SEasonal PErformance factor and MOnitoring for heat pump systems in the building sector
SEPEMO-Build

Easy to understand" guidelines for installation of reliable and energy efficient heat pump systems as a basis for courses and certification of installers within the scope of the RES directive, Annex IV
D5.6.

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1. Introduction

1.1 Objective and context of the "Guidelines-project"

Heat pump technology is very promising in the fields of energy saving, CO_2-emission reduction and promotion of sustainable energy. Many successful projects have been realised in recent years. However, at the other hand, too many projects have been reported where the results were disappointing. In this study guidelines have been formulated that should lead to successful heat pump applications, thus minimizing the latter category.

The guidelines are based upon lessons learned from both a majority of successful and a minority of failing projects in The Netherlands. We have been working from an optimistic point of view, which is quite important, because prominent stories in the media about failing heat pump projects obviously have an impact that goes far beyond the real significance of the problem in detail. So we don't say: "One small leak and the complete tyre is flat". We prefer the statement "If we know how to prevent the leak, the complete tyre will function as it should."

With this study we try to contribute to the establishment of successful heat pump concepts for various applications in the domestic sector by presenting guidelines for a clever approach and preventive measures.

Target groups for the study are all persons involved in the process of establishing heat pump systems: We focus on decision makers, designers, installers and exploiters/operators.

1.2 Structure of the report: Following phases in the process of realisation

Very much has already been written and said about the design and functioning of heat pump systems. In this study, extended use has been made from existing sources (see chapter on references) and various experts have commented on drafts of the study. Our ambition in this study is to present the guidelines in a structured approach following the different phases of the realisation of a heat pump project. We follow the method used by ISSO[1] in the Netherlands. In their publications, they use the MKK-model (Model for Quality Control of Climate Installations). This model contains the following phases:

- Programme phase
- Design phase
- Elaboration phase
- Realisation phase
- Use and maintenance phase

The publications by ISSO, based upon this MKK model, are technically oriented. The main target group includes designers and installers. In this report also good attention is paid to the communication with buyers/future inhabitants. The key word is management of expectations and securing sufficiently high performance levels.

2. Area of interest, scope of the study

The key-conclusion of this study will be: Follow an integrated process. "Integrated" should refer to various dimensions. The most important dimensions are:

- Process
- (Technical) components
- Organisation.

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[1] The ISSO-foundation is a Knowledge Institute for the Installation Branch in the Netherlands

Integration in the dimension of process means, that at each stage the overall process should be kept in the picture. Especially the final target, being a satisfied user, should be kept in mind. But also possible effects of momentary actions on future stages should be considered.

Integration in the dimension of technical components means that all components should be dimensioned simultaneously and integratedly, in order to arrive at an optimum composition and tuning of the system.

Integration in the dimension of organisation includes, that the persons involved should operate in a team, should appoint the final responsibility and should be well aware of each other's problems and boundary conditions.

In Figure 1 the combination of the heat pump system and the building is depicted in its main technical components, including an indication of the responsible persons. Together with the inhabitants' behaviour this leads to the performance of the system.

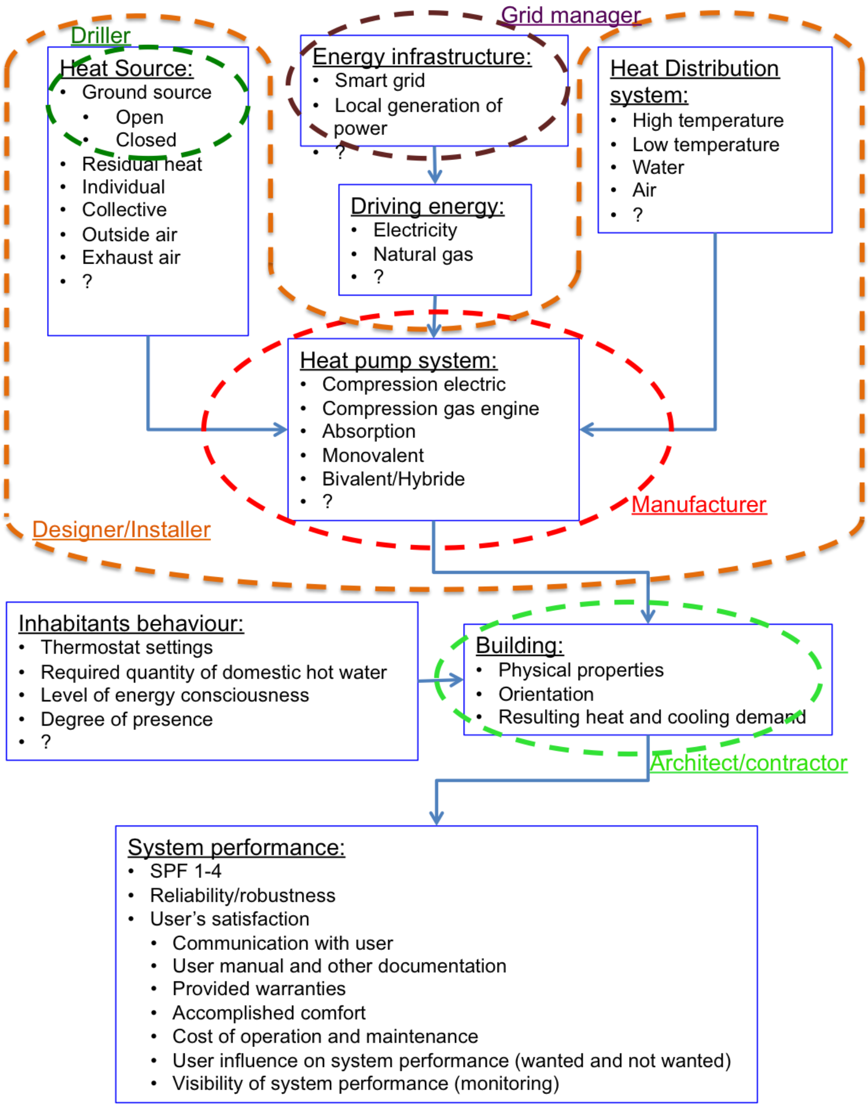

Figure 1. Heat pump system, responsibilities and surrounding elements

The final target of each system installation is good system quality and performance, which has various dimensions. The picture shows that it depends on many factors and that many organisations are involved. Every step in the realisation process and each actor/participant should be focussed at that final target.

In Figure 2 the process-dimension is depicted.

At a sufficiently high level of abstraction the ideal realisation process is always the same, in particular for renovation of existing dwellings and for new to build houses. The block at the left suggests, that the team of involved actors and suppliers (Building team) should meet at all stages. The block at the right says, that future users/inhabitants should be involved.

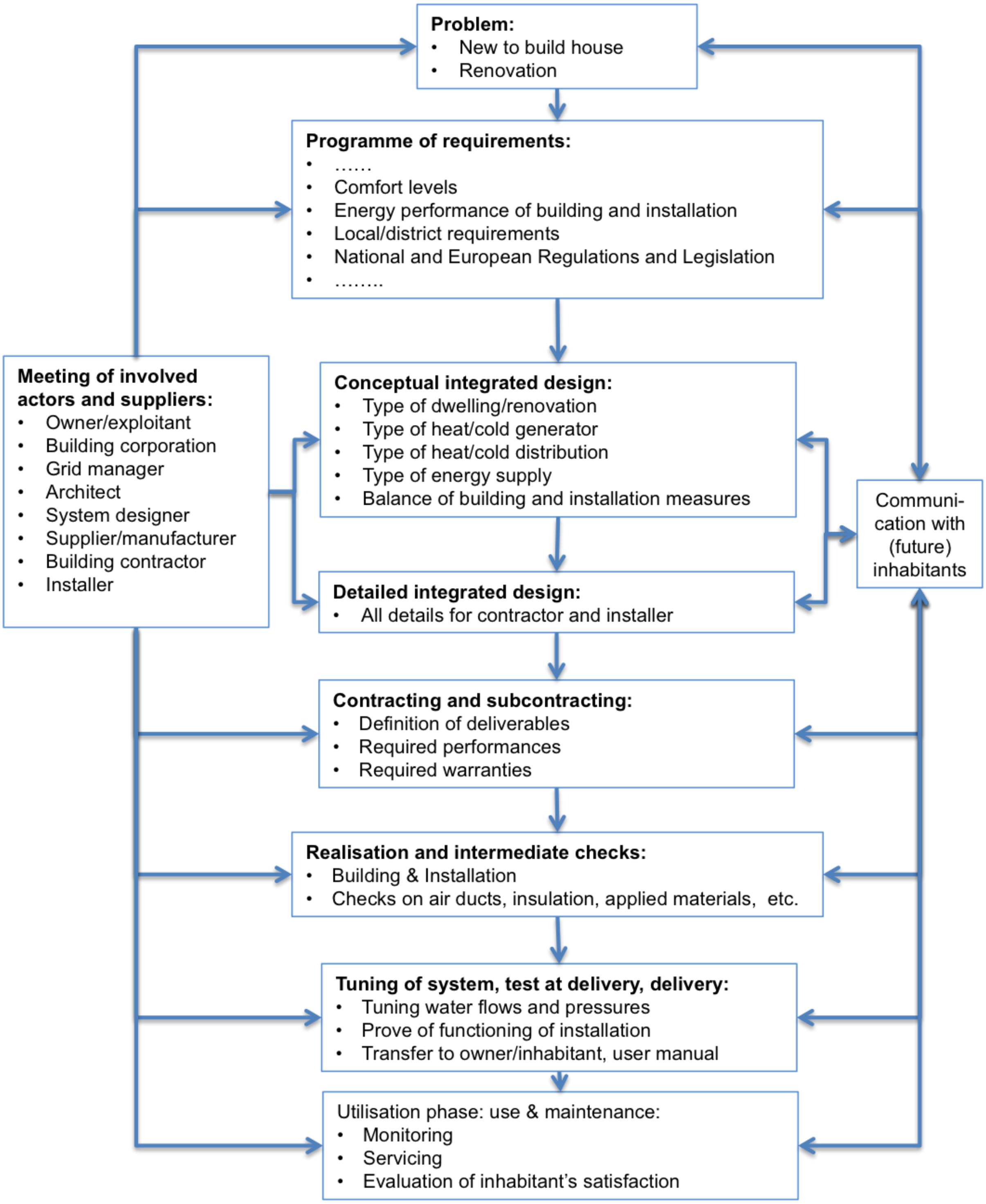

Figure 2. Heat pump system realisation process and actors

3. Relevant characteristics of heat pumps

This is not a handbook on heat pumps. Therefore, we will not explain the heat pumps in detail. A list of relevant characteristics of heat pumps will do.

The efficiency of heat pumps is favoured by a temperature lift as small as possible. So required are:

- a source temperature as high as possible
- a supply temperature as low as possible

Heat pumps show higher investment costs than the reference system (which in the Netherlands is the condensing high efficiency natural gas fired boiler). Therefore, the number of operating hours of the heat pump should be as high as possible and the heat pump capacity as small as possible, under the boundary condition of the desired contribution by the heat pump to the heat demand of the house.

Apart from its dependence on the building physics, the energy demand of dwellings varies strongly with the inhabitants' behaviour. A heat pump system should be designed as robust as possible against this almost unpredictable influence: In the end, the heat pump system should be able to function at high efficiencies under a broad range of energy demands.

Basically, a heat pump is a superior energy concept when compared to conventional technology. However, to maximize the energy yield of the concept, heat pump systems seem, at least in the beginning, more complicated. Moreover, they are more sensitive to the behaviour of the user. For that reason, communication with the future users is of utmost importance, to explain the special character of the system and to "manage the expectations".

4. The concept of "(system) quality" [3]

In literature several definitions of quality are used. We mention only a few, just to show the different points of view. This is relevant in the present study because these *"Guidelines"* are aimed at improving system quality of heat pumps.

Quality is:

- Fitness for use (Joseph Juran),
- Performance x Acceptance (Q = P x A) according to Wim Scharpé,
- Conformance to requirements (specifications) according to Phil Crosby,
- The whole of characteristics of an entity that refer to the capability of the entity to satisfy both specified and self-evident needs, according to the Netherlands Standardisation Institute,
- The whole of characteristics and properties of a product or service that make it meet the specified and self-evident needs (ISO 8402).

We think that in this overview there are no elements that are not relevant to heat pump systems. In particular the inclusion of *self-evident* needs should be kept in mind: apparently not all requirements have to be specified explicitly and so "reasonableness" comes into the picture.

In quality affairs, the inhabitant (owner) provides the yardstick. For him accomplished comfort, cost (over the life cycle), energy use and robustness (flexibility) and reliability are the most important issues. The inhabitant has also expectations, based on (i) experiences in former dwellings (in the Netherlands mostly with a condensing natural gas-fired combi-boiler), (ii) brochures and (iii) user instructions. In particular the experience with the condensing boiler makes the bar lying at a high location. Condensing boilers:

- have high quality labels, both for heating and domestic hot water,
- have always sufficient capacity for heating and domestic hot water,
- show high efficiencies,
- have a good price/performance ratio,
- are closed,
- are compact and light-weight,
- produce hardly any noise,
- are easy to install (wall-hung) and in maintenance,
- are well designed and
- have a good reputation and are well known.

5. The Guidelines

5.1 Programme phase (preparation of the project)

This is the phase in which the project is planned. Points of attention are:

At the very beginning, define the integral quality of the project in the considered area. I.e. the overall energy performance and reliability aspects of the total project should be clearly stated. Describe the overall project in such a way, that the contributions of the various elements of the project to the overall system performance are clear.

***Example**:*

It should be clear how the different measures that contribute to the building performance are divided between building physics and installation technology.

Although building-physics and installation-technology have equivalent effects upon the energy performance of a building, priority should be given to the building related measures. This is also in line with the "Trias Energetica"[2], that expresses the fact that avoiding or minimising an energy demand is basically better than fulfilling it with even the highest efficiency. It is also by reducing the heat demand of the building, that we can largely compensate for the unpredictable users' behaviour.

***Examples**:*

- *If we apply balanced ventilation with heat recovery, the effect of the thermostat setting by the inhabitant is reduced, because at a higher indoor temperature more heat is recovered from the exhaust air. The same holds for the application of a heat recovery system at the shower. If our children take showers of 30 minutes instead of 15, more heat is recovered from the discharge water flow. Both examples show options to make the system robust against variations in user behaviour.*
- *The demand for cooling can be reduced by applying (outdoor) sunblinds.*

Be aware of the secondary effects of building measures and quality. Keep in mind that a good heat pump system needs a well-designed dwelling. E.g. don't try to compensate for failures in the building envelope by applying a heat pump system.

Examples/illustration:

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[2] In The Netherlands the "Trias Energetica" is a concept, expressing the priorities of possible energy saving measures: 1. Reduce the energy demand as much as possible. 2. Fulfil the remaining demand as much as possible using sustainable energy. 3. Fulfil the remaining demand with fossil fuels, at the highest possible efficiencies.

- *If a dwelling is well-insulated and fitted with heat recovery systems, the resulting heat demand is small and can be transferred through a low temperature heating system. So the effect is double: a lower heat demand to be covered at a higher efficiency of the heat pump.*

- *At the other hand, when, given an overall well-designed system, errors are made in the building process (e.g. insulation not conform specifications), the negative effect is three-fold: (i) higher heat demand, (ii) lower heat pump efficiency (due to higher supply temperatures), (iii) lower heat pump capacity (also due to higher supply temperatures) leading to a larger contribution of the peak load boiler. In the Netherlands a larger part of the so-called heat pump system failures are caused by shortcomings of the building contractor.*

Inform the energy companies involved about the energy systems to be applied in the new to build area.

Example:

Electrical heat pumps require a stronger grid for electricity, especially if the auxiliary or back-up heating is electric (which is generally not recommended here; pros and cons should be considered carefully!).

If combinations of energy technologies are to be applied, than that information should also be passed tot energy companies involved. In general, the considerations about smart grids, if any, should start already at this stage.

Example:

If apart from electrical heat pumps also cogeneration systems are planned, a strong reduction of the electric grid may be possible: It is obvious that heat demand controlled cogeneration systems produce electricity that (i) is synchronous with heat demand and (ii) can, therefore, feed electric heat pumps.

Certain types of heat sources have impact on the preparation of the infrastructure of the building site. If ground heat exchangers are foreseen, they will usually be installed at the very beginning of the project, together with other infrastructural tasks (drinking water, gas, electricity, sewage system, data lines, etc.).

Example:

The application of water wells for a collective heat and cold source/storage system for individual heat pumps will in most cases be installed in an early stage of the project. In other cases the main "heat source grid" is installed in the beginning, and the branches later.

Air source heat pumps may have outside units that affect the surroundings.

Example:

The outside units produce noise and may change the aesthetics of a building.

Communication between partners at the building site that were not accustomed to meet so far.

Example:

Users of heavy equipment should be well informed about the presence of a collective heat source system, to avoid damage.

Parties to be contracted: All partners that contribute to a heat pump system should guarantee quality and reliability of their deliveries. Where certification schemes are available, suppliers and installers should be certified. There should be one single authority that is responsible for the quality of the total project, and functions as a desk for questions, after-sales service and complaints.

Example:

Contract only installers that have proven experience with heat pump systems. A project developer should prove himself by guaranteeing that e.g. an ill functioning heat pump is replaced within 24 hours, without sending the inhabitant from pillar to post. In particular a strict and sound regulating of the final responsibility for the overall project is of great importance for the heat pump branch. By some *way or another it seems that in most projects the logo of the heat pump manufacturer is most visible, making him the favourite address for complaints, regardless of their origin.*

Be aware of regulations (and the changes therein) when dealing with ground source heat pumps.

Example:

In the Netherlands regulations are under development aiming at optimising the use of the ground as a source/storage for heat and cold.

Develop a reasonable and transparent exploitation plan.

Example:

This is extremely important for collective systems and for systems where the installation is not owned by the house-owner. If inhabitants only pay for the Gigajoules delivered, the price should be certainly not higher than for conventional systems. The system should be such, that inhabitants are (and feel!) rewarded for energy-conscious behaviour.

Communication with future owners or inhabitants. It is in this stage, that the planned dwellings will be offered on the market and future owners/inhabitants start showing interest. It is very important to manage the expectations of those interested in a well-considered way.

Example:

For heat pump systems all aspects should be mentioned and clarified. For an electric heat pump system not only lower costs for gas, but also the higher costs for electricity should be mentioned. For a collective heat source the costs for exploitation should not be "forgotten". Users should be informed about the rebound-effect and the impact of their users' behaviour on the systems' performance: Although the heating system has a high efficiency, its final energy use still remains proportional to the heating demand as created by the inhabitant. So heating all rooms in the house, taking long showers and ventilation by opening all windows will still lead to high energy bills (although lower than with the reference system). It should be very clear to the inhabitants/users that their very behaviour is in between their heat pump system and their energy bill. For those who are interested in the issue, an estimation of the life-cycle cost of the system should be available.

Communication should also include the possibility of a service and maintenance contract as well as an explanation of the guarantees connected to the purchase.

5.2 Design phase (determining the concept)

A lot of knowledge on heat pump system design is available in the Netherlands and abroad. Handbooks, publications are written and courses and trainings can be followed. These sources of information and experience should be used. A larger part of failing heat pump systems has been designed or realised with ignorance of this knowledge.

Example/illustration:

In the Netherlands ISSO is the main publisher of publications for the designers and installers target group. The EHPA issues courses for installers in the framework of certification of installers.

Be sure and guarantee that the integral system (area infrastructure, building and the heat pump installation) is designed in an integrated process. Everything is connected to everything. A chain is only as strong as its weakest link. Be well aware that an integrated system cannot be realised by a not-integrated team of workers.

Example/illustration:

These systems are usually realised by a large "orchestra" of different players. Let them start well-tuned on common starting points, let there be a strong, inspiring and qualified director. Only a limited list of possible "false chords":

- *dwelling less insulated→higher heat demand→higher contribution of auxiliary heating.*
- *incorrect estimation of user behaviour→ higher heat demand→(etc).*

- *distance between underfloor heating tubes larger→higher supply temperature→lower COP and lower hp-capacity→disappointing energy use.*
- *Changes arising from ill-considered cost reductions.*

A well-designed heat pump system needs a well-designed dwelling. If sufficient measures in this domain have been taken, a heat pump system can be very satisfying.

Example:

In a well-insulated, airtight dwelling, fitted with a proper ventilation system with heat recuperation, a (very-) low temperature heating system can be applied. The resulting low energy demand covered by a high COP will satisfy the inhabitant and lead to a high Seasonal Performance Factor (SPF).

At the other hand, due to building failures (e.g. cold bridges, badly fitted windows and frames) the planned underfloor heating system might be unable to deliver the required comfort in the room.

Be aware of heat losses to neighbouring apartments in apartment buildings.

Example/illustration:

In particular in low energy collective buildings, where the outer skin is well insulated, walls between the apartments should be also relatively well insulated. In the Netherlands problems occurred in a new built apartment building during the period that only few apartments were occupied. The low capacity heat pump system, designed for the expected low energy demand, could not accomplish the required temperature comfort due to the heat losses to 4 unoccupied neighbouring apartments.

Be well aware of the space needed for heat pump system equipment.

Example/illustration:

Heat pump systems are often larger than conventional systems, especially when storage vessels are included. So suitable space should be reserved. "Suitable" also includes attention for acoustic aspects. Preferably wall hung units should not be connected to parts that function as sounding boards.

Don't allow changes in the building design without considering the consequences for the installation design.

Example:

If the insulation level of a dwelling as described in the original design is decreased for (say) cost reasons, the heat demand of the dwelling, as well as the temperatures of the (say) under floor heating system will increase. Consequently, the increased heat demand of the dwelling (i) will be delivered by a heat pump at lower COP (ii) that delivers a smaller share (iii) in the (say) hybrid system. All together these are three negatives consequences, resulting from a single, perhaps ill-considered, change.

Be aware of the energy use of sub-systems.

Example/illustration:

Keep the hydraulic system as simple as possible. Minimize the number of circulation pumps. Use underfloor heating dividers without pumps. Let circulation pumps be controlled by the control system. Be clever in dimensioning collective heat source systems. Collective heat source systems should show a performance of at least $COP_{source}>20$ *(source energy divided by pump energy).*

5.3 Elaboration phase (selecting and detailing specific components)

After a heat pump concept has been selected during the previous phase, a specific heat pump manufacturer is selected in this phase. Apart from straightforward aspects like cost and performance, especially aspects in the field of reliability should be considered very carefully.

Example:

Is the heat pump immune for "mistreatment"-influences from the heat pump system? I.e. does it have protections against too high and too low temperatures/pressures preventing that off-design situations lead to damage?

Heat pump manufacturers have a great interest in the quality of the system in which their heat pump is condemned to function. Use their experience during the design phase.

Example/illustration:

Most manufacturers prefer being involved in the detailed design to being confronted later with complaints from users.

Monitoring heat pump systems may serve several purposes and should be included in the system. Keep in mind that heat pumps do exist that already include monitoring facilities (because it was a requirement on the German market in relation to a subsidy-scheme).

Example/illustration:

When a heat pump system is monitored, the supplier of the system can easier plan the maintenance of the system; he can replace <u>curative</u> maintenance (after failing of the system) by <u>preventive</u> maintenance (depending on the condition of the system). Monitoring will also contribute to the learning curve of the installer and designer of the heat pump system.

Monitoring can provide the user with the fun of feedback about the effects of his behaviour, thus reducing the rebound-effect. Monitoring may be combined with a low tariff facility by the energy company for clients who allow the shutting down of their system during specific hours; the monitor will show this, including the "penalty" of refusing this shut down.

The capacity of the heat source should be sufficiently large. Especially when the capacity of the heat source is difficult to increase later on, as is the case with ground source heat exchangers, larger is always better than smaller.

Example/illustration:

Only few people realise, that an increasing COP requires an increasing heat source capacity. If a first heat pump is replaced by a second better one, or if during the life time of the heat source system the heat distribution system is converted to still lower temperatures, the load of the heat source will increase. The resulting lower source temperatures may nullify these later improvements.

The capacity of the heat pump should be well chosen. A large heat pump (compared to the heating demand) will lead to high investment cost, and the heat pump will also cycle on/off. A small heat pump will lead to a large demand of back up heat. So there is a trade off depending on the investment cost and the fuel costs. Be well aware of a dilemma caused by the uncertainty of the unknown inhabitant behaviour and, consequently, the heat demand.

Example:

Especially in bivalent or hybrid systems the choice of the capacity of the heat pump is of crucial importance. A small heat pump contributes relatively strong to the yearly heat demand; each increment does less. See also the measures mentioned under 5.1 that decrease the dependence on user behaviour.

5.4 Realisation phase (building phase)

Even in the best heat pumps, moving parts generate sound. Proper placing and connecting the heat pump should prevent sound transmission.

Example:

Use flexible tubing to connect the heat pump to the hydraulic system. Don't fix it to sounding board-like walls. Obviously, this issue should also be part of the detailed designing process.

The quality of the building and installation should be checked during the building and installation process. Checks have especially to be made on aspects that cannot be repaired afterwards.

Example:

Everything that will be covered (literally or figuratively) during later stages in the building process should be checked. Ducts for ventilation should be checked on deformations or blockages resulting *from pouring concrete, underfloor heating systems should be checked on leaks before pouring the floors, wall insulation should be checked before applying the outer walls, ground heat exchanger tubes should be pressure-tested before inserting them in the borehole, etc.*

Before delivery, the installation should be fine-tuned and tested; the dwelling should undergo a final test on its thermal qualities. Preferably, a standard protocol should be developed and mandatorily applied, that should be part of a heat pump system quality label.

Example/illustration:

At delivery, the heating system should be tuned (set points of water flows) carefully and by a test run its well functioning should be verified. The air tightness of the dwelling should be checked with a so-called blower door test, the insulation quality by infrared photography, etc.

At delivery, a user manual should be handed over to the inhabitant.

5.5 Use and maintenance phase

After approximately half a year, the system supplier should contact the inhabitant in order to inventory the experiences with the heat pump system.

Example/illustration:

Even when there are no problems, which may be expected when these guidelines are respected, the inhabitants will appreciate this form of after sales service. It also gives them a get-at-able opportunity to talk about experiences that not yet led to complaints, but still potentially might do so. Important to check is how the users think about the realised comfort and their energy bills. Also try to get an impression about their users' behaviour. This type of contacts may well contribute to the installers experience.

Be flashingly quick in service at system failures.

Example/illustration:

Every system break down is one too much. However, when it happens, it provides a great opportunity to show a high quality of after-sales service. Do it in such a way that the user forgets the original problem and only remembers the service delivered.

6 Integration of the building/realisation process

In order to arrive at a building that is satisfying for all involved, all aspects of the building (comfort, cost, physical quality, quality of installation, sustainability, aesthetics, etc.) should be covered in an integrated process of design, realisation, checks, use and maintenance. To achieve that, all "suppliers" of these aspects should act in an integrated harmonized way, focussed at a common target. Our suggestion for that target is a satisfied user of the dwelling, under the boundary conditions of alignment with the (political) targets defined by the society. Working in an integrated way, with several parties involved, requires communication. In this paragraph the main issue is communication. We take for granted that there are inevitable duplications with the previous sections: it is justified by the importance of the communication-issue.

In figure 3. the main players in the process are depicted, connected by numbered lines of communication.

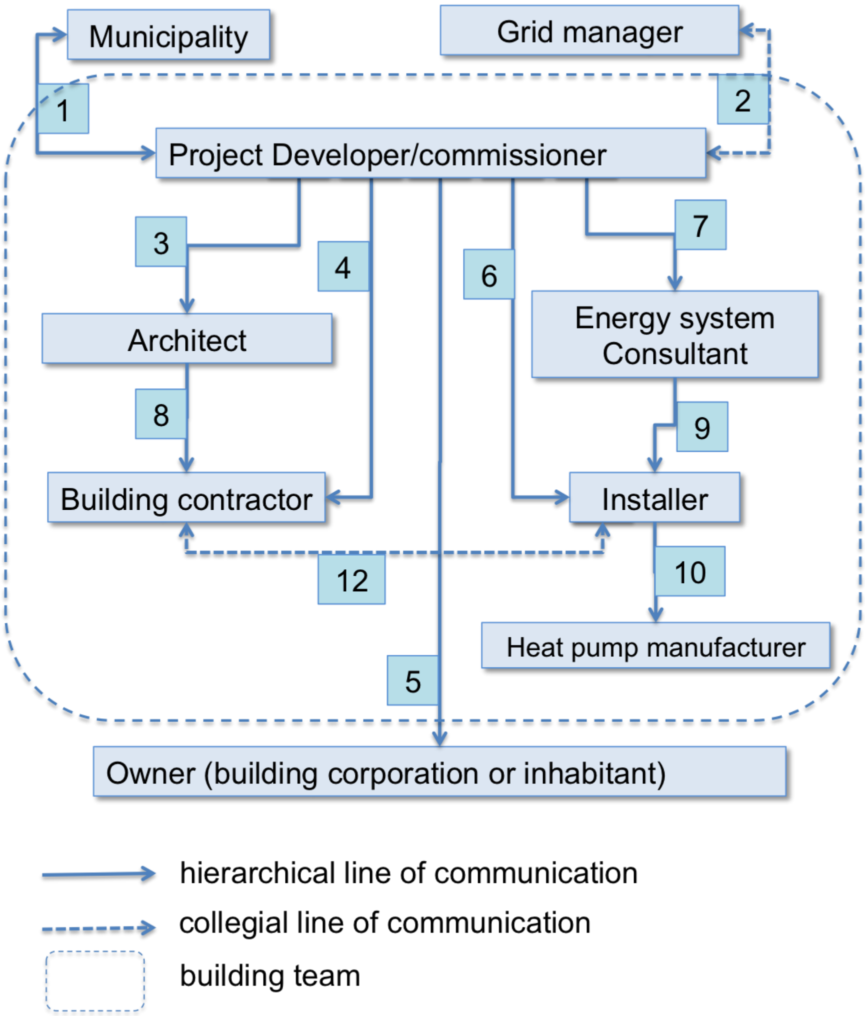

Figure 3. Players in the building process and their lines of communication

In the following, we will discuss the required types of communication, where the figure suggests that the Project Developer is the spider in the communication-web:

1. Municipality (Mu) ←→ Project Developer / Commissioner (PrD)

The municipality may have developed policies to develop new areas or to renovate other areas. It may have targets set with respect to sustainability, etc. These policies and targets are the boundary conditions for the PD to work within. The PD may have his own idea(l)s, so a clear and open discussion is required for both parties to understand each other. The latter is of course a prerequisite for all communications that are discussed here: They should be open, parties should try to mutually understand each others points of view, discussions should be rounded off with written conclusions and/or agreements and these should be communicated to other parties in the process wherever relevant.

Mu and PrD should be very reluctant in their discussions to make premature discussions on design-details of the energy system (which happens too often). E.g. the Mu may have the political target to optimise the use of geothermal heat or to apply heat and cold storage systems, however, a decision at this stage may jeopardise the design-process in a later stage. This type of decisions should be discussed with the Energy System Consultant (line 7).

2. Grid Manager (GrM)←→ Project Developer (PrD)

The grid manager has to know well before the project is realised what grid loads for electricity and gas may be expected. Massive implementation of electric heat pumps may overload the existing electric grid. The GM may wish to express ideas about smart grids with local energy production (photovoltaic) or local energy conversion (combined heat and power from gas).

3. Project Developer (PrD) ←→Architect (Arch)

These parties should discover an optimal balance of building aesthetics, functionality and sustainability. If the architect is charged with checking the building place (which is suggested in figure 3), this is also subject of this communication. If the energy system put specific requirements to the building (e.g. room for equipment, underfloor heating, wall-heating, minimum insulation requirements, concrete core activation), this is the communication line through which the architect should be informed.

4. Project Developer (PrD) ←→Building Contractor (BuC)

The PrD is charged with contracting the BuC. This is a very intense line of communication. The building contractor should receive a detailed Programme of Requirements. It should be agreed upon that the work is checked during the building process and at delivery by an independent party.

5. Project Developer (PrD) ←→Owner (Ow)

The main communications are around the moment of decision of buying the building (concerning the design (if still open) of the building and the installation and warranties and maintenance contracts) and at delivery showing that the "product" is conform the requirements as agreed upon.

6. Project Developer (PrD) ←→Installer (Ins)

The business communication (contracting) is along this line of communication, while as regards content, the installer should be managed by the Energy System Consultant (see line 7). This way of working should be covered by the contract between PrD and Ins.

7. Project Developer (PrD) ←→Energy System Consultant (EnSC)

The PrD contracts the EnSC. The contract includes the programme of requirements as regards the energy system of the building as well as the relevant boundary conditions that should be fulfilled by the building contractor. These include all physical aspects of the building that determine its heat and cold demand and the functioning of the system.

8. Architect (Arch) ←→Building Contractor (Buc)

In this line of communication, the Arch checks the quality of the BuC's work during the process. This should be regulated in the contract between PrD and BuC (line 4).

9. Energy System Consultant (EnSC) ←→ Installer (Ins)

In this line of communication, the EnSC checks the quality of the Ins's work during the process. This should be regulated in the contract between PrD and InC (line 7). Also subject of this communication line are the innovative aspects of the energy system, if any, which with the installer may not yet be accustomed.

10. Installer (Ins) ←→Heat Pump manufacturer/supplier (HPM)

We assume that it is the Installer's responsibility to select the heat pump type and its manufacturer or supplier, based on the programme of requirements that he receives through lines 6 and 9.

11. Project Developer (PrD) ←→ All parties

Just because he is "spider in the web" the PrD plays a predominant role and consequently has a big responsibility in keeping all focussed at the same general target. He is the party that should explain the relevant details of the project to all involved, knowing that other parties can only play their role well if they understand the details of it thoroughly. The PrD should also check that the communications in which he doesn't participate (8, 9, 10 en 12) take place.
The PrD also chairs the building team (dotted square in figure 3).

12. Building Contractor (BuC) ←→ Installer (Ins)

These parties have to communicate simply because they are working at the same place, at the same time. They should tune and plan activities in such a way that they don't frustrate each other's efforts. The communication is collegial, as should be established in their contracts with the PrD.

7. References used

[1] Lente-akkoord; *Do's and don'ts for project developers (NL: Do's and don'ts voor ontwikkelaars); NEPROM, December 2011*

[2] DHPA; Practical experiences of members

[3] Wolferen, Hans van; *Quality of Heat Pump System Guaranteed?* (in Dutch). Presentation at DHPA meeting of 23 June 2011

[4] Paul Friedel, Peter Oostendorp, Peter Wagener; *Heating of dwellings* (in Dutch, "Warmte in de woonomgeving"); GasTerra, 2012-05-15; (chapter 12: Examples)