in 2022

Similar to the first case study in this report, due to external changes since Spring 2022, new calculations had to be done for the above assessment of options. With a new net-billing prosumer system included into the calculations, a comparison of the previous net-metering and the new net-billing system has been made (see Table 6-6). For both cases, energy prices as per Spring 2022 have been used. It can be concluded that the PV system would cover about 40% of energy required for heat pump. Table 6-7 shows the recalculation of parameters for the IES based on the latest data, indicating that the payback time, under present circumstances, will be longer (over 15 years). Better results would be obtained within the energy cooperative in the commune, as it was shown in the previous chapter.

Table 6-6. Comparison of old net-metering and new net-billing system

Parameter	net-metering	net-billing	Unit
PV capacity	50	50	kW
AEP - annual energy production by PV	50	50	MWh/a
Direct use of PV gen.	20%	20%	
Useful PV energy	38.0	31.0	MWh/a
Share of demand	50%	41%	
Total savings	78,941	69,706	PLN/a
	18,358	15,153	EUR/a

Table 6-7. Expenditures and savings for complex renovation and introduction of IES

CAPEX	Unit	Weak
HP	EUR	840,000
PV	EUR	225,000
Total	EUR	1,065,000
Payback time	years	15.3

Finally, for the IES option an overview of technical, legal, social, environmental, and other barriers and their characterisation is shown in Table 6-8.

Table 6-8. Overview and characterisation of barriers to IES in school building

Technical barriers	Legal barriers	Social barriers	Environmental barriers	Other barriers
Lack of experience in IES design, construction, maintenance	Lack of novel financial tools for IES implementation	Lack of trust among stakeholders		Unstable energy policy
	Constantly changing legal environment	Lack of knowledge on IES		
Limited area around the building for boreholes			In the case of ground heat pumps, specific drilling approval is obligatory	
Heat demand cannot be covered only from RES				
	Lack of implementation regulations for energy cooperatives			

6.5 Co-creation for energy system and IES planning

As in the case of the Pucka Street housing associations, transformation of the local heat and power supply system of the school building should take place with the participation and involvement of the facility owner and its users. Deciding on an investment requires not only examining and analysing the technical condition of buildings, heat sources and possible technical solutions, but also the needs and expectations of its users. After all, the system should ensure that it is functional and provides thermal comfort to users at an acceptable cost level.

Taking the above into account, a survey was conducted in November 2020 among stakeholders, i.e., representatives of the owner, manager, administrator, and users. Due to the ongoing Covid-19 pandemic, it was impossible to organise a physical meeting and conduct a direct discussion. For this reason, a concise brochure presenting the current state of the heat source and heat and electricity supply system of the school was developed. The brochure also contained information about selected RES options, as well as an initial proposal for IES as a suggested optimal solution, including installation of heat pumps with a total capacity of 100 kW (supported by a PV system on the roof of the building) as the primary heat source and the use of one of the oil boilers as peak and backup heat source. Part of the IES would be a PV installation with a maximum power capacity of 50 kW.

The brochure was supplemented with a 16-question questionnaire. The packages were sent by post and completed questionnaires were sent back to BAPE by traditional mail. In total, six opinions were obtained, including three from school management and users and three from the school owner, the Choczewo commune office. The results are as follows:

1. Only 16.7% of the respondents believe that the school interior provides thermal comfort. Half of the respondents indicate that the temperature in the facility is too low during wintertime.
2. At the same time, over 80% of the respondents emphasise the high costs of heating and the large share of electricity costs in the commune's budget.
3. 33% of the respondents assess the air quality during the winter as average, while another 33% consider it bad. All respondents would like the air quality in the commune to be improved.
4. Environmental awareness of school owners and users is high. At school, a gradual replacement with equipment with low electricity consumption is taking place. At the same time, lighting sources are gradually being replaced with energy-saving LED technology.
5. Further replacement with energy-saving equipment and lighting sources is planned.
6. Stakeholders are interested in heat and power supply system modernisation. At the same time, they are aware that it will be necessary to move away from oil as heat energy carrier in favour of more ecological sources.
7. Respondents are aware that modernisation of heat and power supply system will require capital expenditure. They are also aware that more favourable financing is possible for RES.
8. Respondents are also aware that an environmentally friendly modernisation of the energy system will contribute to the commune’s ‘green image and they intend to promote implemented solutions.

Moreover, stakeholders suggested that it would be appropriate to train young people on RES under the RES4BUILD project. It can be concluded that:

a) Stakeholders are ready for changes in the school complex’ heat and power system.
b) Costs of heat and power constitute a significant share in the commune's budget. Therefore, stakeholders support modernisation that will ensure failure-free heat supply as well as contribute to costs reduction.
c) School equipment and lighting are successively being replaced with energy-saving ones.
d) It is important for stakeholders that energy transformation takes place with the use of modern, clean technologies.
e) It is important to further raise environmental awareness, also among students, and to build a ‘green image’ of the commune.

Raising awareness – meeting with students at school in Choczewo

One of the outcomes of the survey in two locations in Choczewo was stakeholders’ proposal to conduct training for young people under the RES4BUILD project on RES and integrated energy systems. For this purpose, a presentation was prepared, and senior students and their teachers actively participated in the class. The presentation was shared with school authorities and the energy agencies association SAPE-POLSKA (2022) for further exploitation and dissemination.

Specific co-creation steps utilised in case study

Designing an IES solution for the school and the palace is a time-consuming, multi-phase process that requires cooperation with many stakeholders like representatives of the commune (public authorities and owners), administration of the facilities and end users, energy consultants, designers, suppliers, financial institutions, etc. For that, the following steps have been undertaken within the case study analysis.

Step 1 - The first step was a **meeting with representatives** of the commune, school manager and operator of the school's boiler room in December 2019 and a discussion on the outline of cooperation in the field of modernisation of the heat and power supply system.

Step 2 - In November 2020, **concise information for stakeholders** was prepared presenting the current state of heat source as well as heat and power supply system for school buildings. The information - in the form of a brochure - also included a description of selected RES solutions as well as an initial modernisation proposal. The solution included also an IES comprising of heat pumps installed as the primary source and using one of the oil boilers as the peak and backup source. Heat pumps could be supported by a PV system on the roof of the building. Due to legal regulations, the PV installation should be a micro-installation with maximum power of 50 kW.

Step 3 - **Survey conclusions** based on stakeholders' responses.

Step 4 - **Analysis** if it is possible to extend the project by modernizing the heat and electricity supply system for the ‘palace’ and implement an IES consisting of air heat pumps and PV installation at two locations: the school and the palace.

Step 5 - Indication of the possibilities of obtaining **financial support**. Financial instruments are currently under development for the next budgeting period 2021-2027 and new opportunities will appear (see Annex I).

Step 6 - Defining forms of **stakeholder cooperation** for investment implementation.

Step 7 - Project **implementation**.

To sum up, the process of project preparation is well advanced in this case study. Further actions depend on introduction of proper legal regulations allowing to choose an adequate organisational form and new financing rules allowing to obtain funds for the investment.

7. Case study: IES-based improvement existing industrial plant

7.1 General introduction of case study

This case study considers the retrofit of the production facility of electrical and optical components, which has been operational since 2002 and which is part of a multinational group (for confidentiality reasons, the name of the company is not revealed in this chapter). The building hosts the following functions: production, laboratories, a warehouse, offices, and social areas.

Around 700 people work at the plant, in one or two shifts. The company is interested in limiting the use of fossil fuel-based energy for electricity and heat (through heating oil, see Figure 7-1) and reduction of its carbon footprint.

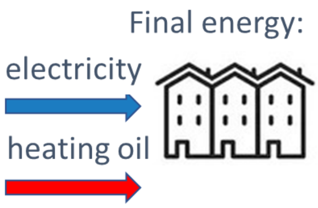


Figure 7-1. Final energy delivered to the building

7.2 Current situation - status of building and present energy technology

The company building was built in the 1990s and has been modernised since then in steps, including replacement of windows and improvement of the building insulation. The construction is made of sandwich-panels of steel sheet and Expanded Polystyrene (EPS) insulation. Table 7-1 and Figure 7-2 show the main areas of the building, while Table 7-2 shows the building's U-values (Wikipedia, 2022).

Table 7-1. Main areas of the building and operational heating systems

No	Name	Floor area [m^2]	Heating system
1	Production P	3,062	VAC
2	Production FO	594	VAC
3	Production RF	588	VAC
4	Warehouse EDC	1,436	Heat blowers
5	Warehouse S	2,458	Heat blowers
6	Offices, social areas	1,156	radiators/ VAC
	Total	**9 294**	

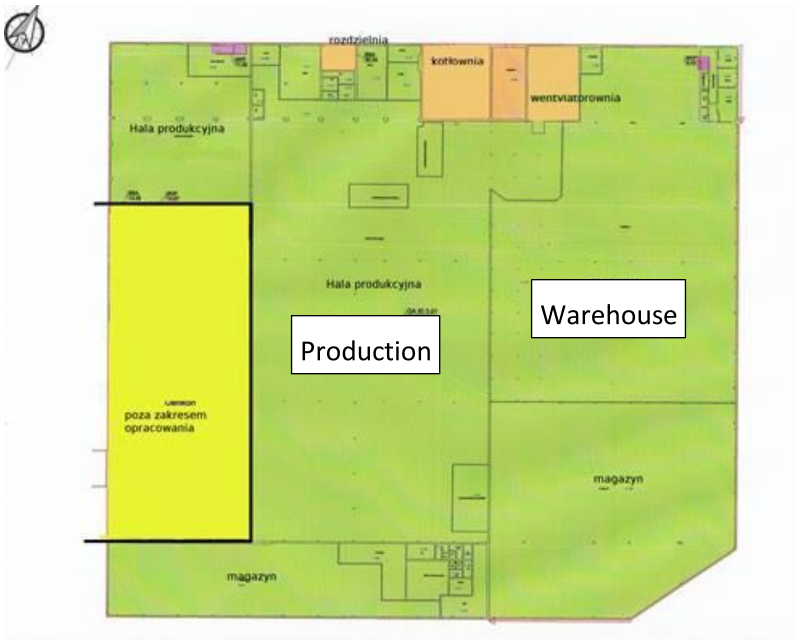


Figure 7-2. Scheme of the building layout

Table 7-2. U-values of the building

U-values	Walls	Roofs	Windows	Skylights	Gates, doors
W/m² K	0.21-0.39	0.27	1.60	3.30	0.90-1.60

Several **energy efficiency steps** have been already introduced in the building, including:

- a new compressor.
- switch lighting to LED, which is partly done, with complete replacement planned.
- air locks installed at the warehouse gates.
- the oil boiler has been replaced, and
- HVAC units with better temperature and humidity control, and insulation, which are in progress/planned.

Heat is supplied by the building's own boiler room with the following parameters:

- Two oil boilers of 780 and 475 kW (Viessmann);
- Heat supply parameters: 80/60°C; and
- The boilers are serviced, and their efficiency measured; an example of a flue gas test is shown in Table 7-3.

Considering the energy profile of the building, the maximum heat demand for design conditions (-16°C) is less than 450 kW.

Table 7-3. Example of the boilers' flue gas test

		Boiler	
No	*Parameter*	*1*	*2*
1	Measured combustion efficiency	92.4%	92.8%
2	Flue gas temperature	176°C	179°C
3	Lambda	1.30	1.26
4	Estimated annual efficiency	**90%**	**90%**

The **Heating, ventilation, and air-conditioning (HVAC)** is based on mechanical ventilation with cooling and heat recovery (crossflow recuperation and rotary regenerators). The estimated volumes and capacity of ventilation systems are shown in Table 7-4; their electricity demand is shown in Table 7-5.

Table 7-4. the ventilation system's estimated volumes and capacity

	Supply	Exhaust	Heat demand	Heat use	Cooling demand	Cooling use
Area	m^3/h	m^3/h	kW	GJ/a	kW	MWh/a
Production hall	53,160	56,660	290	1,419	190	212.8
Warehouse	7,000	8,080	21	111	0	0
Offices, social	5,350	5,350	29	79	0	0
Total	**65,510**	**70,090**	**341**	**1,609**	**190**	**212.8**

Table 7-5. Estimated electricity demand for ventilation

	Capacity	Electricity use
Segment	kW	MWh/a
Fan drives	56.1	228.1
Cooling – central units	67.9	76.0
Individual air conditioners	40.9	9.8
Total	**164.9**	**313.9**

The building's **electricity supply** has the following characteristics:

- Electricity is supplied to the building via two transformer stations at 630 kVA and 800 kVA.
- Electricity is paid for at a uniform rate (so-called Tariff B21[3]).
- The annual electricity consumption in the building in 2019 amounted to 1 146 MWh/year.
- Peak capacity exceeds 500 kW.

Figure 7-3 shows the building's use of heat and electricity during 2016-2019.

[3] Tariff B21 is a single-zone tariff for large companies, supplied from medium voltage networks, with a contractual power greater than 40 kW.

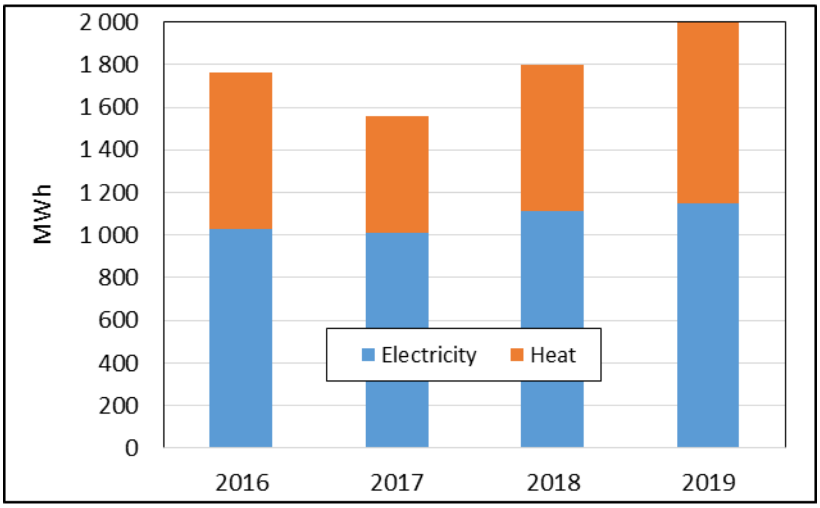


Figure 7-3. Use of heat and electricity during 2016-2019

According to the company, the volume of production and resulting load and working hours change from year to year. Use of heat and electricity depends on the production intensity in the given period, such as shown in Figure 7-4.

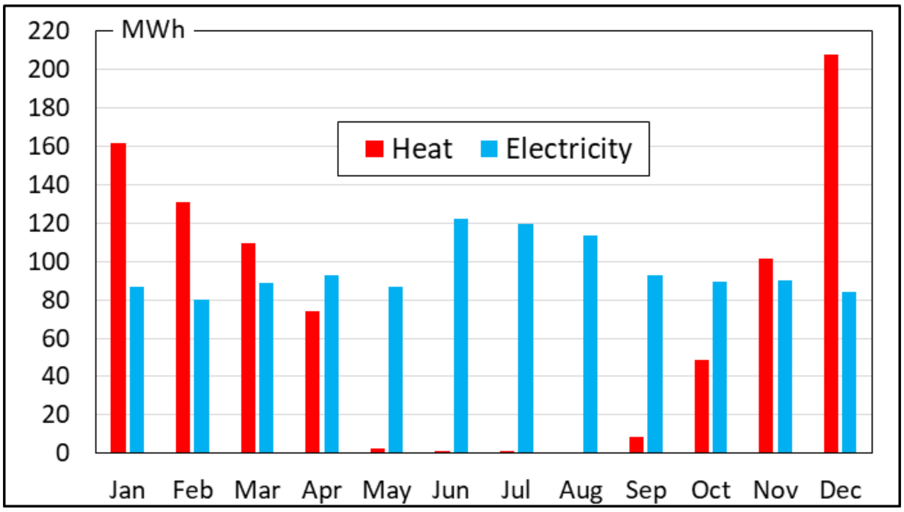


Figure 7-4. Use of heat and electricity throughout 2019

7.3 Current situation – stakeholders and how they are organised

The **key stakeholders** for this case study are the company and the business group that own it, as well as the Municipality. Furthermore, several supporting technical, regulatory, financial, and social stakeholders can be identified to partake in a participatory assessment of energy system improvements in the building, including via IES (see Table 7-6).

Table 7-6. Overview of supporting stakeholders for the case study analysis at the production plant

Case study supporting stakeholder	Main stakeholder characteristics / activities
Financial service providers (Banks, venture capital / special funds, as well as equity providers)	One of banks supporting investments. Special environmental funds. Support was available in previous rounds of EU funding, expected in the 3rd round (after 2020). Third party in EPC contract.
Key technology suppliers	Developers and suppliers of relevant technology in the areas of PV, heat pumps and control systems. Key technologies: - PV installations - reversible heat pumps in HVAC systems - control system
Key industry or other relevant association	PV and heat pump producers and installers HVAC producers and installers
Key public agencies	Regional Director for Environmental Protection in Gdansk (only when EU funds are applied for) District Headquarter of State Fire Service Energy Regulatory Office DSO (ENERGA)
Provincial governments, municipalities and/or delegated permitting organizations	The Municipality, the Mayor District Authority, District Head Spatial plans, building conditions and permit, environmental reports
Consulting and legal service providers	Consulting agencies, regional energy conservation agencies (Association "Energy and environment conservation" SAPE-Poland), energy auditor (if thermo-modernisation is included), (construction designer, housing association administrator

7.4 IES options for case study building and co-creation steps

There is not a natural gas nor a district heating network nearby the production plant. A possible conversion of fuelling the boiler biomass, i.e., wood pellets, instead of oil, is not possible because of a lack of required space for pellet storage around the building. As the production process for the company requires clean air a solid fuel boiler is not well suited at the location. Given the relatively uniform and stable power load of heat and electricity and availability of a big roof area conditions are favourable for use of PV installations for supplying building power needs.

The possible IES solutions for this case study are:

A. To install a PV system and heat pumps with deep boreholes, which in combination cover base load of heating and partly the demand for electricity. However, the area needed for boreholes around the building is limited; the only potential location for deep boreholes for heat pumps is at the small area of the company site. Most of the heat for the production hall and warehouse is delivered by mechanical ventilation. This could be covered by heat pumps installed in air-conditioning central units.
B. Small PV installations, covering HVAC demand, especially when heat pumps based on exhaust air are introduced in the ventilation system.

The potential capacity of PV installations can reach 1,000 kW, which is within the limit for a ‘small’ installation so that simplified regulatory procedures apply. Small RES sources (50-1,000 kW) cannot take part in net-metering, so any surplus generated electricity would be sold to the DSO at a relatively low price, i.e., about half-price of the purchased electricity.

However, during the planning of retrofitting the building it has been found that the roof has no load reserve, and even adding some insulation would require strengthening the roof. Hence, installing rooftop PV panels is not possible, neither is any area available on the ground for placing PV panels at the company site (some extensions of the building necessary for changing production profile are planned).

As an alternative wind energy was considered as there are suitable wind conditions in the area, with possible productivity at about 2,000 MWh/MW. A wind turbine (WT) of 0.5-1 MW capacity would be technically possible to be installed. However, current Polish law prohibits installing wind turbines within a kilometre from residential housing for this size of a wind turbine. There are plans to amend the law regulating wind energy generation to ease this restriction, but presently this law prohibits the wind energy option. Therefore, with solar PV technically and wind energy regulatorily unfeasible, the company's management has decided to undertake measures aiming at improvement of energy management at the site as the first step. Improvements of energy management and use of RES have been consulted with BAPE.

Finally, for the IES option an overview of technical, legal, social, environmental, and other barriers and their characterisation is shown in Table 7-7Table 6-8.

Table 7-7. Overview of barriers to potential IES implementation in case study building

Technical barriers	Legal barriers	Social barriers	Environmental barriers	Other barriers
Limits of possible additional roof load for PV installation	Lack of financial tools for IES implementation			
Limited area around the building for boreholes			Deep drilling requires special permits from authorities	
				Uncertainty on future energy price
Limited area for a wind turbine	Not possible to install 0.5-1 MW wind turbine			

8. Case study: communal multifamily building in Mały Klincz

8.1 General introduction of the case study

This case study analyses the feasibility of RES improvement for energy supply in communal multifamily building in Mały Klincz, a village of 460 inhabitants in the Kościerzyna rural commune in the Province of Pomerania. The co-design process for this building has been tailored, as it depends on the Commune, municipal services office, and end-users' capabilities and availability. The building belongs to Kościerzyna commune and is the only building of such kind in the village (Figure 8-1).

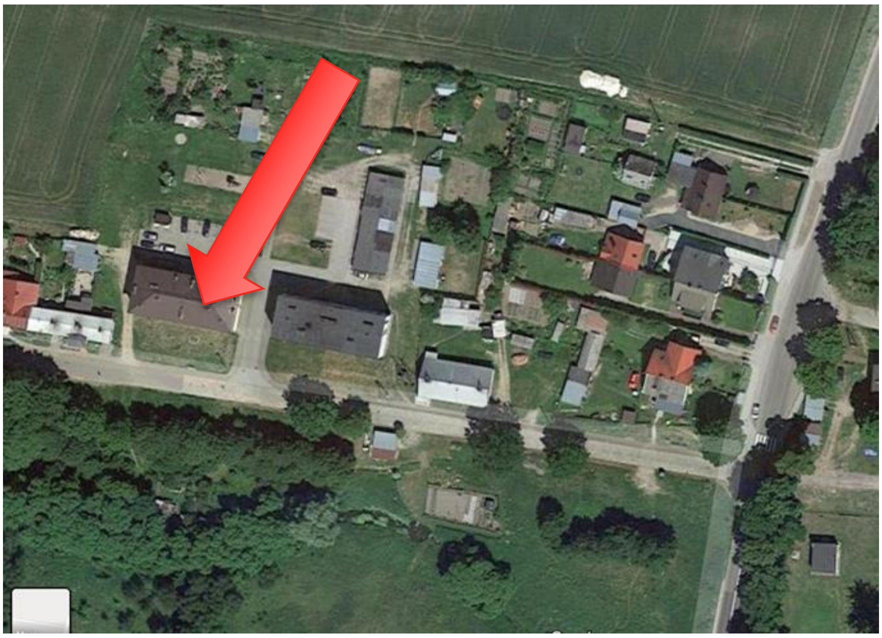


Figure 8-1. Location of the case study building at Mały Klincz

The case study for the building in Mały Klincz was considered at the initial stage of the RES4Build project to explore the potential for RES, possibly combined into IES. For two months activities were undertaken such as contacts via telephone and email, sharing information and organising meetings at the Municipality of Kościerzyna with the Head of the Municipality and representatives of the municipal service office ZKG (the building administrator). However, at the later stage, analysis showed very limited potential of IES implementation in this case, so that the focus has mainly been on solar PV installation.

The multifamily building is a stand-alone building with its own heat supply system based on electricity. There is a parking lot and a small recreational area next to it. The building was constructed to offer housing to low-income families who cannot afford buying their own house. The input data from the building was collected and processed from December 2019 through February 2020.

8.2 Current situation – status of building and present energy technology

The building dimensions are 12x28x11.5 m. There is one staircase in the building, three floors, a basement, and a roof void. The building has 15 apartments: four one-room, six two-room, and five three-room apartments. The apartments are equipped with kitchens and bathrooms with bathtubs, washbasins, and toilets. Inhabitants pay their rent monthly to the municipal services office. The rent is set annually and currently it is 2.60 PLN/m^2. Typically, there are delays in rent payments (according to commune administration, the building owner).

The building was built in 2011 using traditional technology. It is made of 24 cm thick cellular concrete blocks with 12 cm thick mineral wool insulation. It has a multi-hipped roof and the ceilings, which are made of reinforced 16 cm concrete plates, are insulated with 20 cm mineral wool. The roof is made of a wooden construction covered with steel tiles and has a slope angle of 20^o. The windows are placed in plastic frames and have a U-value of 1.7-1.8 W/m^{2}K. Entrances to the buildings have self-closing doors to prevent cold air penetration. The building is in good technical shape and does not require modernisation.

Figure 8-2. Building no. 39 in Mały Klincz (front side)

Figure 8-3. Building no. 39 in Mały Klincz (back side)

Technical data for the building based on the recent survey is presented in Table 8-1, while U-values are shown in Table 8-2.

Table 8-1. Technical data for the building

Parameters	Unit	Mały Klincz 39
Useful floor area	m^2	1,163
Floor area of flats	m^2	876
Building height	m	11.35
Flats	-	15
Inhabitants	-	62
Walls insulation (mineral wool)	cm	12
Ceiling under the roof insulation (mineral wool)	cm	20

Table 8-2. U-values (previous and present standards)

Years	U-values	Walls	Ceiling under roof	Windows
2009-2014	W/m^2 K	0,30	0,25	1.9
2020-2021	W/m^2 K	0,20	0,15	0.9

The building does not currently meet applicable thermal insulation standards, which are now more demanding in terms of energy conservation. However, adjusting thermal parameters of the building to current standards would not be a profitable investment due to high investment costs and relatively small savings.

Heating and domestic hot water (DHW)

Heating and DHW preparation are based on electricity, although in three apartments electric heaters have been replaced with wood fireplaces, due to high energy costs. The apartments are equipped with electric heaters and flow-through electric heaters installed above the sinks. From here, hot water is distributed to bathtubs and kitchen sinks. The design of electrical installation also provided for assumed connection of kitchen electric stoves. However, due to high costs of electricity the ovens are supplied with liquid gas from individual gas containers.

All flats are equipped with electricity and water meters. Residents settle accounts with service providers on their own. The basement and common parts of the building, i.e., staircases and external lighting of the building consisting of two wall lamps, are metered separately. These elements are the property of the municipal services office, which settles the energy consumed with the supplier. The costs of this energy are charged to residents and are included into the rent rate. Electricity meters are located at the entrance to the building.

Figure 8-4. Power box

Electricity is delivered to the building via a low-voltage cable line. The electricity box is placed on the outside wall of the building (Figure 8-4). Administrative lighting circuits (basements, corridors, staircase, external lighting), socket circuits, administrative equipment circuits as well as residential switchgears are supplied from the main switchgear (Figure 8-5).

Figure 8-5. Main switchgear at the building entrance

Electricity consumption and supply

Electricity in the building is used for heating, hot tap water preparation, indoor lighting, staircase, basements, external lighting as well as for the purpose of supplying household appliances, audio/video devices and IT. There are neither motion detectors nor mechanical ventilation or air conditioning in the building. Lighting in the building's staircase was renovated in 2019, whereby lamps were replaced by LED lights and two lighting points were removed, leading to an energy savings of 24%.

Table 8-3. Electricity consumption in the building in specific months in kWh

2019/2020	Staircase/cellars lighting	2019
10.09.19-22.11.19	44	Jan
21.11.19-17.01.20	188	Feb
17.01.20-11.03.20	80	Mar
12.03.20-11.05.20	73	Apr
12.05.20-9.07.20	120	May

A low-voltage cable line delivers electricity to the building. Main fuses for each flat are 64A. Electricity consumption for common use is metered (staircase, basement) separately. Internal installations are made of copper wires (type of YDYp 3x1,5 mm^2). Residents settle electricity bills with the distribution company on their own. The electricity consumption costs of the common areas of the buildings are split between flats. The Electricity tariff used for housing is the so-called G11 (see elsewhere in this report) and is controlled by the Energy Regulatory Office (URE).

Table 8-4. Power supply characteristics

	Unit	Cable Line
Power supply		LV, 3 phase
Main fuses / per staircase	A	64
Switchboard		good technical conditions
Ordered capacity	kW	2
Tariff	-	G11
Variable price of electricity	PLN/kWh	0.2283
(Including VAT 23%)	EUR/kWh	0.156

8.3 Co-creation for energy system improvement in case study building

The following technical retrofitting options can be considered for the building:

A. Conversion of electric heating system into installation of biomass/gas boiler in the building supported with PV systems on the rooftop,
B. Conversion of electric heating system into connection to the district heating supported with PV systems on the rooftop,
C. Conversion of electric heating system into installation of heat pumps in the building supported with PV systems on the rooftop, and
D. Installation of PV systems on the rooftop.

Considering local conditions and existing installations in the building, the options can be assessed as follows. Option A is hampered as there is neither internal water heating nor a hot tap water installation in the building. This would make the construction of these systems very costly, while no energy savings would be generated. Moreover, there is no space for construction of fuel storage and boiler installation, neither is there a gas supply system in the neighbourhood of the building. Also for options B and C, the cost of constructing an internal installation would be very high and there is no district heating in the vicinity of the building (needed for option B) and there would be organizational issues and arrangement of the apartments (in option C). Due to these limitations, there is no scope for IES implementation in this building. Instead, as installing rooftop solar PV panels is feasible in all options, the further case study analysis will be limited to PV installation alone to reduce electricity demand from the grid, thus reducing the costs of heating and power for tenants and reducing environmental impact of energy used.

The area of the south roof slope of the building equals to 100 m^2. It is possible to install 10 kWp or a bigger system employing efficient 350 Wp PV (or higher efficiency) panels on the roof. Average annual electricity production (AEP) over a period of 15 years in this area of Poland can be conservatively assumed as 1 MWh/a per 1 kWp installed, taking into account reduction of PV productivity by 0,5% annually.

A PV system of a capacity below 50 kW is treated as a micro-installation, and thus requires limited approval. For micro-installations with a capacity of less than 10 kW, 80% of surplus energy delivered to the grid operator can be recovered during higher energy demand periods. It has been assumed that all energy generated in PV systems will be used directly by the building. Only in an exceptional situation, surplus energy will be delivered to the distributor network for future use. The PV system costs are typical for PV micro-installations of this size; system parameters are summarised in Table 8-5.

Table 8-5. Parameters of the PV system.

No	Parameter	Unit	Value
1	Annual electricity consumption (estimation)	kWh/a	90,000
2	Average demand for power during PV operation	kW	over 8
3	Average electricity price	PLN/MWh	670
4	peak capacity of PV installation PV	kW_p	10
5	Electricity generated for own use	kWh/a	10,000
6	Expenditures	PLN	49,200
7	Annual savings	PLN/a	6,700

Financial assessment and funding options

Basic economic project parameters for the PV solution for this case study are summarised in Table 8-6. These consider present and expected prices, costs as well as the regulatory and financial environment, whereby it is assumed that the electricity price for households (tariffs of group G) is controlled by the Regulator and is not expected to rise faster than the consumer price index for inflation (CPI).

Table 8-6. Expenditures, costs, and savings of the PV system solution in the case study

	PLN*	EUR*
Expenditures	49,200	11,442
Avoided electricity purchases	6,700	1,558
O&M costs	134	31
Savings	6,566	1,527
Payback time (years)	**7.5**	**7.5**
* The exchange rate PLN/EUR is 4.3		

Comparison of necessary expenditures and future savings shows a pay-back period typical for micro-PV installations. The feasibility analysis, based on commercial assumptions (reference period 15 years and a discount rate of 4.0%), gives the results of the project economics as in Table 8-7:

Table 8-7. net present value and internal rate of return outcomes

NPV	PLN	23,803
IRR	%	10.3%

Retrofitting investments in housing, especially in case of low-income families, can be justified for social and environmental reasons. Currently, prosumers can use a supporting system based on net-billing (as described in Annex I of this report) though it is less profitable for investors.

A loan at preferential terms is available from *Pomorski Fundusz Pożyczkowy* (Pomerania Loan Fund) for entrepreneurs, local government units, organisations conducting economic activities, such as housing associations. The loans budget is approximately 13 million Euro (57 million PLN) and a preferential interest rate (from 0.25%) is available to investors who meet the preference criteria with de minimis aid or aid provided for in Articles 40, 41 and 49 of GBER[4]. The maximum renewable energy loan amount is approximately 3.5 million Euro (15 million PLN) with a repayment period of up to 15 years. *Bank Gospodarstwa Krajowego* (2022) provides financial assistance to investors implementing thermo-modernisation and renovation projects with a premium of 21% of the costs for thermo-modernisation projects together with the installation of RES micro-installations.

Feasibility and risks of the proposed case study solution

The project as proposed for this case study building is feasible especially when supported by special funding schemes (as explained above). The main risks to the project are higher than assumed investment costs, although prices of PV panels tend to decrease continuously (World Economic Forum, 2021).

Household electricity prices are regulated by the State Energy Regulatory Office (URE) and shall not

[4] General Block Exemption Regulation: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A02014R0651-20210801

rise over the inflation index in foreseeable future. Preconditions necessary to achieve successful implementation of the case study solution are as follows:

- After discussions within the project group, a clear and feasible project proposal including technical, organisational, and financial aspects shall be presented to key stakeholders.
- A scheme of sharing avoided electricity costs shall be developed and accepted by the commune and tenants.
- The Commune mayor shall ensure support to the project.
- The Power distributor shall provide two-way metering system to the building.
- Selection of technology providers is essential to select high-quality and reliable products.

This study was handed over in November 2020 to Kościerzyna Commune authorities (owner of the building) and the building manager.

9. Policy context for sustainable buildings in The Netherlands

Further to the ambitions of the EU Green Deal and the accompanying policy package Fit for 55, the Netherlands government coalition, installed in January 2022, has strengthened the Dutch climate goals from 49% emission reduction to 55% reduction of CO_2-eq. by 2030 (compared to 1990 levels) (Government of the Netherlands, 2022). For that a Climate and Transition Fund will be established with a budget of € 35 billion for the period 2022-2032. Besides emission reduction, the agreement also refers to the planned cessation of gas production from the 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.

For the built environment, the coalition agreement contains a long-term (at least until 2030) National Insulation Programme for accelerated, smart and social insulation investments in dwellings. Earlier, in the 2019 National Climate Agreement (Government of the Netherlands, 2019), it has been agreed that the built environment should be CO_2 neutral by 2050, to be achieved by an intermediate goal of 3.4 Mton CO_2 emission reduction within the sector by 2030. This targets seven million dwellings and around one million other buildings, including office and event hosting buildings. In support of this, the Netherlands Government designed a Transition Visions Heat (TVH) (RVO , 2019), with plans for the insulation of buildings and phasing out of the use of natural gas at the local level.

The process of developing local TVH plans is governed at the municipal level where municipalities indicate how many residential and other buildings are planned to be insulated and made natural gas free until 2030. The case studies in this chapter, where applicable, refer to such plans as formulated by the relevant municipality. TVHs, which are eventually based on a dialogue with a broad range of local stakeholders, including real estate owners, residents, and energy network companies, also indicate which districts and neighbourhoods are dealt with first and which future energy alternative is considered. TVHs then form the basis for more detailed 'district implementation plans' ('wijkuitvoeringsplannen') for each district, street or area within the municipality will be determined (RVO , 2019).

As explained in Spijker, et al (2020), new buildings, both residential dwellings and office and utility buildings must be nearly energy neutral (in Dutch 'bijna energieneutraal gebouw' or BENG). With BENG the Netherlands implements that EU Directive Energy Performance of Buildings (EPBD) (RVO, 2020), thereby focussing on three criteria: a maximised energy consumption (in KWh/m^2-year); a maximised use of fossil fuels (in KWh/m^2-year); and a minimum share of RES in the building (in %). The values for these criteria are specified per type of building (e.g., office building, education, sports facility, shop, hotel/restaurant). The objective of the policy instrument is to promote innovative measures, which are not yet standardised in the market, i.e., widely diffused, but which could accelerate buildings meeting BENG criteria.

Finally, as of 1 January 2023 it is mandatory for office buildings in the Netherlands to obtain an Energy label of C at least (label A being the label with lowest primary energy consumption). This implies that the consumption of primary fossil fuels in office buildings cannot be higher than 225 kWh/m^2 per year. Without this label, a building can no longer be used as an office (RVO, 2018).

10. Case study: Cultureel Centrum Zuidhorn, community centre

10.1 Introduction to case study

For the Dutch case studies in this report, three buildings have been selected, each with a different ownership structure, functionality and thus user profile: a community centre, a health care facility, and a building envelope for hosting commercial events. As a community centre a case study on the Cultural Centre Zuidhorn (CCZ) has been selected. CCZ was built in 2007 as a facility to host cultural and societal organisations and activities, such as a library, a music school, a theatre, film, workshops, etc. CCZ also offers office space and meeting rooms with a capacity upto 130 people. Zuidhorn is a village with 7,200 inhabitants, located in the Municipality of Westerkwartier in the Province of Groningen (see Figure 10-1).

Figure 10-1. Location CCZ Zuidhorn

JIN established contact with the board of the CCZ, through a contact within its network when JIN staff were exploring case study buildings for RES4Build. The interest was gained as the building, while relatively new, has had problems with indoor air quality resulting in health problems for people active in the building, especially those working in the offices. On 5 August 2020, JIN staff (Eise Spijker and Wytze van der Gaast) met with the chairman of the Stichting CCZ (SCCZ, the building's management board). SCCZ is responsible for the day-to-day management of the building; the building is owned by the Municipality Westerkwartier, which is also responsible for the building's maintenance.

The case study has subsequently been conducted by JIN and ARUP, whereby JIN focussed on the co-creation aspects (stakeholder roles and responsibilities as well as the building organisation), while ARUP carried out a technical analysis of the energy performance of the building with potential solutions for improvement.

Figure 10-2. Front view Cultural Centre Zuidhorn

10.2 Current situation – status of building and present energy technology

The building's characteristics

This section provides a technical review of CCZ and provides advice to stakeholders about which steps can be taken in the process to improve the building's energy performance and air quality: both for the users and the sustainability performance, while keeping in mind the ownership and financial constraints. Based on the primary scope of the RES4Build project, the review only focuses on the ventilation, heating, and cooling aspects of the case study. Performance of health systems (drinking water, foul water, rainwater, sanitary) are not included in the scope of this study. Lighting (controls) are only addressed where it relates to building control and/or internal heat gains.

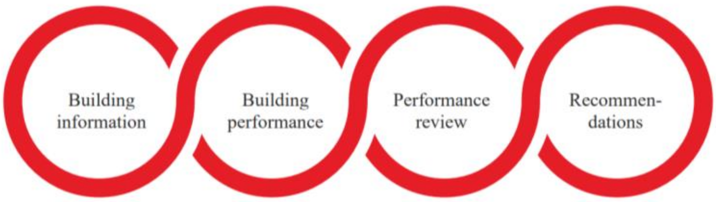


Figure 10-3. Technical review case study

The following information was collected from a range of sources:

Table 10-1. Data collected for this review

Type	Source
Architectural drawings	To be built set by Artes; August 2006
Mechanical and sanitary drawings	Revision set by CroonWolter&Dros (CWD, maintenance partner), September 2007
Building management system access	Priva system; acceded through CWD; viewed May-June 2021
Building user interview data	Gathered by JIN; 2021 (see elsewhere in this chapter)
Energy performance of PV	Summary of yield; CCZ
Maintenance interview data	Interview by Arup and JIN; April 2021
Building images	www.Saxarchitecten.nl; visited May/June 2021
	Site visit pictures; JIN; August 2020

The building is in the residential area of Zuidhorn; the streets surrounding the building are relatively quiet (see Figure 10-4). Next to the building is an open park. Parking spaces are positioned in front of the building. The 'backyard' of the building contains trees and a bike parking.

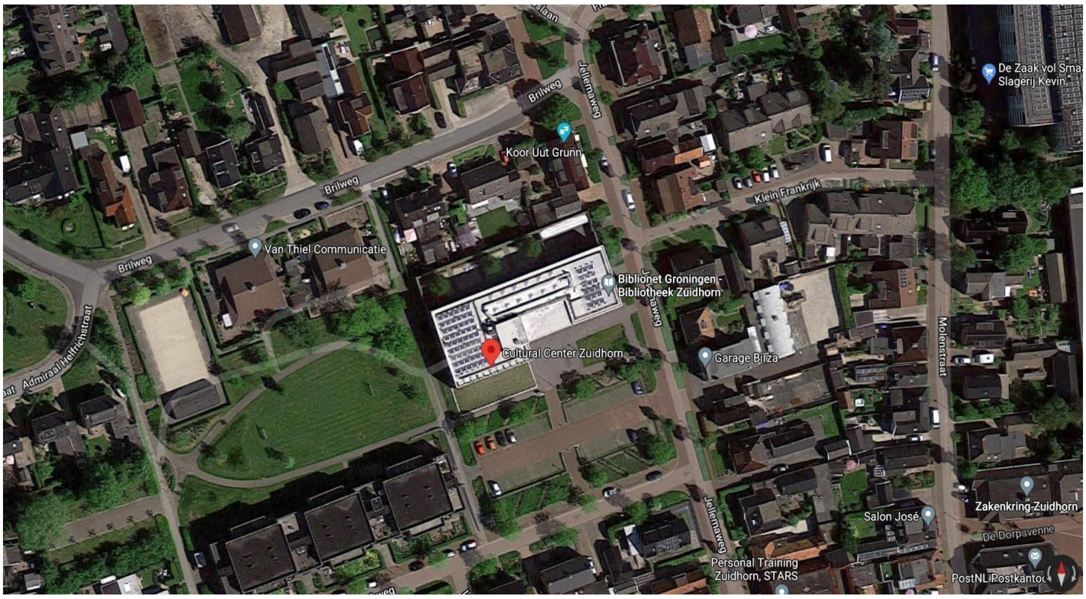


Figure 10-4. Google maps view of the building

The following data describes the architecture of the building:

- Building size and surface: 695 m^2 (ground floor 380 m^2 and first floor 315 m^2).
- Orientation: The building has the long façades towards south-southeast and north-northwest (see Figure 10-5).
- Thermal performance: as specific calculations and/or measurements were not available, the thermal performance of the façade has been estimated based on architectural sections at an Rc-value of 2.5 m^2K/W for the roof, the façade and the floor. The U-value (Wikipedia, 2022) for the glass and aluminium window frame have not been determined in this assessment. According to the Royal Netherlands Standardization Institute *(NEN, norm* 1068), the building regulations for the U-value are 4.2 W/m² *K (NEN, 2012).

- Air tightness: There is no data of the air tightness of the building.
- Shading: There is no external shading.
- Façade openings: Table 10-2 shows an overview of opening per building orientation, based on architectural views. Additionally, several skylights are placed in the roof.

Table 10-2. Overview of openings per orientation

Facade orientation	North	East	South	West
Specific	NNW	ENE	SSE	WSW
Degrees	340	70	160	250
Total area	**165**	**70**	**165**	**70**
Windows	15.6	5.4	19.8	4.2
Blue curtain wall			17.6	
Orange curtain wall			23.6	
Doors	3.8	2.6		
Entrance	26.2	5.6		
Total opening area	**45.6**	**13.6**	**61**	**9.8**
Opening percentage	28%	19%	37%	14%

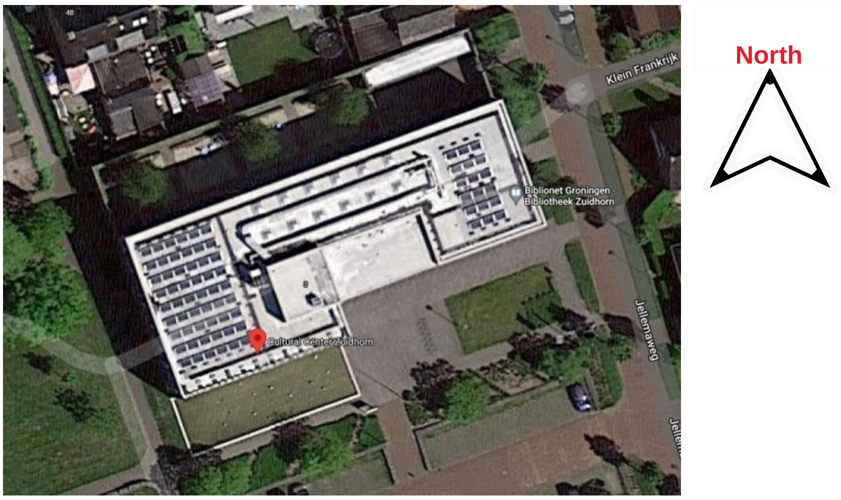


Figure 10-5. Top view of the building

The building's energy system and performance

This section describes the building performance in relation to its users, surrounding climate, control, and management. A technical description of the equipment for heating, ventilation, and air-conditioning (HVAC) can be found in Annex 2. For the building CCZ no specific performance ambitions have been formulated, but it is assumed that these will be aligned with the sustainability vision and ambition of the Municipality of Westerkwartier (Gemeente Westerkwartier, 2020), which aims at halving CO_2 emissions by 2030 and realising net zero emissions by 2050. There is no specific information though on how this ambition is planned to be achieved for the building CCZ.

Table 10-3 shows aspects related to the maintenance of the several technical components of the building CCZ.

Table 10-3. maintenance aspects for CCZ building

Aspect	CCZ building
Building handover date	2007/2008
Building services handover date	2007/2008
Performance review during 1st year after handover?	Unknown
Building monitoring	Yes, since 2008 through the building management system (BMS) through Telecontrol in Amersfoort. Scope: - Review failures on components: monthly - Review temperatures and flows: monthly - Additional reviews during holiday periods.
Long term maintenance plan	Not available; under responsibility of CCZ supported by external parties.
Building services maintenance contract	- Yes, contract with services list; reviewed annually following NEN 2767 (good/moderate/poor) (NEN, 2022). - Reports were reviewed: no major deviations. Heating and cooling perform well. Filters are part of regular maintenance according to legal requirements. - Review of comfort/complaints not included in the scope.
Improvement	- There is no improvement plan. - Suggestion by CWD to improve the integrated control of the current systems. With limited budget, this could lead to improvements. CWD has skills to do Energy Performance Assessments, but there is no scope for that in current maintenance contracts.

There is only limited data available on the actual behaviour of users in the building. As initial building design criteria are not available, it is not possible to compare the current use with what was intended in the building design. An analysis was performed by the building's technical manager (appointed by the municipality) on the available fresh air flow per room for the number of people that normally use the space (SCCZ, 2021). This analysis indicates that in general fewer people populate the rooms than the maximum that is allowed when considering air supply requirements. The analysis assumes that 40 m^3 of fresh air is available per person; data on the total simultaneous occupancy of the entire building is not available.

Quality of indoor environment

As explained elsewhere in this chapter, as part of the co-creation process, the users of the building completed a questionnaire, the results of which were discussed with the gbm in a meeting on 1 March 2021 (see Table 10-6 for a summary of users' feedback). Based on review of the building operation system (GBS) and building data, the following conclusions can be drawn on various comfort parameters, such as air quality and thermal comfort.

The **air quality** in a building can be defined by the *fresh air flow per area or per person* and the indoor air quality, based on particles. Of the latter, no data is available in the CCZ building, but for assessing the first parameter the abovementioned analysed by the building's technical manager (SCCZ, 2021) can be used to conclude that the designed fresh airflow per person (40 m^3/h) is higher than the minimum required by the national law standards, but lower than what is advised according to quality criteria for indoor comfort, i.e., 45 m^3/h per person for mixing ventilation (BREEAM Nederland, n.d.). Table 10-4 shows the relation between occupancy, available maximum airflow in the building CCZ and advised values for airflow. The actual maximum capacity is the sum of individual actual population per room as identified in the analysis by the building's technical manager.

Table 10-4. Analysis of available fresh air in the CCZ building

Parameter	Amount	Quantity
Actual maximum population (sum of all rooms)	255	people
Capacity Air handling units	7000	m^3/h
Fresh air per person, with actual maximum occupancy	27.5	m^3/h/person
Design fresh air per person	40	m^3/h/person
Maximum simultaneous occupancy with design air flow	175	people
Proposed fresh air per person	45	m^3/h/person
Maximum simultaneous occupancy with proposed air flow	155	people
Diversity to be applied, according to design air flow	69%	
Diversity to be applied, when advised airflow applied	61%	

It can be assumed that during normal use of building spaces, the full occupancy of all rooms will not be achieved, so that a 100% diversity will not be required. It is, however, relevant to monitor the total number of people in the building, to assure proper air quality for all. This analysis has been done at a high-level and it does not consider the effect of providing fresh air in a space with a low number of people, while many people are present in a different space. At the co-creation meeting on 9 Septemer 2021, the comment was made by the building's technical manager that the "the actual airflow is in many cases significantly lower than the designed value", which calls for further research to understand how this was measured or determined.

In most building spaces, the actual number of people is less than the maximum allowed (to enable fresh airflow per person of 40 m^3/h), but in a few spaces the occupancy exceeds the maximum number of people for sufficient fresh air (0.11 Grote zaal, 0.12 Kleine zaal, 0.07 Foyer, and 1.18 Muziekschool (Ocean). It has been advised to SCCZ to review the air quality of these spaces and provide measures for high occupancies.

Thermal comfort is determined by the air temperature, radiant temperature, draught, humidity, and air speed. Of these parameters, only data on air temperature is available in a limited number of rooms (see Annex 2). Data collection on the other parameters could support the improvement of thermal comfort control in the spaces. The GBS contains measurements for indoor temperatures, which can be assessed for a short period in the past. During the timeframe of this review the data was incidentally monitored, showing that indoor temperatures (in the rooms with temperature sensors) exceeded 25°C (17 June 2021), while the valve for cooling was fully opened at that time (Figure 10-6, see red circle). This indicates that no extra cooling can be delivered by the air handling unit at such moments.

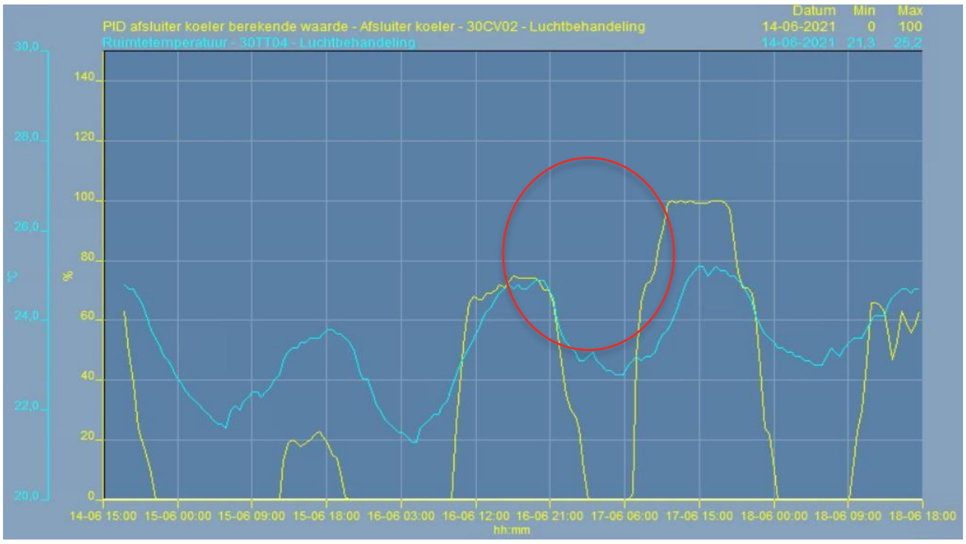


Figure 10-6. Snapshot from the building management system (GBS)

Outdoor climate

As the building was opened in 2007, probably the climate year 1964-1965 was used for its design, implying the following assumptions regarding outdoor temperature: a maximum outdoor temperature of 28°C, and a minimum outdoor temperature of -10°C. Since the building's design and delivery, new standard climate reference years have been introduced to better consider actual outdoor climate conditions in building design: NEN 5060, version 2008 and recently 2018 (NEN, 2021). For instance, in recent years, relatively high average annual temperatures have been measured, with 2014 and 2020 being the warmest years with an annual average of 11.7°C. According to KNMI (the Netherlands Meteorological Institute), the average annual temperature gradually increases, with regular peaks around 12 or even above 13°C up to the year 2050 (measured for KNMI station Eelde, which is closest to Zuidhorn). Figure 10-7 shows the implications: the CCZ is built against average annual temperature levels ranging from 7 to 10°C at maximum, while in the next decades it will face annual temperature averages from at least 10 to over 13°C. Obviously, the increasing outdoor temperatures will have consequences for the thermal comfort inside the building.

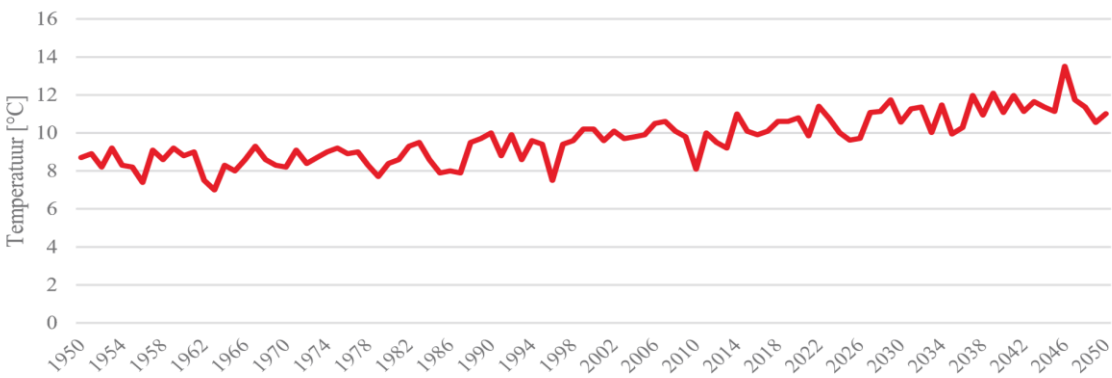


Figure 10-7. Measured annual temperatures at the KNMI weather station in Eelde combined with KNMI scenario temperatures for the location Eelde (KNMI, n.d.)

The building's energy performance

The building CCZ has a registered energy performance label A, which indicates that the building is sustainable. The label is based on the theoretical EPA-U methodology (energy performance advice for utility buildings) (Netherlands Enterprise Agency - RVO, 2017). The building's energy use is registered through gas- and kWh-meters, while the yield from the rooftop photovoltaic panels (PV) is registered in the inverters. The building is not equipped with digital meters that could show a dynamic metering pattern; instead, energy use is registered manually by the building's technical manager (see Figure 10-8).

CCZ has installed 72 solar PV panels on its rooftop in two areas: one area with 18 and another with 54 PV panels. The estimated Watt peak per panel is 250 Wp, or 18,000 Wp in total. For calculating average annual energy production, the Watt peak capacity is multiplied by a factor of 0.9, i.e., 250 Wp x 0.9 = 225 kWh a year per panel or 16,200 kWh for all panels together.

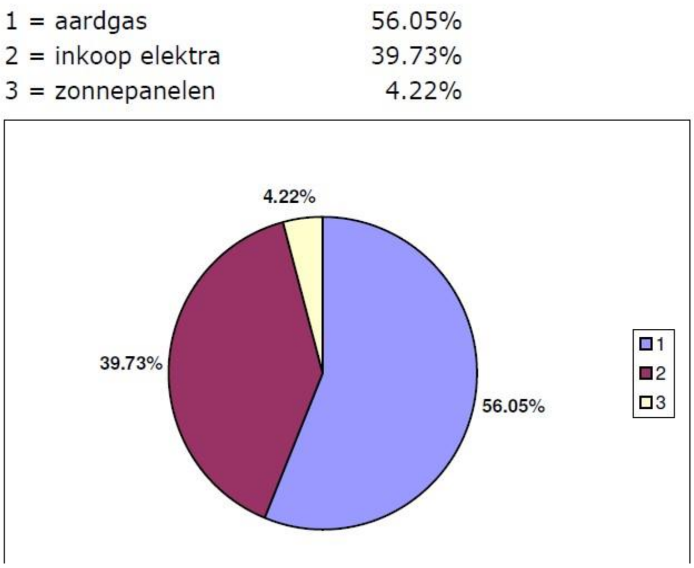


Figure 10-8. Primary energy use CCZ: natural gas (1), purchase electricity (2) and yield from rooftop solar PV (3); data collected by SCCZ's technical manager (7 July 2021); cumulative data during February 2008-June 2021.

Using the new guidelines in the Netherlands for labelling the energy efficiency of buildings (NTA 8800) (EPG, 2021), including the measured energy use of buildings (for really energy neutral buildings, in Dutch: *Werkelijk energieneutraal gebouw* or WENG), the energy performance of CCZ can be determined in kWh/m^2 per year (based on measured kWh and natural gas in combination with the approximated generation of the PV panels, see Table 10-5). As a result, the building is categorised as 'efficient' (in Dutch: 'zuinig'*) in the years 2017-2018 and 'very efficient' (in Dutch: 'zeer zuinig'*) in 2019 and 2020 (whereby the finding for 2020 is probably due to the low electricity use during COVID-19 lockdown restrictions).

Most energy is used from primary energy sources (natural gas and electricity from the grid), while around 10% is generated through the solar PV panels. In this view improvements are possible to increase the share of RES, e.g., by increasing the yields of the solar panels.

Table 10-5. Approximation of CCZ's energy performance

Year	Performance	Compared to WENG*	Primary energy use (approx.)	Percentage sustainable energy (approx.)
[-]	[kWh/m^2 per year]	[Definition]	[kWh/m^2 per year]	[%]
2017	123.07	Zuinig*	111.41	9
2018	112.97	Zuinig*	101.32	10
2019	106.84	Zeer zuinig*	95.19	11
2020	82.09	Zeer zuinig*	70.44	14

**The definitions 'zuinig' and 'zeer zuinig' are based on an average of a mixed-use building. No indicators are calculated as these are partly unknown and not part of the scope.*

The energy use and costs are monitored on an annual basis. Gas use for the boilers is transparent as it is measured and calculated by the utility company. For electricity it is unclear which part is used by the building and what is generated from the photovoltaic panels. The amount calculated in the energy meter shows the use and feed of electricity into the network from the total system (building + PV). Energy cost data for gas is available, though energy cost data for electricity is missing for several years (Figure 10-9). A major reduction is visible in the year 2020 for electrical energy use, which is likely due to the COVID-19 related lockdowns. It is visible that the effect on gas use is limited, showing a likely difference between the users' impact on the energy demand and that of the building itself.

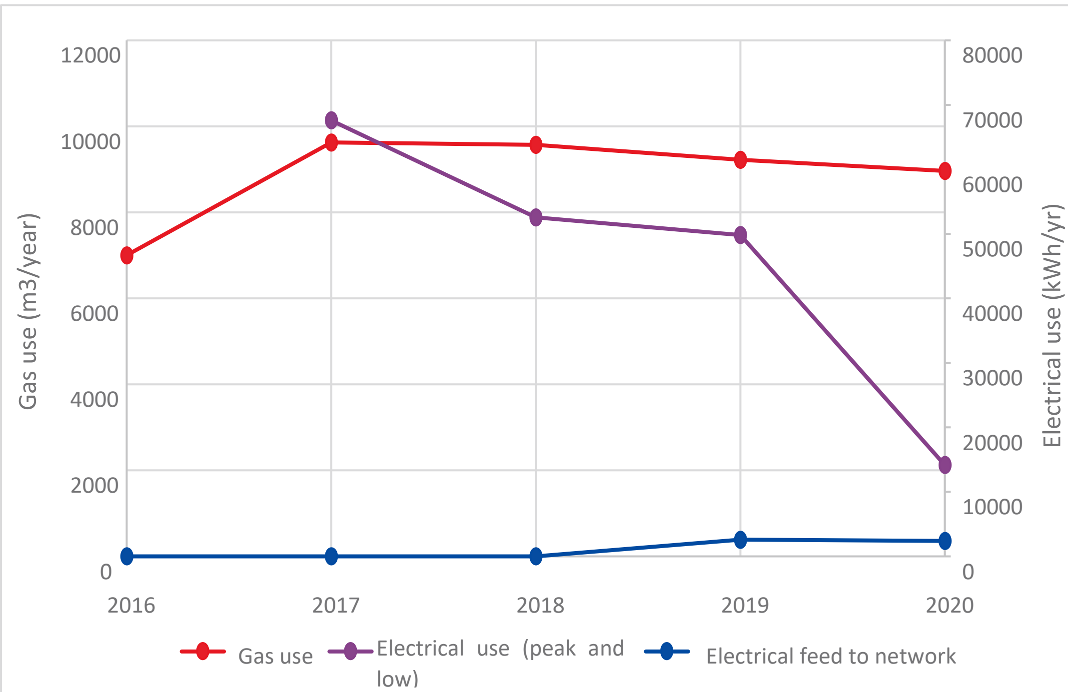


Figure 10-9. Summary of energy use over recent years

Figure 10-10 shows the energy costs data for electricity and gas consumption for 2016-2020. Data for 2017-2018 is representative for electricity and gas costs, although cost data for the electricity network are not available. For the missing years, data has been extrapolated, resulting in an estimate for total energy costs for a period of 5 years. The annual costs for energy amount to approximately 8,000-10,000 Euro or 50,000 Euro in total for 2016-2020. This is a reference number which can support decision making on investments for energy efficiency measures.

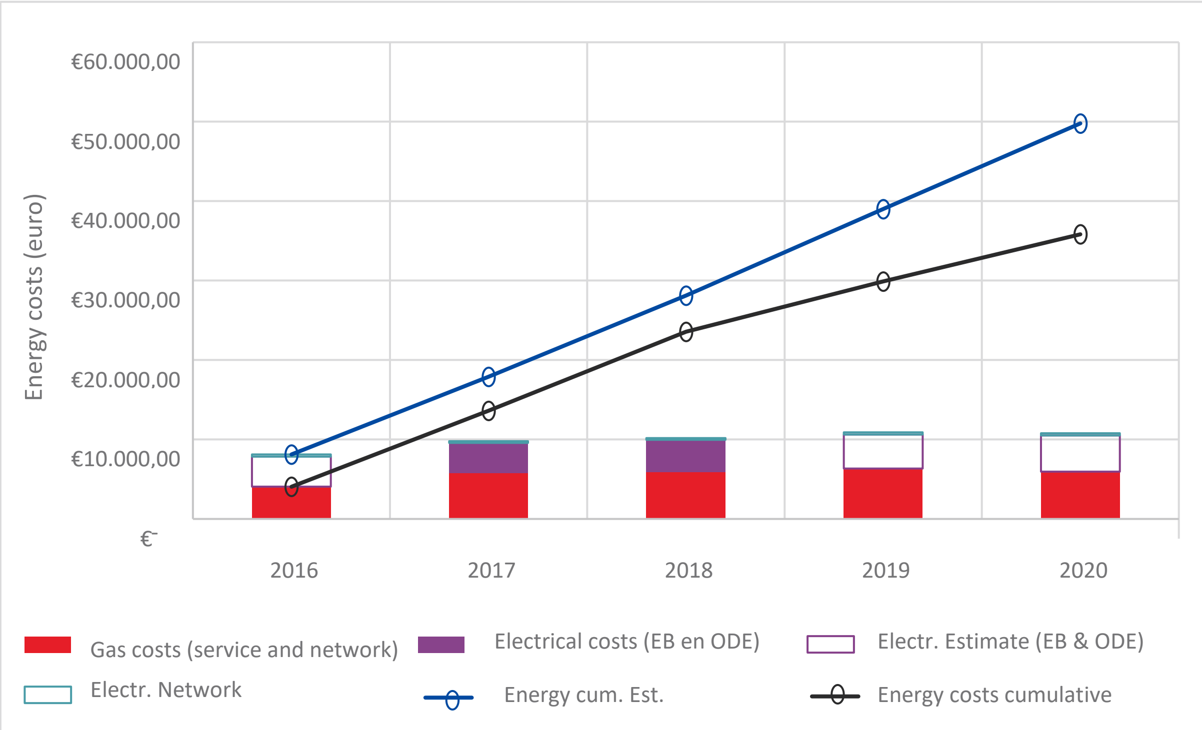


Figure 10-10. Summary of energy cost data (some electrical cost data is missing) over recent years

Conclusion of CCZ energy performance

The technical review done for the building CCZ has been incomplete to the extent that for several parameters no data was available. Annex 3 contains an overview of these data gaps with an indication of how these have influenced the results of this assessment. Nevertheless, from the available data the following can be concluded about the performance of the building:

- The ambition of 50% CO_2 emission reduction by 2030, as stated by the municipality Westerkwartier, is not clearly implemented in the building use and maintenance: none of the users and/or maintenance parties are focusing strongly on enhancing energy performance.
- The indoor quality for comfort is overall in line with the minimum requirements for buildings, but some spaces in the building underperform below that. There is a risk of overheating in the building, which is probably related to outdated assumptions for the outdoor climate.
- The quality of HVAC systems is monitored at the level of individual components, but actual performance of the systems is not. This results in data gaps regarding detailed energy use, thermal comfort in many rooms, actual air flow, PV yields, etc.
- The building skin seems to be of proper quality for the time when it was built, but it will

underperform when aiming for CO_2 emission reduction goals.
- The building owner has limited contact with the end users. Complaints are collected and forwarded to the maintenance party, who review the quality of the systems according to their scope.

10.3 Current situation – roles and organisation of stakeholders

As a first step in co-creation process for energy improvement and scope for integrated energy systems (IES), three questionnaires were prepared, in January 2021, for, respectively, the users of the building, its owner and operator, and the company contracted for maintenance of the building's equipment. The questions were selected from the tool *NTA 8800, developed by NEN* (2021)*, as appropriate for and targeted at the type of user. Users of the building, the owner (municipality) and operator (SCCZ) were asked about, i.a.:*

- *the building management, i.e., whether* a rental agreement and/or service level agreement (SLA) exists to establish facility services and who is responsible for the facility management of the building.
- What the internal communication looks like in terms of quality of services, indoor quality, energy use behaviour, etc.
- How complaints are handled and what arrangements have been made in terms of health and safety policy.
- Use of the building and its (energy) installations.
- Awareness among users of energy saving measures.
- How complaints are handled.
- How they can operate the energy equipment, e.g., using blinds and whether they experience noise and draught.

The maintenance company was asked about, i.a.:

- The organisation of the building maintenance system and who has access to and responsibility for it.
- Measurement and registry of energy use in the building.
- Whether the building has an environmental and energy policy in place (e.g., energy label, environmental action plan, compliance with ISO 14001 norms).
- Energy and building performance data management and building operation system.
- Internal communication, with users, operator and building owner.
- The type of maintenance contract, e.g., whether it contains performance indicators.
- Status of energy installation components, including whether indoor air quality is checked and managed.

On 1 March 2021, a video call was organised to discuss the completed questionnaires with users and SCCZ. As the questionnaires had a different information focus, it was decided to first have separate meetings with the users (and the board) and the maintenance company CroonWolter&Dros (the latter took place on 9 April 2021; the municipality declined the invitation to complete the questionnaire, referring to SCCZ and the maintenance company as more suitable respondents). After these meetings, and after completing the technical analysis of the building (see above in this chapter), a broad stakeholder meeting was held (on 9 September 2021), including users, SCCZ, maintenance company and the Municipality as the building owner.

At the meeting on 1 March 2021, stakeholders stressed the need for an active municipality involvement in this case study. In their view, from the start in 2007, there have been problems with the building's energy performance and, particularly, the indoor air quality, which frequently results in health problems (e.g., headaches) and users having to leave their offices early. Users suggested that the capacity of the equipment for energy and air quality might be insufficient for the energy and comfort needs of the building. Users explained that these problems have been communicated to the Municipality (as owner), but this has not resulted in improvements, despite the checking of the equipment by the maintenance company CroonWolter&Dros.

The following detailed points emerged from the discussion of the questionnaire responses by users and SCCZ:

- SCCZ points out to users how they can optimise their behaviour to save energy, such as keeping the doors closed. However, users consider that unworkable when it is too hot inside and there is too little oxygen indoor. Generally, users consider the indoor climate system insufficient, especially in the offices where people have 8-hour working days, given that the rental contracts contain a good indoor air quality as a condition. Users claim that the measured CO2 level indoor is 1400 ppm, which should be below 800 ppm in a well-ventilated space. The Dutch health service organisation RIVM sets an upper limit of 1200 ppm CO2 in an indoor environment (Dusseldorp & Bruggen, 2007). Consequently, users open the door to let fresh air in. There is a general feeling among stakeholders (users and building management) that CCZ is a complex building to heat and cool.
- It is unclear for users how many people exactly (can) work in the building in the different spaces. At the library and the music school, people walk in and out, so the occupancy of the space varies, while in the offices on the first floor the occupancy is higher per m2 than on the ground floor. Users are unaware whether the rental agreement contains a clause on the maximum number of people per room. SCCZ indicates that occupancy of office space should be in line with the standards set by law.
- SCCZ indicates that in 2020 an adjustment has been made in terms of air ventilation so that air no longer circulates, and fresh air is drawn in from outside.
- SCCZ does not have a budget to invest in energy system improvements; investments are to be commissioned by the municipality as the owner. Only sustainable energy measurements with a payback time of less than five years are usually undertaken, as such measurements are mandatory by Dutch environmental law.
- There is dissatisfaction among users about the handling of complaints. These are reported to SCCZ, which passes them on to the municipality (as owner), after which the maintenance firm CroonWolter&Dros is called in to check the equipment. Usually, no problems with the operation of the equipment are found, so that the case is considered solved and closed. However, during these checks the overall energy performance of the building is usually not checked, neither does a registry exist to keep track of complaints and how these are dealt with. SCCZ does not have the option of asking for a different maintenance contractor, nor is it known what agreements the Municipality has with CroonWolter&Dros. As SCZZ is not the building owner and does not pay rent to the municipality, it does not have a real 'means of coercion' either.
- Users explain that in the first years of the building's existence, measuring equipment was installed, to 'fine tune' the equipment, but this has not been common practice since then. Users would like to see a more structured and frequent measurement of the energy performance and the indoor quality of the building.
- SCCZ pays the energy bill for which it receives a subsidy/compensation from the Municipality.

Hence, there is no direct financial incentive to reduce energy consumption at SCCZ. Moreover, the subsidy is provided by a different municipality department than the department that is responsible for the municipality's building stock and investments therein.

Table 10-6 presents a summary of the findings, sorted per topic (excluding functional use of building facilities as the review focuses only on energy use and system performance).

Table 10-6. Indoor environment quality of CCZ as perceived by the users

Topic	This project
Effectiveness / speed of response to requests for changes	Users explain that complaints are registered, followed by a check by the maintenance company on site who claims to have solved issues. However, users see not improvement in building performance. Actions by the municipality are slow.
Air quality in summer	Some drought experienced from supply diffusers, no major issue.
Air quality in winter	Users complain about dry air.
Light: artificial; glare from light; natural light; glare from sun and sky; overall	Solar/sky glare control not available in all locations. Artificial lighting works as expected.
Temperature in summer	High perceived temperatures (towards extreme levels) in the summer on the first floor.
Temperature in winter	No information
Noise: from users; other; from outside; overall	No information
Control over cooling; heating; lighting; noise; ventilation;	Users report that temperature is difficult (not) to control on both floors; it is not possible to open windows. Users claim to be aware of energy-wise control, but it is unclear for them how to operate it.
Productivity (perceived)	No information
Personal safety in building an its vicinity	No information
Health (perceived)	There are no agreements on safety (as in law on working conditions).

On 9 April 2021 a meeting was held by JIN and ARUP with the maintenance company CroonWolter&Dros (CWD, in person of Robert Toren) with the objective of obtaining insights on the technical operation of the energy system in the building of CCZ and data for conducting a technical analysis (by ARUP). CWD is responsible for the maintenance of the heating and cooling equipment of CCZ; it does not maintain the solar panels on the building's rooftop. The following observations were discussed:

- The building was built in 2007-2008 and since then there has been a maintenance contract with a list of components to be checked annually. Checking the reports reveals no major deviations between required and observed performance; generally, the equipment for heating and cooling operates well. The maintenance contract also contains preventive checking of materials such as filters, as mandated by law. The GBS can be managed remotely.
- Installations are not checked according to qualification as set by NEN 2767 ('good', 'mediocre', 'bad') (NEN, 2022), but temperature deviations are checked as well as air flow rates.
- The multi-year maintenance plan is managed by the SCCZ, for which it hires third parties. CWD is not part of that process.

- CWD staff are aware, from informal conversations with users, that the indoor climate feels stuffy and warm. These complaints, however, are not formally communicated with CWD, as this is not part of the maintenance contract between CWD and the municipality. As a result, while equipment in the building operates normally, this does not necessarily lead to a satisfactory indoor climate. Possibly, low-budget improvements could be made through a better alignment of the existing equipment, so that their overall performance improves.

Figure 10-11 gives an overview of the stakeholders of CCZ and how they are connected; Table 10-7 provides further details on stakeholder interlinkages.

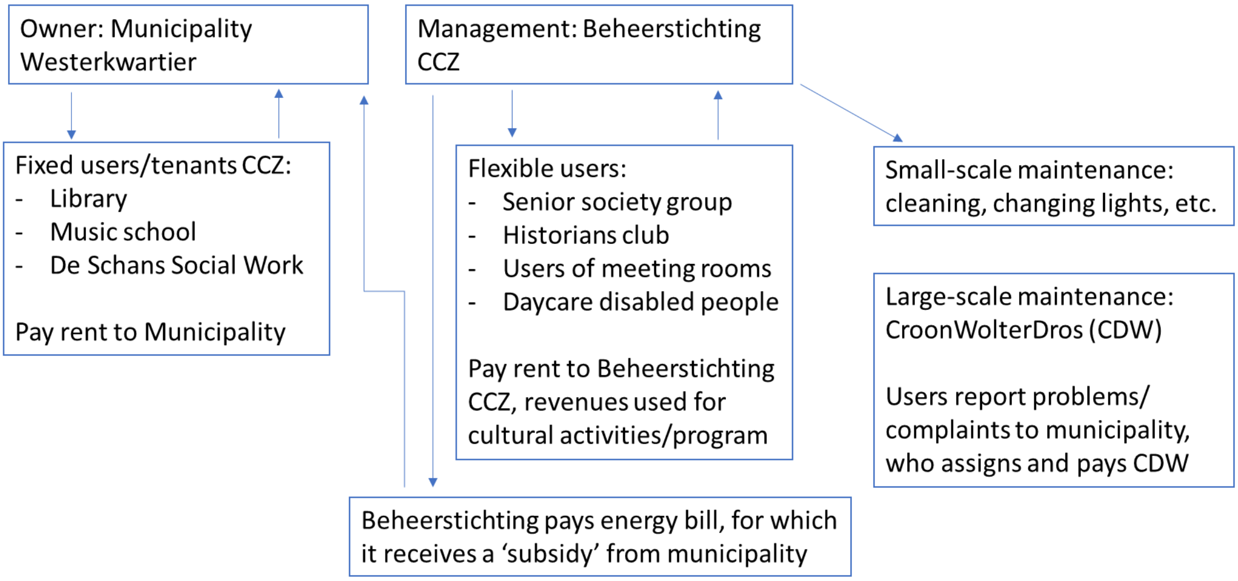


Figure 10-11. Organisation profile CCZ

Table 10-7. Building information: ownership and relations stakeholders

Entity	Organisation	Responsibilities	Notes
Building Owner	Municipality Westerkwartier	Building maintenance Rental contract with SCCZ	Primary contact for building tenant if issues arise
Building Users	Bibliotheek Zuidhorn (Library) Muziekschool Zuidhorn (music school) Tintengroep (De Schans social work)	As per the rental contract	
Building tenant	Stichting Cultureel Centrum Zuidhorn (management board SCCZ)	Daily maintenance Complaints registration Exploitation of meeting rooms	All building users are related to the SCCZ.
Building services contractor; mechanical	CroonWolter&Dros	Annual maintenance of building services	No direct contact with building users/tenant. Contracted by owner

From the stakeholder consultation (users of the building, SCCZ, and CWD) the following can be concluded:

- Energy performance of the building is not the main concern of the users, which are the health issues due to the poor indoor climate. When users call for improvements, it is aimed at improving the air quality in several spaces of the building.
- Complaints about the indoor environment are communicated with the owner, the Municipality, who informs the maintenance company CWD. As per their maintenance contract, the company checks the operation of the equipment, not its overall performance in terms of energy and indoor air quality.
- SCCZ does not have a budget to invest in new equipment and has little leverage power towards the owner as the board is exempted from rents.
- As a result, the overall sentiment is that strong improvements are required and possible, but the current organisational structure does not incentivise this.

10.4 IES options for case study building CCZ

Technical options for IES at CCZ

In line with the methods used within the RES4Build framework the case study was analysed to define several measures for improvement. The measures relate to the innovative components from the RES4Build framework, and they relate to the methodology of the proposed co-design process. The measures are listed in Annex 4 and ranked in terms of priority (short, medium, long term), typology (architectural, HVAC, etc.), and necessity (minimum, added value).

Among the solutions for implementation in the longer term, an IES solution has been recommended for improvement of the HVAC system. An important rationale for this recommendation is the building's likely disconnection from the natural gas network in the medium term, so that alternative energy options need to be considered. The recommended IES for CCZ is to replace the boiler and chiller (when these have reached the end of their lifetime) with an innovative heat pump, which could be, by that time, the magnetocaloric heat pump developed by RES4Build. The heat pump would then be connected to a heat source, such as a closed-loop thermal storage system in the adjacent park. The system can be equipped with the building thermal energy storage (BTES) controller to optimise performance and thus yield of the solar PV panels at the rooftop. Within the current situation at CCZ, most improvements, including in comfort levels, can be obtained from individual short-term measurements, but the proposed IES enables the owner (the municipality) to align the energy performance of the building CCZ with its own climate and sustainability ambitions.

10.5 Co-creation for IES and energy system improvement in CCZ

On 9 September 2021, the case study findings were presented to the stakeholders (users, SCCZ, CWD, and the municipality Westerkwartier). At the meeting, a summary was provided of the issues as communicated by the users, mainly related to the complaints about insufficient indoor climate comfort in the building, causing dry air and consequently headaches. The RES4Build team introduced a range of solutions ranging from improvements for consideration in the short and an IES for implementation in the longer term, also to be in line with the Municipality's climate and sustainability ambitions (as explained above; see also Annex 4).

From the co-creation meeting, it appears that there is a lack of cooperation between the stakeholders involved, so that problems are not tackled integrally, but separately. There are several examples of this:

- In 2021, measurements were carried out in parts of the building (requested by one user for the office area that they rent) to analyse what could be the source of the health complaints. These measurements are done by an external measuring company, commissioned by the Municipality, while SCCZ, the day-to-day management board, was not aware of this activity. By focusing only on a part of the indoor space, an overall picture of indoor quality has not been obtained. Moreover, the commissioned measurements only focus on indoor CO_2 levels, which is not an indicator of inflow of fresh air. SCCZ's own measurements (SCCZ, 2021) show that fresh air inflow is insufficient. These findings are to be discussed by the board and could lead to the advice of conducting air flow measurements within the entire building.
- As explained above, the maintenance is focussed on installation components and not on building performance.
- The current use of the building is different from what was anticipated at the time of construction, but responsibilities and maintenance have not been changed. The existing situation is therefore not in line with current user needs.
- The Municipality has formulated sustainability goals, but measures to achieve these are not implemented in the building of CCZ. The main driver for the municipality to undertake actions at CCZ seems to be to reduce complaints about the indoor air quality, and not energy saving.

At the same time, the stakeholders elaborated on suggestions for energy improvement (in addition to the solutions suggested by the RES4Build partners, in Annex 4), such as:

- Collaboration with adjacent buildings, such as Holt and Waard, to formulate a joint energy strategy, which could lead to a joint investment in a heat pump for common use.
- Introducing a change-over-system in the floor heating in the joint areas of the building, so that both heating and cooling can be offered. This system was not installed in the building construction but could be considered for future energy performance improvements.

Table 10.8 summarises, based on the discussion in this section, opportunities and barriers for IES in the case study CCZ.

Table 10-8. barriers and opportunities for IES in CCZ

	Opportunities	*Barriers*
Technical	There are issues with the indoor ventilation quality; improving that could be done as part of an integrated sustainability improvement of the building. According to Dutch energy labelling standards, the building is categorised as 'efficient'.	The CCZ is built against average annual temperature levels ranging from 7 to 10°C at maximum, while in the next decades it will face annual temperature averages from at least 10 to over 13°C. Increasing outdoor temperatures will have consequences for the thermal comfort inside the building.
Policy	Municipality of Westerkwartier aims at halving its CO_2 emissions by 2030.	No specific information though on how this ambition is planned to be achieved for the building CCZ.
Economic		IES investment costs are relatively high; potential energy cost savings are insufficiently valued by Municipality to compare against costs of IES. Therefore, IES is considered long-term solutions.
Social / organisational	Strong desire among users to improve indoor comfort levels CCZ, which could be an opportunity for a wider sustainability improvement.	Building performance is not monitored; only individual components are maintained. As per the organisation structure (ownership, management, users, maintenance) there are insufficient incentives to accelerate energy saving measures.

Recommendations

With a view to the technical review and the stakeholder consultations, the following recommendations from the RES4Build case study have been made:

- The Municipality of Westerkwartier will soon present a Multi-Year Maintenance Plan (MJOP) for buildings in the municipality. This plan can be examined in terms of whether it leads to improvements with respect to the energy consumption and indoor climate quality of its buildings, including CCZ.
- Technically, it seems that most health complaints stem from an inadequately functioning ventilation system; this could be readjusted, following a building-wide measurement, including air flow measurements.
- Provide a good, systematic complaints register that is kept by SCCZ, whereby the handling of complaints is supervised.
- Review the organization with respect to cooperation between stakeholders (owner, management foundation and users) to prevent insularity and to enable an integral approach to problems.

11. Case study: MartiniPlaza Groningen, event hall

11.1 Introduction

As explained in former chapter, for the Dutch case studies in this report, three buildings have been selected, each with a different ownership structure, functionality and thus user profile. As a commercial building case study, the MartiniPlaza event centre, based in the city of Groningen, has been selected. MartiniPlaza is among the top-five of multi-purpose event centres in the Netherlands.[5]

The aim of the case study is to explore sustainable energy options for the building complex, including IES. For that, regular meetings have been held with the stakeholders, including MartiniPlaza's executive director and manager of logistics and the Municipality of Groningen as full shareholder, to assess the complex' status, technological operation, and services provided, as well as how the MartiniPlaza can transition from the present strong dependence on natural gas consumption towards a low- or zero-emission energy system. With respect to the latter, the case study has analysed how the 'RES4Build toolkit' can support this. Along this work, MartiniPlaza's management communicated an urgency to take short-term measures in the building to quickly reduce natural gas consumption and therefore energy costs. The case study communication with stakeholders also resulted in concrete short-term energy system improvements. In addition, the case study has focussed on the ventilation, heating/cooling, and water service aspects. Performance of other systems (e.g., wastewater, rainwater, sanitary) is not included in the scope of this study.

Figure 11-1. MartiniPlaza main entrance

MartiniPlaza is an independent multipurpose event building. The building consists of spaces for theatre, fair events, dance events, a restaurant, and professional basketball purposes. The building

[5] Location: MartiniPlaza, Leonard Springerlaan 2, 9727 KB Groningen, the Netherlands.

was first commissioned in 1969, after which multiple extensions and refurbishments have taken place. The building complex is located on a larger plot, the Martini Trade Park, which is owned by the municipality (see Figure 11-2). The case study has considered potential synergies between MartiniPlaza and the Martini Trade Park office/public buildings considering the municipality's vision on sustainable development of the Martini Trade Park area, of the aim for the trade park to become fully independent from natural gas by the year 2030. To achieve this goal a fully electronically driven energy generation and distribution grid could be considered, such as an Aquifer Thermal Energy Storage (ATES).

Figure 11-2. Top view of MartiniPlaza (south) and Martini Trade Park (north), total area in red

11.2 Current situation – status of building and present energy technology

The building characteristics

MartiniPlaza is a complex consisting of multiple areas (Figure 11-3), including exposition halls, a restaurant, a basketball hall, and a theatre. These spaces were built in 1969 and have been renovated since then during different time periods. Due to the diversity of the building, it is a challenge to find solutions that are satisfactory for each area and for the entire building complex. Regarding the latter, the following common characteristics can be identified:

- A relatively poor insulation value of the building skin,
- An assumed poor air tightness,
- The roof structures are based on a steel spaceframe system, with a relatively low capacity; and
- A central heating plant based on Combined Heat and Power (CHP) and gas fired boilers,

resulting in relatively high energy bills.

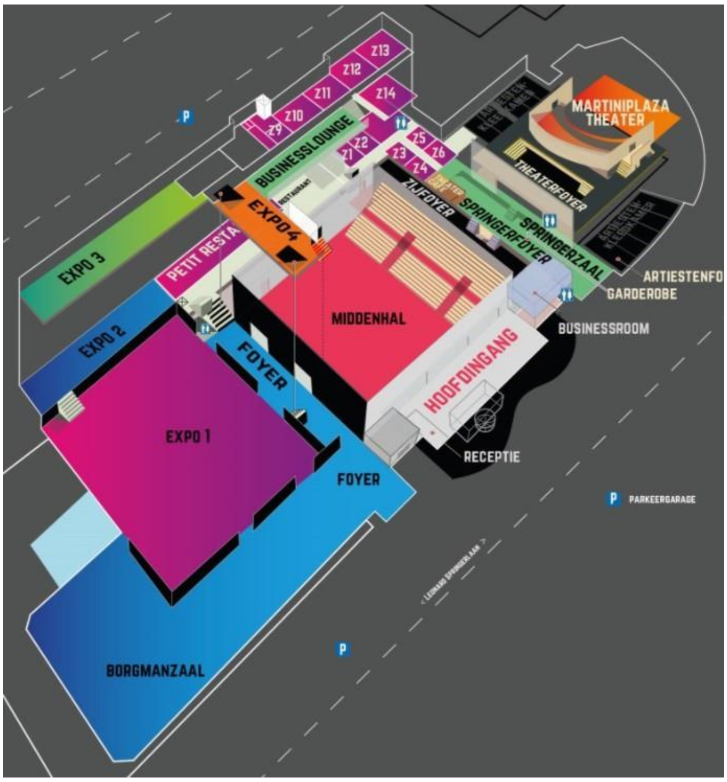


Figure 11-3. Different areas in the MartiniPlaza building

The individual building spaces are further characterised below.

MartiniPlaza theatre & Theatre Foyer

The theatre with 1500 seats is situated within a larger area of the MartiniPlaza building. The hall has a steel-structured roof, covered by decorative cloth. Fresh air is provided through a plenum underneath the seats, where small openings in the steps provide the distribution. The theatre's foyer has a warm appearance, with warm colours and suitable décor, but during colder seasons the climate system does not perform as desired so that the place can be experienced as cold/chilly. Local heating can be considered for improving the thermal comfort.

Figure 11-4. Theatre and Foyer with the steel frame

Centre Hall & Expo 1

The centre hall is where Groningen's basketball team Donar has its home matches. The hall has been renovated to meet the requirements for professional basketball, with removable structures in case of other events. The Expo 1 hall can be used for dance events and fairs and will probably be demolished (and replaced by a new building) around 2030. Its full height is approximately 18 meters which is needed for, e.g., dance events, during approximately 20% of the time. Hence, most of the time a lower height could be acceptable for, e.g., fairs. The high ceiling requires a significant amount of air and energy to achieve comfort on the ground. In meetings with MartiniPlaza's management a movable ceiling has been proposed, to be placed at the desired hight for each event. A lowered ceiling reduces energy needs as a smaller volume of the hall needs to be heated.

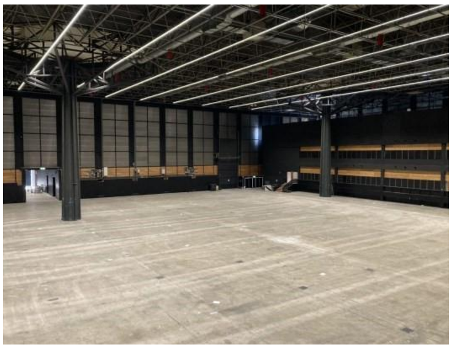



Figure 11-5. Centre Hall (left, for basketball) and Expo 1 hall (right)

The building's energy system and performance

This section describes the individual components of the MartiniPlaza's system for heating, ventilation, and air-conditioning (HVAC). The **heating** for the building is provided by a CHP system, which was installed in the 1980s (see Figure 11-6). It provides for 300 kW baseload heating. The system is on lease, which includes a performance check and payment based on the system's hours of service. In addition, eight high-efficiency gas boilers are installed for meeting peaks in the building's heat demand. From the boiler area the heat is distributed at 60 °C to the several areas of the complex, via air handling units, radiators and the newly placed nivolairs in the Borgmanzaal. Presently, the use of heat per area is measured individually; smart metering is part of the sustainable maintenance plan to be implemented during the next years.

Figure 11-6. Combined Heat and Power system enclosed in sound absorbing cabinet

Expo 1 has air handling units placed on its rooftop containing a heat recovery system and heating and cooling coils. Figure 11-7 shows how the air supply is installed underneath the ceiling; improvements to lower the supply, in combination with the lowering of the ceiling, are currently in development by the maintenance team of MartiniPlaza.

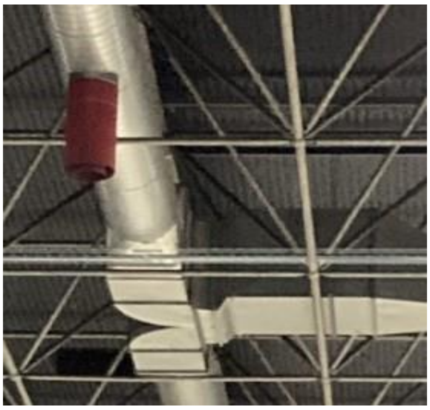


Figure 11-7. Air distribution in Expo1, in red the air supply of Expo 1 can be seen

To provide warm water to, for instance, the dressing rooms, with showers, next to the basketball hall, water is heated by boilers and circulated through the complex. Potentially, in the future, the hot water system can be linked to heat pumps and solar heat storage buffers.

Building performance

The municipality of Groningen has the **ambition** to become energy neutral by the year 2035 (Gemeente Groningen, 2018). In addition, the municipality explores ways to disconnect several districts in the city from the natural gas grid by 2030 for certain parts of the city, including the location of the Martini Trade Park. The longer-term vision for sustainable energy at the MartiniPlaza will have to consider this ambition. While the above ambition is not immediately relevant in the short term, MartiniPlaza has a very strong incentive to reduce the use of electricity and in particular natural gas as the energy prices have risen extremely strongly (approximately by 600%) between the Fall of 2021 and June 2022.

Energy Label

The MartiniPlaza has a registered energy performance label of C with an energy index of 2.29, indicating that the building is not energy efficient. The label is based on the theoretical EPA-U methodology (energy performance utilities) (RVO, 2020). It is mentioned though that this label was registered before the solar PV panels were installed, so that the actual energy performance is better. Yet the building's energy performance can be improved further, such as by taking short-term measures to reduce energy use and longer-term actions to shift towards RES for the HVAC system.

11.3 Current situation – roles and organisation of stakeholders

The building is owned MartiniPlaza B.V. (Ltd.) with the Municipality of Groningen being the only shareholder. MartiniPlaza has different teams for maintenance of the building and management of the events hosted at the complex. The two main tenants are professional basketball club Donar (main hall) and Van der Ende theatre productions (theatre hall).

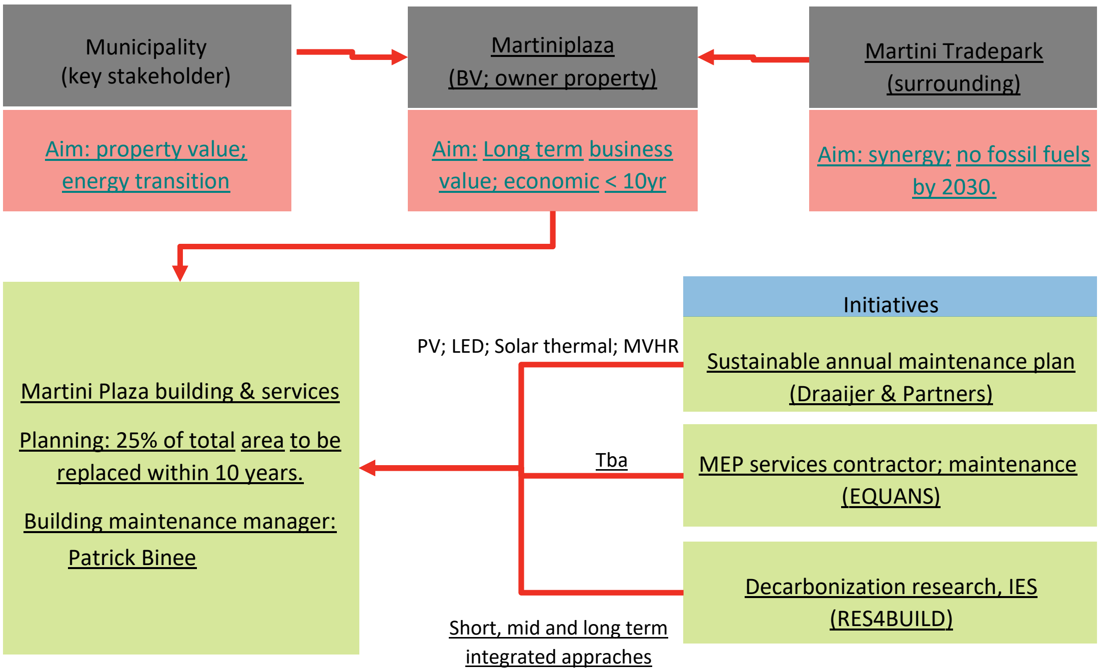


Figure 11-8. Overview of and connection between MartiniPlaza stakeholders

On 16 November 2021 a detailed discussion was held between the MartiniPlaza management and the RES4Build partners JIN and ARUP. This meeting was a continuation of three previous discussions:

- 9 June 2021: Consultation municipality coordinator MartiniPlaza and Martini Trade Park and JIN about case study research set up under RES4Build. Conclusion: the focus will be on MartiniPlaza with consideration, where feasible, of interlinkages with Martini Trade Park, considering the municipality's vision development for the property and the sustainability objective.
- 21 September 2021: follow-up meeting with the Municipality of Groningen and JIN to work out case study set up in further detail (discussing JIN-ARUP's case study proposal) and prepare for meeting with MartiniPlaza CEO.
- 26 October 2021: Introduction of case study with MartiniPlaza CEO and JIN. Conclusion: MartiniPlaza is interested in partaking in the case study; preparation of meeting with MartiniPlaza's Operations manager and Building and Technology coordinator.

On 16 November 2021, the MartiniPlaza stakeholders expressed their interest in the techniques being developed within RES4Build, including the integration of energy solutions. For example, MartiniPlaza has many solar PV panels on its roof and a series of solar collectors. However, most of the electricity generation through solar PV takes place in the summer months, when the MartiniPlaza has its lowest energy demand.

For the period 2021-2030, a new maintenance plan has been prepared with maintenance costs estimated at €10 million. With this, the building will be maintained in combination with sustainable energy improvements. For example, LED lighting is used, and 1500 solar PV panels have been placed on the roof.[6] However, these are relatively small steps and there is no comprehensive plan yet for sustainable energy consumption in the MartiniPlaza. As a result, major investments in sustainable energy are not being made; there is a possibility that two halls (appr. 25% of the total complex) will be dismantled and rebuilt in ten years' time.

With respect to CO_2 emissions, neither MartiniPlaza nor the Municipality of Groningen (as sole shareholder) have formulated a target for the complex. However, a vision is being developed by the Municipality for the area surrounding Martini Plaza, i.e., the Stadspark and the Martini Trade Park, which includes the pillar of 'Sustainability'. MartiniPlaza has had exploratory talks with parties at the Martini Trade Park about mutual energy exchange, but those talks are still in an early phase. For MartiniPlaza sustainability is a factor of interest. Firstly, it helps in terms of profiling the complex towards customers. Secondly, energy savings are welcome to save energy costs. Currently, the building has a building management system that keeps the temperature at a desired level and switches off the heating when possible.

The case study RES4Build supports MartiniPlaza to transition the complex towards an energy neutral future. As far as vision development is concerned, the development of the MartiniPlaza complex itself as well as the development of Martini Plaza in conjunction with the development of the Martini Trade Park have been considered. This has been done via two workstreams:

1. Contribute to *long-term strategy*, aimed at sustainability in the MartiniPlaza in the broad sense: energy, comfort, water, social, area development.
2. Sustainability improvements in the *short term* (between now and ten years), aimed at translating the requirements of operational security and economic interest into sustainability goals. The result of this work stream could be the identification of sustainable energy solutions that could perhaps be applied as a pilot in MartiniPlaza.

11.4 IES options for case study MartiniPlaza

In line with the objectives of RES4BUILD, the case study considered how the energy performance of the building complex could be improved with help of innovative technical components, such as those developed within the project. Of these, the innovative **multi source heatpump** with its optimised design of the vapour compression with low-GWP refrigerant[7] could, in principle, be applicable in the MartiniPlaza, but conclusions on its feasibility for the building can only be drawn after the first trial version shows improved efficiencies. The results of the ongoing studies on the technology in RES4Build will be shared with the MartiniPlaza management when available within RES4Build.

Moreover, given that MartiniPlaza is located at the wider office building area of the Martini Trade Park, RES4Build's **Borehole Thermal Energy System** (BTES, see Figure 11-9) could be an option for developing a small energy network for the heating and cooling at the Martini Trade Park (for MartiniPlaza and its surroundings). BTES or ATES (based on aquifer storing) could optimise energy

[6] The PV generation setup in total consist of 1800 PV panels. The total energy generation per year is approximately = 375.000 x 0.9 = 405 MWh per year (415 MWh according to the website www.duurzaamgebouwd.nl).

[7] Refrigerants with a low global warming potential (GWP).

flows in the building complex considering the occurrence of large imbalances between the warm and cold wells. Currently, no ATES systems are installed nearby MartiniPlaza, according to the Dutch ATES scanning tool (WKO tool) (RVO, n.d.).

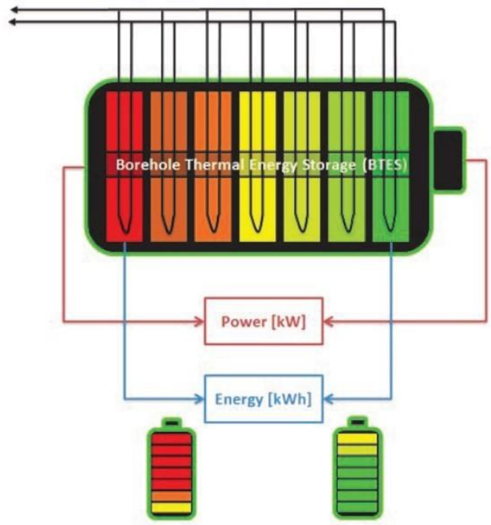


Figure 11-9. Schematic overview of BTES to store heat comparable to batteries

To optimise the use of individual energy system components, such as the ones described above, the **simulation platform**, as being developed by RES4BUILD, can support the MartiniPlaza to obtain a better insight on its energy use during certain events. The tool would be helpful to develop and predict the building's energy demand. With the use of a few input factors the tool's 'greybox model' can calculate and optimise these energy demand profiles. The tool uses input factors which are known by MartiniPlaza, such as the number of people attending an event and the building properties such as the Rc-values of the façade. For MartiniPlaza a test case has been performed by setting up a model, together with RES4BUILD partner VITO, including the following properties:

- Thermal zones: RC values of the façade and the U-values of the windows,
- Ventilation: Air changes per hour and the heat recovery efficiency,
- Heating and cooling system: heat pump properties and domestic hot water (DHW) values, and
- User behaviour: internal gains (persons present during events).

With these properties, the model can simulate current and further HVAC system scenarios for the building. However, as MartiniPlaza is a diverse and therefore complex building, the model has been first run for one area, the Expo 1 hall. With that, the impact of lowering the ceiling could be assessed. When the energy demand profile of the area is known, the model can simulate towards an optimal situation, such as cost minimisation or comfort maximation or a combination of both. With the thus simulated profile the actual energy profile can be altered to an optimised energy profile compared to the current controls, which still meets the comfort criteria (see Figure 11-10).

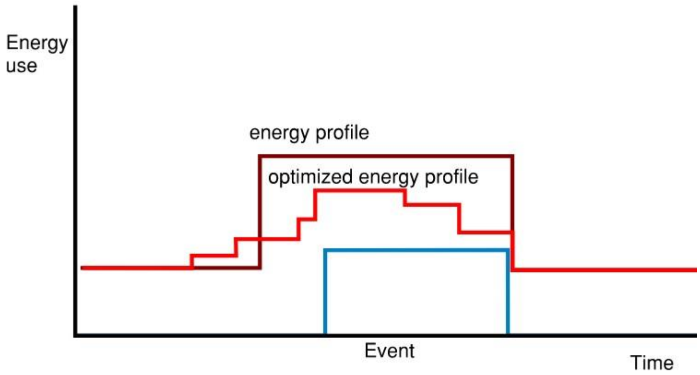


Figure 11-10. Schematic graph of the optimised energy profile compared to a standardised profile

The tool Building Energy Management System (BEMS) uses building data in combination with modelling and forecasts to optimise the performance of a building's energy systems, including the components explained above. Considering the different installations in MartiniPlaza, BEMS could thus considerably contribute to reduction of energy use and costs. Figure 11-11 shows a potential BEMS set up for the MartiniPlaza; encircled in green (right hand side) are the components which are already in use at the MartiniPlaza, while the red circle shows the components that could potentially be implemented in the building towards a smart energy management system.

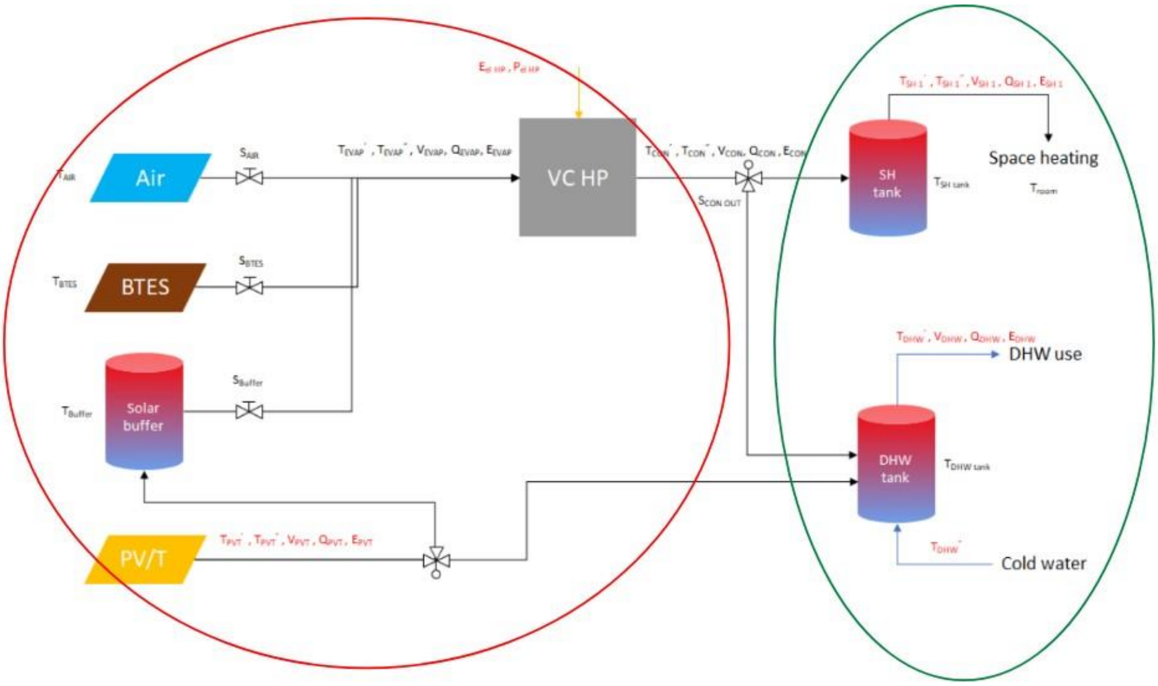


Figure 11-11. Schematic piping and instrumentation diagram of the systems that can be integrated into BEMS

Table 11-1 shows an overview of opportunities and barriers for applying IES at the MartiniPlaza complex (and its surroundings).

Table 11-1. Overview of barriers and opportunities for IES at the MartiniPlaza.

	Opportunities	*Barriers*
Technical	- MartiniPlaza is multifunctional building with different energy needs at different moments, which makes the building suitable for optimisation of energy supply and demand through BEMS. - Potentially close connection with adjacent business park for further exchange of energy.	Presently, the MartiniPlaza has a poor insulation performance. IES would need to be preceded by energy saving, insulation measures.
Policy	Municipality of Groningen is in process of vision development for a sustainable future for the MartiniPlaza and adjacent buildings, which potentially creates space for IES investments in the future. Among the adjacent buildings are office buildings which together form the Martini Trade Park. These buildings are mandatory to obtain an energy label C, at the risk of being no longer eligible as office building. This put additional policy pressure on them to adopt energy saving measures, possible in cooperation with the MartiniPlaza.	It is yet unclear what the future situation for heat supply for the district will look like. According to the municipality's roadmap for 2035, the district will be served through a district heating system, but technical, economic, and organisational details are unknown yet.
Economic	Due to accelerated increase in energy price, there is a stronger incentive among MartiniPlaza management to act and save energy use and costs	As part of the building (i.e. the Expo hall) may be replaced within about ten years, investments must have a pay-back time of less than ten years. This can be problematic for innovative and relatively new IES solutions.
Social/ organisational	The MartiniPlaza management turned out to be very receptive to recommendations by the RES4Build partners, to realise energy saving for lower energy costs	As it is not yet clear what the Municipality vision looks like for a sustainable MartiniPlaza and Martini Trade Park district, it is unclear who will have to take the first steps and responsibility for wider IES application.

11.5 Co-creation for IES and energy system improvement in MartiniPlaza

The above technical assessment and discussion of potential IES options has been extensively discussed with MartiniPlaza stakeholders in a co-creation process throughout the case study analysis. In the case of MartiniPlaza, regular meetings were held with the building owner (represented by the MartiniPlaza CEO), the main shareholder (the Municipality of Groningen), the maintenance company, and MartiniPlaza's Co-ordinator Building & Technology. These consultations resulted in an important lesson that considering stakeholders' knowledge and preferences, as well as concerns, makes it more likely that the eventually chosen energy solution is both technically of high quality, but also considers existing processes and concerns, e.g., the long-term maintenance plan, existing contracts with maintenance parties and sustainability visions for the building and its environment (e.g., interaction MartiniPlaza and Martini Trade Park).

For example, co-creation sessions between the Coordinator Building & Technology of MartiniPlaza and RES4BUILD partners Arup and JIN, several solutions were suggested for 'quick wins', to reduce energy consumption in the short term. Few of them were implemented (or started) shortly thereafter:

- Introducing a charging basis for tenants split between basic rent and energy costs, to engage tenants in the ambitions of MartiniPlaza. For this, support was found in the marketing department and additional submetering is planned.
- Combining the proposition of enhancing air tightness with the quality of roof finishing and the limitations for structural load available for use. The user had knowledge of additional benefits, through which energy measures could be combined and deemed feasible.

Life cycle assessment in support of the business case for sustainable energy solutions

As explained above, the long-term vision on MartiniPlaza contains a plan to dismantle the Expo Hall and replace it with a modern, sustainable hall, shortly after 2030. At the same time, current energy consumption in the hall is relatively high due to poor insulation of walls and the ceiling, which results in relatively high energy costs. The main challenge in finding energy saving solutions in the Expo Hall is that these need to have a payback time of less than ten years, as otherwise the investment is not financially viable.

In the case of the MartiniPlaza, the co-creation between MartiniPlaza stakeholders and RES4BUILD partners, after proposing the lowered ceiling to minimise HVAC energy **and** proposing a life cycle cost approach, a business case was suggested, including:

- Temporary elements in the ceiling (theatre trusses), which can be dismantled and reused in the longer term (in a new version of the Expo Hall), and
- Service costs reduction, as repairing hanging elements, such as lights, becomes easier when the ceiling can be lowered (instead of using lifting platform to reach a fixed ceiling).

Considering life cycle aspects has thus resulted in a suggested solution that improves the business case for energy saving measures and strengthens the skillset of the building's operational management.

Scenarios for IES at MartiniPlaza

The co-creation for IES at the MartiniPlaza focussed on a workstream short term and a workstream long term. For the short term, solutions have been considered, as discussed above, mainly for the purpose of reducing energy consumption (and thus energy costs). Solutions identified for that have a pay-back time of less than ten year (the approximate time that part of the complex will be dismantled and replaced with a new building) or can still be used (e.g., in parts) in a future setting. These solutions, including options for IES, are listed in Annex 5. Regarding the longer term, solutions have been identified in the co-creation process thereby distinguishing measures for the medium to longer term.

These measures can be applied at the level of individual building parts, e.g., theatre or Expo Hall 1, or at the level of the entire building. Regarding Expo Hall 1 no measures have been specified for the longer term, assuming **a rebuilding scenario** in which this hall will be dismantled and replaced after a decade from now with a new hall. However, should the shareholder (municipality of Groningen) and owner (MartiniPlaza) consider a **renovation-only scenario**, then all measures suggested for the MartiniPlaza complex in Annex 5 could be applicable for the Expo Hall 1 too.

Interestingly, in all three categories of short-, medium- and longer-term measures **interaction and collaboration with the adjacent Martini Trade Park** is foreseen. While for this case study review a **MartiniPlaza-Martini Trade Park scenario** is considered only qualitatively, it is foreseen that in the short term MartiniPlaza and Martini Trade Park could identify potential business models for future implementation based on exchange of surplus solar PV electricity produced at the MartiniPlaza's rooftop during, e.g., the summer season when MartiniPlaza's events frequency is rather low. Also, business models could be initiated for a common heat pump or BTES for efficient use of heating and cooling. Part of this activity is to assess current energy systems, including contracts and relationships with suppliers, and how these would need to be (re)arranged in a common sustainable energy roadmap for MartiniPlaza and Martini Trade Park.

In the medium term, several sustainable energy generation solutions for the common roadmap are to be assessed in detail, including heat pump, BTES and BEMS, whereby MartiniPlaza would take the role of energy supplier of both electricity and heating and cooling to adjacent buildings of the Martini Trade Park, or even elsewhere. In the longer term a new sustainable energy strategy for energy generation and distribution will be implemented, possibly, if considered technically and economically feasible, in collaboration Martini Trade Park.

12. Case study – Royal Visio, health care real estate

12.1 Introduction

For the Dutch case studies in this report, while the CCZ and MartiniPlaza case study focus on a specific building, the Royal Visio case study focusses on organisation that must manage a complete real estate portfolio. One of the objectives for Visio will be to develop a robust strategy and action plan to be able to meet future energy and climate targets by implementing IES within their entire building portfolio. To illustrate the implications of such a strategy in more detail we have also selected the Visio site in Vries, The Netherlands as a case study site.

Building portfolio

As a health care facility Stichting Koninklijke Visio (Foundation Royal Visio) was selected. Royal Visio provides specialist healthcare to people with visual limitations (e.g. blind and visually impaired) which are often combined with other physical or cognitive impairments. Royal Visio has a history dating back to 1808 when the Institute for Education of the Blind was founded in Amsterdam. Since then, it has merged with several other healthcare organisations to take the current official name of ‘Koninklijke Visio’ in 2009. (source).

Figure 12-1: Geographical spread of real estate portfolio

Royal Visio has a sizeable real estate portfolio (about 300 locations, with an estimated total asset value of 57 mln. EUR) spread out on different smaller and larger sites throughout the country (see Table 12-1 and Figure 12-1). About 75% of the buildings that are used by Royal Visio are in use for assisted housing and day care, 17% is used for revalidation, 6% is used for providing education / training, and 2% is in use as office space.

Table 12-1: Organisational information

2019	Number	
Number of clients	17,307	Revalidation and advice
	604	Inbound residential and daytime activities
Number of students	1,840	On regular schools with Visio support
	415	On Visio schools
Number of employees (fte)	1,641	Healthcare professionals
	248	Education staff
Annual turnover	≈165	Million EUR
Annual real estate management budget	≈20	Million EUR
Real estate portfolio asset value	≈57	Million EUR

The current (2021) real estate portfolio has an estimated floor surface of about 125,000 m^2 and is partially owned (70%) and rented (30%). The real estate portfolio is diverse with larger and smaller buildings of different vintage, and with different primary functions.

Case study site: Visio in Vries, The Netherlands

One of the larger Visio sites, located in Vries (see Figure 12-2), The Netherlands includes about 40 buildings, of which many were built in the 2003-08 period. The Vries site has the basic characteristics of a small suburban area, with several client houses, a restaurant, swimming pool and recreational centre as well as workshops and office spaces. On this site Visio would be able to pilot both building specific and collective IES solutions.

Figure 12-2: Overview of building on Vries site, Royal Visio

To meet its building related 2030 CO_2 emission reduction target Royal Visio would mainly need to reduce its gas consumption considerably by nearly 50%. This is equivalent to about 0.7 mln m^3 of natural gas (or 0.18 mln m^3 of natural gas for the Vries location). Currently, the CO_2-footprint analysis of Royal Visio accounts zero CO_2 emissions for electricity consumption since Visio has a power purchase contract for wind energy produced in Europe.

JIN already established initial contact with representatives of Royal Visio already before the start of the RES4BUILD project to ensure effective collaboration and co-design. In November 2019, Royal Visio (location Vries, The Netherlands) acted as the host for the RES4BUILD General Assembly. A (semi-)open stakeholder on the Visio case study was also organised as a back-to-back session. Since that event, several follow-up interactions between JIN, ARUP, and Visio (and where appropriate also with relevant Visio energy and construction/maintenance subcontractors) have been organised. During stakeholder workshop five key challenges for 'greening' (energy savings, and lower CO_2 emissions) the real estate portfolio of a health care organisation – like Royal Visio – were discussed (see Figure 12-3). All five challenges are relevant both at the level of the building portfolio as well as the case study level (i.e. individual building or group of buildings).

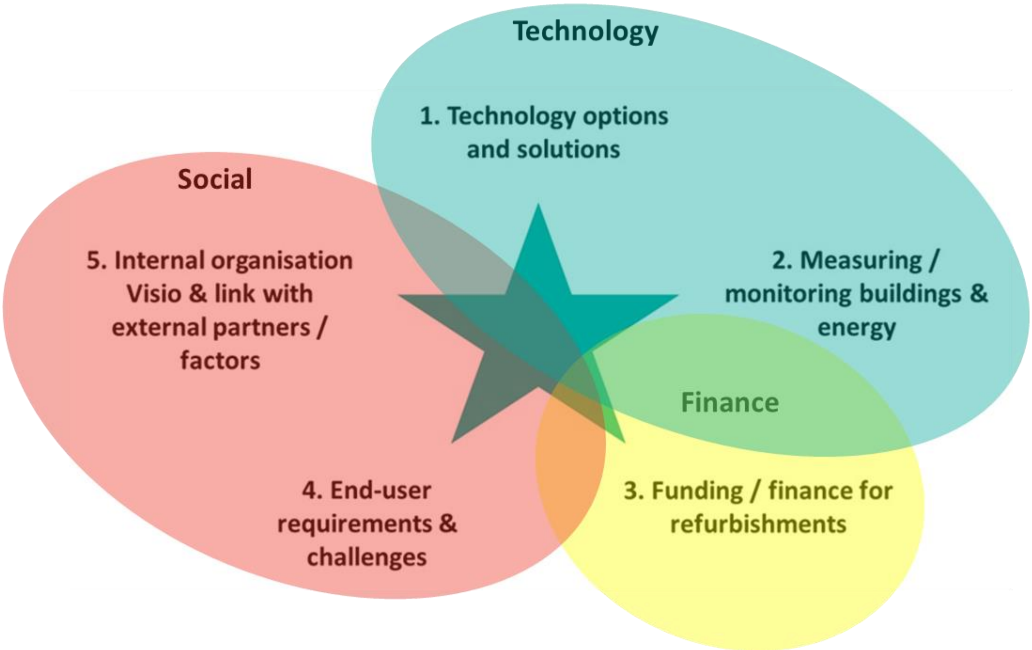


Figure 12-3: Five key challenges

The ***first*** (technology) challenge for Royal Visio is to determine (for each site, and building) what technological options and solutions are available (e.g. Integrated Energy Systems, all-electric, local heat grid, additional insulation, etc.). Due to that Visio's real estate portfolio comprises a broad range of different building types, with different vintages a 'one-size-fits-all' approach seems unlikely to be feasible. Moreover, in some cases only considering building specific IES solutions may be suboptimal and collective IES solutions may be better. On specific Visio locations, like the Vries site, several groups of buildings with relatively homogenic characteristics can be found closely together. Other buildings in the portfolio are located in (sub)urban areas that are targeted for a roll-out of local heat grids.

A ***second*** (technology) related challenge for Visio is to have the proper (time series) data available on building quality/characteristics, as well as energy use, and energy system characteristics (e.g.

vintage, type/quality of insulation, double glazing in place?). A robust dataset and (energy) monitoring system is needed at the proper level of detail to enable robust investment decision making. To illustrate, the site in Vries comprises about 40 individual buildings, while only a dozen gas and electricity meters are currently in place. As such, Visio currently does not have a dataset that is of sufficient quality to determine both the quality and energy performance of a specific building. This is problematic when one wants to assess the effectiveness of specific building interventions/ renovations. On top of that Visio owns buildings of which part are connected to the energy grid as a small-user, while other buildings are connected as a major-user. The type of grid connection has implications for the associated energy supply contract terms and conditions (i.e. small- or large-consumer prices) which in turn influences the payback period of individual energy and climate measures.

The ***third*** (financial) challenge for Royal Visio is to devise a financing strategy for this multi-annual 'real estate portfolio' renovation process. While some buildings will be excluded (sold off) from the portfolio in the coming decade(s), most of the current real estate portfolio will remain in use and will require some type of energy renovation to ensure the energy and climate targets are met. While the organisation has adequate own funding / reserves for piloting some building refurbishments, it will require considerably more financial resources to fund the transition for all buildings on the mission towards to a low-emissions or energy neutral buildings portfolio. On top of that the recent energy price increases, as well as increasing and structural shortages in supply of building and installation materials and technically skilled labour, make the financing of proposed actions challenging.

The ***fourth*** (social) challenge relates to the specific requirements and needs that Visio staff and clients have in relation to the buildings and energy systems they use and experience on a day-to-day basis. While CO_2-savings and energy efficiency are important overall sustainability objectives, the specific clientele of Royal Visio, as well as Visio employees should be able to work and live with the offered buildings and systems in a safe and comfortable manner. Visually impaired clients, for example, require a specifically tailored lighting plan, while there are also non-standard hot water requirements for physically impaired clients. Also, the recreational facilities such as the swimming pool onsite in Vries are running at non-standard temperatures. Part of the design and implementation process for introducing novel IES systems in the buildings in use by Visio clients and staff should thus be proper consultation and recognition of end-user needs and requirements.

The ***fifth*** (social) challenge for Royal Visio to be able to green their real estate portfolio is to ensure that the organisation itself is adequately staffed and equipped to manage and implement this continuous energy renovation process that will take several decades. For example, the typical time span for real estate maintenance contracts closed by Royal Visio is three years. In 2019 a new three-year agreement for the 2020-22 period - valued at 10.9 mln EUR - was signed and early 2020 the multi-annual maintenance plan (MJOP) was updated. While this will aid in advancing the implementation of incremental energy renovations, a long-term 2030, and 2050 energy renovation strategy is not yet available. Also, the internal organisation is likely to face challenges in terms of capacities and availability of skilled staff being able to focus on specific implementation programmes (e.g., efficient lighting programmes, or end-user requirement consultations).

Energy and climate targets

In line with existing energy efficiency and climate policy frameworks, Royal Visio is subject to the following key regulations:

- The EU Energy Efficiency Directive (EED) requires organizations to perform periodic audits and implement energy saving measures with a payback period of five years or less.
- The Dutch National Climate Agreement includes sectoral agreements and CO_2 targets. For the built environment so-called CO_2-roadmaps (link)[8] will need to be developed by different real estate owners/user groups (e.g. public real estate, health care real estate, etc.). Organizations in the health care sector will have to be reduced their CO_2-emissions by 49% in 2030 and 95% in 2050. Individual organizations in the health care sector will need to develop 'CO_2-roadmaps' that indicate the measures/actions to be taken to meet the climate goals.

Visio thus needs to reduce its organisations' CO_2 emissions, while at the same time also reducing its overall energy efficiency performance. While both ambitions seem to align well (i.e. reducing building related energy use generally also reduces the companies CO_2 emissions), there are some CO_2 saving measures that could also result in an increase in energy consumption (e.g. when a heat pump replaces a gas-fired boiler, CO_2 emissions could be lower but energy consumption could increase) or vice versa (e.g. where LED lighting results in an increase of gas use for heating). Moreover, for the health care sector it will be important to determine which emission factors should be used in the CO_2 accounting systems for real estate owners/managers.

The case study has subsequently been conducted by JIN and ARUP, whereby JIN focussed on evaluating the social (organizational, stakeholder roles and responsibilities as well as the building organisation) and financial (financing options, payback times) aspects, ARUP carried out a more technical analysis of the energy performance of the building portfolio with potential solutions for improvement, with a specific emphasis on the Vries site.

12.2 Current situation – status of building and present energy technology

Building portfolio characteristics

Royal Visio has a sizeable real estate portfolio (about 300 locations, with an estimated total asset value of 57 mln EUR) spread out on different smaller and larger sites throughout the country (see Figure 12-1). About 75% of the buildings that are used by Royal Visio are in use for assisted housing and day care, 17% is used for revalidation, 6% is used for providing education / training, and 2% is in use as office space. The current (2021) real estate portfolio is highly diverse in terms of vintage, building characteristics and energy use profile. Visio has an estimated total floor surface of about 125,000 m^2 and is partially owned (70%) and rented (30%).

The vast majority of the organisations' real estate portfolio related CO_2-emissions stem from its energy use (electricity + natural gas) for lighting, heating, and cooling. In 2020, Royal Visio's total electricity and natural gas consumption was resp. 5.7 mln kWh and 1.4 mln m^3. This represented a total building related CO_2-emissions level of 2.156 tCO_2 per year (see Table 12-2).

[8] A CO_2 roadmap shows for each individual building in the building portfolio the planned measures, and their expected CO_2 savings as well as required investments. This resembles a multi-annual maintenance plan but puts more emphasis on energy conservation and CO_2 savings, and less on more traditional like-for-like replacements or maintenance actions.

Table 12-2: Energy use and CO_2 emissions Royal Visio (2020)

	Electricity	Gas
Energy consumption per year (total, all buildings)*	5,766,036 (kWh)	1,373,711 (m^3)
Total annual CO_2 emissions (tCO_2/y)**	0	2.156

Source: *Energy audit report Royal Visio, INNAX; 2021

Source: **Royal Visio CO_2 footprint report, Climate Neutral Group; 2021

One of the larger Visio sites, located in Vries (see Figure 12-2), The Netherlands includes about 40 buildings, of which many were built in the 2003-08 period. The Vries site has the basic characteristics of a small suburban area, with several client houses, a restaurant, swimming pool and recreational centre as well as workshops and office spaces. On this site Visio would be able to pilot both building specific and collective IES solutions.

To meet its building related 2030 CO_2 emission reduction target Royal Visio would mainly need to reduce its gas consumption considerably by nearly 50%. This is equivalent to about 0.7 mln. m^3 of natural gas (or 0.18 mln m^3 of natural gas for the Vries location). Currently, the CO_2-footprint reporting of Royal Visio accounts zero CO_2 emissions for electricity consumption since Visio has a power purchase contract for wind energy produced in Europe.

The following data/information was collected from a range of sources:

- Energy monitoring data
- Multi annual maintenance plans (MJOP)[9]
- EPA-U reports for specific buildings
- EED reports (2017, 2021)
- CO_2 footprint report
- Detailed maps with gas and electricity infrastructure (Vries site only)

The data/information collected in most cases relates to the entire building portfolio. Where possible and relevant we isolated data/information specifically for the Vries site. For the full building portfolio, we provide a more generic assessment of the data/information, as they are relevant for decision making also for the Vries site.

Building portfolio's energy system and performance

The EED reports (2017 and 2021) provide more information about the energy performance of buildings and associated building characteristics. As part of the legal requirement (part of the Energy Efficiency Directive) to periodically (every 4 years) Visio contracts a subcontracted

[9] Visio has subcontracted a building and construction company to help them with developing and implementing the multi annual maintenance plan (MJOP) for the building portfolio. The current MJOP works with the principle of like-for-like replacement. As such it has some limitations for introducing more sustainable, innovative, and integrated energy systems. Moreover, the MJOP is object- or building-specific and does not automatically aggregate the different measures through time to allow for a more programmatic approach for upgrading their building portfolio. More recently, Visio and the subcontracted construction company have taken efforts to update and transform the MJOP into a sustainable annual maintenance plan, which will deviate from like-for-like replacements and will introduce energy and CO_2 saving measures.

consulting firm. As part of this EED company audit ('organisatie audit')[10], the consulting firm performs a range of building checks and site visits and reports back to Visio which energy saving measures can be taken and what the respective estimated payback times are. A more in-depth analysis of two EED audit reports from 2017 (covering 65 buildings) and 2021 (covering 33 buildings) provides a number of insights.

The estimated total cumulative investments for all measures in both EED reports was EUR 1.27 mln. (2017) and EUR 8.26 mln. (2021). For both EED audits, Visio provided basic building and energy data to the respective subcontractor responsible for drafting the EED report. In both cases, the consultant executed site-visits to identify any data/information gaps, and to assess which energy conservation measures could be implemented. For estimating the electricity and gas savings, the investment costs and payback times for each measure a software package was used. Visio received the final EED report in pdf format, and in one case also received the complete background excel with the key data for the proposed individual energy saving measures.

In both EED reports the following key observations/recommendations for Visio by the consultant were highlighted.

- Firstly, Visio's building energy monitoring system is incomplete. For example, on the Vries site, with around 50 buildings there is only 1 electricity meter installed (major user connection; GVB). While there are more gas meters in place in Vries (a mixture of major user; GVB and small user; KVB meters) it can be that several buildings are connected to a single meter. Efforts are being made by Visio and contracted service providers to install more (smart) meters, the absence of building-specific metering shows that it will is challenging to ex-ante determine and ex-post monitor the effectiveness of potential energy saving measures.[11] Despite these efforts, it is expected that also in the future for specific energy saving measures, and for specific buildings Visio will likely remain to have to rely on estimated savings.
- Secondly, both EED reports show payback times (PBTs) for many energy saving measures that are too high for health care organizations like Visio. This is mainly due to the relatively low electricity and gas prices that Visio has contracted (via Intrakoop[12]). A significant share of the energy use is supplied via major user connections (GVB). Within The Netherlands, major users pay significantly lower energy prices. The other buildings that have a small-user grid connection pay energy prices that are more in line with regular consumer prices.
- Thirdly, both EED reports also indicate that Visio's organizational structure (both internal and in relation to external contractors and service providers) makes effective building and energy management more complex.

We also performed an assessment of both EED reports to check for any commonalities and/or key differences in the type of energy saving measures proposed (***Annex 7. Assessment of EED and CO2 footprint reporting***). We observed some significant differences/changes in EED reporting within a relatively limited timespan of four years (2017 – 2021). We also discuss some issues associated with

[10] Visio is allowed to perform a so-called 'company audit'. With such a periodic audit not all buildings in the portfolio will be audited, but a significant sample of buildings will be audited.
[11] The energy metering infrastructure, especially on the Vries site has limitations as not each individual building has a (smart) meter installed. During the RES4BUILD project, Visio was already undertaking efforts to increase the placement of smart meters. Due to COVID restrictions, the placement of additional smart meters was delayed.
[12] Intrakoop provides professional collective purchase services to associated health care organisations. It purchases specific products and services on behalf of a large group of health care organisations.

the high-level nature of the data and information provided through the EED and CO_2 footprint reports that report at the concern level ('ondernemignsrapport').

12.3 Current situation – roles and organisation of stakeholders

Stakeholder engagement

The stakeholder consultation process with Royal Visio and other relevant stakeholders started in 2019, during the semi-open workshop which JIN and Royal Visio co-organised. 'Greening Visio's' real estate portfolio was the title of the event, where different speakers were invited to talk about technical, social (organisational), and financial challenges for health care organisations with the ambition to implement energy conservation and CO_2 reduction strategies.

Table 12-3: Overview of stakeholder consultation sessions

Date	Location	Description
21-11-2019	Vries, The Netherlands	Semi-open stakeholder workshop 'Greening Visio' (back-to-back with RES4BUILD General Assembly), with a guided site visit, and presentation from Royal Visio, ARUP, SEGON, BAM FM, and Province of Drenthe
07-02-2020	Vries, The Netherlands	Semi-open stakeholder session follow-up discussion on site with Visio staff. Discussion about next steps and data/information requirements.
11-02-2020	Huizen, The Netherlands	Group discussion session on building and energy data/information exchange with Visio, Hellemans Consulting, BAM-FM. Objective is complementary data/information collection on buildings and energy.
14-07-2020	Online	Follow-up group discussion session on building and energy data/information gaps with Visio, Hellemans Consulting, BAM-FM. Objective is complementary data/information collection on buildings and energy.
18-11-2021	Online	Online discussion between Visio, ARUP, and JIN on remaining information/data gaps, organisational, institutional, and financial challenges for sustainable real estate management of Visio and possible IES solutions.
06-01-2022	Online	Online discussion between Visio, ARUP, and JIN on organisational, institutional, and financial challenges for sustainable real estate management of Visio and possible IES solutions.
07-04-2022	Online	Online discussion between Visio, ARUP, and JIN on organisational, institutional, and financial challenges and solutions for sustainable real estate management of Visio and possible IES solutions
20-04-2022	Online	Follow-up discussion between Visio and JIN on integrating internal procedures for EE and CO2 strategies.

The workshop was the official kick-off of the 'Royal Visio case study' where the RES4BUILD project would explore in what way Integrated Energy Systems (IES) could be deployed in Visio's sizeable real estate portfolio. After this workshop several follow-up meetings (see Table 12-3) have been conducted to exchange data/information, discuss data gaps, the various technological, organisational, and financial challenges that Visio is facing with respect to IES implementation and what possible solutions / strategies there are to enable effective IES implementation. These meetings have been vital to determine the real knowledge gaps and needs of Royal Visio with respect to understanding and supporting them to implement IES solutions in the real estate portfolio.

Stakeholder interactions

To better understand the stakeholder and policy environment in which Visio has to operate when it comes to greening their building stock, we have performed a stakeholder network analysis. A detailed stakeholder network analysis helps us to better understand the role of individual actors/organisations with whom Visio is collaborating to implement the desired actions.

Figure 12-4 shows the complex stakeholder network. Each actor or stakeholder has a significant role to play within Visio's ambitions to green their building stock. In some cases, the relationship between Visio and another stakeholder is more structural, while others have a more ad-hoc nature. Some stakeholder relations have a direct impact on the technological issues and challenges, while others have a direct impact on Visio's financial and organisational actions.

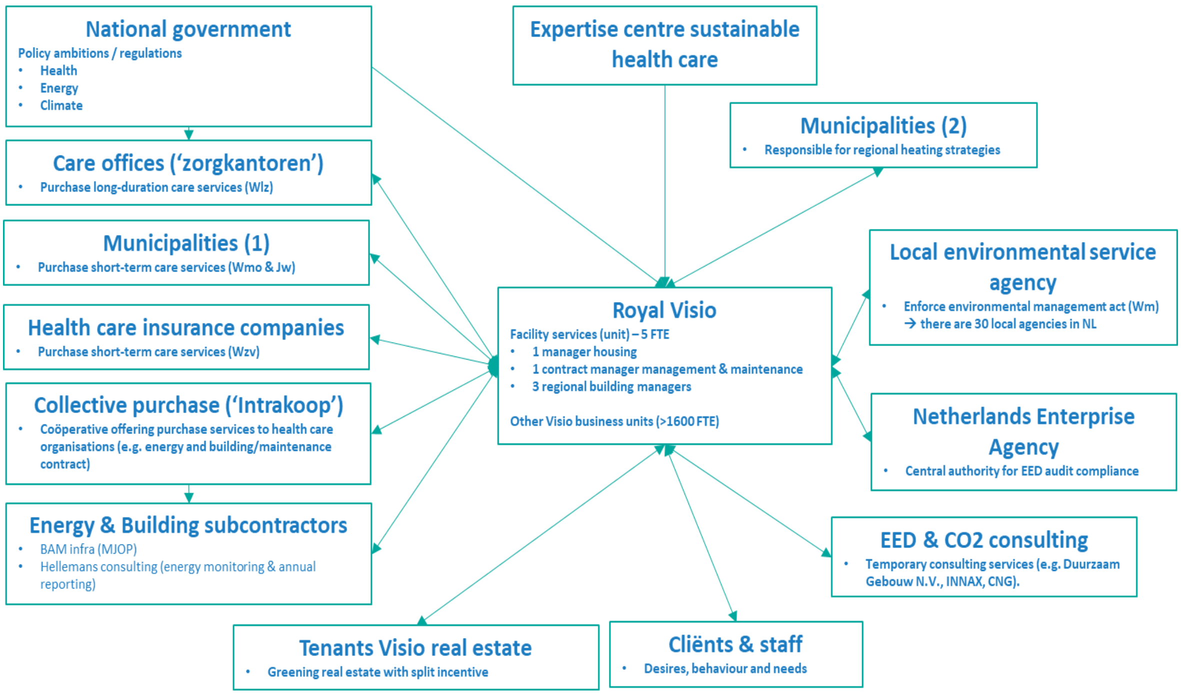


Figure 12-4: Stakeholder network mapping; Royal Visio

In ***Annex 8. Overview of Royal Visio's stakeholder network*** we provide an overview of the different stakeholder roles. To illustrate the complexity of some of the stakeholder relations we provide some examples below.

Building-specific vs. local collective approaches: Visio has contracted a building and maintenance company (BAM FM) to help with regular maintenance/replacement of building components, as well as the development of a new sustainable multi-annual maintenance plan. Here Visio relies on the knowledge and expertise of BAM FM to help with selecting the right technologies for bringing down the CO_2 footprint of the building stock.

The current way of working by BAM FM and Visio is still mainly focused on maintenance and identifying building-specific approaches, and less on more localised and integrated or collective approaches. In terms of number of buildings and building functions the Vries site is similar to a small suburban area. On this site a collective approach may also be feasible, especially since Visio is the sole owner of the buildings on site.

Assuming that for Vries a more collective approach involving the implementation of IES for multiple buildings is considered (e.g. a local heat grid), the local municipality also needs to be involved. As part of the Climate Agreement, all Dutch municipalities have to develop and implement so-called alternative heating plans for all (sub)urban areas and villages (i.e. area plans or 'wijkplannen' in Dutch). Within The Netherlands, most of these strategies are focusing on three main IES concepts, including:

- **All-electric**: generally, involves building-specific IES solution based on solar-PV and heat pumps (similar to RES4BUILD solution),
- **Hybrid / renewable gas:** in less densely populated areas, or areas with buildings with a limited/moderately thermal performance, or areas for which it will be very costly to upgrade the thermal performance of building, often hybrid heat pumps in combination with the supply of renewable gas (e.g. biogas, or hydrogen) are considered,
- **Heat grids**: In more densely populated areas and/or areas with large excess supply of (waste) heat from industries often local (low, mid, or high temperature) heat grids are envisaged,

The alternative heating strategy for the municipality of Tynaarlo, The Netherlands (where the Vries site is located) can thus have a direct impact on which IES technology concept will be implemented. Whatever IES strategy, Visio will implement for the Vries site, at some point this will need to be aligned with the local area plans of Tynaarlo. Given that Visio has buildings located throughout the country, there will be a need to liaise with several more municipalities on this matter.

Relying on contracted service providers: At the centre we find Visio's facility services department (5 FTE) which provides housing services through real estate portfolio management. While Visio has its own staff responsible for real estate management, Visio does not have all the required technical, energy, purchase, etc. expertise/skills in-house to fully self-manage, maintain and 'green' their real estate portfolio. Here the facility services department (Visio) must rely on the expertise and services of several (sub)contracted organisations. These include:

- Collective purchase organization (long-term relation)
- Building and construction services company (period contracting)
- Energy monitoring and reporting services (periodic contracting)
- Energy efficiency and CO_2 consulting service providers (ad-hoc contracting)

Income dependency and financial and operational planning horizon: Any investments in real estate have to be covered by Visio's income streams. Visio has four main income streams stemming from the different national health and society support policy frameworks. These are:

- Wlz – Long-term care act
- Wmo – Act on societal support
- Jw – Youth law
- Wzv – Law on health care

Each law has its own specific rules and conditions on how funds are transferred, on how and how long care services are contracted, and to what extent costs for housing/real estate are covered. Each law has its own specific rules, but also is implemented and enforced by different entities. For example, the Wlz includes a specific compensation for providing housing services. This is called the Normative Housing Component. The NHC (link) compensation is periodically evaluated and annually indexed to adjust for inflation. The NHC compensation is part of the integrated compensation rates for Wlz care services provided. Wlz care services are purchased by so-called 'care offices' (zorgkantoren). There are about 31 regional care offices within The Netherlands. Knowing that Visio provides care services throughout the country, Visio has to liaise with multiple care offices. Both the Jw and Wmo laws are implemented and enforced by municipalities. There are about 345 municipalities within The Netherlands. Also, here Visio has to liaise with multiple municipalities in parallel to coordinate the provision of these health care services. For the Wzv Visio has to liaise with most Dutch private health insurance companies who are contracting specific health care and related services.

It is important to note that the duration of most health care contracts from Wlz, Wmo, Jw and Wzv differ in terms of duration. This can range from short-term care contracts of a few days, or longer-term contracts of several years. However, most health care contracts do not go beyond five-year duration. As a result, Visio cannot easily extend its strategic and financial planning and investment strategy beyond 5 to 10 years.

Energy and climate public stakeholders: To meet the organisation's energy and climate goals, Visio has to liaise with several other stakeholders. Of course, contracted service providers for building maintenance and energy management are important actors here, but aside from these Visio also liaises with the Netherlands Enterprise Agency ('RVO'), and the local environmental service agencies ('Omgevingsdienst'). RVO is the competent authority for the EED auditing. Visio has to submit the EED audit report to RVO for review and approval.[13] After approval the EED reports are available to all local environmental service agencies who are in charge or ensuring compliance with the EED requirements. There are 30 regional environmental service agencies in The Netherlands. Given that Visio is operating in different areas of the country, there are working relations with multiple agencies. Visio has indicated that the different agencies do not apply a similar working method, which makes it challenging for Visio to coordinate and meet all requests efficiently. Visio indicated that several regional agencies do not fully understand the company wide approach that Visio is allowed to apply for EED compliance. A company-wide approach implies that Visio can assess which measures to take for a specific selection of buildings (and not the full building portfolio). The enforcement agencies are sometimes not aware of this, and sometimes indicate in their observations that Visio is non-compliant for several buildings.

Aside from this, the Dutch municipalities are the competent authority for developing regional alternative heating strategies. As part of the National climate agreement, all Dutch municipalities will have to develop and submit a transition strategy for heating ('Transitievisie Warmte'). This strategy had to be finalised by the end of 2021. After that so-called 'area plans' will need to be developed which specify how a specific (sub)urban area will switch to a more sustainable form of heating. The possible alternative heating strategies can range from building-specific (all-electric) heating systems based on heat pumps and solar PV, but also more collective systems relying on low-, mid-, or high temperature district heating, or renewable gases, such as biogas, biomethane and/or hydrogen. Especially, these area-plans have a potential significant impact on the different measures and options that Visio will (have to) implement in their building portfolio. In extreme cases Visio could invest in a building-specific IES system, while the local area-plan indicates that a

[13] Visio indicated that RVO is making good efforts with integrating the EED procedures with the EML (list of recognised measures). However, RVO indicated that they need at least two more years to effectively integrate these two sets of energy efficiency regulations.

local heat grid will be developed. For the site in Vries, Visio has already made initial efforts to discuss with the local municipality how the area-plan could look like. But to date the relevant municipality has not yet been able to provide more details and guidance. Also, in relation to the area planning process, Visio will likely have to liaise with several municipalities throughout the country.

Energy and climate private stakeholders: Internally, when implementing energy and climate measures, Visio has to ensure that the associated activities do not conflict with the normal day-to-day care activities (i.e. with clients and staff). For example, a major renovation of several client houses involves quite detailed planning, and often results in a house-by-house approach to limit the time vulnerable clients must be located elsewhere. Also, any complaints about the housing services, such as for example with heating (too cold?) or cooling (too hot in summer?) need to be addressed. While, in principle procedures are in place for staff and clients to voice their needs and complaints, it can often be challenging for the facility services staff to adequately address all of them appropriately and timely. Aside from clients and staff, also the energy (billing, comfort) and building (maintenance, defects) related aspects with the tenants from Visio real estate need be coordinated.

In addition to these stakeholders, Visio also relies upon the (ad-hoc) services of subcontractors to help them with preparing the EED audit report, and the CO_2 roadmap. For the EED audit reporting in 2017 and 2021 a different engineering consulting company was contracted. For the 2021 reporting, also a company-wide CO_2-footpring report was developed. However, the EED and CO_2-footprint reporting did not match the CO_2-roadmap tool provided by the Dutch expertise centre sustainable health care. As a result, Visio has to migrate all EED audit data into the new tool and assign specific emission factors to the individual measures.

While the excel-based CO_2-roadmap tool provides an elegant overview dashboard and enables tracking of EED and CO_2 targets, there is a small limitation to the tool that make it less user friendly. The tool only allows one specific energy price to be included to automatically calculate the PBT. Given that Visio has different energy purchase prices (small- and large-user prices), this is not realistic. Of course, Visio can create to separate data repositories and cluster small-user and large-user buildings, but this is less efficient for extracting information for decision making.

A more fundamental challenge is that the tool is not allow for easy clustering or aggregation of specific measures or building types. Moreover, the tool, just as the EED audit only focusses on building specific measures, which could ignore some opportunities for implementing more cost-effective collective solutions. To illustrate, assume that for most of the individual client houses on the Vries site, the EED report and the CO_2-roadmap indicate that heat pumps with solar pv have an estimated PBT of 15 years. The key message to management would be to not implement the investments. However, a more advanced data analysis of the different measures may be needed to identify any potentials for collective measures. For the Vries site, it could maybe imply that a small low temperature heat grid that supplies all client houses and some officer with a large on-site heat pump could be more cost effective (e.g. have a PBT or 10 years).

The example of a building specific versus collective IES approach for the Vries site also raises a question of finance. While the assumed PBT of the collective option seems favourable here, the disadvantage is that the up-front investment will also be larger. Making such a sizeable investment at once puts a strain on the financial situation of Visio, while within a building-specific approach the investment can be spread out over more years. The NHC compensation indexation as part of the Wlz, for example is more aligned with a phased investment approach, while in some cases a larger investment at once could have an overall lower total life cycle cost.

12.4 IES options for Royal Visio case study site, in Vries

To determine the suitability of new IES technologies to reduce energy consumption and CO_2 emissions for the Vries site the existing building stock was analysed in more details. For this, we used the following information:

- Age and maintenance quality of the building and systems
- Expected costs for maintenance and replacements in the upcoming years
- Annual energy data for the total site; on building level (2018 full; 2019 half)
- Some information on users and building/renovation dates for a couple of properties
- For some properties - information on the energy labels. Including data on building property information, such as insulation values and system types
- Multi-annual maintenance plan (MJOP); from 2015, revised in 2020 and 2021 update
- Reports on energy improvement measures and carbon reduction plans.
- Preference from Visio to focus on building typology similar to Rietwal 6-8

An initial assessment of different energy technology options for the Vries site is provided in ***Annex 9. Initial assessment of technical options for Vries site***. The buildings in Vries are fully owned by Visio and provide a range of different functions, including residential property (client housing), office locations for staff and objects aimed to provide specific care or facilities (e.g. a swimming pool, workshop, meeting venue/hall). Some of the buildings are rented out to specific care providers.

Building maintenance is organized through long term contracts, with BAM as general maintenance contractor and Hellemans as energy consultant. The buildings differ in age, ranging between initial construction dates 1925 and 2016. Natural gas is used for space heating and hot tapwater. Due to continuous use and the healthcare function, the use of tapwater is higher than expected for this specific housing typology.

The Visio site in Vries hosts:

- 40 buildings
- Approx. 17,000 m^2 Gross Floor Area
- Approx. 136,000 m^2 terrain area
- Energy labels ranging between D and A.
- Façade insulation up to Rc=4.5 m^2/W

Figure 12-5: Typology of property: blue is healthcare-residential; green are supporting functions, e.g. offices, gathering functions, sport facilities.

Figure 12-6: Typical house on the property

Most buildings have a residential function (i.e. on-site client housing), mainly terraced single family houses. Visio indicated a preference to starts with these building typologies, similar/comparable to Rietwal 6-8 (see Figure 12-7). The ambition is to start small with one or a few buildings (to gain experience) and expand and scale up the approach from there. Options to review integration of IES with the other buildings/utility functions on site are 'nice to have's'.

Based on existing information from EPA-W or EPA-U reports, advice is given which properties are most relevant for initial case study (and implementation) of measures. The table below shows argumentation for selection.

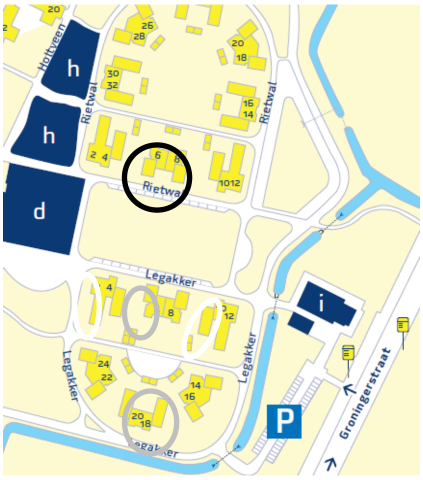


Figure 12-7: Area plan with explanations of buildings (Rietwal 6-8 in circle)

Table 12-4: Case study reference buildings for Vries site

	Rietwal 6-8	Legakker 6 (and 8)	Legakker 18-20
Owners' preference for case study	X	-	-
Nearby open water (option for thermal storage)	X	-	-
No. of comparable residences	8	8	8
PV(T) applicable	Very applicable (total flat roof)	Very applicable (total flat roof)	Applicable (partial sloped; partial flat roof)
Users known?	Yes, Stichting Amigo	5 users?	5 users?
Year of construction	2005 (users-document)	1980? (GIS data)	1980? (GIS data)
EPA assessment? And thereby information about systems?	No	Yes	Yes
Insulation values: façade – roof – ground floor	n/a; probably similar to Legakker 6-8 and Legakker 18-20	3.0 – 4.0 – 2.8 m2K/W	3.0 – 4.0 – 2.8 m2K/W
Actual gas use (2018)	38 m3/m2	42 m3/m2	30 m2/m2
Predicted gas use (EPA)	n/a	10 m3/m2	9 m3/m2
Assumptions for use (EPA): internal load	6 w/m2 (ISSO)	6 w/m2 (ISSO)	6 w/m2 (ISSO)
Assumptions for use (EPA): average space temp	16.5°C (ISSO)	16.5°C (ISSO)	16.5°C (ISSO)
Assumptions for climate (EPA):	TRY De Bilt.	TRY De Bilt.	TRY De Bilt.

Royal Visio's preference is to **use Rietwal 6-8** as a case study object (see Table 12-4). This building is comparable to Legakker 6-8 and Legakker 18-20. In terms of geometry, the Legakker 18-20 is slightly different, due to a partially sloped roof. This results in a bit lower applicability for renewable energy from solar. These three objects are relevant for the IES assessment for the 'RES4BUILD concept', which is based on the medium insulation values, a low temperature heating system and balance ventilation system with heat recovery. To improve the efficiency of the RES4BUILD IES system it would be beneficial to enhance the insulation values.

Special focus in the case study should be given to the building use. As per the EPA study, the predicted energy for heating and hot tapwater is **significantly** lower than the actual measured

values in 2018, by a factor 3-4. The reasons are to be found in:
- System performance
- User behavior
- Outdoor climate differences

The EPA-report for this property (Legakker 6-8) dates from 2017[14]. Sustainable annual maintenance plans (MJOP) are available from 2021. Due to very low kWh-prices for electricity that Visio pays, the payback times (PBTs) for many energy saving measures are too long. Therefore, the proposed measures:
- Have low cost and high electricity reduction:
    - *Replace lighting with LED technology*
    - *Addition of occupancy sensors to limit energy use for lighting*
- Have low cost and reduce gas use for space heating:
    - *Roof insulation on a natural moment*
    - *If relevant, insulation of cavity walls.*
    - *Insulation of piping connections and valves, to limit thermal energy losses.*
- Reduce electricity use from the grid, whereby the investment can be partially compensated with subsidies:
    - *Placement of PV panels for renewable electrical energy*

Relevant regular (like-for-like) replacements, such as a gas fired boiler - which in some cases are scheduled for 2022 in the MJOP - should be reconsidered when aiming for further CO_2 emission reductions.

Our assessment of the available data/information shows that the current way of data/information gathering, logging and management could benefit from a more integrated and structured approach in line with a specific protocol, such as *ISSO 104: Sustainable Management and Maintenance of property*. ***See Annex 11: Integrated data collection and management*** for more details.

Different IES concepts

In this section we explore three different IES options for Visio for a subset of buildings at the site in Vries. We mainly focus on RES4BUILD-like IES concepts, which are PV(-T), heat pump based. The three options focus on the transition to a predominantly all-electric IES. The three approaches are:

I. a building specific all-electric IES approach,
II. a collective all-electric IES approach for a building block, and
III. a large-scale collective all-electric IES approach for multiple building blocks on site.

The key technical components of the three options are included in Table 12-5.

Table 12-5: Key components of IES options for Vries site

[14] The information in the EPA reports is high-level. Due to the limitations in the energy monitoring system on the Vries site, the data is not detailed enough for a proper energy assessment. For this, annual data of energy use on hourly basis for the specific building is preferred, combined with technical assessment of the building envelope.

	Building specific IES	Building block IES	Large-scale collective IES
Air/water heat pump	X	-	-
Water/water heat pump (building)	-	X	-
Water/water heat pump (centralised)	-	-	X
Heating / cooling grid	-	X	X
Solar PV(T) panels	X	X	X
Indoor thermal buffer	X	X	X
BEMS	X	X	X
BTES	-	X	-
ATES	-	-	X

The different IES concepts considered in this section are described in more detail in ***Annex 10. Three IES concepts for Royal Visio in Vries***.

Costs overview (indicative)

For the IES concepts 1 and 2, cost indications are given below. The capacities of the heat pumps and the indicated PV/T collector area are derived from building and energy data of the RES4BUILD case study reference buildings (see Table 12-4). The numbers are extrapolated to the surface area of the building Rietwal 6-8, which has an area of 271 m^2. An overview of the indicative investment costs is presented in Table 12-6. The total investment costs of concept 1 are €60,000 (ex VAT), and Concept 2 are €85,000 (ex VAT). This initial and indicative cost estimate excludes costs for engineering, project management, groundworks for installing the heating/cooling grid, as well as any potential modifications to the electricity grid. Since more than 1 user/household are living in the buildings the capacities and costs are above the values for normal households.

Table 12-6: Overview of investment costs for two IES concepts (indicative)

Concept 1: Building specific IES		Concept 2: Collective IES per building block	
Installation component	Costs (EUR)	Installation component	Costs (EUR)
Heat pump		**Heat pump + BTES**	
Air/water heat pump 30 kW	20,000	Water/water heat pump 30 kW	24,000
Tank (boiler) for space heating and DHW & system control	10,000	Tank (boiler) for space heating and DHW & system control	12,000
Materials (10%)	3,000	Materials (10%)	3,600
Installation	5,300	Installation	6,300
Profits / risks (6%)	2,300	Profits / risks (6%)	2,800
		BTES	20,000
		Optimization by connecting multiple buildings to BTES	3,000
Sub-total	**40,600**	**Sub-total**	**65,700**
PVT		**PVT**	
16 m2 panels	12,960	16 m2 panels	12,960
PVT tank	1,500	PVT tank	1,500
Materials	1,446	Materials	1,446
Installation	2,500	Installation	2,500
Profit / risks (6%)	1,100	Profit / risks (6%)	1,100
Sub-total	**19,506**	**Sub-total**	**19,506**

Total (Ex. VAT)	**60,106**	**Total (Ex. VAT)**	**85,206**

The cost indications of the two IES concepts and the current installation (gas-fired boiler heating system), over a period of 15 years, are compared. Within this cost overview the investment, maintenance costs are considered (see Table 12-7 for input data).

Table 12-7: Input data for cost overview

Input data	
Investment costs	
- Gas boiler	€ 4,775
- Concept 1: Air/Water heat pump	€ 60,000
- Concept 2: Water/Water heat pump - BTES	€ 85,000
Operational costs	
- Electricity price (per kWh) (range)	€ 0.05 – 0.443
- Gas price (per m3) (range)	€ 0.2 – 1.966
- Maintenance (per year)	2.5% of investment costs
Concept 1	
- COP Space heating	3.66
- COP Domestic Hot Water	4.25
Concept 2	
- COP Space heating	4.4
- COP Domestic Hot Water	8.2
- EER Cooling conventional	2.6
- EER Cooling Air/Water Heat pump	3.5
- EER Water/Water Heat pump	71.4
- Factor gas m3 to kWh	9.77
- Yearly gas usage (m^3)	7000
- Cooling energy demand ($kWh/m^2/year$)	19.29
- Building floor surface (m^2)	271.5

For the electricity and gas prices we assume two extremes, with very low prices that represent prices for major users (GVB) before the recent energy price increases, and at the other extreme high prices that represent prices for small users (KVB) after the recent price increases.

Box - ISDE subsidy for business users and homeowner associations

The Dutch Investment subsidy for Sustainable energy and Energy Savings for business users (ISDE) provides a subsidy for:

-(Hybrid) heat pumps
-Solar boilers
-Solar pv panels
-Small-scale wind turbines
-Connections on heat grids

The available subsidy funds are limited, and specific terms and conditions apply. One key condition is that Visio would have to request for the ISDE subsidy before the purchase agreement has been signed. Moreover, the ISDE subsidy will not be granted in case the organisation will also fiscally benefit from it via the tax deduction on energy investments scheme (EIA-scheme).

If we compare all three energy options for the two extreme energy price scenarios, we can see that in the low energy price scenario the gas boiler always be the most cost-effective during the 15-year period. In the high price scenario, both concepts 1 and 2 become more cost effective relative to the gas boiler after about 12 years (excluding any subsidies).

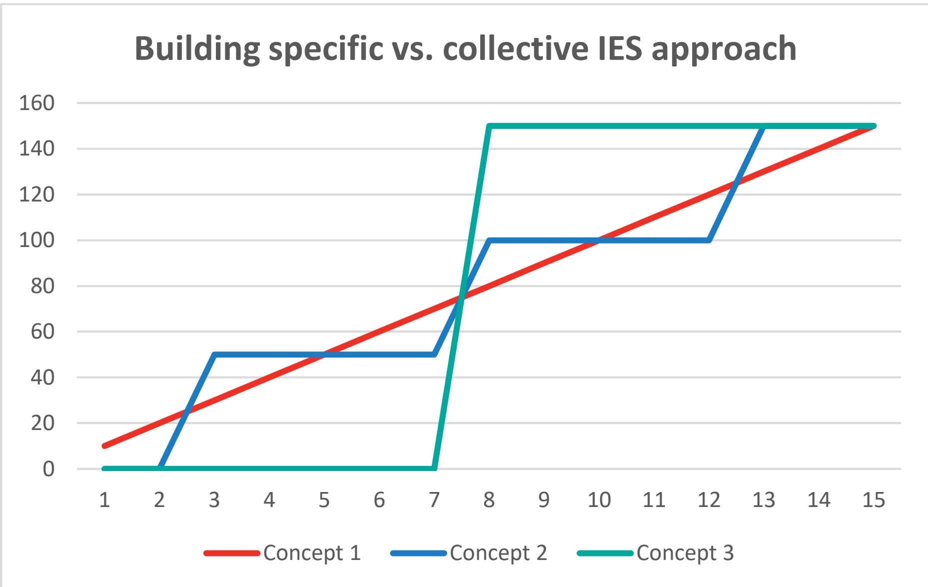
If we assume a public subsidy of around EUR 6,000 for the 30-kW heat pump (in the high price scenario), concept 1 and concept 2 would become more cost-effective relative to a gas boiler after respectively 10.5 and 11.5 years. A EUR 6,000 subsidy would be feasible via the Dutch ISDE subsidy scheme (***see box above***).[15]

Combining concepts 1 and 2 investments also with (subsidized) investments in solar pv panels could even further improve the overall economics of the energy investments as it could partially isolate Visio from future energy price increases, or even reduce the overall electricity price and costs. If in the high price scenario, the investments in solar pv panels would bring the average electricity price per kWh down with about 33% (to about 0.3 instead of 0.443 EUR/kWh), both concepts 1 and 2 would become more cost-effective relative to a gas boiler after respectively 7 and 9 years.

The above shows that aside from the technical engineering for IES concepts, also a robust financial-economic analysis is needed that includes also a range of incentive schemes (e.g. fiscal incentives and subsidies).

Implications of a building specific vs. collective IES approach

Aside from the economic considerations of which of the three IES concepts would provide the best PBT, each concept has its own practical (dis)advantages. Figure 12-8 illustrates the key difference between the three IES concepts. Concept 1 shows a more gradual trend line, in which each calendar year a similar effort is made. At the other extreme, there is concept 3 where a large one-off investment is made in a limited period.



[15] See the list of accepted heat pumps, and associated estimated subsidy amounts: https://www.rvo.nl/sites/default/files/2022-06/ISDE-Apparatenlijst-warmtepompen-27-juni-2022.pdf

Figure 12-8: Building specific vs. collective IES approach to building upgrading

A *building specific IES approach* (Concept 1) would allow for a more gradual or phased approach, where in year one, the first building is upgraded, and in year two, the second, etc. This typically lowers the risk profile of the activity as the project development, and planning is more simplified. Moreover, the investing organisation obtains more real-life experience and data regarding the costs and performance of different energy and CO_2 saving measures. Also, upgrading one or a limited number of buildings at the time can also limit any operational and capacity losses (i.e., downtime of the amount of available floor surface area)[16]. The advantage of this approach would be that the refurbishment activities can be better planned to coincide with the natural maintenance moments within a buildings' life cycle.

A phased building-specific approach would entail a series of smaller investments that are spread out over multiple accounting years (see Table 12-8). However, at the same time, a phased approach would spread out the construction activities on the Vries site over a very long period.

By taking such a gradual approach for the full building portfolio; the company's energy and CO_2 targets for the building portfolio for 2030 and 2050 may not be met on time.

Table 12-8: Comparing the technical, social, and financial implications of building specific vs. collective IES approaches (indicative)

	Building specific IES	Building block IES	Large-scale collective IES
	Concept 1	***Concept 2***	***Concept 3***
Technical			
Allows for a phased approach for construction through time?	Yes	Yes	No
Problematic for on-site client/staff housing/workspace logistics	Low	Moderate	High
Involves ground works	No	Yes	Yes
Electricity grid modifications needed?	Most likely	Most likely	Limited (one large connection for central heat pump)
Discomfort for building users during future maintenance	Key items outdoors	Key items outdoors	Key items outdoors
Social			
Coordination, project management and stakeholder management effort	Moderate	High	Very high
Number of stakeholders involved during implementation phase	Limited	Moderate / high	High
Number of end-users (clients, staff) impacted by construction and maintenance activities	Limited	Moderate / high	High
Financial			
Allows for a phased approach for financing the investments through time?	Yes	Yes	No
Upfront investment requirement	Moderate	High	Very high

[16] Temporary relocating Visio clients on the Vries site can be challenging due to the specific condition and needs of the respective client(s).

A collective or grouped IES approach would enable the upgrading of a larger subset of buildings at the same time. Concepts 2 and 3 could potentially allow for a more scalable and faster approach to reduce energy consumption and CO_2 emissions. Both concepts can have significant benefits in terms of economies of scale, transaction costs (e.g. engineering and project management costs). However, since both concepts involve significant ground works (ATES/BTES) project development may become an issue as relevant permits may need to be obtained.

Depending on the specific IES concept design, there can be significant economies of scale and there is potential to limit or avoid over dimensioning of some of the IES system components (e.g. excess boreholes). This, in turn, could have advantages for limiting the costs of operation and maintenance. However, a collective IES approach will most likely require a more detailed preparation and planning phase, as more stakeholders are involved (see ***Annex 8. Overview of Royal Visio's stakeholder network***). This is the case when a collective IES approach for the entire area – in which the respective buildings are located - is foreseen. This can occur, for example in case a Visio building is set to be connected to a local district heating system as part of the local municipal area plans for alternative heating (see Section 12.3**Error! Reference source not found.**). Also, a grouped approach would require a larger sum of up-front investments for a more limited time span. To enable such a collective IES approach the organisation's funding and financing strategy will need to be aligned with the required IES investments plan.

Financing options for IES

In **Annex 12. *Trends and options in health care real estate finance*** we provide some background information on the different options for financing IES investments in health care real estate. In this section we provide a brief discussion of the different financing options available to Visio for the three different proposed IES concepts for the case study site in Vries.

All three proposed IES investment concepts mainly include different components of an energy installation, like heat pumps, PV(-t) panels, BTES/ATES systems, controllers, etc. For most of the client houses the quality of the building envelope (thermal performance) is of a sufficient level to retrofit with a low-temperature heating system. Also, most client houses are equipped with a floor heating system. However, for the other buildings on site (i.e. non-client houses), significant additional investments in the building envelope, as well as the heat discharge system (radiators) may be needed to allow for retrofit with an all-electric low-temperature heating systems.

For (future) investments we consider own funding or a traditional bank loan as the primary sources of funding for Royal Visio for all three IES concepts. This is in line with their ambition to maintain full (legal) ownership of their building portfolio. A similar approach could also be applied for the energy installations but depending on the specific IES concept there may be some interesting alternative financing options provided by Dutch IES system providers, see (Spijker, et al., 2020)[17], such as 'Klimaatgarant', 'The FCTR E', 'Eteck', 'ThuisBaas', 'Grunneger Power', 'WOAB', 'Renolution', 'Dura Vermeer', 'Koninklijke VolkerWessels', 'BAMwonen', 'BENG Nederland', 'WoonlastenNeutraal Renoveren' and 'Voor de VVE'.

[17] See the D4.1 'Good Practice of Integrated Energy Systems – On Integrated Energy Systems in the built environment in Poland and The Netherlands' report sections 4.2 and Annex III for a more detailed description and discussion on Dutch IES system providers.
https://res4build.eu/results/download/d4-1-ies-good-practices

Some of these IES service providers (e.g. The FCTR E, and ThuisBaas) target individual (household type) buildings and offer an integrated all-electric package consisting out of a heat pump, solar pv/pv-t and auxiliary installations (e.g. buffer) for retrofitting buildings with minimum energy label C. These integrated packages are offered for sale but can also be part of a lease/rent + service agreement which can be accompanied with an energy performance contract. This option could fit with Concept 1, where building specific investments will be made.

For Concepts 2 and 3 external investments in energy installations can be attracted with the help of IES companies / organisations offering ESCO services or are professional developers and managers of small heat grids (e.g. Eteck, Dura Vermeer and BAM).

Aside from targeting professional and/or for-profit organisations for attracting external investments, Royal Visio could also decide to collaborate with a local energy cooperative and offer the community to financially participate in the investment in for example a large solar pv project on site (e.g. large rooftop or ground-mounted system).[18] Offering the nearby cooperative to invest in a collective energy project would not only help Royal Visio to limit the total amount of own funds to be invested, but can also help to create more goodwill, and acceptance of the local community. The same logic may also apply for developing a local heat grid but is generally more complex and riskier (e.g., technologically more challenging, higher development and planning costs, larger investment sum) relative to a community developed PV-project.

12.5 Co-creation for IES and energy system improvements

For Royal Visio the fundamental challenge is to develop and implement a robust approach to roll-out IES solutions for their entire building portfolio. This will require selection and integration of suitable energy and CO_2 saving technologies and practices, better communication, integration and coordination of stakeholder activities and relations, as well as a sound strategy for financing the required investments.

On the status of building and present energy technology

From the information and discussion provided in Section 12.2 and ***Annex 7. Assessment of EED and CO2 footprint reporting*** we provide the following conclusions and recommendations.

1-Significant gaps in building energy monitoring; Without a robust energy monitoring system it is difficult to determine the (cost-)effectiveness of different energy/CO_2 saving measures in individual buildings,

- Improve energy monitoring, by placing additional smart meters.[19]

2-Poor payback periods: The EED reporting show poor payback periods for many energy and CO_2 saving measures. This can mainly be attributed to the (relatively) low energy prices that ‘major

[18] There are already many good examples of successful rooftop/ground-mounted pv projects in The Netherlands that have been developed and financed by energy communities/cooperatives.
See for example: https://loenenenergie.nl/wp-content/uploads/2020/11/Informatiedocument-AFM.pdf and https://loenenenergie.nl/wp-content/uploads/2020/11/DEF-Informatiememorandum.pdf

[19] *Note:* At the Vries site, Visio – together with its’ technical partners already started with placing additional smart meters.

users' such as Visio have to pay,[20]

- To meet the 2030 and 2050 energy and CO_2 targets, buildings – that are expected to remain in use - will need to have a net zero CO_2-emission performance. It can be expected that by 2050 non-zero emission buildings may be taken out of service as per climate law. As a result, it is recommended to make IES investment decisions not solely based on economic metrics, such as a payback period of <5 or <10 years.

3-Limited added value of EED reports; The analysis of the organisation level EED reports ('Ondernemingsrapport') show that i) given the consistent use of default values/data for costs, energy and financial, savings, ii) lack of available detailed background data on key assumptions and methods, and iii) exclusion of significant cost items – the EED reports should be regarded as high-level documents with limited added value for informed decision making on specific IES investments. The information embedded in both organisational level EED reports contain too high uncertainties resulting in very high uncertainty ranges.

- The information provided by contracted consultants through the organization level EED reports and associated data are relatively high level and insufficient for robust IES investment decision making. The underlying 'building level' EED reports ('Vestigingsrapport') provide more relevant data and information. The real added value of any EED reporting process relates to technical assessment and measurements proposed by the contracted technical experts based upon the site visits; and much less in the specific financial-economic assessment that is being made based upon default values. It is recommended that Visio commissions relevant technical experts to perform building inspections and provide detailed assessments of the specific technical measures that are needed to make the respective building net-zero CO_2 emissions by 2050. The relevant cost data and energy price data can be collected from different sources, or real/pilot projects by Visio and can be validated by the different stakeholders with whom Visio is collaborating.
- Visio could commission such technical advisory services for specific building types that represent a larger share of the full building portfolio. For such an assessment the technical details are more relevant relative to the estimated financial, energy and CO_2-saving performance as these will be much less precise for decision making. When the recommended measures are due, Visio would have to provide a more detailed financial planning based on more accurate cost data, and assessment of the true energy and CO_2 saving impact.

4-Unclear CO_2 accounting rules: Our assessment of the CO_2-footprint information has shown that there is an inconsistency between Visio's own CO_2 footprint reporting (executed by a subcontracted consulting firm) and the CO_2 accounting rules agreed upon by the health care sector. This refers to the allocation of CO_2 emissions associated with the use of externally sourced (renewable) energy, like electricity or gas in buildings. The two different accounting principles have a significant impact on the CO_2-footprint of the organizations' building portfolio, and thus also on the process, action, and measures needed to meet the CO_2-targets for 2030 and 2050,

[20] Even with the recent drastic increases in energy prices, the PBTs for Visio have not radically changed, since this is (partially) offset by increased costs for building and construction costs (e.g. materials, transport costs for imported materials, equipment), as well as increasing labour shortages for building, construction and energy installation workers.

- We recommend Visio to follow the CO_2 accounting rules as applied within the Dutch CO_2-roadmap process in the health care sector.[21] The key rule here is that the health care organization cannot claim zero emissions for renewable energy purchased from the grid with the help of Guarantees of Origin. The proper emission factor for electricity would then be 0,556 $kgCO_2$/kWh. This approach deviates from the accounting rule applied within the latest Visio CO_2-footprint reports (for 2020, and 2021), where a 0 gCO_2-eq./kWh emission factor was assumed. The recommended approach would enable Visio to claim CO_2-savings for investments made in electricity saving measures, energy efficiency and (rooftop) solar-pv panels. However, applying the new accounting rule would more than double Visio's reported CO_2-footprint emissions for 2020 and 2021.

5-Non-integrated and harmonized data logging; there is a need for a more robust centralized and structured process of building and energy data logging and management. The current decentralized and scattered nature of data logging and updating creates inefficiencies for effective real estate portfolio management,

- We recommend implementing a more centralized and harmonized data collection and management process for building, energy, and sustainability data/information. For this the ISSO 104 standard for: Sustainable Management and Maintenance of property could be used (see ***Annex 11: Integrated data collection and management*** for more details).

6-Building-specific vs. building-portfolio level IES planning; Despite that Royal Visio is taking many of the basic formal steps and protocols needed to manage their building portfolio, and reducing their energy consumption and CO_2-emissions, these existing procedures mainly serve the implementation and decision making for IES for individual buildings. For example, both the multi-annual maintenance plan, combined with an EED audit operate at the level of implementing measures at the individual building. While at the operational level this is a useful level of detail, an extra step may be needed to aggregate measures. While, the current building-specific approach, for example would enable aggregation to create a portfolio-wide program for specific energy/CO_2 saving measures (e.g., LED roll-out 5-year program), it does not provide direct guidance for scaling-up the implementation of IES systems comprising out of different measures (e.g., cavity wall insulation + heat pump + solar PV) and covering multiple (similar) building types (e.g. building-specific approach versus a collective approach). This will require a more tailored approach where specific IES solutions can be implemented over (relatively) homogeneous segments of Visio's building portfolio.

- We recommend that Visio, together with relevant technical partners aim to develop a more integrated approach, where next to developing IES strategies for individual buildings, also a more programmatic IES approach is developed for specific building types or specific building sites.

On the roles and organization of stakeholders

From the information and discussion provided in Section 12.3 and ***Annex 8. Overview of Royal Visio's stakeholder network*** we provide the following conclusions and recommendations.

We conclude that Visio's 5 FTE facility service department is operating in a highly complex stakeholder environment. There are many stakeholders that have an impact on Visio's day-to-day

[21] https://www.expertisecentrumverduurzamingzorg.nl/veelgestelde-vragen/groene-stroom/

operations for managing their building portfolio (e.g., municipalities, construction partners, consulting companies, etc.).

Within this environment there is continuous movement with e.g., subsequent changes in energy, climate, health care laws, and new energy technologies entering the market, as well as developments in the local area alternative heating strategy from municipalities, etc. For Visio there is not only a need to keep up to date with these developments and changes, but they also need to coordinate, and communicate with all these stakeholders to ensure the process of greening their real estate portfolio operates smoothly and efficiently.

The fact that Visio's real estate is spread across the country and falls under the 'jurisdictions' of many different governing authorities (e.g., municipalities and local environmental service agencies 'Omgevingsdiensten') makes this stakeholder engagement process more challenging. We acknowledge that Visio Facility Services already has ongoing contacts/interactions with most of these stakeholders, but that often still is on an ad-hoc basis and sometimes only reactive. Implementing a more proactive and structured approach would require more workload for Facility Services.

- To get a better control over this stakeholder environment, we recommend Visio to develop and implement a more coordinated and structured stakeholder (or relations) management. This first would start with an inventory assessment that identifies key stakeholders and maps the role of different stakeholders. Next to that the nature and function of the stakeholder relationship is described. Appointing a relations/stakeholder manager would provide a structural solution, but in the early stages perhaps a number of internships could help Visio with making an inventory assessment, where for example relevant information is gathered on all the local area heating plans for all the municipalities where Visio buildings are located.

The fact that most of the key relevant technical services (building and maintenance, energy monitoring, energy/EED and climate consulting) are outsourced increases the risk of inertia in Visio's IES implementation and decision-making process. Visio's strong reliance on external stakeholders for informing the decision-making process and action planning/implementation, creates an environment where it will be difficult to fast-track certain efforts. Our assessment of the stakeholder roles, interdependencies and dynamics shows that timely involvement, communication, and engagement with relevant stakeholders is vital for Visio to implement its IES actions effectively and efficiently for the full building portfolio.

- Here we recommend that Visio periodically evaluates which types of skills, expertise, and capacities it wants to keep external/outsourced, and what skillsets/expertise may need to be internalized. This could also involve a periodic evaluation of the different consulting and service provider contracts to see if they enable Visio to meet its energy and CO_2 ambitions.

Towards a sustainable Visio with IES

From the information and discussion provided in Section 12.4 we provide the following conclusions and recommendations.

For the site in Vries, we conclude that for most of the buildings on site[22] the thermal performance of the building envelope is in principle suitable for application of low-temperature, all-electric IES solutions, based on a combination of heat pumps, solar energy and/or a ground-source energy

[22] This relates mainly to the building types that are used for client housing, while some of the buildings with another function the thermal performance is more heterogenic.

storage system (ATES/BTES). As such e conclude that – aside from regular maintenance on the building envelope – the bulk of the future IES investments may focus on energy installations. In Section 12.4 we explored the potential of a range of different energy systems, including solar (PV, PV-t), heat pumps, ATES/BTES systems. Some technical options, like aqua thermal energy from surface water were considered as not realistic (see ***Annex 9. Initial assessment of technical options for Vries site***).

At the Visio case study site in Vries, The Netherlands we conclude there is potential for both building specific IES approaches (Concept 1), as well as collective IES solutions that link a subset of buildings to one interconnected energy system (Concepts 2 and 3). See ***Annex 10. Three IES concepts for Royal Visio in Vries*** for more details.

Some of the (dis)advantages of a building-specific (e.g., phased smaller investments) versus a collective (one-off large investment) IES approach are discussed in Section 12.4.

For the Vries site a more advanced/detailed techno-economic assessment would be needed to validate the feasibility of all three concepts. Particularly, for Concepts 2 and 3, which involve more ground works on the site, there could either be significant barriers (e.g. permitting, competing energy/water grids) that could limit their feasibility. At the same time, any ground works that are already foreseen on existing underground infrastructure (e.g. water, energy grids, data) or roads/pavement, could also provide an opportunity for the implementation of a local mini heat grid in Concepts 2 and 3.

We provide an indicative economic assessment of Concepts 1 and 2, relative to a gas boiler investment. From this we conclude that within the economic evaluation also any potential (future) energy price changes are considered as well as any financial incentives (e.g., fiscal discounts or subsidies). Here it will be relevant to have sufficient knowledge of the different financial incentives for both building specific versus collective IES solutions as they may differ.

With respect to financing IES investments we explore several options, ranging from own-funds, bank loans, financial/operational lease, renting to crowd-/community funding (see also ***Annex 12. Trends and options in health care real estate finance***).

We conclude that – given that we anticipate that the bulk of the energy and CO_2 saving investments will be on energy installations – for the Vries site there is scope for attracting external investors or project developers (e.g., ESCO, local energy cooperative) that could provide energy services via rent, lease contracts of with the help of crowd-/community funding via a local energy cooperative.

While Visio has a strong preference to keep full ownership and control of their real estate, the option to attract third party investments for the energy installations/services could become relevant. For example, in a scenario where it will be challenging for Visio to fully self-finance the required investments for upgrading all buildings in their real estate portfolio by 2050. Within Visio's building portfolio, the Vries site would be one of the few locations where an investment in a collective IES system (Concepts 2 and 3) via a third-party investor may be possible.

- Especially for the Vries site, we recommend that Visio (together with its technical partners), performs technical (feasibility) assessment for IES systems both at the level of individual buildings, as well as for all the buildings or groups of buildings at the site. For the energy system design this could mean that a mini-heating grid with an ATES/BTES system may be favoured over a building-specific approach, either for ease-of-maintenance reasons or investment purposes (e.g., in case of a third-party investor providing heating services). Similarly, there could be some techno-economic advantages for setting up a larger scale on-site solar pv project relative to several smaller rooftop pv mini projects for individual buildings. For example, the existing on-site electricity connection could be large enough to host a single larger rooftop pv project or a larger ground-mounted pv park. This may limit the installation costs and may facilitate the application for a specific subsidy (e.g., ISDE).

- For the Vries site we recommend that Visio does not ex-ante exclude the option of a third-party investment in an on-site collective energy (for heating/cooling or electricity) system. We also recommend Visio ensures that in their IES investment planning it keeps up to date with the latest changes in the financial incentive schemes. This can be ensured through the assistance of Visio technical and consulting partners but can also be supported through inventory assessments made by interns/students (e.g., real estate investment/finance internships) at the Facility Services departments.

13. Conclusions and recommendations

In this report, seven case studies in Poland and the Netherlands have been analysed to identify key conditions for successful implementation of IES solutions in existing buildings. The case studies explored for potential IES options what would be potentially feasible combinations of clean energy technologies for each building. A prominent aspect of the case study analysis has been how IES options can be aligned with stakeholders' preferences, such as building comfort, fitting in longer term building or government sustainability visions, *etc*. Spijker, et al. (2020) already elaborated that for successful implementation, IES solutions need to be technically feasible, financially viable and acceptable from a societal and organisational perspective. The case studies have shed more light on how each criterion adds weight to decision making for individual building and building portfolio retrofit projects.

Annex 6 summarises the IES assessment for each case study in this report, by identifying obstacles and opportunities for suggested solutions from a technical, financial, and participatory perspective. In all case studies several **technical** opportunities for IES have come to the fore, such as:

- Using IES enhances efficient use of solar PV systems, heat pumps and existing heating systems,
- IES opportunities could be strengthened by establishing technical connections between buildings, so that one building's energy demand can be met by surplus energy supply by another adjacent building, or nearby space (e.g., a park) is available for BTES, and
- Energy efficiency improvements are being undertaken or planned in several of the case study buildings, such as replacing metering equipment, and insulation of outer walls and ceilings.

Where technical obstacles or barriers have been identified in the case studies, these are often related to:

- A lack of or insufficient energy metering equipment or data on the thermal performance of buildings,
- The need to replace the internal heating and DHW installations in the building,
- A lack of space at and around the building for storing pellets for the sustainable heat component of an IES solution,
- A lack of space at and around building to install deep boreholes,
- A building's rooftop being insufficiently strong for carrying the weight of the solar PV panels required for IES, and
- A lack of systematic collection of data on buildings and energy performance.
- Increasing shortages in availability of skilled labour (builders, installers), and relevant components and materials.

From a **financial perspective**, particularly the Polish case studies, but also the Visio case study in the Netherlands, identified some financial obstacles for IES, such as:

- the discouraging effect of the changing legal and policy environment for different incentive schemes, such as solar PV exploitation on the attractiveness of the prosumer system, making investments in solar PV systems less attractive for building owners,
- the lack of funding (or access to funding) for case study building owners to invest in relatively expensive IES options together with necessary thermo-renovation measures, for which, in most case studies, payback times of over 10 years have been calculated. This obstacle has recently increased due to the strong increase in the price of IES as well as energy efficiency equipment and in personnel costs related to installing IES and energy efficiency measures,
- low profitability (poor payback periods) of deepening thermal modernization to the standards

of a low-energy building in buildings that were insulated few years ago.

At the same time, both Polish and Dutch case studies, based on co-creation findings, illustrate how the recent energy price increases have triggered interest of building owners and users in investing in energy efficiency measures. Not only does this reduce energy costs in the short run, considering higher energy prices in the longer run also shortens the payback time for energy improvement investments, such as IES. In particular, in the Polish case studies this would still require clearing the obstacle that investments require capital availability in the short run.

From a **legal perspective**, particularly the Polish case studies identified some obstacles for IES, such as:

- practically there is no possibility to install wind farms onshore despite favourable wind conditions,
- hindered construction of PV installations and limitation of the scope of IES and thermal modernization of historic buildings, and
- long and complicated permitting procedures in case of deep boreholes.

The case studies also have provided a wide range of **organisational and stakeholder-related aspects** that could stand in the way of successful IES implementation. For example, for the Dutch case studies it can be concluded that while the technical and financial obstacles are there, they are often considered solvable and rather easily outweighed by technical and financial opportunities, organisational bottlenecks could seriously hamper implementation of IES solutions. For example,

- In one case study, where a municipality is the building owner, it is not yet clear how the municipality's carbon neutral vision will be implemented in the building. As a result, the need for investment in (IES) energy improvement is driven by the technical depreciation rate of the equipment. Moreover, the building owners, management and administration that is responsible for reimbursing energy costs are different, loosely connected, stakeholders, so that a common urgency to upgrade the energy system towards a more sustainable and lower-cost system, could be lacking.
- In one of the Dutch case studies, sustainability is an overarching goal to be achieved in the longer term, but the staff and resources for implementing this vision are insufficient.
- In one Dutch case study, the organisation is responsible for managing a sizeable building portfolio across the country, which results in a highly complex stakeholder environment, which requires the organisation to interact with many local stakeholders. These interdependencies are a key contributor to inertia in the decision-making process.
- In another case study, unclarity about the long-term (i.e., 10-year) planning for the building prevents present management from taking energy improvement measures with a payback time of more than ten years, which possibly prohibits current IES investments that could otherwise have supported sustainable, low-carbon energy efficiency improvements.
- In one of the Polish case studies, it was highlighted that IES would require a common decision making instead of each homeowner associations having to take individual solutions.

Generally, the case studies have shown that, while often substantial, finance and technology-related challenges are often solvable, but require early-on involvement/inclusion of relevant (external) expertise for coherent, integrated planning. Moreover, building specific IES solutions in multi-stakeholder contexts are relatively easy to implement as the building context and preferred solutions are generally homogenous. Instead, when considering IES solutions for a more heterogenous real-estate building portfolio, such as in the Dutch case study for multiple health care buildings, more heterogenous technology packages and finance solutions are required, which can easily lead to a quickly growing information and data intensity and emerging micro-management, rather than overarching guidance and decision-making.

In terms of participatory opportunities, both Polish and Dutch case studies have explored, with stakeholders, the benefits of collaboration between buildings and their owners. In the Polish multifamily buildings and the primary school and kindergarten cases, the option of establishing energy cooperatives has been highlighted as a solution to supply renovated settlements of buildings with RES from PV farms and use of building-level heat pumps. In the Dutch case studies, it has been explored how reaching out to neighbours or adjacent parks and districts could strengthen the potential for IES, as it could help collectively produce, store, and distribute energy produced via IES, and strengthen the business model for that. Finally, both in the Polish and Dutch case studies, it has been found that stakeholders in general are (increasingly) aware of the benefits of energy system improvement and several case studies also experienced that building management has been receptive to suggested improvements, to be even carried out in the short term, albeit not all directly related to IES.

The case studies in Poland and the Netherlands have demonstrated how the planning and (preparing for) implementation of IES would be supported by undertaking the following co-creation steps:

1. **Scoping co-creation meeting** with key stakeholders on the status of the building, including its energy system, and plans and priorities for improvement, whereby preferred improvements may not always directly relate to energy issues, but sustainable energy solutions may nevertheless contribute to solving these.
2. Conduct a **technical assessment** of the building and its energy system, in terms of quality of the building envelope, the HVAC system, hot water provision, metering equipment and electricity supply. This assessment forms a starting point for identifying technical solutions, including of IES options.
3. Provide **concise information** to residents and/or building users on potential energy options, for awareness raising and supporting stakeholders in taking well-informed decisions.
4. **Technically and financially assess** suggested improvements, in terms of initial capital requirements and payback times, as well as an indication of the possibilities for **obtaining financial support**. This could result in a list of investment to be done in the short term and those that are more feasible in the longer term, such as most IES. It is important to observe the consistency between short- and long-term investments, so that short-term investments are not to be replaced in the longer term but could be integrated into long-term solutions. For example, the flexible ceiling in a Dutch case study as a short-term energy saving measure could be designed in such a way that its components can be reused in a longer-term solution for the building.
5. Defining **forms of stakeholder cooperation** for investment implementation, including collaboration with adjacent buildings who partake in the IES solution and energy cooperatives.
6. Prepare for project **implementation**, including a financially viable business model.

Analysis of cases where integrated energy systems are implemented leads to following policy recommendations:

1. **Stability of the national energy policy** is a strong facilitating factor. In Poland, changes in energy policies, especially in phasing out fossil fuels, have destabilised markets for investors, technology, and material suppliers. For instance, the introduction of the prosumer net-metering scheme in Poland enabled phasing-out fossil-fuelled boilers in semi-urban areas and in the countryside, leading to a growing interest among end-users of all sectors, including

from the supply side to deliver IES. However, since April 2022 the prosumer scheme has been downgraded from net-metering to net-billing, which has reduced the feasibility of IES for residential customers. Additionally, financing of renovation with IES of residential and public buildings is not clear for the coming years in Poland.

2. Implementation of IES becomes more effective if accompanied by support for thermo-modernisation activities (if justified). Otherwise, the efficiency of IES will be lower or the investment is unprofitable. Therefore, financial incentives would better focus on supporting both areas (IES and retrofitting).
3. It is recommended to create one-stop-shops to facilitate end-users in finding comprehensive information, energy consulting and receiving substantive and organizational support for energy efficiency and IES projects.

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Annex 1. Financial and other incentives for IES in Poland

Financial instruments supporting investments in energy efficiency improvement and renewable energy sources are characterised by periodicity, variability, and uncertainty in obtaining financial support. However, the interest in all forms of support is high. The following are available and planned special financing and other incentives in order to convert fossil supply systems to renewable, integrated energy supply systems for houses in Poland:

Prosumers – system valid until 31 March 2022

Housing associations can become a prosumer of renewable energy. A renewable energy prosumer, in accordance with the Renewable Energy Sources Act, is an entity that meets the following conditions:

- produces electricity only from renewable energy sources in micro-installations for its own needs,
- is the end user, i.e., does not use energy for the purposes of generating, transmitting or distributing electricity,
- purchases electricity on the basis of a comprehensive agreement, and
- electricity generation is not a prevailing business activity.

Micro-installation in this case implies installation of renewable energy source with a total installed electrical capacity not exceeding 50 kW. Owners of micro-installations are exempted from connection fees. The distribution system operator (DSO) is responsible for the installation of a bidirectional meter and security measures.

Renewable energy prosumers have the option of balancing the energy consumed with the energy fed into the grid. In case of installations above 10 kW, the quantitative coefficient necessary for billing is 0.7 kWh (energy consumed) for each 1 kWh fed into the grid.

The figure below illustrates the principle of prosumer net-metering.

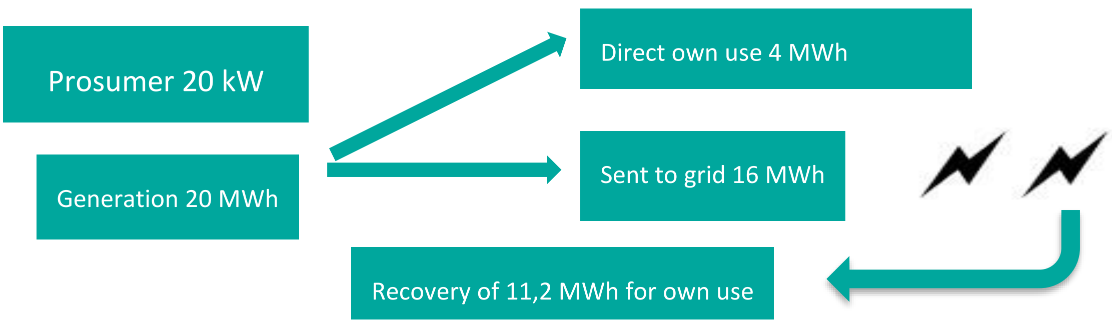


Figure A-1-1. Prosumer scheme – net-metering (70% recovered)

Source: BAPE's own study

Prosumers – system valid from 1 April 2022

According to an amendment to RES Act adopted on 2 December 2021, net-metering will be replaced with a system of selling surplus electricity from photovoltaics (net-billing) at an average price from the last month on the day ahead market. However only 20% of the prosumer deposit for each month could be recovered in future months. The new system will extend the return on investment by over 30%. The new billing system should, on the one hand, discourage prosumers from oversizing their installations and, on the other hand, stimulate self-consumption by installing energy storage.

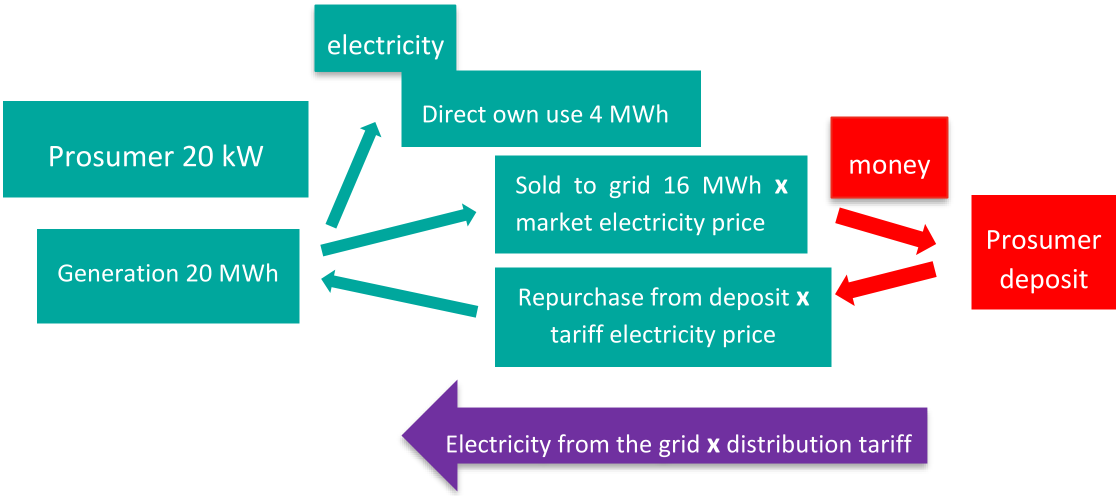


Figure A-1-2. Prosumer scheme – net-billing

Source: BAPE's own study

RES Loan from the Regional Operational Program for Pomerania Voivodship 2014-2020

The loan supports projects in RES situated in the Pomerania Voivodeship. A loan on preferential terms is available for entrepreneurs, local government units, organisations conducting economic activity including housing associations. The loans budget is ca 13 million Euro (57 million PLN). A preferential interest rate (from 0,25%) is available for investors who meet the preference criteria with *de minimis* aid or aid provided for in Articles 40, 41 and 49 of GBER (General Block Exemption Regulation). The maximum renewable energy loan amount is ca. 3,5 million Euro (15 million PLN) with a repayment period of up to 15 years. More info can be found at: www.pfp.gda.pl

My Power (Mój Prąd)

The programme Mój Prąd has been implemented by the National Fund for Environmental Protection and Water Management and has already had three editions. It supports investments in PV installations with a capacity of 2-10 kW electricity generation for the needs of individual households. The interest in this programme was so high that the funds allocated for this purpose were exhausted in October 2021. The fourth edition of the programme began in April 2022 and it is going to be opened until the end of the year or until the funds run out. This new edition supports investments in PV installations with energy storage. Unfortunately, such solutions are still unavailable for multi-family buildings as in the case studies discussed in this report.

Clean Air (Czyste powietrze)

The Polish National Fund for Environmental Protection and Water Management has, through Regional Funds, been operating the "Clean Air" programme for a few years, which targets single family building owners to replace heat sources and insulate houses. The scheme has been recently modified to support thermal renovation of buildings with implementation of integrated own PV installations and heat pumps.

The scheme allows for the phasing-out of coal and reduction of local pollution and GHG emissions. A similar scheme is planned to be introduced for multifamily buildings. However, as in My Power, such solutions are still unavailable for multi-family buildings.

More info can be found at: https://bape.com.pl/wp-content/uploads/2022/02/1_2-Finasowanie-modernizacji-energetycznej-w-budownictwie-WFO%C5%9A-MLeszczy%C5%84ski.pdf (in Polish)

Warm flat (Ciepłe mieszkanie)

The National Fund for Environmental Protection and Water Management plans to support housing associations and housing cooperatives in the second half of 2022. The fund will support installations that will eliminate individual ineffective heat sources for solid fuels such as:

- condensing gas boiler,
- electric heating,
- air/water or air/air heat pumps, and
- connection to a common effective source.

Additionally, the support can be offered for:

- internal central heating and hot tap water installation and gas installation from the gas connection to boiler,
- replacement of windows or doors separating premises from the staircase, unheated space, or external environment (dismantling included), and
- mechanical ventilation with heat recovery (ventilation with an air handling unit and recuperator).

In case of modernisation of multi-family buildings, especially those located in non-urban areas, which are currently not equipped with central heating and hot tap water installations, the possibility of obtaining funds for internal installations will be very important.

The Voivod Fund for Environmental Protection and Water Management in Gdańsk

This regional fund grants loans of up to 80% of the eligible costs. Beneficiaries may include housing cooperatives and associations, local government units, entrepreneurs, *etc*. The funds are intended for heat source replacement and thermal modernisation.

Financing in Pomerania Voivodship in 2021-2027

The activities planned in the regional energy sector are reflected in *European Funds for Pomerania 2021-2027 (FEP)*. As per March 2022, the scope of assistance is at the stage of arrangements with relevant institutions. In total, FEP 2021-2027 funds will amount to EUR 1,674,092,590.

Measures to improve energy efficiency will include following investments:

- comprehensive thermal modernisation projects, including adaptation of buildings to the requirements for zero- and plus-energy buildings,
- development of energy management systems in buildings or internal lighting reducing power consumption, and
- replacement of individual heat sources using solid fuels (boilers or stoves) in multi-family or public buildings with low-emission sources, primarily renewable energy sources and connection to municipal heating network.

In terms of renewable energy sources, it is planned to support:

- construction and expansion of RES, including energy storages with particular emphasis on distributed prosumer energy, including connection of RES to power grid or heating networks,

- organization and construction of energy islands, and
- organization and construction of energy clusters, energy cooperatives and energy communities operating in the field of renewable energy.

Regulatory and market data has been collected and analysed, including trends in electricity and fossil fuel prices at the markets and for end-users, incentives supporting energy efficiency measures and renewable sources in public sector as well as residential, commercial and industrial sectors. Furthermore, regulatory and market data (including trends in electricity and fossil fuels prices at the markets and for end-users, incentives supporting energy efficiency measures and renewable sources in public sector as well as residential, commercial, and industrial sectors) were collected and analysed.

As previously mentioned, also in the case study analysis and concluding chapter **Error! Reference source not found.**, the legal environment (constituting the basis for IES implementation) changes too frequently because of changes in country's energy policy. A classic example is the policy towards investments in wind turbines. Until 2016 this RES sector was growing rapidly when sudden drastic changes in national regulations were introduced which has led to a complete paralysis of the wind energy industry nowadays. On the other hand, the situation on the electricity and natural gas market in Poland, where prices are rising drastically as per Spring-Summer 2022, seems to be contributing to positive changes in the approach to RES, including IES.

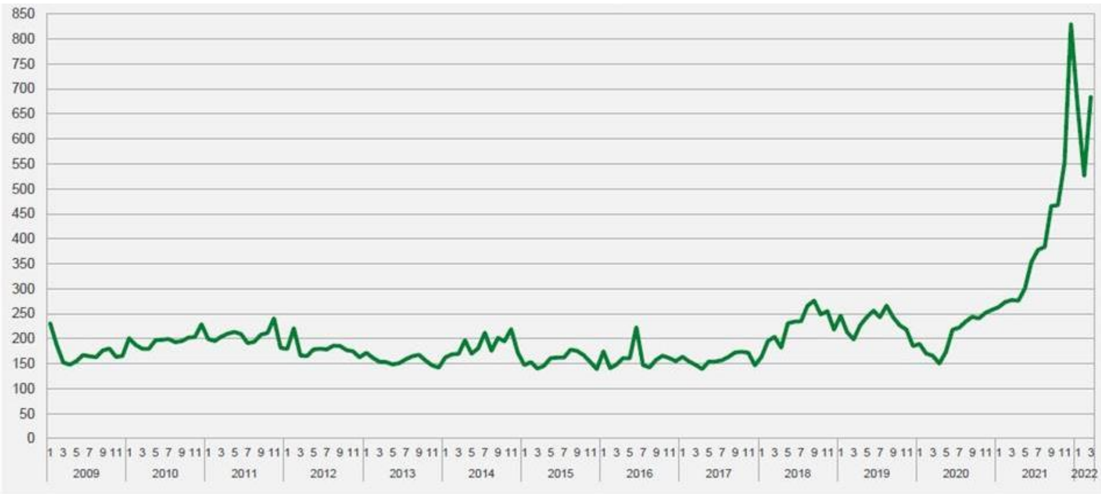


Figure A-1-3. Monthly weighted average energy prices (PLN/MWh)

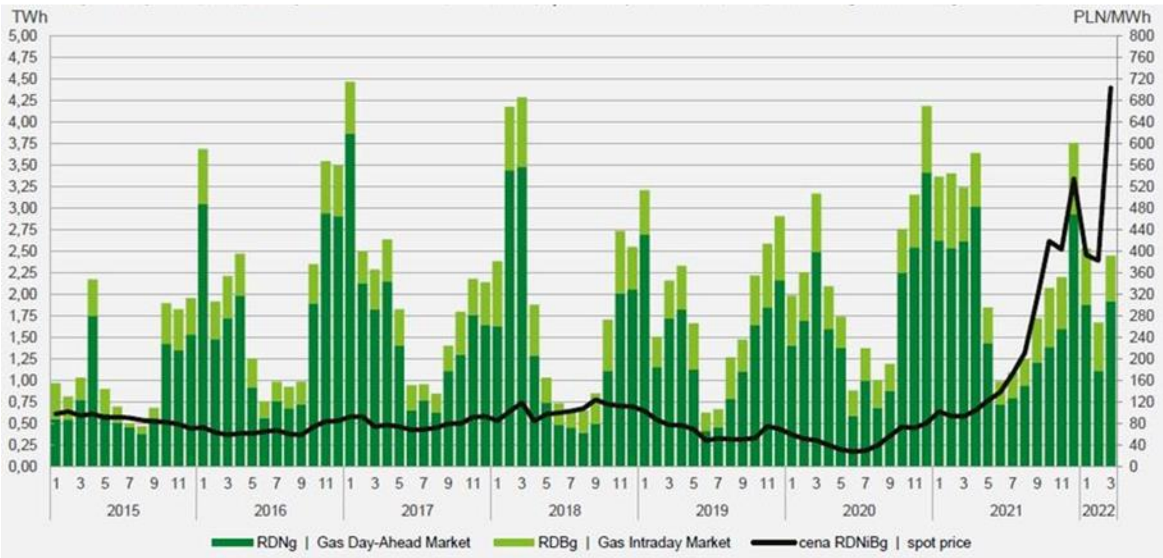


Figure A-1-4. Changing electricity and natural gas prices in Poland (PLN/MWh)

However, high inflation currently places investors in a difficult decision-making position, especially when it comes to repayable financing instruments. Further development of IES depends on clearly defined priorities for energy transformation, prices stability in labour and supply market as well as legal solutions facilitating implementation of investments.

Annex 2. CCZ - Heating-ventilation-air-conditioning system

In Chapter 10, the case study of the building Cultureel Centrum Zuidhorn (CCZ) has been analysed in detail. In the technical assessment of the current energy performance of the building, a detailed analysed has been performed of the operational system for heating, ventilation, and air-conditioning. The individual elements are elaborated on below.

Ventilation

Table A-2-1: Ventilation system CCZ

Parameter	Sub	Value
Short description	Building	Balanced ventilation system with mechanical supply and mechanical return air flows. Air supplied through central AHU with heat recovery. Capacity based on 100% fresh air. Separate systems for exhaust of toilets and storage. Supply air and return air through ceiling diffusers in the user spaces. AHU positioned in an enclosed technical room near the roof/
Ventilation Capacity	AHU	7,000 m^3/h supply;
	Exhaust toilets	Tbd
	Exhaust panty/storage	Tbd
Central systems	AHU	- Thermal wheel - Heating battery with frost protection - Cooling battery - Fresh air supply filter - Return air filter - Constant volume fans
	Fancoils	- Heating battery - Cooling battery - Fan
	Fans	- Constant / variable flow
Distribution	Description	Supply air ducts partially exposed on roof; partially indoors. Distribution through central corridors with noise damping components supplying room take-offs.
	Quality	Supply air insulated with 35 mm mineral wool. Return ducts not insulated. Air tightness (LUKA class) unknown.
End systems	Diffusers	Ceiling or wall diffusers, providing mixing ventilation from high level. In some location high level return air diffusers, in some location overflow with acoustic damping.
	Fan coil units	Wall units including fan for recirculating room air and cooling battery.

Figure A-2-1. Ducts on the roof; view of air handling unit in technical room.

Figure A-2-2. Noise damping return air plates; ceiling of double high library.

Heating

Table A-2-2. Heating system

Parameter	Sub	Value
Short description	Building	Two gas boilers are generating the heat. The heated water is transported to the battery of the AHU, radiators and floor heating.
Heating capacity	Gas boilers	101 kW total.

Central systems	Gas boilers HR 107	- 1 x Remeha Quinta 65: 61 kW per boiler - 1 x Remeha Quinta 45: 40 kW per boiler - Cascade set up
	AHU	- Heating battery
Distribution	Water	- Short-circuit pipe - Transport pump
	Air	- Preheated air is distributed
End systems	Radiators	- Set point temperature based on outdoor temperature - Thermostatic valve
	Underfloor heating	- Stand alone control, - 2-way valve module - Pump for heat mixing system

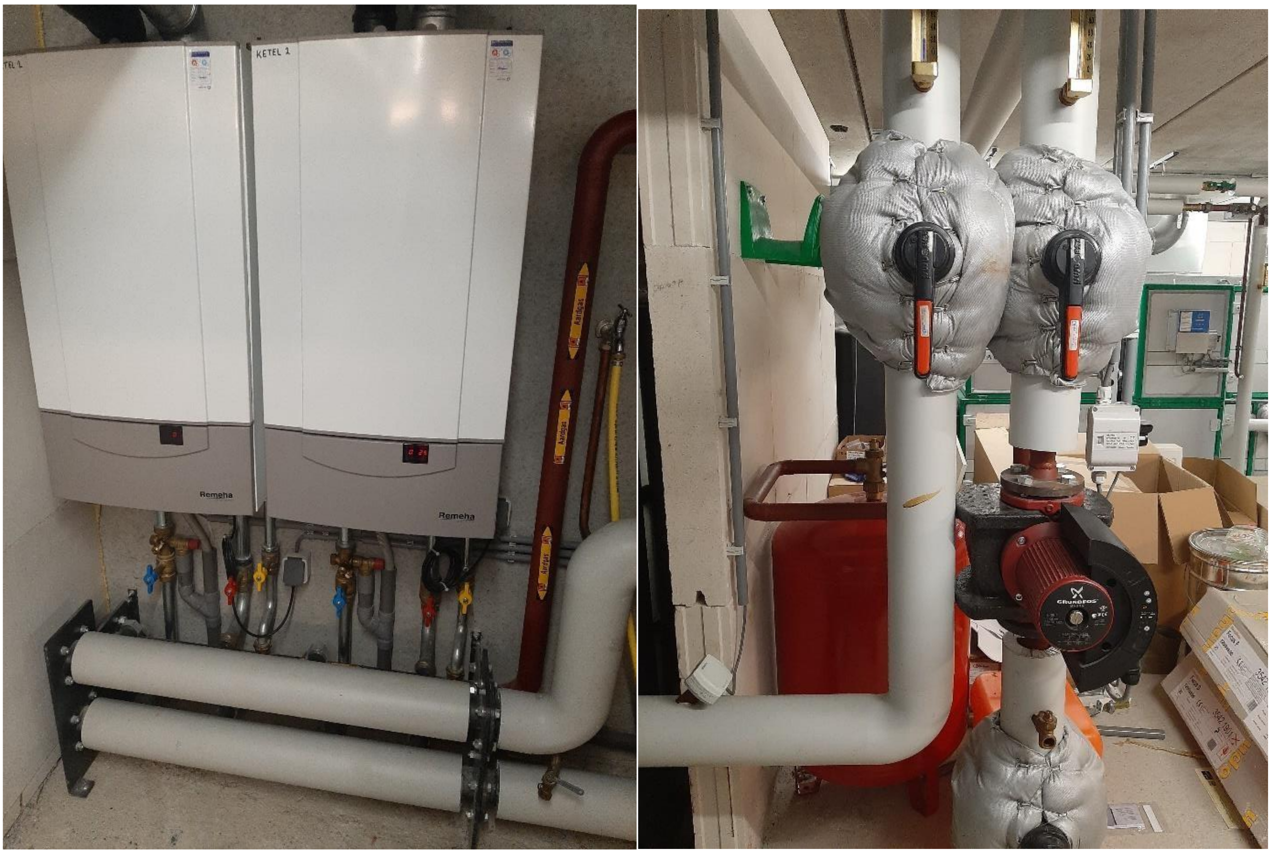


Figure A-2-3. Gas fired boilers, valves in distribution.

Cooling

Table A-2-3. Cooling system

Parameter	Sub	Value
Short description	Building	The chiller situated on the roof generates the cooling. From there the cooling is transported to the AHU cooling battery, local duct coils in supply air duct for the ground floor and fancoil units placed on the

		first floor.
Cooling capacity	Chiller	42.3 kW
Central systems	Chiller with 2 scroll compressors	- Type: GEA (0182) noise optimised model - Refrigerant = R 410A - Power consumption = 17.0 kW - ESEER = 3.93
	AHU	- Cooling battery
Distribution	Water	- Distribution pump
	Air	- Top cooling via cold air grille
End systems	Fan coil units	- 2- way valve module
	Duct coils	- 3-way valve module (overstort)

Figure A-2-4. Wall fan coil unit in south facing office

Renewable nergy systems

The building has multiple PV panels installed. The panels are divided into two areas. Panels are positioned in a ventilated setup on the roof with an approximate angle of 5-10°. Orientation of the panels is SSE. Inverters are positioned in the technical room on the roof.

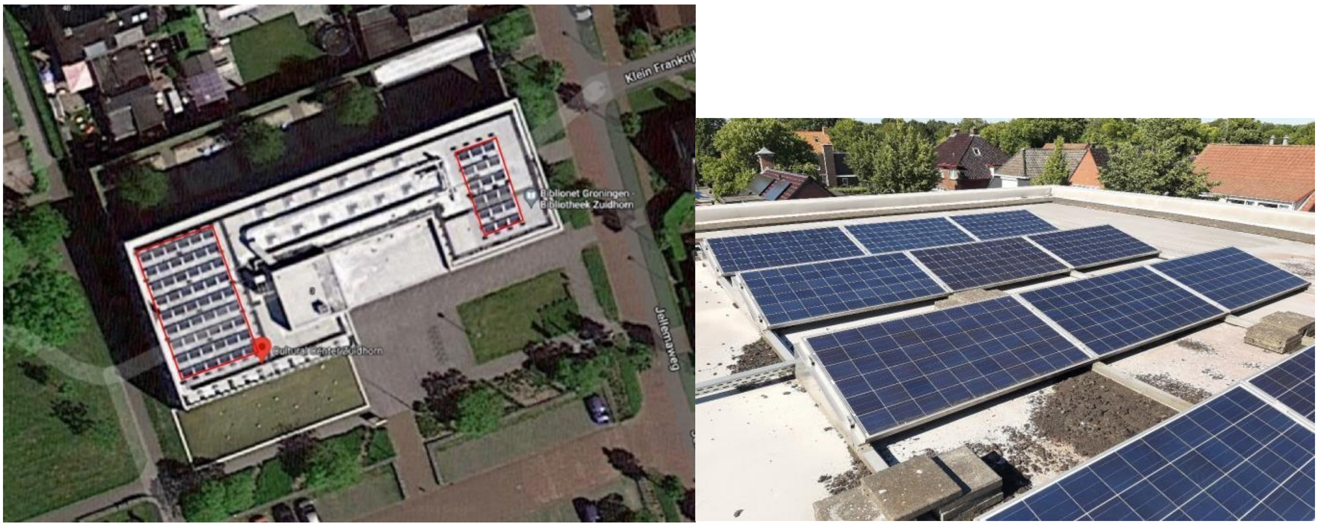


Figure A-2-5. Top view of building; showing PV panels; roof view of PV panels

Figure A-2-6. Inverters in technical room

Building control & monitoring

The software and hardware of the installed building management system (BMS) is developed by Priva, which is a commonly used BMS in the Netherlands and can be compared to for example Schneider. The fan setup in the BMS is different than on the schematics, which show the correct situation. With the setup as seen on the schematic the fans are correctly installed considering air leakages in the thermal wheel. However, as leakages in the thermal wheel are still possible, it is recommended that, during the replacement of components in the air-handling unit, the possible leakages are considered. For example, when replacing the ventilators, the pressure drops over the wheel can be measured this will give insight on the potential leakage of return air to the supply side.

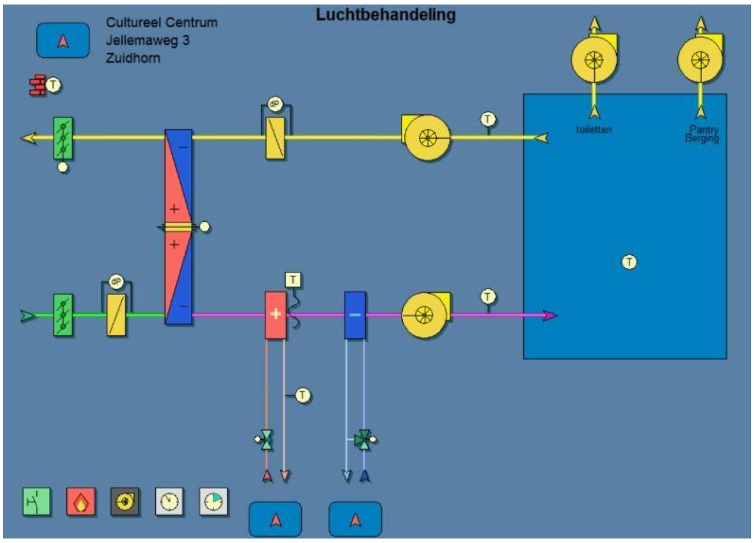


Figure A-2-7. BMS schematic overview of the AHU

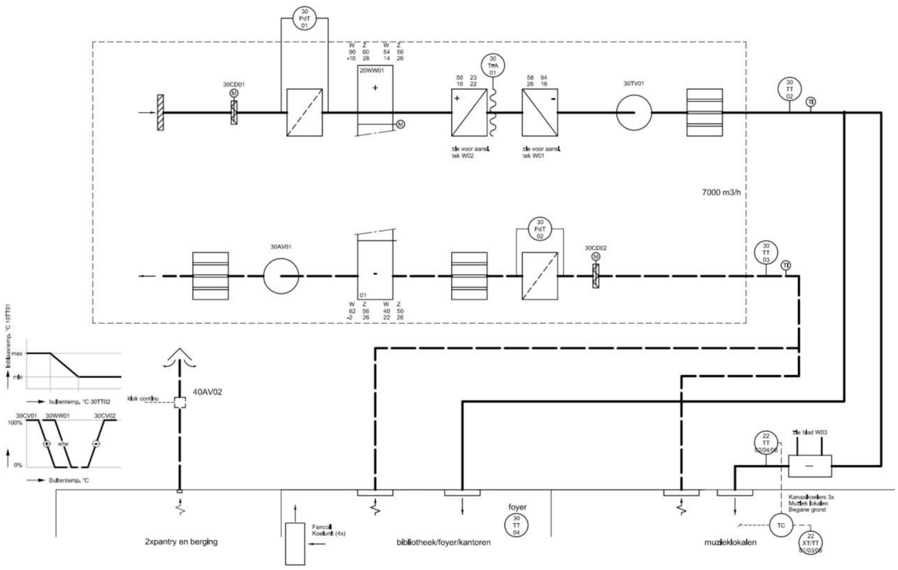


Figure A-2-8. Drawing schematic overview of the air-handling unit, the correct setup.

Heating and cooling system

Below, the two boilers are shown (left); on the right the different heating groups are shown.

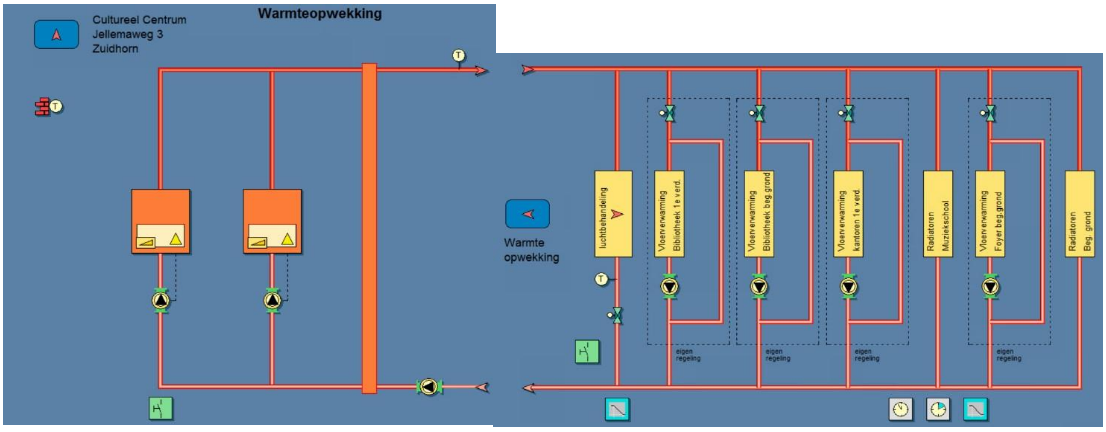


Figure A-2-9. Overview of the heating system

The cooling system is in the diagram below:

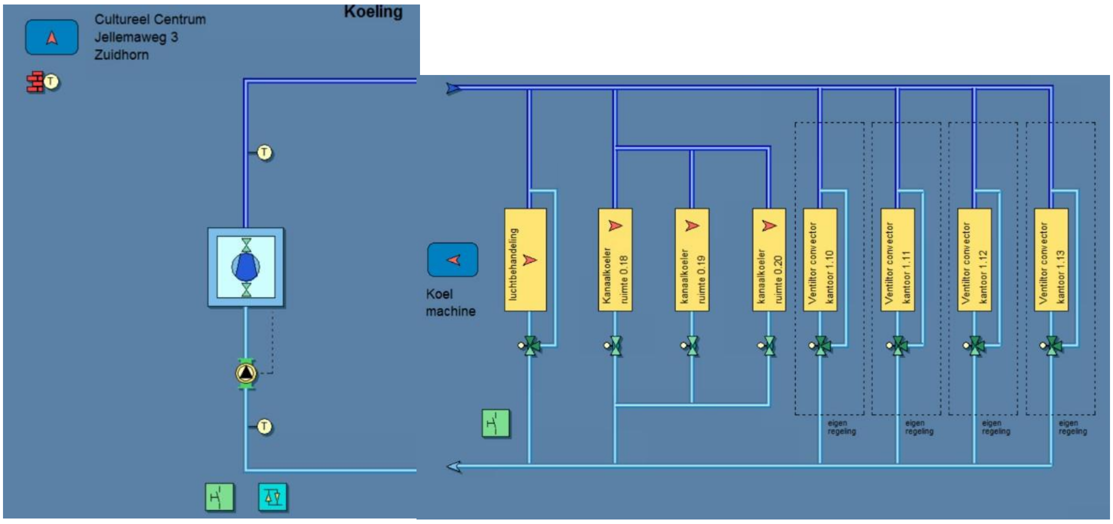


Figure A-2-10. Overview of the cooling system

Table A-2-4. Performance control

System	Subsystem	Monitoring parameters	Signalling / setpoint	System check and alarm
Air handling unit	Ventilators	Pressure differential over filter	Ventilator switched on / off (based on schedule)	Alarm when pressure over the filter drops below a set value
	Thermal wheel	Inlet Temperature	PI controller (percentage rotation wheel) based on inlet temperature	Alarm when the wheel disfunctions

	Heating battery	Inlet Temperature	PI controller 2-way (percentage opening valve)	Alarm when return water temperature is below a set value
	Cooling battery	Inlet Temperature	PI controller 3-way valve (percentage opening valve)	No alarm
\Heating system	Gas boilers	Outdoor Temperature	Heating curve, based on outdoor temperature.	Alarm when boiler disfunctions
	Floor heating	Standalone room temperature	No signal	No alarm
	Radiator	Thermostatic valve	No signal	No alarm
Cooling system	Chiller	Chilled water temperature supply and return	Setpoint chilled water Supply	Alarm when chiller disfunctions
	Duct coil	Standalone room temperature	PI controller 2-way (percentage opening valve)	No alarm
	Fan coil	Inlet room temperature (local measurement)	PI controller 3-way valve (percentage opening valve)	No alarm

In the figure below, the categories are shown on how the data is reported and communicated It is possible to reset the operation schedule to holiday and control the periodic pump settings.

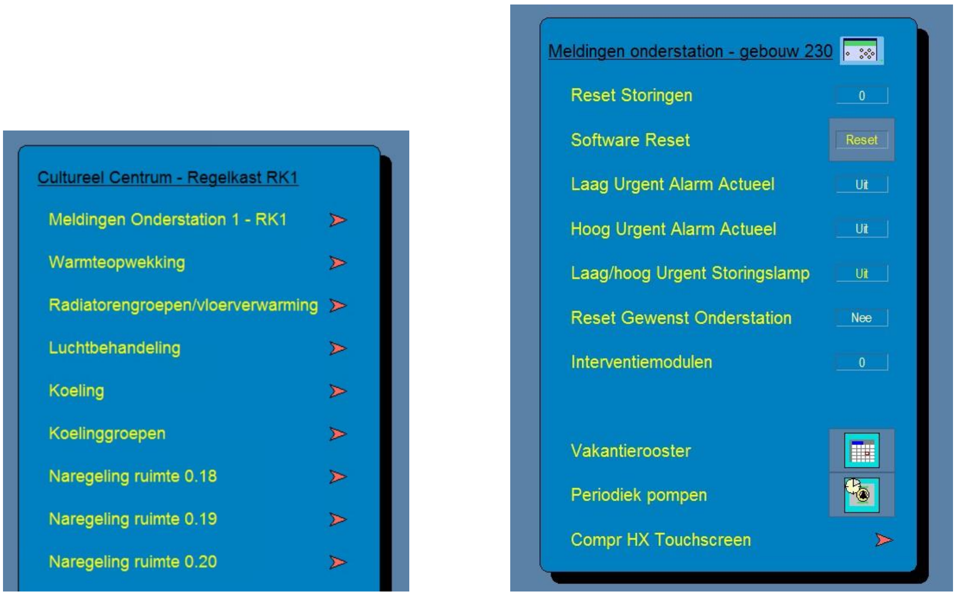


Figure A-2-11. Reporting and control in BMS

Annex 3. Data gaps in energy performance analysis case study CCZ

Category	Data gap	Impact
Financial performance	No full overviews of energy costs; no information on building maintenance cost or long-term maintenance planning. No information on social costs for illness as result of deemed low quality air- or thermal quality.	Unclear where opportunities are for smart and integral investments and how these can benefit the users.
User behaviour	Limited information available on user occupancy and behaviour	Unclear if experience of low air quality is related to system or use.
Thermal skin	Quality of thermal skin could only be determined high level, no measured data available e.g., for airtightness and thermal quality.	Uncertainty about the quality and therefore improvement methods difficult to propose.
HVAC systems	No measurement reports available on e.g., actual airflows and actual system flows for CHW and LTHW.	Unclear if systems perform as designed.
Electrical systems	No information available of the electrical systems in the building (lighting; energy use per LV cabinet; details of PV system).	Unknown how the distribution of electrical energy is within the building.
BMS data	Historic data in the BMS only includes the past 4 days, therefore a full annual performance is missing. Temperature sensors are placed in a small number of spaces with limited measurement parameters.	Unclear if how the thermal comfort related complaints relate to the building use, skin, or system performance.
Energy	No hourly energy data available from gas- and electricity meters	Unclear how annual energy relates to daily or seasonal changes in use.

Annex 4. List of measures recommended for energy performance case study CCZ

Timeframe	Type	Title	Steps	Res4Build category	Necessity	Who to implement?
1. Short term	Analysis	Electrical	Contract electrical installer to review performance of PV panels and to propose optimisation of lighting system.	Co-design	Minimum	Municipality
1. Short term	Analysis	EP	Perform Energy Performance Assessment for the building, based on initial EPC and input used in current NTA8800 methodology	Tools	Minimum	Municipality
1. Short term	Control & Measurement	Additional sensors	Gain knowledge of the buildings behaviour by expanding measurements of indoor comfort. 4. Temperature measurements in working spaces. 5. Indoor Air Quality: CO_2 and Relative Humidity (RH) measurements in the working spaces.	Components	Added value	Installer
1. Short term	Control & Measurement	Sensors in all rooms	Expand measurement points to all functional rooms in the building and log the results on annual basis in the BMS.	Components	Added value	Installer
1. Short term	Control & Measurement	Dynamic monitoring & control	Enhance performance of current systems by analysing their integral functionality through automated analysis in combination with static and visual review. Implementation of an energy monitoring system (EBS - Energie BewakingsSysteem). The EBS is part of the Erkende Maatregelen, a list drafted by the RVO and shows mandatory measures (since the return of investment is within 5 years). The EBS can be coupled on the digital meters. It is recommended to connect the PV inverters to the EBS as well.	Tools	Added value	Installer / automated, see further.
1. Short term	Control & Measurement	External sensors	Expand BMS with external parameters for proper control of indoor thermal comfort: CO_2, wind speed, irradiation and humidity.	Components	Minimum	Installer
1. Short term	Control & Measurement	Smart meters	Apply smart meter for electricity and gas to monitor hourly profiles and costs.	Components	Minimum	Utility company / installer
1. Short term	Management	Feedback	Provide feedback to the building users on design assumptions and current performance to enhance acceptance and involvement.	Co-design	Added value	SCCZ; supported by maintenance

						party / owner.
1. Short term	Management	LTMP	Retrieve long term maintenance plan to give insight in planned costs for maintenance and replacement and to find 'natural moments' for optimization.	Co-design	Minimum	Municipality
1. Short term	Management	Ambitions	Review assumptions on ambitions for the project: is the building complying with local goals and ambitions? Assess goals and convert to practical improvements steps for the building to reduce CO_2 emissions to 50% and finally to zero.	Co-design	Minimum	Building owner (municipality) and / or building users.
Timeframe	**Type**	**Title**	**Steps**	**Res4Build category**	**Necessity**	**Who to implement?**
2. Mid term	Analysis	Recom-missioning	(Re)commission the building to calibrate existing systems with the current use and quality ambitions. E.g.: a. Calculate the necessary heating and cooling capacity for specific rooms to achieve limited exceeding temperature hours (Possible with Vabi Elements). b. Redefine the ventilation distribution to the new lay-out and occupancy behaviour. c. Recalculate the volume flows of the heating and cooling installations to the new layout. d. Where relevant, make adjustment to existing system (adjusting airflows, water flows or providing additional components).	Co-design	Minimum	Installer
2. Mid term	Architectural	Façade	Add external shading to spaces oriented to the south façade in order to minimuze external gains.	Components	Added value	Municipality
2. Mid term	HVAC	Cooling	Local cooling systems are applied in a limited number of rooms: the gathering spaces on the ground floor and the offices behind the large facing window. Other spaces are cooled through the air handling unit, resulting in limited control. Air handling unit is controlled on space temperature in single room, could result in mismatch between demand and supply of cooling to the room. Provide addittional measures for local control on cooling and additional	Components	Added value	Municipality

			capacity			
2. Mid term	Management	As a service	Improve the incentive for the installer to optimise building system, by updating the current contract to a performance-based contract, also stimulating re-use and end-of-life aspects.	Co-design	Added value	Municipality
2. Mid term	Architectural	Façade	Analyze actual quality of thermal skin and review possibilities for enhancement, to reduce load on HVAC systems a) The window and frame properties: thickness of the double glass, the heat resistance Uvalue and solar heat gain ZTA value. b) Measurements of air/cold leakages (koude bruggen) in the façade (Infrared measurements during cold days can give insight on leakages in the window frames). c) The effects of the solar radiation in the workspace (for example infrared measurements of the floor temperature on a sunny day).	Analysis	Added value	Municipality
2. Mid term	HVAC	AHU	Adapt AHU with variable fan speed and control based on measured CO_2 levels in the rooms through sensors.	Components	Minimum	Municipality
2. Mid term	Lighting	LED	If relevant, replace current lighting with LED, controlled on daylight & presence.	Components	Minimum	Municipality
Timeframe	**Type**	**Title**	**Steps**	**Res4Build category**	**Necessity**	**Who to implement?**
3. Long term	Architectural	Insulation	Enhance insulation value of (minimum) roof and glass (secondary) façade. When enhancing insulation of roof; add green layer.	Components	Minimum	Municipality
3. Long term	HVAC	Boilers	The heating boilers are highly efficient, the lifespan of the boilers is around 15 years. In the coming years the boilers must be replaced.	Components	Minimum	Municipality
3. Long term	HVAC	Integrated Energy Solution	Plan for disconnecting from gas network: Replace boiler and chiller at the end of their lifespan with an innovative heatpump (at moment of replacement, optionally from the Res4Build program. Link the heatpump to a heatsource, such as a closed loop thermal storage system in the park nearby. Equip system with BTES controller to optimise performance on PV yield.	Components	Minimum	Municipality

Annex 5. Energy saving solutions for MartiniPlaza, incl. IES

Short term measures – Area in MartiniPlaza – The level of necessity – Responsibilities

Steps	Area of application	Necessity	Who
Insulation and placing new ceilings for the roof in the Foyer, via a building physics study to find solutions for correct insulation types and methods.	Theatre Foyer	Added value	Building owner
Placement of local heating systems, for example floor heating or include localised IR heating, can be placed in walls suited to the décor.	Theatre Foyer	Added value	Building owner and building users
Reuse of heating generated by the cooling units and freezers of the restaurant.	Restaurant	Added value	Building owner
Further development of the moveable ceiling for Expo 1 and measures for insulation of roof and walls.	Expo hall 1	Added value	Building owner
To identify the energy demand of the building and its different functions.	Building level	Minimally required	Building owner and / or building users & RES4BUILD
Mapping of the current controls in the building, to get a better understanding of the behaviour and possible improvements of the functioning.	Building level	Minimally required	Building owner (municipality) & RES4BUILD
Lower the supply temperature for heating distribution, preparing for future scenarios.	Building level	Minimally required	Building owner
Apply smart sub metering per building area (in progress).	Building level	Minimally required	Building owner
Further study on passive measures that can be applied: for example, using solar heat on the south façade via glass and greenhouse method, or reflecting solar heat by placing reflecting roof materials.	Building level	Added value	Building owner
Upgrading the sustainable maintenance plan with future energy scenarios.	Building level	Minimally required	Building owner / EQUANS
Contact maintenance company (EQUANS) for feasible sustainable energy generation strategies.	Building level	Added value	Building owner and EQUANS
Study on potential subsidies for measures that are applicable for the dimensions of MartiniPlaza.	Building level	Added value	Building owner and municipality

Identify business cases in which all parties are involved. In the case multiple scenarios are considered.	Martini Trade Park	Minimally required	Building owner, municipality and Trade Park community
Current development of contracting and sustainable role in the Trade Park future roadmap.	Martini Trade Park	Added value	Building owner, municipality, and Trade Park community
Prepare Martiniplaza's organisation for sustainable long term sustainable maintenance of the property. Refer to guidance as per ISSO 107, LCA and LCE approaches. Optional to include sustainability quality label (BREEAM organisation / In use)	Building level	Added value	Building owner
Discuss feasibility of the current CHP system and the long-term approach with the current service supplier	Building level	Minimally required	Building owner, EQUANS and Roukema

Medium-term measures – Area in MartiniPlaza – The level of necessity – Responsibilities

Steps	Area of application	Necessity	Who
Design and implementation of the movable ceiling system (in agreement with manufacturer)	Expo 1	Minimally required	Building owner
Study to optimise the controls of the building, hence the connection between smart metering, occupancy, and system generation optimizations.	Building level	Minimally required	Building owner
Connect the available subsidies to the chosen strategies as found during the short-term steps.	Building level	Minimally required	Building owner, EQUANS
Develop different sustainable energy generation solutions, conduct a study to provide the most suitable solution for the MartiniPlaza.	Building level	Minimally required	Building owner, municipality
Identify the possibilities for the sustainable roadmap of Martini Trade Park with Martiniplaza as energy supplier, for both electrical as heating and cooling.	Martini Trade Park	Added value	Building owner, municipality, and Trade Park community

Long term measures – Area in MartiniPlaza – The level of necessity – Responsibilities

Steps	Area of application	Necessity	Who
Implementation of smart building control strategies, based on the findings from the short and medium-term measures.	Building level	Added value	Building owner
Implementation of the new sustainable energy strategy for generation and distribution, possibly in collaboration with the Municipality and the Trade Park.	Building level and/ or Martini Trade Park	Added value	Building owner, municipality, and Trade Park community

Annex 6. Summary assessment case studies: technical, financial, and participatory

Table A-6-1. Challenges and opportunities for successful IES implementation

	Case study Poland 1: 4 multifamily buildings (Housing associations)					
Analysed IES solution	**Technical**	**IES challenge (-) or opportunity (+)**	**Financial**	**IES challenge (-) or opportunity (+)**	**stakeholders**	**IES challenge (-) or opportunity (+)**
decentralisation of the heat supply system by installation of heat pumps with deep boreholes in each building supported with rooftop PV systems	installations will require combining control systems into one integrated system to ensure efficient use of solar energy	+	changing legal environment, presently discouraging from prosumer system	-	difficult decision-making process by either each association or as one common project	-
	it is necessary to replace the internal heating and DHW installations in the building	-	there is no financing available for jointly implemented energy efficiency measures and RES	-	high awareness of stakeholders as to need of energy transformation	+
			payback time above 10 years	-	professional advice as to implementation of the project required	+ / -
			presently high inflation	-	establishing an energy cooperative might be a solution	+
			growing energy prices	+ / -		

	Case study Poland 2: Primary School and Kindergarten					
Analysed IES solution	**Technical**	**IES challenge (-) or opportunity (+)**	**Financial**	**IES challenge (-) or opportunity (+)**	**stakeholders**	**IES challenge (-) or opportunity (+)**
IES based on a heat pump and PV and combined control systems into one integrated system	heat in Palace is not metered and the building is not insulated	-	high heating costs	+	high awareness of stakeholder as to need of energy transformation	+
	heat consumption by the school can be considered low	+	presently high inflation	-	professional advice as to implementation of the project required	+ / -
	School heating system is suitable to be supplied from heat pumps	+	growing energy prices	+ / -	establishing an energy cooperative might be a solution	+
	controls of the heating loops require retrofitting	+				
	heating system is in good technical shape and does not require intervention	+				
	commune interest to extend the project by including Palace building	+				

	Case study Poland 3: Communal multifamily building in Mały Klincz					
Analysed IES solution	**Technical**	**IES challenge (-) or opportunity (+)**	**Financial**	**IES challenge (-) or opportunity (+)**	**stakeholders**	**IES challenge (-) or opportunity (+)**
lack of IES implementation, only PV installation for building own purposes was suggested	relatively easy technical solution	+	changed legal environment, presently discouraging from prosumer system	-	high awareness of stakeholders as to need of energy transformation	+
	Case study Poland 4: Industrial plant (company name confidential)					
Analysed IES solution	**Technical**	**IES challenge (-) or opportunity (+)**	**Financial**	**IES challenge (-) or opportunity (+)**	**stakeholders**	**IES challenge (-) or opportunity (+)**
IES of deep boreholes heat pumps and PV or wind turbine electricity generation	roof structure of weak construction cannot carry PV installation load	-	growing energy prices	+	The company management interested in greening of the production, open for innovations	+
	further energy efficiency measures undertaken to reduce energy demand	+	reasonable period of pay-back expected	+	present law does not allow for wind turbine; some positive changes foreseen	- / +
	energy management system planned to be implemented	+				

	Case study the Netherlands 1: Cultural Centre Zuidhorn					
Analysed IES solution	**Technical**	**IES challenge (-) or opportunity (+)**	**Financial**	**IES challenge (-) or opportunity (+)**	**stakeholders**	**IES challenge (-) or opportunity (+)**
Innovative heatpump, linked to heat source, e.g., closed loop thermal storage system	improve ventilation system for better comfort	+	current boiler and chiller have not yet reached end of lifetime	-	complaints about building energy performance not adequately addressed	-
	nearby park available for locating BTES	+	investment to be made by Municipality	+ / -	No clear link between municipality's carbon neutral vision and improvements in CCZ building	-
	Data on energy performance not systematically collected	-			Building maintenance and energy cost reimbursement are in different municipality departments (no incentive to energy saving)	-
	BTES controller to optimise PV yield (improve yield of currently underperforming rooftop panels)	+				

	Case study the Netherlands 2: MartiniPlaza					
Analysed IES solution	**Technical**	**IES challenge (-) or opportunity (+)**	**Financial**	**IES challenge (-) or opportunity (+)**	**stakeholders**	**IES challenge (-) or opportunity (+)**
Smart building control + energy strategy with adjacent area for generation/distribution of electricity, heat and cooling.	insulation of outer wall	+	Given the planned refurbishment of the building in about 10 years, the payback time must be less than 10 years at least	-	the only shareholder, the Municipality of Groningen, is developing a sustainable vision for the building and its surroundings.	+
	flexible ceiling for lower HVAC energy use	+	Energy costs have increased strongly due to higher natural gas price	+	However, as the municipality vision is not yet determined, improvements now are 'paralysed'	-
	infrastructure for energy links with adjacent buildings (not yet available, but technically feasible)	+/-			Building management is very receptive to advice and willingness to change.	+
	Data on energy performance available	+				

	Case study the Netherlands 3: Visio health care					
Analysed IES solution	**Technical**	**IES challenge (-) or opportunity (+)**	**Financial**	**IES challenge (-) or opportunity (+)**	**stakeholders**	**IES challenge (-) or opportunity (+)**
Three novel all-electric IES concepts. Concept 1: Building-specific IES heating solution with air/water heat pump; Concept 2: Collective IES heating solution with water/water heat pump for several client houses with BTES system; Concept 3: Collective IES heating solution with water/water heat pump for entire case study site with ATES system. Referenced to conventional building-specific gas boiler system	General good quality of thermal performance of building envelope of client houses on case study site in Vries	+	Overall poor payback period for individual energy and CO2 saving measures	-	Highly complex stakeholder environment - Coordination and communication issues - Many skills/services are outsourced via contracts - Interdependencies source of interia in decision-making and action planning	-
	Lack of or incomplete building and energy data - Insufficient smart meters present on case study site - Insufficient detail, quality and coverage of building/ energy data from EED reporting - Non-integrated / non-harmonized nature of data	-	Planning, management of investments in building-specific IES solutions vs. planning, management of investments in building portfolio (trade-offs vs. synergies)	+/-	Following up / keeping up to date with the local developments and planning by municipalities on alternative heating strategies (local area plans)	+/-

	logging and management					
	Capacity and planning restrictions - Underground infrastructure (permitting, and planning ground works) - Increasing shortage of labor (builders/installers) and materials - Limiting energy grid capacities	-	Challenge of detailed investment planning - Inaccurate cost data - Increasing building costs - Attracting sufficient investment finance - Changing incentive schemes (fiscal, subsidies)	-	Unclarity about proper usage of CO_2 footprint accounting rules in the sector	+/-
			Increasing energy prices	+		
			Increased use/availability of alternative investment finance options in health care	+		
			Opportunities to attract third-party investments in energy installations	+		

Annex 7. Assessment of EED and CO_2 footprint reporting

In this Annex we provide a comparative assessment of two EED reports for two consecutive reporting periods (2017, and 2020) for Royal Visio and discuss some gaps and challenges of these EED reports. In addition, we also provide an assessment of the CO_2 footprint reporting and discuss some gaps and challenges.

Comparing two EED reports

more detailed overview of different categories of proposed energy saving measures.

- For the measures with ***short (<5 year) payback times*** (see Table A-7-1), we see insulation of fittings and piping and cavity wall insulation recurring in both reports, but in the 2021 reporting new measures such as behavioral measures and efficient lighting were included.
- For the ***insulation measures*** (see Table A-7-2) we see conventional roof, wall, floor insulation measures being proposed. In both reports we observe no significant changes in the overall relatively poor (estimated) PBTs.
- For the ***energy installations*** (see Table A-7-3), we see more significant changes in the set of technologies and measures considered. In the 2021 EED audit we see that electricity based heating and hot water installations, such as heat pumps, heat recovery units, and instant heaters are considered. Solar thermal installations were only referred to in the 2017 EED audit, while the 2021 EED audit also included frequency regulation (efficient pumps). While overall the PBTs for most installation measures are improving, many measures for specific buildings (aside a few exceptions) still have a too long (estimated) PBT. Notably for solar PV and efficient lighting we see that the PBT ranges have improved significantly, with some specific measures (for specific buildings) with interesting PBTs.

Measures with short PBT

In the 2017 EED audit a total of 130 individual energy measures were considered out of which 34 measures have an estimated payback time (PBT) of less than five years. For the 2021 EED audit a total of 252 individual measures were listed out of which about 50 had a PBT of less than five years.

Table A-7-1: Low PBT (<5 years) measures in 2017 and 2021 EED audit report

2017 EED audit	2021 EED audit
Insulation of fittings and piping (26x) Cavity wall insulation (1x) Hydronic balancing (7x)	Behavioural measures (6x) Insulation of fittings and piping (21x) Efficient lighting; LED retrofit, sensors (16x) Wall insulation; cavity (4x) Heat saving measures; installation, radiator foil (3x)

Insulation measures

For insulation measures the 2021 report shows a broader range of potential measures. Both reports show clearly that cavity wall insulation is a low-cost measure with very low PBTs. However, wall insulation from the inside still has a relatively high PBT. HR++ and triple glass have increasingly unfavourable PBT in 2021 relative to 2017 as HR++ has already become the standard. Floor insulation overall still has poor PBT often close to PBTs of 20 years or more. PBTs for roof insulation show a broader range in the 2021 report (6-74 years). This range makes it difficult to implement a more programmatic approach for roof insulation.

Table A-7-2: Insulations measures in 2017 and 2021 EED audit report

Measure	2017 PBT (#)	2021 PBT (#)
Windows (e.g. HR++, triple etc.)	- 7-29 years (10x)	- 17-170 years (16x)
Floor insulation	- 26-51 years (3x)	- 17-70 years (5x)
Wall insulation	- <5 years (1x cavity)	- <5 years (4x cavity) - 9-34 years (5x inside)
Roof insulation	- 7-10 years (4x)	- 6-74 years (18x)

Energy installations

In both EED reports solar PV panels were listed as potential measures (52x in 2017 and 27x in 2021). However, in this four-year period the PBT for solar PV has improved considerably from 25 to 42 years in 2017 to 10-15 years in 2021. The 2021 EED report also included two ground-based solar PV options which showed a relatively good PBT of 9 years. For efficient lighting there is a clear trend that for several buildings and situations LED-based lighting systems have more favourable PBTs in 2021 relative to 2017. However, still quite a few efficient lighting options have 10-30 years PBTs.

Table A-7-3: Energy installation measures in 2017 and 2021 EED audit report

Measure	2017 PBT (#)	2020 PBT (#)
Solar PV	- 25-42 years (52x)	- 9-27 years (27x)
Solar thermal	- 11-39 years (8x)	
Heat pumps		- 6-30 years (28x)
Heat recovery units		- 30-35 years (2x)
Instant heater		- 18 years (2x)
Efficient pumps (frequency regulation)		- 7-97 years (10x)
Motion detection	- 40 years (2x)	- 5-70 years (16x)
Efficient lighting	- 13-40 years (13x)	- <5 years (15x) - 10-30 years (46x)

While in the 2017 EED audit, solar thermal boilers (8x) were also listed as a potential energy measure, the 2021 EED audit excluded this option. However, the 2021 audit did introduce a broad range of 'new' electricity-based energy installation options, including heat pumps (28x), heat recovery units, instant heaters. However, excluding a few exceptions with reasonable PBTs (5-15 years) most of these 'new' measures have unfavourable PBTs often going well above 15 years.

Building portfolio's CO_2 footprint performance

The 2017 EED report only provides estimates of CO_2 emissions for transport fuel consumption. The 2021 EED report provides data CO_2 emissions related to transport, but also on (estimated) CO_2 savings for building specific energy saving measures. The 2021 report was also accompanied by a separate CO_2 footprint report that applies to the whole organisation. In Table A-7-4 we can see that the 2020 CO_2 footprint is significantly lower relative to 2019. This is due to the lower emissions in transport/mobility and can be directly related to the COVID pandemic. However, building related emissions in 2020 were also lower, which could be caused by more (office) staff working from home during the COVID pandemic. It is interesting to observe that within the CO_2 footprint reporting no CO_2 emissions have been accounted for Visio's electricity consumption. This choice is based on the green power purchase contract that Visio has secured via a collective purchase organisation (Intrakoop).

Table A-7-4: Visio CO_2 footprint (2019 and 2020)

CO_2 emissions	2019	2020
Buildings		
Electricity	0	0
Heating	2,514	2,156
Mobility		
Cars	10	6
Company vans	110	29
Private cars	1,752	740
Air travel	291	59
Total	4,677	2,991

For the proposed building-specific measures the 2021 EED report provides some estimated CO_2 savings. However, the report does not provide a full explanation of the specific method and emission factors used for calculating the estimated CO_2 savings.

If we look at the two examples for 'Location A' in Table A-7-5 we find that estimated CO_2 savings from the PV panels and the LED lighting are, rather low relative to what one would expect from such sizeable investments. Also, if we follow the logic of the CO_2 footprint report, any electricity savings by Visio will not result in any additional CO_2 savings as the consumed green power from the grid (with an assumed zero CO_2 emission). Aside from this inconsistency it is not clearly indicated in the EED report how these emission estimates have been calculated, and which emission factors have been used.

Table A-7-5: Background data for individual measures (EED audit report 2021)

Location (building code or address)	Measure	Investment (EUR)	Savings (kWh)	Savings (Nm^3)	Savings (EUR)	CO_2 reduction (kg CO_2)	PBT (years)
Location A	PV-panels	118,850	42,924	x	11,390	28	10.4
Location A	LED lighting	64,855	-16,714	+1,020	10,66	8.8	60.8
Location B	Heat pump for hot water	12,000	-4,619	1,203	108	-2.5	110.9

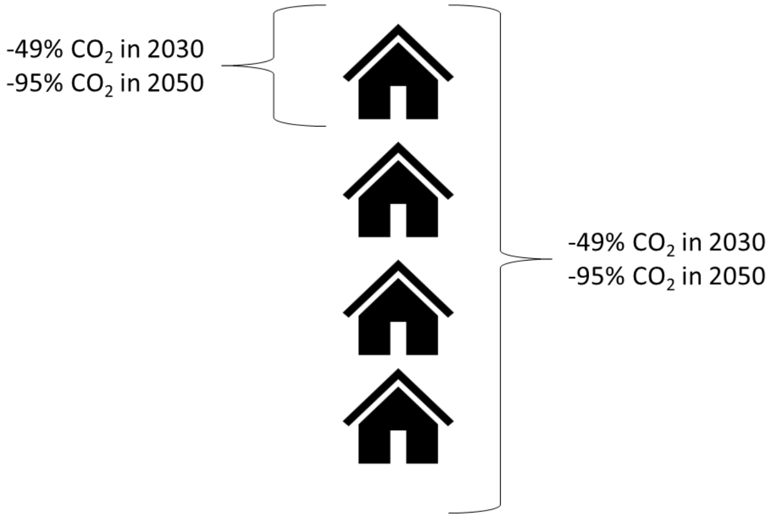
We can also observe from Table A-7-5 that both in terms of energy and CO_2 there can be so-called 'negative savings'. For the LED lighting and the heat pump overall electricity consumption will go up, while gas consumption will go down. While for the LED measure this still results in an estimated CO_2 saving, for the heat pump the estimated CO_2 emissions will increase.

Discussion on building portfolio's CO_2 and energy performance

Visio's overall energy and climate ambitions are aligned with other health care organisations. As part of the Dutch National Climate Agreement, sectoral agreements have been made and specific CO_2

reduction targets have been set. For organisations in the health care sector CO_2-emissions will have to be reduced by 49% in 2030 and 95% in 2050. Each health care organisation will have to develop so-called 'CO_2-roadmaps' that indicate the measures/actions to be taken to meet the climate goals.

Figure A-7-1: Portfolio wide targets instead of building specific targets



One of the main challenges, for Royal Visio will be not just to improve the energy and climate performance of a single building, but to improve the overall performance of their entire building portfolio. The 2030 and 2050 energy and climate targets apply to Visio as a whole, and not to individual buildings (see Figure A-7-1). This enables Visio to apply a more optimized and phased approach with respect to IES implementation in their building portfolio. Knowing that the building portfolio is diverse the set of measures to be implemented will likely be diverse. On top of that the 'natural moments' when to perform energy renovation will differ throughout the building portfolio. By having a portfolio wide target not all buildings will have to follow the same trajectory for when, which energy conservation / CO_2 reduction measures will be implemented (as long as the company as a whole meets the overall targets).

Data availability and quality

Most of the existing data/information sources referred to in the previous section, such as energy monitoring data, multi annual maintenance plan, EPA-U reports, EED reports, CO_2 footprint reports include many relevant elements and data points that are useful for developing and implementing a more programmatic and integrated approach for sustainable real estate management. However, most of this data is not integrated and managed into one central database. The data is either available only in word format, or a separate excel file and in quite a few cases are not available in a harmonised format and/or is controlled/managed by another subcontractor. Ideally, Visio would operate a (cloud-based) centralised building portfolio and energy database which can be updated/revised by Visio staff and/or relevant subcontracted partners.

At this stage we consider that the current protocols, and structures for (centralised) energy and building portfolio data logging and real estate portfolio management are insufficient to facilitate informed investment decision making by Visio in IES systems. We provide some additional information on a protocol for more structured and centralised data collection and management in Annex 11: Integrated data collection and management.

Our analysis, below, also suggests that the available building and energy data on Visio's building portfolio is not always sufficiently reliable (e.g. inaccurate or incomplete). This increases the uncertainty within the (investment) decision-making process.

Organisation level EED reporting

We can observe a clear evolution in the level of detail of the basic data that is provided (see Table A-7-6 and Table A-7-7). Both audits provide a cell with information on the following:

- 'location'
- 'measure'
- 'investment', and
- 'estimated PBT'

Table A-7-6: Background data for individual measures (EED audit report 2017)

Location (building code or address)	Measure	Investment (EUR)	PBT (years)
Location A	PV installation	25,000	31
Location A	Replace lighting	50,000	23

However, the 2021 audit provides more information on (estimated):

- 'electricity savings',
- 'gas savings',
- 'financial savings', and
- 'CO_2 reduction'

Table A-7-7: Background data for individual measures (EED audit report 2021)

Location (building code or address)	Measure	Investment (EUR)	Savings (kWh)	Savings (Nm^3)	Savings (EUR)	CO_2 reduction (kg CO_2)	PBT (years)
Location A	PV-panels	118,850	42,924	x	11,390	28	10.4
Location A	LED lighting	64,855	-16,714	+1,020	1,066	8.8	60.8
Location B	Heat pump for hot water	12,000	-4,619	1,203	108	-2.5	110.9

However, also with the more elaborate 2021 EED report data/information it will be challenging for Visio to implement action plans for energy- and CO_2 saving measures. This is mainly related to the 'hidden' data and assumptions that is used for calculating 'investment', 'savings' and 'CO_2 reductions'. This underlying background data is not available to Visio, neither are some of the underlying assumptions.

'Measure': To assess the size of the investment it is good to know for each location how many 'standard units' of a certain measure are assumed. For example, in Table A-7-7 we see PV-panels being proposed as a measure at an investment of EUR 118,850.

The EED does not describe the measure in some level of detail. For example, we do not know the watt-peak capacity of the individual PV panels, or the number of PV panels, the minimum required grid connection, etc. On top of that we do not know for this measure which cost components are included and excluded (e.g. materials, such as panels, optimizers, roof mounting system, labour/montage costs, or any costs associated with adjusting the grid connection). Similarly for other proposed energy saving measures in the EED report we also do not have technical background information on e.g. the number of LED lights (of x-watt), the square meters of HR++ glass, the capacity (Kw) of the proposed heat pump, etc.

'Investment': Also, with respect to the estimated aggregate investments, there are some relevant underlying variables and assumptions lacking in the EED reports. First of all, the different investment components are not specified (e.g. panels, labour, converter). While it may not be the primary objective of EED reports to provide detailed cost data for financial and economic planning, within Visio there clearly is a need to have a better grasp on the relevant cost items for specific measures. Secondly, the EED reports do not indicate for each individual measure which costs items are excluded. The 2021 EED report only includes a general disclaimer on which costs are excluded from the estimated investment amounts. These include:

- All amounts are excluding value added tax
- All amounts are excluding indirect costs, such as engineering and work-preparation[23]
- PV panels are excluding any feed-in subsidy (or any other financial incentives)

As a result of both factors, the uncertainty range of the estimated investment amounts is likely to be significant. If Visio wants to implement a group of suggested measures, all individual measures will have to be recalculated based on more realistic and building/location-specific data and assumptions. While Visio could perform such a 'revision and updating' task themselves - based on own experience with implementing certain measures - the current way (excel template) in which the EED audit data for individual measures is provided does not meet basic requirements for further analysis and processing (i.e. not user friendly). Moreover, the EED data does not cover the full building portfolio, but a subset of buildings.

'Savings' gas and electricity: For these cells 'estimated' or 'deemed' energy savings are typically used as default/standardized values. Such estimates often deviate from real savings and may require further and more in-depth assessment. Aside from the gaps in having building-specific energy consumption data there are a number of other issues. For example, the assumed energy yields of PV panels for the average Dutch building can deviate significantly from the realistic PV yield for a building owned by Visio. Factors, such as shading, orientation (South, East, West), slope, etc. are generally not included in the EED assessment. Further assessment would be required to highlight the best locations for PV panels to minimize PBT.
Similarly, the underlying assumptions and data inputs for estimating the deemed energy savings for efficient (LED) lighting are not included in the EED data report (e.g. frequency/duration of use). There are also several electricity saving measures that result in an increase in consumption of natural gas for heating (and vice versa). These 'dissavings' are relevant for determining the overall energy performance of the measure, but also can have an impact on the net CO_2 impact of the measure.
The reports also clearly indicates that the deemed energy savings for individual measures for a specific

[23] Inflation corrections, price fluctuations in materials, equipment, permits, complementary research costs, architectural adjustments, engineering, possible costs for altering grid connection, etc. are not considered within the calculations.

building cannot 'simply' be aggregated to get an overall energy savings estimate. This would require a more integrated assessment of the building's overall energy performance when different measures are to be implemented at the same time. This information gap hamper Visio's decision-making process for implementing IES systems in their building portfolio. While Visio does not have such technical expertise available in-house, it would have to request for such services as part of their existing building maintenance and energy consulting subcontracting.

'Savings' financial: To calculate the financial savings of a specific measure the deemed energy savings (electricity and/or gas) can be multiplied by the electricity or gas prices. However, both EED reports do not clearly indicate which energy prices have been assumed for calculating the financial savings for individual measures. Visio confirms that contracted energy prices have been communicated, but the EED reports do not make explicit links to proposed measures for individual buildings and whether they are connected to a major-user or small-user grid connection.[24] To use the EED data for further analysis it is important to include such variables in the calculations and link them to specific energy saving measures for individual buildings (*See box*).

Box - CO_2-roadmap excel tool for sustainable healthcare

The Dutch Expertise Centre Sustainable healthcare (Expertisecentrum Verduurzaming Zorg, EVZ) provides a CO_2-roadmap tool (link) to healthcare organisations. The excel-based tool is similar to a multi-annual maintenance plan (database), in which all building data can be imported and energy/CO_2 saving measures for all relevant buildings can be inserted. The tool includes a dashboard, which provides an aggregate overview of key performance metrics including e.g.:

- *Cumulative investments / savings*
- *CO_2-footprint*
- *Energy use (electricity and natural gas)*
- *Own renewable PV production*
- *Energy costs*

Visio does not (yet) make use of this tool. The key benefit of this tool is that it integrates quite a few of the key data flows from:

1. *the multi-annual maintenance plan,*
2. *the periodic EED reports, as well as*
3. *the CO_2-footprint report*

These three activities have been executed by three different service providers and were implemented more or less separately from each other (i.e. not fully integrated). Having all relevant building and energy data logged in one central file/location will be useful for Visio to keep a full overview, identify data/information gaps, and enable faster and informed decision making.

While there are merits for a more centralised or integrated approach for data collection, storage, and processing, such a database would also need to be accessible (online) for Visio's longer-term and short-term subcontractors for building and maintenance, and energy consulting.

*Specifically, for Visio, however, the tool has some (subtle) limitations. If we have a closer look, we see that the tool (top of the 'Dashboard' worksheet; see Figure A-7-2**Error! Reference source not found.**) only allows the user*

[24] We re-iterate that a large subset of Visio's buildings are getting energy from the grid via a major-user connection (generally very low energy prices), while the other buildings are supplied via small-user connections (generally higher energy prices). This, for example means, that for exactly the same energy saving measure the estimated PBT can be significantly different from one building with a major user connection to another building with a small user connection.

to insert one price for electricity and one price for natural gas that will be used to calculate the financial savings for all proposed CO_2-saving measures in all buildings. Visio could solve this by making two separate building databases, of which one would include the buildings connected to a major-user grid connection, and the other one would include only the buildings with a small-user grid connection. This, however, would be impractical from the perspective of more integrated building portfolio and data management.

Figure A-7-2: Screenshot from part of Dashboard worksheet from CO_2 roadmap tool from EVZ

CO_2 reduction: Both reviewed EED audit reports also indicate the importance of reducing CO_2-emissions. However, this mostly focusses on reducing CO_2 emissions from transport, while the methods and parameters for estimating the CO_2 emissions from energy use in buildings are not included. If we take the examples from Table A-7-7 (above) we see that the estimated CO_2 savings for the two first measures are resp. 28 and 8.8 kg. Given the sizeable investment (resp. EUR 118,850 and EUR 64,855) and energy impact such CO_2-savings appear rather low. The EED 2021 report does not provide further information on the method and emission factors used to calculate the estimated CO_2-savings.

With respect to the estimated energy savings, analysis of the 2021 EED report also shows that there are for example measures that reduces gas consumption but at the same time increases electricity consumption (or vice versa). For example, in the EED report many LED lighting measures show an electricity saving, but also indicate an estimated increase gas use. Also, introducing heat pumps will reduce gas consumption, but will increase electricity usage. Such energy 'dissavings' have an impact on the net CO_2-effect. However, the magnitude of this effect largely depends on the emission factors (EF) applied within the calculation of the CO_2 impact. To determine the CO_2 impact, we have found two alternative approaches to greenhouse gas accounting.

Table A-7-8: Energy use and CO_2 emissions Royal Visio (2020)

	Electricity	Gas
Energy consumption per year (total, all buildings)	5,766,036 (kWh)	1,373,711 (m^3)
Total annual CO_2 emissions (tCO_2/y)**	0	2,156

Source: **Royal Visio CO_2 footprint report, Climate Neutral Group; 2021

The *first approach* is included in the CO_2 footprint report for Visio by (Climate Neutral Group, 2021). They assume an emission factor of 0 $kgCO_2/kWh$ for green electricity from the grid, provided that guarantees of origin for renewable electricity are also purchased (see Table A-7-8). In their report the Climate Neutral Group, derives this assumption from the internationally recognised GHG Protocol (link). The following emission factors are applied:

- Hydropower from Iceland/Scandinavia is considered 'grey' electricity = 0.556 kg CO_2/kWh
- Green electricity (water, wind, solar) = 0 kg CO_2/kWh

- Green electricity (biomass) = 0.075 kg CO_2/kWh
- Natural gas = 1.884 kgCO_2/Nm^3

With these different emission factors, CNG differentiates between the various sources of electricity. While all three above options can be considered renewable electricity, the imported hydropower is not considered zero CO_2 emission. The main way to differentiate between the different forms of green electricity is via the associated purchase of Guarantees of Origin (GoO).

Since Visio has a green electricity purchase contract for European wind energy, CNG applies a 0 gCO_2/kWh emission factor. With this accounting rule in mind any electricity dissavings, or inefficient use of electricity will not lead to a higher CO_2 footprint of Visio's building stock. This is important to mention since most IES systems in the built environment will likely reduce gas consumption at the expense of increased electricity use. With this GHG accounting approach there will be no incentive for Visio to select those IES systems, installations, and appliances that have a low power consumption (or adequate thermal insulation levels).

A *second approach*, to GHG accounting is provided by the Dutch expertise centre for sustainable health care (EVZ). Within their CO_2-roadmap tool, EVZ applies the following emission factors for electricity and gas:

- Electricity = 0.556 kgCO_2/kWh
- Natural gas = 1.88 kgCO_2/Nm^3

EVZ also provides further guidance on how to account for any green electricity purchased from the grid.[25] As part of the CO_2-roadmap approach it has been decided that any CO_2 emission reduction resulting from the purchase of green electricity from the grid cannot be counted as CO_2 reduction by the health care organisation. Only energy/electricity saving measures, as well as own production of renewable electricity can be claimed as CO_2 reduction (via rooftop PV). This radically changes the CO_2-footprint of Visio's building portfolio. In Table A-7-9 we can see a difference of 3,206 tCO_2 per year between the two GHG accounting approaches. This in turn has a significant impact on Royal Visio's plans and actions to reduce its CO_2 emissions.

Table A-7-9: Two different CO_2 footprints of Visio's building portfolio (2020 energy data)

		Electricity	Gas
Energy consumption per year (total, all buildings)		5,766,036 (kWh)	1,373,711 (m^3)
Total annual CO_2 emissions (tCO_2/y)	GHG Protocol (CNG, 2021)	0 (tCO_2/y)	2,156 (tCO_2/y)
	CO_2-roadmap (EVZ, 2022)	3,206 (tCO_2/y)	2,156 (tCO_2/y)

[25] *"De inkoop van groene stroom via certificaten telt in de routekaart niet mee als CO_2-reductie, omdat vergroening van het elektriciteitsnet elders belegd is. Dit geldt voor zowel certificaten van directe afname bij wind- of zonneparken als voor certificaten die via energiebedrijven gekocht worden. Er is afgesproken dat in de routekaart CO_2-reductie van elektriciteit besparende maatregelen en eigen duurzame opwek wél mee te tellen. Hoewel dit gaat om indirecte emissie levert het direct milieuwinst en financieel voordeel op. Stroom die niet geproduceerd hoeft te worden, hoeft immers ook niet vergroend te worden."*
Source: https://www.expertisecentrumverduurzamingzorg.nl/veelgestelde-vragen/groene-stroom/

Annex 8. Overview of Royal Visio's stakeholder network

Table A-8-1 provides an overview of the different stakeholders, their main role/function and key relevance (or impact) on Royal Visio's strategic decision making. With such an increasing number of stakeholders/organisations involved in managing and maintaining Visio's real estate a clear understanding of each other's role and responsibility is needed.

Table A-8-1: Overview of stakeholder/actor roles

Stakeholder	Main role/function	Relevance for Visio
Visio facility service department	The in-house staff of Visio working on real estate management and maintenance comprises out of one manager housing, one contract manager management and maintenance and three regional building managers.	This department is responsible for providing Visio with day-to-day housing services by coordinating all (sub)contracted service providers and for ensuring compliance with energy and climate goals and regulations.
National government	Via the implementation of European energy directives, and (inter)national climate agreements, the Dutch government implements a range of energy and climate policies.	The key energy and climate policies for Visio, are: -The implementation of Energy Efficiency Directive (EED), EED audit and associated Dutch environmental management act which mandates that energy saving measures with a payback period of <5 years should be implemented[26] -As part of the National Climate agreement, the health care sector is required to develop so-called 'CO_2-roadmaps', which indicate the different measures/actions Visio will take to meet the 2030, and 2050 national climate targets.
Local environmental service agency ('Omgevingsdienst')	There are 30 local environmental service agencies in The Netherlands. These agencies are responsible for enforcement of the implementation of the EED and the Dutch environmental management act in their region.	Visio owns real estate across the entire country, and as such liaises with multiple of these agencies.
Netherlands enterprise agency (RVO)	Organisation responsible for managing the national registration of the EED implementation, and energy audits.	The EED audit reports will have to be submitted (online) to RVO each reporting cycle (typically 4 year). RVO is responsible for the review and approval of the EED audit report that Visio submits.
Municipalities (1)	As part of the Dutch Climate Agreement, the Dutch municipalities are the appointed 'director' for developing local alternative heating strategies for the built environment, as well as the development and implementation of the underlying district implementation plans	Given that Visio owns real estate in multiple different municipalities, Visio de facto is a stakeholder in several district implementation plans. These plans govern the new way in which each district will make the transition to alternative and cleaner forms of heating in the built environment. Depending on the districts main characteristics the solutions can range

[26] The energy audit is mandatory for organisations with organisations with over 250 employees, an annual turnover of EUR 50 mln. and a annual balance sheet total of EUR 43 mln.

	(‘Wijkuitvoeringsplan’)	from introducing renewable gases, all-electric solutions to a district heating system. For the Vries site, the transition vision heat plan of the Municipality of Tynaarlo will apply (link). This plan predominantly focusses on building-specific approaches, based on improving the thermal insulation, introducing solar boiler and solar PV systems, and combining it with (hybrid) heat pumps. The municipality sees limited scope for collective solutions.
Regional care offices (‘Zorgkantoren’)	There are 31 regional care offices in The Netherlands. They are responsible purchasing / contracting health care services for clients/patients that require some form of long-term care (‘Wet langdurige zorg; Wlz’).	A substantial part of Visio’s annual revenues stems from providing long-term care (via Wlz care contracts). Visio is contracted by several regional care offices to provide long-term care services. The funding for clients falling under the Wlz regulation also includes costs for providing housing services (‘normative housing component’ or nhc). The nhc compensation is periodically revised to reflect changes in relevant housing cost components, including any changes in costs associated with energy and climate measures in buildings.
Health care insurance companies (‘Zorgverzekeraars’)	These companies provide basic health care insurance for individuals. The decree on health care insurance (‘Wet zorgverzekering’; Wzv) indicates what health care services should be covered by the base health care insurance policies.	Another part of Visio’s income stems from providing health care services with a shorter duration (up to maximum of 1.095 days), such as providing care, support, training, and education to people with sensory impairments.
Municipalities (2)	Dutch municipalities are responsible for the implementation of the Law for societal support (‘Wet maatschappelijke ondersteuning’ or Wmo) and the Youth act (‘Jeugdwet’ or Jw). The Wmo provides (financial) support to assist individuals who cannot fully function in society with some additional support (self-reliance). The Jw provides health care and support for people under the age of 18 years.	Another part of Visio’s income stems from the municipal Wmo and Jw budgets, which also provides funding for shorter term housing services. Wmo supports, personal guidance and daytime activities; as well as support to temporarily relieve caregivers. Wmo can also provide financial support for providing a protected living environment for clients with a mental disorder. Jw also covers housing expenses.
Collective purchase organisation health care (‘Intrakoop’)	Provides professional purchase services to Royal Visio as well as for other health care organisations. By grouping/clustering the recurring purchases of multiple health care organisations, Intrakoop will be able to obtain a better deal within the market.	Visio relies upon Intrakoop to contract specific services that meet the specific needs of Visio in terms of their real estate management, and other services such as energy, office equipment, ICT, human resources, etc.
Tenants of Visio real estate	This group often represents health care or educational organisations that are renting workspace from	As an owner, Visio also has the primary responsibility to reduce the energy use and CO_2 emissions of rented out real estate.

	Visio.	However, this will have to be done in close collaboration with tenants, especially if and when the proposed measures can result in a temporary closure of the building.
Building maintenance service provider ('BAM infra')	Provides Visio with essential building maintenance services.	The type of contract determines the service level for Visio. Organisations like BAM FM offer a broad range of service contracts, such as a traditional contract, a service contract, a performance contract, an integrated contract, an ESCo contract as well as a vested contract.
Energy consulting service provider ('Hellemans Consulting')	Ensures proper energy monitoring and reporting for Visio to serve the annual financial reporting.	Visio relies on these consulting firms to provide good quality feedback, and data on the current energy use of the building stock, as well as improve the energy monitoring system.
Temporary energy/climate consulting service provider ('Innax' & / 'Duurzaam Gebouw', 'CNG')	Provide a range of consulting services to Visio, such as periodic EED audit reporting, as well as CO_2-footprint reporting.	Visio relies on these consulting firms to provide good quality feedback, and data on specific measures to achieve the company's energy and climate goals.
Visio clients and staff	This stakeholder group are the day-to-day users of the buildings managed by Visio.	The needs (e.g. comfort, user friendliness, etc.) of this stakeholder group with respect to housing and energy services have to be met to remain a) an attractive health care service provider, and b) an interesting employer.
National expertise centre sustainable health care (link)	This centre provides relevant information, support, and useful tools to health care organisations in their effort to improve the energy/climate performance of their buildings.	Can serve as an independent knowledge partner in building relevant additional internal capacities at Visio Facility Services

Annex 9. Initial assessment of technical options for Vries site

Technical options

The RES4BUILD program focusses on the development of certain systems. In Figure A-9-1 the main components focus areas are shown. These systems can play a key role in the transformation of the location Vries and meet the sustainable ambitions of Visio.

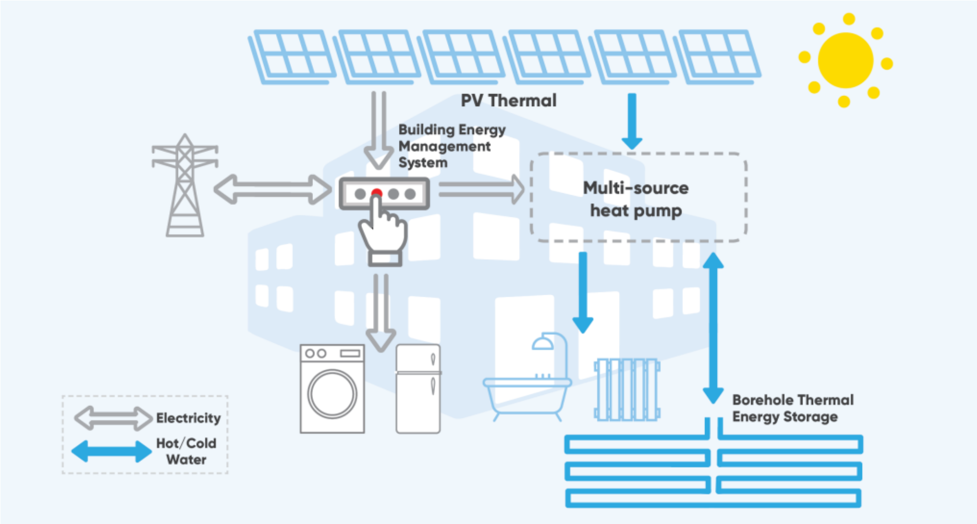
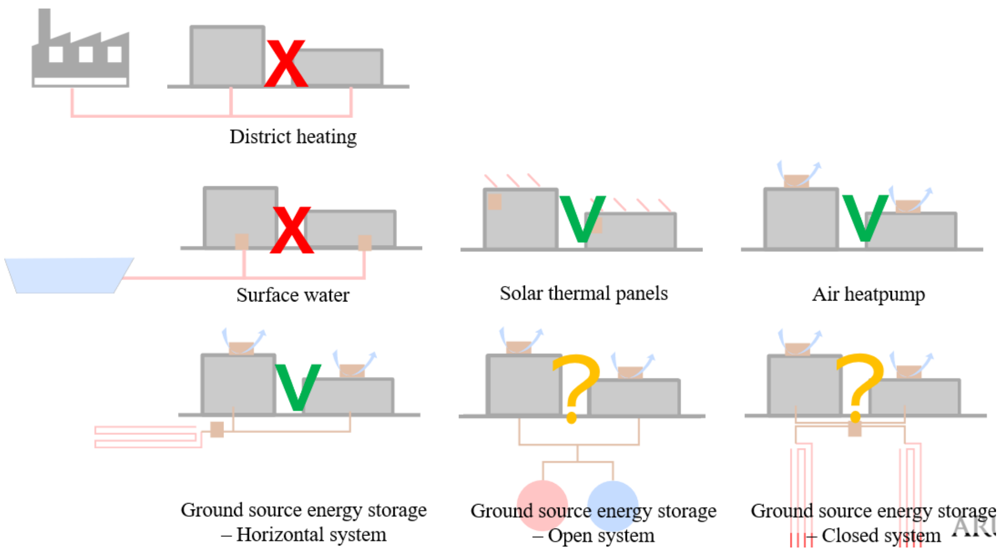


Figure A-9-1: Schematic showing the focus of Res4Build research

A short review and insight will be given in this chapter on how to implement the RES4BUILD components and tools. In previous phases of the RES4BUILD program, alternative heating solutions for the Vries Healthcare facility were explored. During these exercises different methods to heat and cool the buildings were compared and examined for implementation at the healthcare facility.

Figure A-9-2: Overview of the heating/cooling concepts for the Vries Healthcare facility



In Figure A-9-2 the main options presented during the RES4BUILD workshop in Vries can be found. When looking at the different options we find that district heating and the use of surface water (aquathermal) are not feasible for the location Vries. The options that are practically implementable are the solar thermal (PV-thermal, and/or PV) panels, the air source heat pump and the ground source energy storage systems.

In the RES4BUILD program components are developed that can help in the sustainable roadmap of

Visio and the location Vries, for example for the Solar thermal panels "PV/T collector" and heat pumps are part of the RES4BUILD developments. For the ground source energy storage, a Borehole Thermal Energy Storage (BTES) control tool is developed. In addition to that a novel Building Energy Management System (BEMS) is developed. The properties of these RES4BUILD system components and control systems are briefly described in the next subchapters.

PV/T Collector

The PV/T collector (see Figure A-9-3) generates both electricity and heating, it he RES4BUILD program the collector is optimised, yielding both electrical and thermal energy, in range of 300 $kWh_{thermal}$ and 150 $kWh_{electrical}$ per m^2.

Figure A-9-3: PV/T Collector

The building's roof areas look promising for placing the PV/T collectors, see Figure A-9-4, where the green roofs show the possible areas for the placing of PV/T collectors.

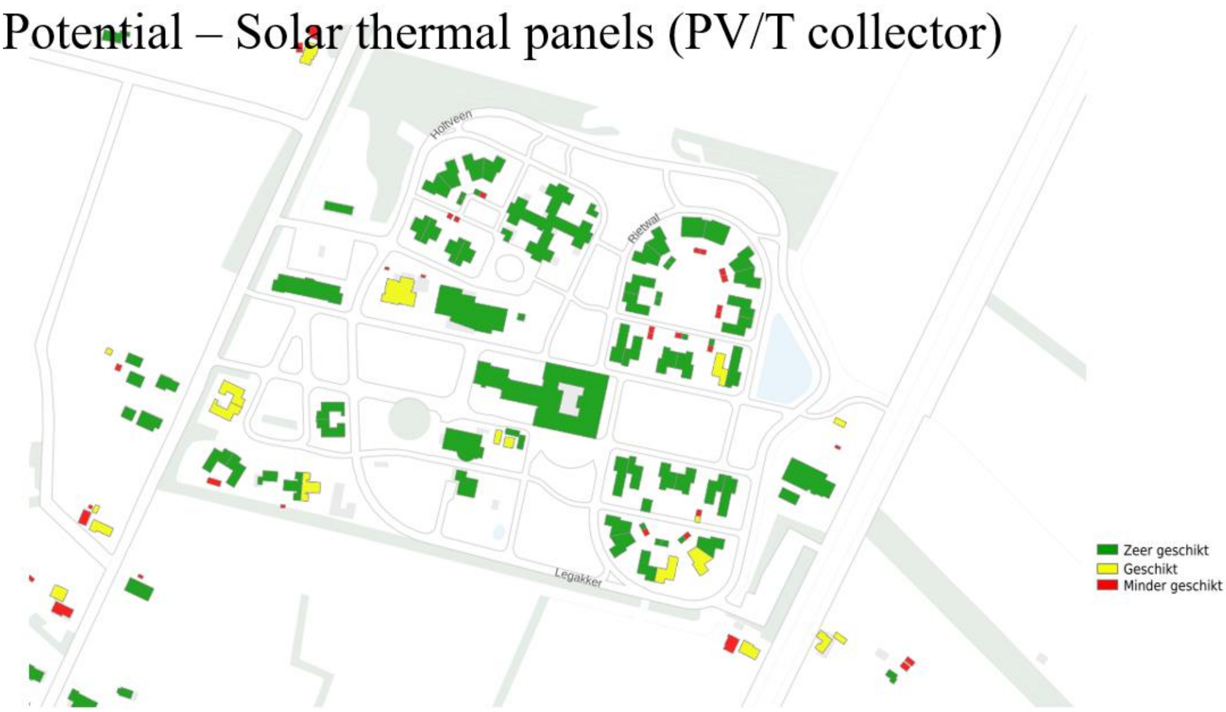


Figure A-9-4: Map of the facility, with in green the buildings suitable for PV/T collectors

Innovative multi-source heat pump

The innovative multi source heat pump is an optimised design of the vapour compression heat pump with low-GWP[27] refrigerant. The development of this innovative heat pump is in the design phase, therefore no conclusion on the potential and implementation can be given yet. When the first trial version shows improved efficiencies, the component could become feasible. The results of the ongoing studies will be shared when available. Aside from this highly innovative multi source heat pump, there already are a broad range of air- and ground source heat pumps on the market. A heat pump can be implemented per building, a building block or even at a larger scale for the entire Vries site.

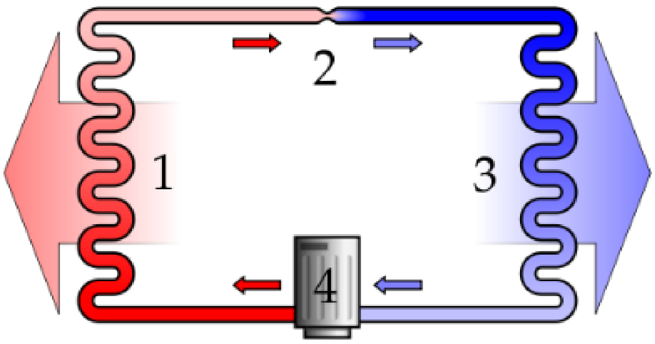


Figure A-9-5: Schematic view of the heat pump process

Borehole Thermal Energy System (BTES)

A BTES system enables the heating and cooling of a building. During the summer the excess thermal energy will be extracted from the building(s), which can be stored underground, while in the winter this heat can be recovered and supplied back to the building to meet the energy needs (Figure A-9-6).

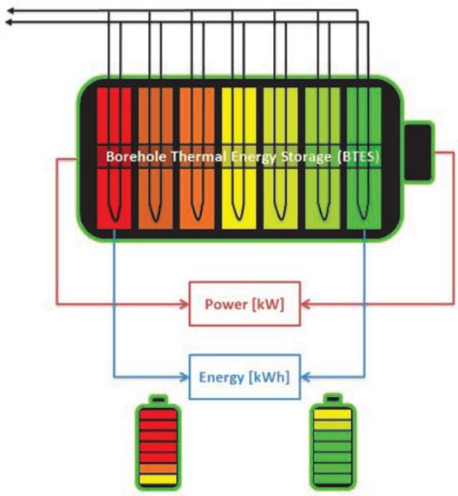


Figure A-9-6: Schematic overview and idea to store heat comparable to batteries

Within the RES4BUILD project a smart BTES controller is being developed. This controller optimises the thermal energy balance in the soil, relating the ‘charging’ or ‘decharging’ of the boreholes in relation to the buildings’ heat pump, users, and control system. In the Netherlands boreholes are

[27] GWP = Global Warming Potential.

common, but (smart) optimization components are not very often implemented.

Similar to the heat pump the BTES systems can be implemented per building, building block or for an entire site. For Visio's site in Vries an aquifer thermal energy storage (ATES), or open system ('open bronnensysteem') is more suitable than the borehole due to the high heating and cooling demands.

At the Vries site no BTES or ATES systems are developed yet. On the map (see Figure A-9-7) inside the square yellow area, no operational ATES or BTES systems have been found in the "WKO tool"[28] (link). The Province of Drenthe informed that the current location is within the intake area of a groundwater extraction zone. Also, within the light purple area several extra conditions / requirements for ground source energy systems apply. On the map (green spot) we see one groundwater extraction system/well at the Visio site.

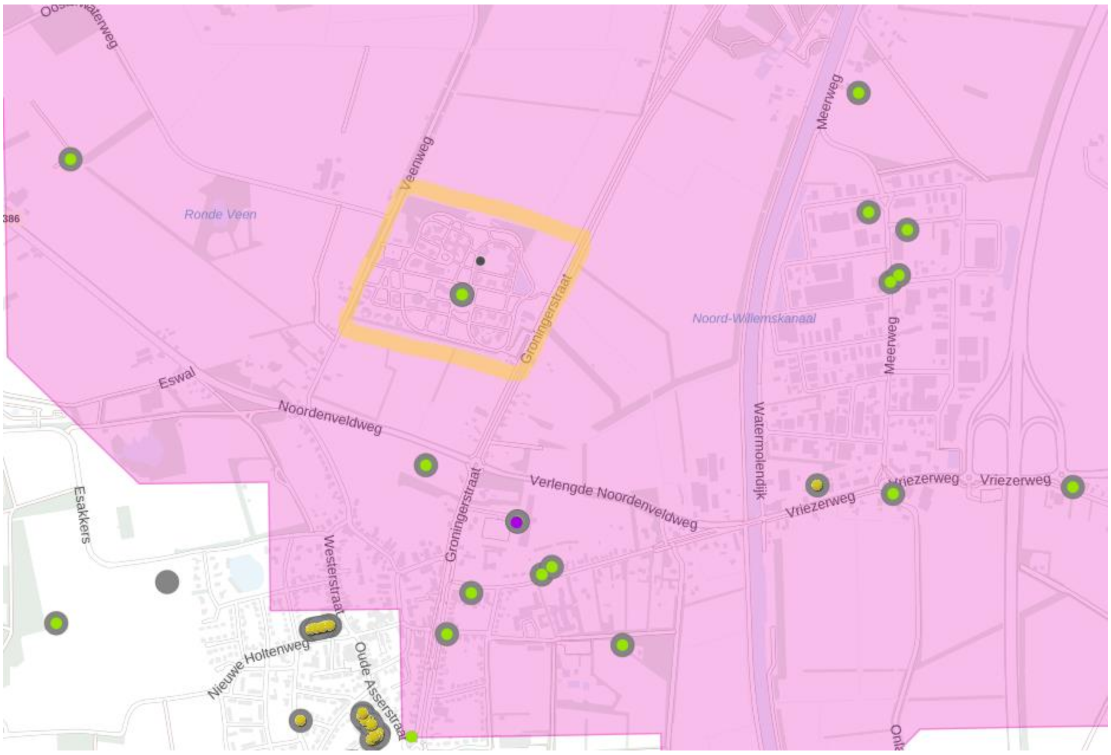


Figure A-9-7: Overview of ground source hydrological systems around the Visio site in Vries

An open geothermal energy system (ATES) would be allowed at this location (permit required). Closed geothermal energy systems (BTES) is only allowed through drilling. The applied refrigerant has an environmental quality equal or better than drinking water. There are no restrictions to the depth of systems.

A little further south from the Vries site (purple spot) we can identify at least one operational ATES system within the same restricted area. Outside the purple area we see several operational closed ground-source energy systems (yellow spot).

Building Energy Management System (BEMS)

The BEMS uses building data in combination with modelling and forecasts to optimise the performance of the energy systems which are in the building (see Figure A-9-8). Components include

[28] The WKO tool is an online information/data platform developed by The Netherlands Enterprise Agency (RVO) showing all ground sourced systems in The Netherlands.

Borehole Thermal Energy Storage controllers and thermal storage (e.g. buffer tanks, BTES or Thermovault). The BEMS brings the all the components together and arranges the optimized functioning of the system aligned with end-user preferences (e.g. self-supply optimized, economy optimized).

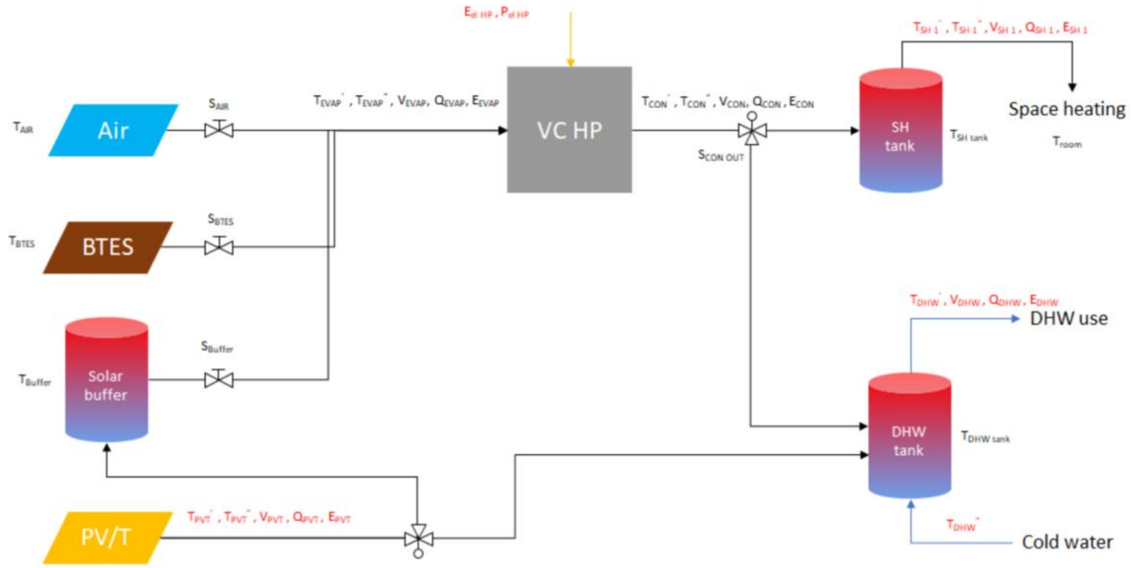


Figure A-9-8: Schematic control diagram of the systems that can be integrated into the Building Energy Management System

Annex 10. Three IES concepts for Royal Visio in Vries

Concept 1: Building specific IES

Concept 1 focusses on the implementation of the RES4BUILD component and tools per building. The reference building types we focus on are the client houses. These buildings generally have an acceptable level of thermal insulation that would allow for application of a heat pump (*the insulation values for the reference building for façade, roof, and ground floor are resp. of 3.0 – 4.0 – 2.8 m2K/W*). These buildings also have a floor heating system, that without major technological changes can also be used for cooling. In this set-up each building has an air source heat pump in combination with PV and/or PV/T collectors on the roof, installed.

Figure A-10-1: Suggested implementation of Air/water heat pump and PV/T collectors

The heat pump is connected to an air-unit placed outside the buildings; in Figure A-10-1 the air-unit is located on the rooftop but can also be placed on the ground nearby the building. The initial IES feasibility assessment (see Annex 9. Initial assessment of technical options for Vries site) we find that the air/water heat pump and PV/T collectors are implementable in the building.

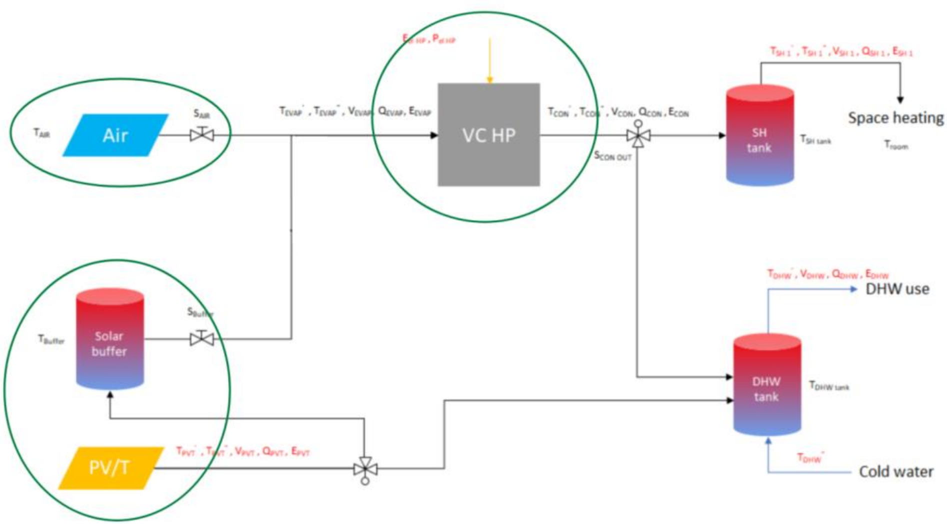


Figure A-10-2: Schematic overview of building specific IES system configuration

A BEMS would act as the central interface and controller of the individual components (green circled components in Figure A-10-2). Via an algorithm the systems operations are optimised during winter and summer conditions.

Concept 2: Collective all-electric IES approach for a building block

For concept 2, an IES solution per building block is given. In this situation each building block has its own small heating/cooling grid. The water/water heat pumps placed per building are connected to the local heating/cooling grid. In Figure A-10-3 the potential 'building blocks' with the heating/cooling grids are shown. The grid is connected to a dedicated BTES. By connecting all buildings in the building block to a single BTES system via the heating and cooling grid it is expected that overall less boreholes need to be drilled (relative to one single BTES system for each building.

Figure A-10-3: solution per building block, in red the heating distribution

The water flows from the underground thermal storage via the grid to the buildings and provides the buildings with cooling and warm water for the heat pump installation in the building (see Figure A-10-4). The selected components are feasible for the location Vries.

Figure A-10-4: Suggested implementation of water/water heat pump, PV/T collectors and BTES per building block

A BEMS, similar to concept 1, can be placed. In this case the air control part is substituted by the BTES. In addition, the BTES will correctly be charged (cooling buildings) and discharged (heating buildings) by the BTES control algorithm (see Figure A-10-5).

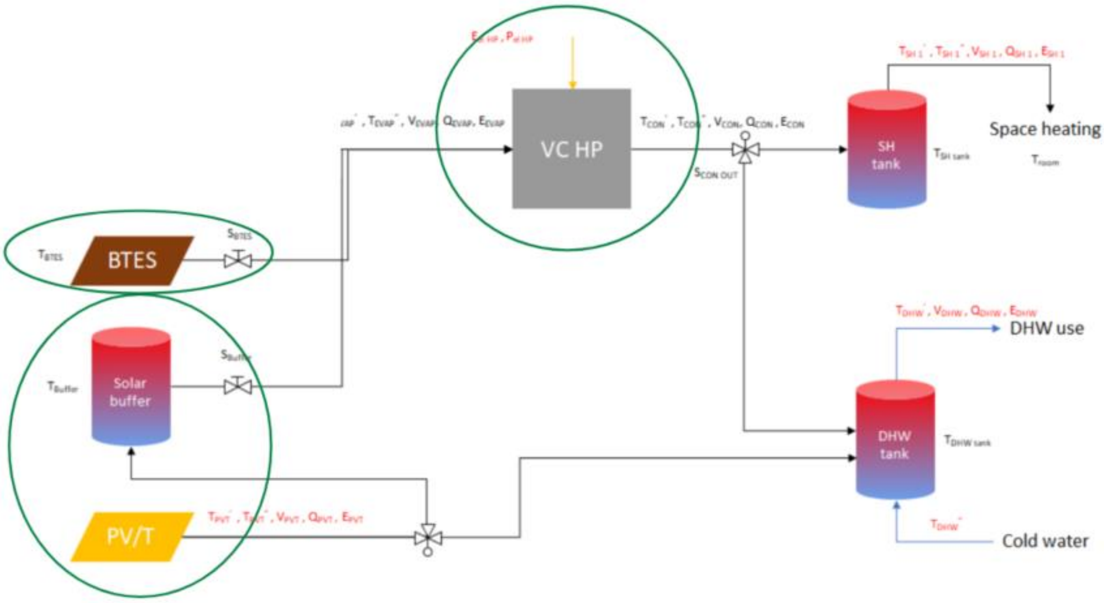


Figure A-10-5: Schematic overview of collective IES system configuration for building block

Concept 3: Large-scale collective IES approach for multiple building blocks on site

The third IES option is a heating and cooling grid that connects all buildings on site (see Figure A-10-6). In this case the heating and cooling is generated in a mechanical plant located on a central location at the site. Because of higher energy generation demands an ATES (open bronnen systeem) will be advised. Via the ATES combined with a centralised heat pump facility, higher energy capacities can be achieved (see Figure A-10-7).

Figure A-10-6: IES solution Vries site (red = heating/cooling grid connected to all buildings)

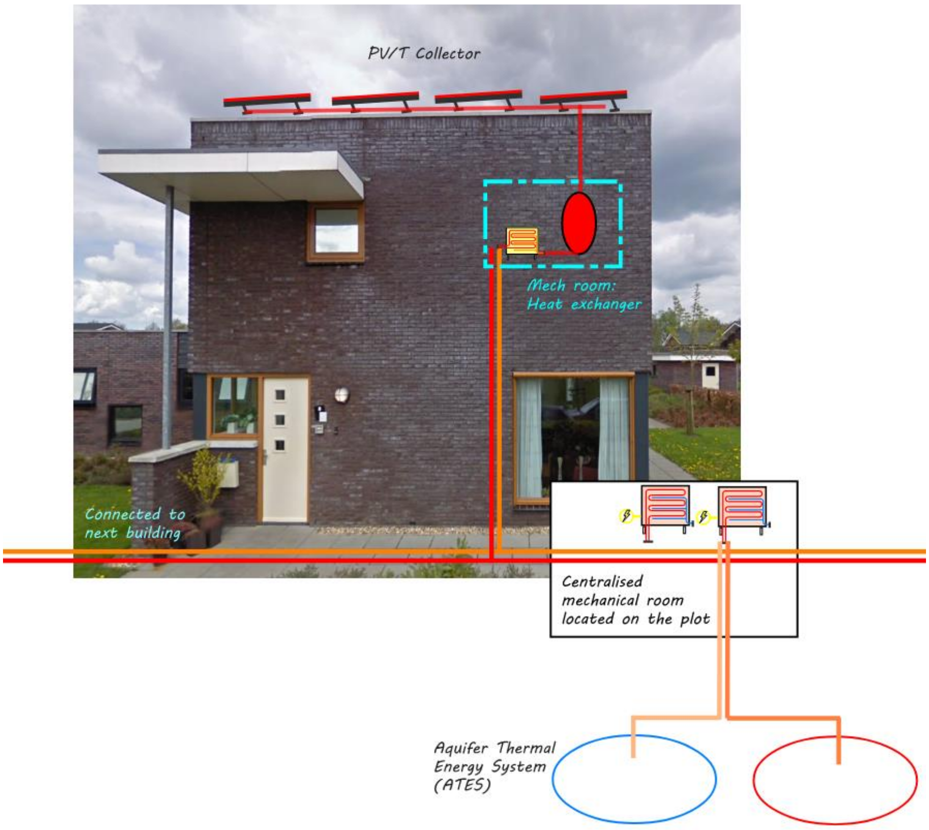


Figure A-10-7: centralised heat pump facility connected to the heating grid

Because the heat pumps are not placed in the buildings, the controls for central mechanical room of the heat pump and the mechanical room in each building will be separated. In Figure A-10-8 the BEMS is divided into a central control part and controls on building level. This controller concept deviates from the RES4BUILD program and should be further developed when required.

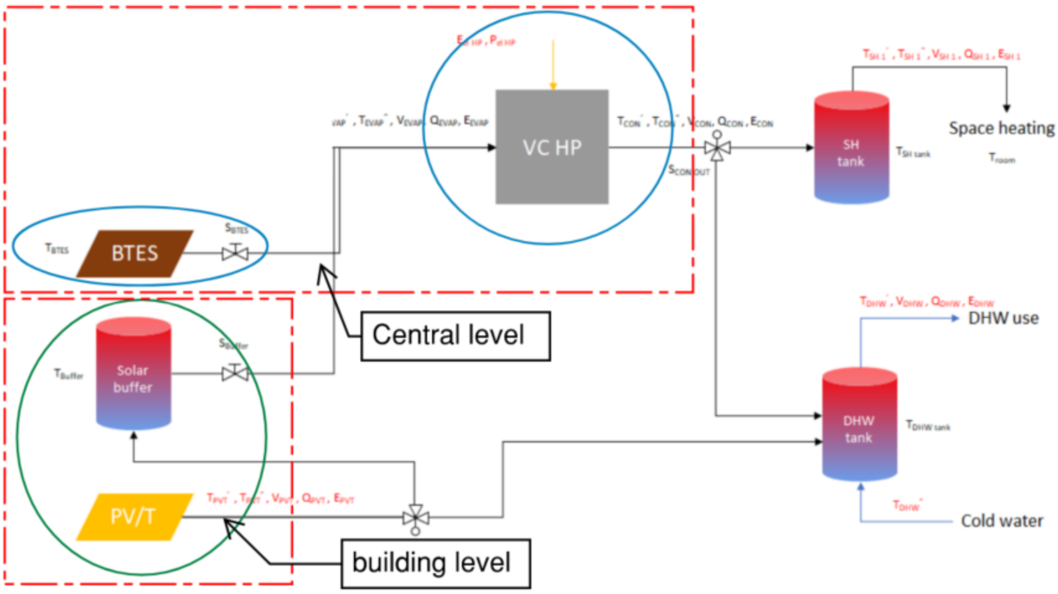


Figure A-10-8: The controls for the buildings and grid are separated, the control at central level manages the heat generation, the building-specific control system manages the valves.

Annex 11: Integrated data collection and management

Property Management and Maintenance

Maintenance of property items is in hands of Facilitary Services (FS). Based on interviews, it is concluded that their scope is limited as the majority of maintenance and energy management tasks is outsourced to other parties, such as Hellemans and BAM. They focus on the technical aspects of property maintenance. The other two aspects: users and organization, are to be covered by FS.

The RES4BUILD team have introduced the local framework as described in *ISSO 104: Sustainable Management and Maintenance of property*. As per this framework it is advised to prepare a systematic dataset, which holds data and communication in three aspects: the users, the building, and the system (Figure A-11-1). To optimize performance in all aspects, these parties should be well represented.

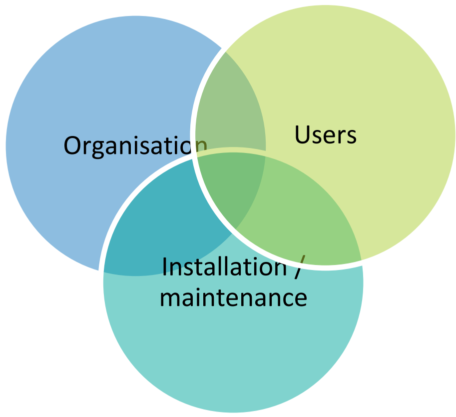


Figure A-11-1: Parties involved in Sustainable Management and Operation of property

If the information is collected on building properties, the ownership, maintenance and use of the building, this information (data) will support in satisfaction on the performance of the building:

- Satisfied users
- Comfortable and healthy environment
- Low-energy use with high energy efficiency
- Well performing building services
- Well maintained building services

A central location of information is currently missing in the organization; so, it is advised to summarize this into a Basis of Design document. Updating and using this central point of information will support decision making for future improvements.

Basis of design document

The following information is to be recorded in a Basis of Design document (Table A-11-1). When applying a standard structure, decisions can be made on transparent information and therefore be communicated properly to decisionmakers and users.

Table A-11-1: Topics and organization structure of the Basis of Design documentation.

Topics for consideration	Proposed organization of information

Performance criteria for indoor comfort User data as basis of design for HVAC Technical building data, envelope and systems Functional description HVAC systems Maintenance records & building log books Links to detailed reports	Introduction / summary Project data User data Functional description Long term maintenance planning Links to detailed reports, such as energy data, bills, annual spend

Data collection

For the Visio organization on location Vries, a review was done on the availability of data. This is summarized in Table A-11-2. This indicates the data gaps and actions to complete the dataset.

Table A-11-2: Data availability and actions for completion.

Type	Data requirement	Assessment for case study Vries (Rietwal 6-8)		
		Importance for IES?	Status of data collection	Reference
Technical	Are manuals for installation components available?	-	Unknown; possibly with BAM	-
Technical	Have components been replaced by non-standard manufacturers? (End-of-Life estimates to use plant replacement as an opportunity to expedite an IES project solution)	-	Information available in DMJOP for major components e.g. boilers. For small components only supplier info available. Probably additional specifications available with BAM / FS.	DMJOP (2021)
Technical	Is a functional description available and is it up-to-date?	+	unknown	-
Technical	Functional use and space plans; up to date?	+	Information available with FS	FS
Technical	Architectural details & materials; up to date?	-	Probably with FS team; not shared on central location.	FS
Technical	Structural data; up to date?	-	Probably with FS team; not shared on central location.	FS
Technical	Building physics data; up to date?	+	General estimations available for reference objects. Specifications probably with FS team; not shared on central location.	EPA reports 2017
Technical	Building services data; up to date? (e.g.	+	Information available in DMJOP for major	EPA reports; NEN 2767

	specifications, capacities on component level. Also performance on system level (demand profiles).		components e.g. boilers. For small components only supplier info available. Probably additional specifications available with BAM / FS.	reports; DMJIOP 2021
Technical	Building management system and the possibility to view it remotely;	-	Available; details not shared	FS
Technical	Energy performance data: EPA calculation and possibly customized advice;	+	Available; 2017, so outdated.	EPA reports 2017
Technical	Reports related to climate studies	+/-	not available	-
Technical	Energy performance data: measurements (annual / hourly): Granular energy profile data, half hourly on electricity, hourly on gas if available	+/-	Expected from added submetering.	Hellemans; quarterly total complex (2019)
Technical	Visual inspection of the building;	+/-	Available	DMJOP / EED
Technical	Visual and functional inspection of local installations, with indicative measurements. Air pressure tests. IR thermographic imaging in winter	-	not available	-
Technical	Implementation of diagnostic support monitoring (data loggers).	-	not available	-
Technical	If remote access to the BMS is possible, this must be done regularly for a few weeks.	+/-	not available	-
Technical	Local data to assess feasibility of renewable sources Locations for PV, geothermal, waste heat streams	+	Available	Energie Atlas
Organisation	Contact details of the contact persons at the original design parties for the building and the	-	Available	FS

	installations;			
Organisation	Contact details of contact persons of the organizations that provide maintenance;	-	available	FS
Organisation	Complaints registration;	+	unknown	-
Organisation	Employee Satisfaction Surveys (MTE) with subject indoor environment;	-	unknown	-
Organisation	Failure reports and failure handling;	-	unknown	-
Organisation	Long term maintenance and operations planning	+	available	DMJOP 2021
Organisation	Performance criteria for indoor comfort defined?	+	unknown	-
Users	Are the internal heat loads and usage times of the current usage (per building function) known?	+	Not available for specific functions; assumptions can be made	ISSO 32
Users	What usage data is the building designed for? Time of use, office, leisure, sleeping, education, assemblies of people, comfort expectations.	+/-	assumptions can be made; additions required from users, especially on use of hot tapwater: define typical shower patterns.	ISSO 32
Users	Information about usage and layout changes;	+	unknown	-
Users	Speaking with users;	+	Ongoing, in the 'energy board'. Results in feedback on typical patterns (long showers, problems with thermal comfort; risk on implementing changes: stressful for clients).	FS
Users	Visual inspection of building use;	-	Unknwon	-

It is advised to complete the dataset, by structuring available information in the proposed Basis of Design documentation. The current information from EPA-, EED- and DMJOP- assessments is high-level and is especially lacking the link to actual use of the property.

Annex 12. Trends and options in health care real estate finance

Financing investments in health care real estate can be done in different ways. Given that Visio owns most of its own real estate, there is a need for a company-wide investment strategy. Aside from divestments (i.e. selling redundant assets) and investments in new built assets, there will be a need to re-invest in the existing building stock. These re-investments will be needed for being able to keep providing professional health care services (e.g. investments in health care automation), regular maintenance and replacement, as well as for improving the energy and CO_2 performance of the building stock.

In a recent survey in the health care sector (FIZI, 2022) 85% of the financial professionals in health care[29] expected to invest significantly more in sustainability in the coming five years, while at the same time only a 44% indicated to have enough room for making these investments. A top-3 of barriers for implementing investments in sustainability were identified:

1. Financing of sustainability (by 57% of respondents)
2. Too limited internal capacity (by 44% of respondents)
3. Capacity shortages with installers/builders (by 39% of respondents)

Other barriers included, insufficient knowledge (by 27%), no internal acceptance/priority (by 21%), insufficient profitability (by 30%), and limiting rules and regulations (by 10%).

The type of investments that Visio will likely have to make in their existing buildings will range from improving the thermal quality of the buildings (e.g. insulating, walls, roofs, floors, etc.) as well as energy installations (e.g. heat pumps, low-temperature radiators, PV(-T) panels, etc.). Mobilising funds for these investments can be done in different ways. Aside from using the organisations own financial resources (e.g. cash capital, or selling of redundant assets), and obtaining a regular (bank) loans, there increasingly are other financial instruments available to the health care sector.

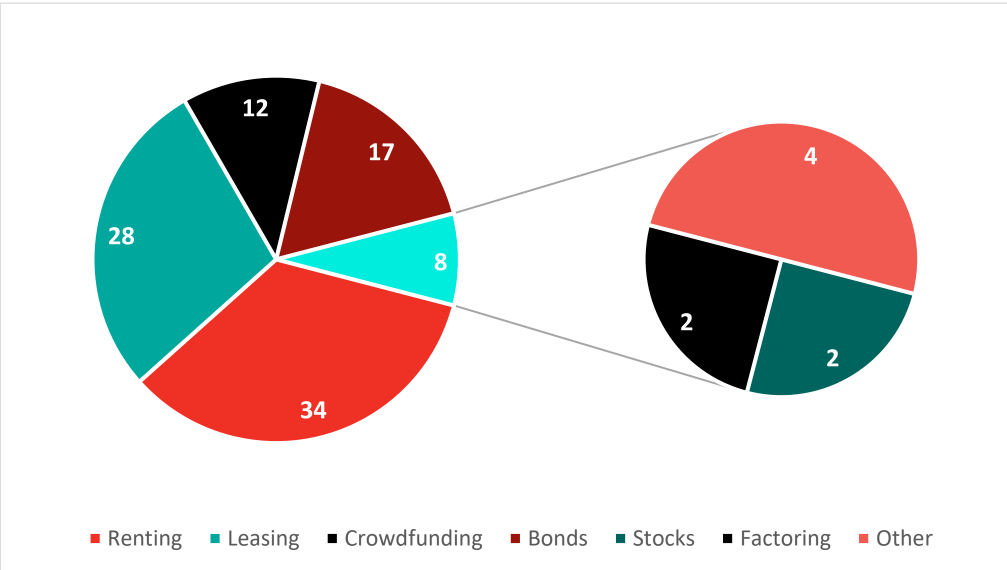


Figure A-12-1: Expected relevance of alternative finance instruments in health care (%-share)

Source: (FIZI, 2020)

[29] For this survey the number of respondents was 95.

In a periodic survey (FIZI, 2020) a network of Dutch health care professionals was asked which financing instruments would become more important in the coming three years (see Figure A-12-1). Key alternative financing instruments included renting, leasing, crowdfunding, and bonds. Other smaller instruments included stocks and factoring.

One of the key advantages of using own funding is that Visio has a relatively high degree of autonomy in the investment decision-making process. Also, own funding would limit any fees associated with the (alternative) financial instrument.

For the first (smaller) pilot investments made by Visio in IES systems this could be an interesting funding option. As soon as the required investment sums will surpass annual housing budget levels, other options to mobilize investment funding may be needed.

For investments in real estate, (bank) loans, renting, leasing is typically used. Leasing can be split in two main categories, operational lease, and financial lease. With financial lease, the health care organisation would pay a fee to the investor but would immediately be the (legal) owner of the asset. With operational lease (is similar to renting an asset) legal ownership of the asset will remain with the investor, but at the end of the lease contract the health care organisation often has the first option to take over the asset.

For existing health care real estate, there is also the option to fund investments by means of sell and lease/rent back contracts. This implies that the health care organisation sells the asset(s) to an investor. As part of the agreement, the investor makes the required investments in the real estate (e.g. insulation, energy installations, etc.). Subsequently the health care organisation leases or rents back the buildings at an agreed fee.

While Visio has a preference to retain full ownership of the buildings, it still may be an interesting option to consider splitting the investments in the building assets in two parts. The first part would be the building envelope (e.g. walls, floors, roofs, etc.), and the second part could be the energy installations and related appliances.

For buildings maintaining full ownership may be sensible from a company perspective, as owned real estate represents a sizable financial asset that can be used as collateral when securing external funding. Moreover, the economic value of most Dutch real estate is relatively stable over time.

For energy installations other financing instruments may be more relevant as they depreciate in economic value over time. For example, for a large solar pv-t roof-top project, crowd- or community funding could be an interesting funding option. Also, for larger collective IES investments that focus mainly on the energy installations (e.g. heat pumps, solar panels, and ATES/BTES systems) an external investor/developer offering a rent, or lease service contract may be preferrable to limit the overall capital requirements.

Building envelope	Ownership (asset on balance sheet?)[30]	Health care organisation responsible for maintenance, repair, and insurance?	Transaction costs (financial)	Project planning and development risk?
Own funding	Yes	Yes	Low	High
(Bank) loans	Yes	Yes	Moderate	High
Rent	No	No	Low	Low
Operational lease	No	Yes*	Moderate / high**	Low / moderate
Financial lease	Yes	Yes*	Moderate / high**	Low / moderate
Crowdfunding	Partial	Partial	Moderate / high	Moderate / high

Table A-12-1: Qualitative comparison of different real estate and energy installation finance options

*Such terms may be negotiable
**In case of sell and lease back the contracting costs can be significant as terms and conditions have to be agreed upon in detail (e.g. which investments will the investor have to make? When should the real estate be delivered for use?).

All the financing options have their own (dis)advantages. Depending on the financing options there can either be full, partial, or no legal ownership of the asset(s). Also, each financing options has its own transaction costs. These can be financial-administrative when they solely relate to the contracting, but also operational when they are related to the risks of project development and implementation (see Table A-12-1). When attracting external finance, there can either be a financial institution (e.g. bank, pension fund, private equity fund) providing a specific financial service, but there are also companies (e.g. ESCO's, installers, building companies, energy cooperatives/communities) that offer project development/investment services, 'building as a service', 'energy as a service' or energy performance contracts with (partial) ownership, lease or rent options.

The recent increases in energy prices provide a good incentive to health care organisations to maintain investments in improving the energy and CO_2 performance of their building stock. However, the latest sector survey by (FIZI, 2022a)[31], clearly shows (by 41% of respondents) that the increased building costs are a primary source of uncertainty for ongoing and new investments in real estate investments[32]. Combined with increasing interest rates, uncertainties regarding (discounts) on health care funding rates, and uncertainty of prices of materials[33].

[30] In case a certain asset is not included in the company's balance sheet, but for example is rented or leased from a third party there is also a different (shared) liability in terms of monitoring, reporting, and implementing measures to reduce the organisations' energy consumption and CO_2-emissions. See for example: https://www.expertisecentrumverduurzamingzorg.nl/wp-content/uploads/2021/03/Hoe-om-te-gaan-met-gehuurd-vastgoed-20210217.pdf
[31] For this survey the number of respondents was 100.
[32] About 28% of the respondents indicated that buildings costs have increased with over 15%, 29% experience building costs increases of 10-15%, and 29% expect increases in building costs between 5-10%.
[33] About 18% of the respondents indicated that the builder/contractor/developer is renegotiating existing price agreements, and 29% of the respondents did not yet experience price renegotiations but expects this will happen in the near future.