Deliverable 2.1 End-user requirements version 1

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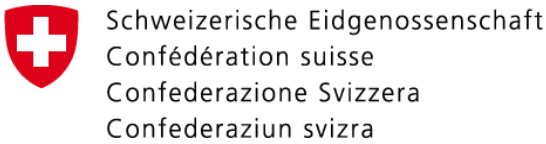

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Abstract

This document describes the requirement activities and results for the SmartHeat system focusing heating conditions that have a significant impact on older citizens. The resulting requirements will serve in a first phase as a guideline for the development of a future SmartHeat prototype.

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1 Introduction

1.1 Preface

This deliverable describes the primary and secondary target user groups of SmartHeat, the user requirement activities and procedures in two partner countries (AT, CH) as well as the results and conclusions for the further system specifications. The structure of this deliverable is organised as follows: Section 1 gives an introduction and short background information about the SmartHeat system. Section 2 focuses on the research goals. Section 3 defines the different target user groups and outlines the recruitment procedure. Section 4 outlines the applied methods for collecting the user requirements. Section 5 includes the main results. Section 6 provides a summary and section 7 the conclusion and recommendations.

1.2 Motivation

SmartHeat is the only heating system with elderly as end-users that levers on IoT (Internet of Things) technologies to improve comfort and energy savings. Therefore, the user requirements had to be gathered within the specific scope of the project. The necessary knowledge to design SmartHeat can not be drawn from existing sources and this document was required to understand the problematic and the needs of the users.

1.3 Scope of the deliverable

The major goal of D 2.1 is to give a summary about the definition of the target user groups and their requirements related to heating and wellbeing. User requirements were analysed from different point of views involving primary users (seniors) and secondary users (formal caregivers: professionals in taking care of elderlies, informal caregivers: family members, relatives). Results are translated into a requirements table highlighting the major requirements of the future SmartHeat system for the following technical development phases.

2 Focus of research

2.1 Goals

The main research goal is addressed within the requirement analysis – how are elderlies‘ living conditions/environment, how do they organise heating in daily life, what are their habits, what kind of problems occur, how do they overcome problems or difficulties, do they need any support, etc.

2.2 Research questions

According to the central objectives of the SmartHeat system to be developed in the course of this project, the following parameters and lead questions were identified as a basis for the underlying requirements analysis.

- **Overall heating behaviour and requirements**
  - How do elderly people organise the heating in their premises?
  - How do elderly people monitor their heating systems in their premises?
  - How do elderly people currently deal with remote controls of their heading?
  - What problems do they face with regard to their daily heating activities (including outcome)?
  - What are the general expectations regarding the effectivity of their heating (e.g. delays between switching on and full effect on temperatures)?
  - Which kind of support is needed to meet their requirements?

- **SmartHeating**
  - How stable / volatile are the preferences of elderly people regarding temperatures in their premises / specific rooms?
  - To what extent do they rely on fixed temperature indications for their well-being rather than personal situational feelings?
  - What are their expectations regarding individual / personal control (contrary to automated control) over the system?
  - To what extent do elderly people align their heating behaviour to the way they behave in their premises (use of rooms)?
  - In how far would elderly people adapt their behaviour to suggestions made by the technical system and under what conditions?
  - What expectations do they have regarding remote control?

- What individual personal factors have to be considered as success factors of the system?
- What privacy concerns might play a role in the development

- **Acceptance of technology**
  - What overall affinity do elderly people have to managing heating devices by use of ICT?
  - What sort of devices (sensors) would they accept in their premises for the monitoring of user-behaviour and physical conditions in their premises (recognition of behaviour, number of persons etc)?
  - What technical devices / platforms for steering and monitoring activities (smartphone, tablets etc.) fit into elderly people` daily routines the most?
  - In how far would elderly people be willing to change their behaviour (active use of new technology) with regard to the steering and monitoring of their heating?
  - In how far / in what heating-related areas would they be willing to switch from personal to automated support?

- **Heating Costs**
  - What impact do heating costs have on the way elderly people organise their heating?
  - In how far would they be willing to change their behaviour if costs were made transparent to them?
  - To what extent do elderly people use existing functions of their heating systems regarding energy savings?

- **Empowerment of secondary users**
  - What is the elderly people's` attitude regarding external steering and monitoring of their heating systems?
  - What information would they be willing to share (physical, medical related data etc.)?

2.3 Problem statement

Most heating systems (traditional and modern) consist of a boiler which sends hot water to radiators. Thanks to a centralised thermostat the system can read the room temperature, hence decide if turning on/off the boiler. The thermostat is usually located in one room, most of the time fixed on the wall, such that it measures the temperature of just that zone of the house, with no knowledge of the indoors temperature in the rest of the house. This might make some rooms cooler or overheated, leading to *high gas expenses* and *lack of comfort*.

Besides all the efforts made in the last decades to improve the management of the heating in the houses, we're still far from an efficient solution: the market has tried to overcome the issues aforementioned by offering a wide variety of mechanical and electronic TRV (Thermostatic Radiator Valve). The TRV is an old fashioned solution (traced back to the '70s[1]) which is basically a thermostat applied to one single radiator: it decides how much the radiator is heated depending on the needs of the room (a cold room needs a hotter radiator and vice versa).
Unfortunately, despite the efforts, the real problem remains still unsolved because each radiator is independent from the other and has no control on the central boiler: there's always a central thermostat regulating the heating of the entire house, whilst being based on the temperature measured in a specific room.

TRVs available on the market nowadays are designed for a standard user but not for elders. They are difficult to configure and to interact with, which automatically excludes elders as potential users and customers. Not only that: an adequate design of such devices can help old people (and not only them) to improve the daily lifestyle and health.

Older adults lose heat more easily through the skin and consequently are more exposed to *hypothermia* problems, especially during winter[2] [3] [4] [5]. Those who suffer some kind of *dementia* can easily regulate in the wrong way the thermostat, causing absurde situations like overheating the house in summer or turning off the heating in the middle of winter[6], eventually leading to heat strokes[7] or hypothermia.
Those who live in a big house with very low occupancy rate of the rooms and high energy bills, would find seducing to reduce the gas related expenses while keeping the same grade of comfort. In this case for example, they might not be able to use efficiently a thermostat because it is complicated or because they have limited mobility.

Nevertheless, few innovative solutions are appearing in the last years in the market which are going towards the right direction. They do not solve entirely the comfort and energy waste issues but they're surely introducing a new philosophy in the HVAC market sector: smart thermostats like Nest,Tado or Netatmo[8] [9] [10] introduce a

[1] https://en.wikipedia.org/wiki/Wax_thermostatic_element
[2] http://www.mayoclinic.org/diseases-conditions/hypothermia/basics/risk-factors/con-20020453
[3] http://www.nih.gov/news-events/news-releases/hypothermia-cold-weather-risk-older-people
[4] http://www.theguardian.com/money/2014/feb/12/high-energy-bill-thousands-risk-hypothermia
[5] http://www.dailymail.co.uk/news/article-2100232/Frozen-death-fuel-bills-soar-Hypothermia-cases-elderly-double-years.html
[6] https://www.caring.com/questions/i-presently-take-care-of-an-89-year-old-man-that-has
[7] http://emergency.cdc.gov/disasters/extremeheat/older-adults-heat.asp
[8] https://nest.com/

new user experience based on extreme simplicity and usability by the user. These innovative solutions surely help the old adults to correctly configure the thermostat but the whole heating system still relies on the temperature measured in a single place of the house. Therefore, the lack of comfort and high energy bill problems do not disappear.

Even though the elders are one of the most delicate and sensible category of our society, the heating systems currently installed all around Europe are not designed around them. Here it is exactly where the SmartHeat project fits in and this is the reason why it is needed a large survey to understand the habits of old people and their carers.

[9] https://www.tado.com/es/
[10] https://www.netatmo.com

3 Target user specification and recruitment procedure

This section defines the different target user groups of SmartHeat and the recruitment procedure.

3.1 Target user specification

In short, SmartHeat addresses the following two target user groups:

Primary users:

- Seniors aged 60 and older
- either male or female
- may have age related restrictions
- may show AAMI (Age Associated Memory Impairment) – not diagnosed as a neurodegenerative disease
- have at least a little experience with the use of modern ICT (TV, mobile phone, Smartphone, PC, Laptop,…)

Secondary users:

- Formal professional and informal caregivers such as family members, relatives, friends, etc. who are taking care of the older person

To work with valid data, the user profiles are related to the CURE-Elderly-Personas. CURE Elderly Personas represent valid archetypical user groups and are based on data from multidisciplinary and cross-national-panel database on health, socio-economic status and social and family networks of people older than 50 years- the SHARE database. The results are 2 CURE Elderly Personas sets – valid for central European countries. CURE-elderly-Personas are a realistic and rich basis for Personas to be used in AAL and familiar projects with the aim of developing products and services for people aged 60 and older.
The discussion about numbers and data of abstract user groups can be stopped when using Personas. Personas let us focus on only a limited number of persons, which reduces the complexity of the problem. By using Personas time will be saved and allow the project members to focus on important aspects.

Benefits of using CURE-elderly-Personas:

- Understandable form of user data
- A transparent, vivid and realistic representation of complex and abstract data
- A strong focus on the target group

- Possibility for realistic and efficient user scenarios

3.1.1 Primary users

To give a deeper insight of the target group the following CURE-elderly-Personas have been chosen since they describe the SmartHeat primary target user group best (see figures below).

3.1.1.1 Older, active user without major restrictions

We have selected the following Persona from CURE-elderly-Personas representing the target group of older, active persons without major restrictions.

Stefan VATER

Stuttgart, Germany

Devoted family man

Age: 63

Family & Home | Social contacts | Income

Cognitive:
Memory:
Diseases:
Symptoms:
Limitations:

About & Family:

Stefan is still working as a product manager and earning well. He is a busy man, but enjoys his time with his wife and children. He is married and has two children, who attend university in the same city. His children live in separate apartments but they come for dinners on weekends and keep in touch daily, since they have a close relationship and often need help from him or their mother.

Limitations/Difficulties in
none

Health

Stefan is healthy and without limitations. He has no diseases other than high blood pressure. He uses drugs to keep it under control. Stefan likes eating well and spends most of his time during the week in his office. He is a bit overweight and trying to bring himself back into shape. He needs glasses to read, which he does not like, since that reminds him of his age.

Diseases

Symptoms
none

Social

Stefan likes being in charge and having control of the ongoing situations. He likes living on a schedule and having a pre-arranged routine. He does not like surprises that spoil his plans. He is active in a social organization for the education of younger generations. He gives speeches about management and shares his experience and know-how with younger generations. He has a lot of friends and an active social life. He is also a religious person and goes to church together with his wife every Sunday.

Psychographics
active,
disciplined,
hopeful,
optimistic,
religious,
likes being in control

Drugs
yes

Hearing
good

Eyesight
glasses

Educational level
high

Risks
overweight

Technology Usage

Stefan knows his way around the web. He is interested in new technologies. He uses the internet to keep in touch with distant friends and shares photos of nights out and of his dogs, but still prefers face-to-face contact whenever possible. He is reasonably comfortable with gaining information from government websites through work-related browsing and is also comfortable with internet banking applications. He received a smart-phone as a gift on his birthday this year and is keen on using it access internet as well.

General attitude towards technology
positive

Devices in use
TV
computer with internet connection
mobile phone

Chart 1: http://elderlypersonas.cure.at

3.1.1.2 Older, inactive user with restrictions

The following user profile should represent the target group of older, more inactive users with some restrictions.

Adelheit HÜFTLEID

Vienna, Austria

Grandma with osteoporosis

Age: 84

Household | Social contacts | Income

Cognitive:
Memory:
Diseases:
Symptoms:
Limitations:

About & Family:

Adelheit has lived together with her children ever since she lost her husband. She is the oldest family member and has three children and six grandchildren. They have no financial problems. She has been a housewife for the most of her life. She was able to stand on her own feet for a long time, but now she is not capable of doing some daily tasks such as cooking or shopping.

Health

Adelheit has many health problems. This year she needed hip replacement due to osteoporosis. Her bones are getting fragile and she is overweight. She cannot walk for long periods of time or stand up after the partial stroke she experienced. For this reason, she mostly sits or lies down at home. It is embarrassing for her to suffer from incontinence. She is cognitively active but she cannot do math anymore and sometimes confuses the day of the week. She also has difficulty in remembering past occurrences.

Social

Adelheit is a modest person and does not have high expectations. She enjoys spending time with her grandchildren, but she feels melancholic and sometimes sad when thinking about the past and missing the people she has lost. She keeps herself busy as best she can by doing housework or in the garden, since she does not want to just sit in the corner without doing anything.

Technology Usage

Adelheit mainly stays at home and watches TV. She is not interested in computers or the internet and cannot understand how they function, even though her grandchildren keep trying to explain it. She thinks that she does not need to use them.

Limitations/Difficulties in

walking 100 meters,
getting up from chair,
climbing stairs, kneeling,
lifting or carrying weights more than five kilos,
dressing incl. shoes & socks,
bathing,
shopping,
doing work around house,
using map in a strange place

Diseases

heart problems,
stroke,
osteoporosis

Symptoms

pain in joints,
heart trouble

Psychographics

positive,
modest,
melancholic,
hardworking,
satisfied with her life

Drugs

yes

Hearing

aid

Eyesight

glasses, cataracts

Educational level

basic

Risks

overweight,
inactive

General Attitude towards Technology

negative

Media - Communication

TV

http://elderlypersonas.cure.at

Chart 2: http://elderlypersonas.cure.at

3.1.2 Secondary users

Secondary users in SmartHeat are divided into two groups:

- Formal Caregivers
- Informal Caregivers

Formal Caregivers in SmartHeat are defined as persons with specific education in care and health that get paid for their work and efforts. These persons can be any medical and care staff who are supporting and caring for elderly in retirement homes or in the homes of the elderly.

Informal caregivers in Smartheat are defined as family members, relatives and/or friends that voluntarily take care of older people without any contracts or payments. The supportive services provided from this group ranges (but not limited to this) from grocery shopping, making the household, helping with sanitary care (if necessary) and being a social companion.

4 Procedure

4.1 Methods

According to the user centered design approach, our basic principles encompass active involvement of potential end users throughout the whole development process in order to understand and meet their needs. This will be carried out by use of different methods.
For the collection of the SmartHeat requirements of primary and secondary users, a mix of qualitative and quantitative methods was applied to cover a broad variety of information from the different target user groups.
As qualitative instrument, focus groups and interviews were selected. Focus groups and interviews are methods for collecting qualitative data and have enjoyed a surge in popularity in HCI research.
As quantitative instrument an online survey was applied focusing on heating habits and usage and acceptance of new technologies. The questionnaire can be found in the annex section.

4.1.1 Group discussions

A group discussion is a data collection method where participants discuss issues based on a guideline which was developed by the researcher. This qualitative approach aims at gathering perceptions, needs, problems, beliefs, etc. from a target audience and enables, in contrast to a survey, to gain deeper insights into specific topics.

4.1.2 Interviews

Based on a (semi-)structured questionnaire, the target groups have been interviewed. In comparison to a group discussion, more focused questions have been asked to gain deeper insight into a topic. It also allows to compare individual responses and to identify the most relevant subjects.

4.1.3 Survey

A survey is a more quantitative approach and focuses on gaining information on e.g. opinions, behaviour or factual information. Surveys focus on larger quantities of interviewees and allow to measure the quantitative weight of different subject areas. It also allows the comparison between different views.

4.2 Recruitment

Both primary and secondary users for interviews and workshops were recruited in Austria by EURAG, in Switzerland by terzStiftung. During the recruiting phase for primary users EURAG and terzStiftung have used their existing database (members of the charities, networks) and contacts from other projects and activities. Further, the partners got in touch with new contacts by applying diverse strategies (e.g. phone calls, flyers, newsletters, E-mails, contacting self-help groups, etc.). 20 persons from 61 to 91 years participated in interviews and workshops.
Formal caregivers – especially institutions that are offering mobile care services. were recruited by EURAG – terzStiftung was responsible for the contact of retirement homes. All together 7 interviews were carried out and give a first insight.

The survey was distributed both offline and online in Austria and Switzerland by using the broad networks of the two end-user organizations. It was structured into five thematic areas: overall heating behaviour and requirements, smart heating, acceptance of technology, impact of heating costs, empowerment of secondary users
The target group for the survey was the same as for interviews and discussions: older adults as defined in chapter 3. Overall 167 questionnaires were completed and could be evaluated.

5 Results

5.1 Results primary users Group discussions and interviews in Austria and Switzerland

To investigate elderly peoples` heating behaviour and problems as well as their preferences regarding automated heating devices in their premises, personal interviews and group discussions with primary users were carried out in Austria and Switzerland in weeks 47 – 48, 2015, as the initial starting point for the present user requirements analysis. Based on the preliminary findings from literature reviews and the first conceptions of the envisaged SmartHeat systems, the investigation was carried out with the objective to get first insights about preferences and requirements by the primary target group. Home environments, domestic behaviour, heating habits and preferences, affinity to technical applications and discussions about smart solution were topics of major interest. Moreover, insights about the overall support by secondary caregivers, with special emphasis on the involvement of caregivers in heating process, was gathered.

The findings of the group discussions and personal interviews were in the first place used as qualitative input for the development of the greater survey that was launched as a subsequent step for in-depth analysis. They were used to specify the required research parameters, the respective questionnaires and their specific content.

The group discussions and personal interviews were carried out by use of semi-structured questionnaires that were mutually developed by EURAG and terzStiftung beforehand. They were similar in both countries for reasons of comparability.

The target group for this preliminary search were elderly people equipped with thermostatic radiator valves at home. Both interviewees without and with mild to moderate physical impairments were invited.

5.1.1 General information about the sample

A total of 20 participants was interrogated in the present phase of the user requirements analysis (Austria: nine participants; Switzerland: eleven participants). Their background reads as follows.

Among the nine Austrian participants were five women and four men in the range 64 to 78 years. The average age was 71.5 years. They reside in very different living conditions - ranging from small apartments in the old buildings with about 50 square meters to private houses with more than 200 square meters. When they were asked about the physical limitations that are hindering them in carrying out their activities of daily living, 8/9 participants responded that they would suffer from no limitations, only one person (female) complained that she is struggling with ascending chairs etc.

In Switzerland five male and six female participants were interrogated out of an age group between 61 and 91 years. The average age was 75.5 years. All participants were equipped with radiators comprising thermostatic radiator valves at home in at least 4,5 rooms. Six of the elderlies live in single family houses, five of them in apartments. Three of the elderlies reported minor physical impairments related to their age, especially regarding their visual, auditory and motoric skills. However, none of them indicated any impact of the impairment on the organization of their heating at home.

5.1.2 Findings from group discussions and interviews

5.1.2.1 General criteria for heating

General heating criteria were discussed in order to find out how elderly people organise their heating, what the motivations of their habits are and what topics they consider important in this regard.

The present target group organises their heating in the first place on the basis of subjective (not any further defined) feelings of ‘well-being’. Well-being through adequate heating is considered an ‘inviolable’ requirement. It should be considered superior to any other considerations such as cost savings. Accordingly, the interviewees hardly accept restraints of their comfort, e.g. through extra effort put into heating or behavioural changes. However, behavioural adaptations as an alternative to optimizations of the heating were raised as an issue. For example, the putting on of warmer clothes in cases when temperatures are being perceived as too low or the opening of windows in situations where the temperatures are too high were examples mentioned.

Inside their houses, rooms are often heated according to intensity of use, i.e. rooms that are infrequently used are often heated less. This type of behaviour is in the first place motivated by cost- and efficiency-considerations and mentioned as the major initiative in the attempt to organise heating activities efficiently.

Apart from that, the respondents generally do not (want to) put much effort into the monitoring of their heating. Heating is primarily geared to fixed temperatures and

regulation of these temperatures is mainly controlled automatically by thermostats which do not require frequent interventions by the end-users themselves. Changes to the settings are carried out only occasionally when subjective feeling requires to do so or when exceptional use of rooms requires action, for example, when guests stay over.

The interviewees tend to heat all of their rooms (those of frequent use) by the same temperatures, irrespective of activities they carry out there (except sleeping rooms and rooms with sparse use such as guest rooms). There are hardly any adaptations of the heating habits to daily schedules such as times of absence. One exception is the night-time. Extraordinary situations such as long-term absences – leaving on holidays for example – provoke adaptations, i.e. switching to lower temperatures or switching the system off.

Most interviewees are rather satisfied with their heating. Minor problems are identified regarding the following factors: Delays of effect when temperatures shall be changed spontaneously; missing solutions for draught and open doors between rooms (there are hardly fixed 'door policies'); regulation and control of air humidity.

The heating equipment of the present sample is described as rather modern and therefore most respondents report only marginal effort in monitoring activities. None of the respondents is familiar with remote controls in the context of heating. Most respondents use timers only for the night. For daytime, temperature preferences stay constant in the course of the day for most respondents and regulation takes place through thermostats or fixed settings of the radiators' valves.

When asked about their expectations for more effective heating, the majority called for quicker effects when the heating settings are changed, for more automatic control without the requirement for additional personal effort (additional monitoring of the values) and – in 'reasonable' contexts – for interactions with other heat sources, where such functions can go beyond the 'reactive' adjustments by thermostats (e.g. anticipations of additional heat radiation by home appliances).

The respondents hardly indicate a need for support when organizing their proper heating activities. Personal independence and action is preferred over handing control over to third persons. Technical support, yet, shall be easily accessible in case of breakdowns or required maintenance.

5.1.2.2 Smart Heating

In order to find out more about heating preferences that can be considered in the development process for the envisaged SmartHeat system, the stability of temperature preferences and the potential use of optimizing features was discussed.

Generally speaking, for any new system to be successful, the interviewees expect high reliability, low need for personal effort (such as for steering and monitoring), strong adaptation to personal needs and living environments, simplicity and solving of actual problems rather than “nice-to-have-applications”.

Most, of the interviewees reported temperature preferences to be rather stable. They orient their heating towards fixed temperature levels which are automatically hold up by thermostats. Although subjective situational well-being was mentioned as the predominant orientation for the settings of the heating rather than a fixed temperature level, the temperature level is used as the primary measure for the setting of the heating. Given the delays of effect of the heating systems, short adaptations are made through regulation of clothing or opening / closing of windows – thus ensuring ‘situational well-being’. None of the respondents from this first phase of the present user requirements analysis uses the level of the radiators’ valves as the major orientation for their heating policies. Most respondents do not see the extra benefit compared to current regulation through thermostats

The respondents would appreciate more automated systems, provided the additional features improve the overall efficiency of the heating in terms of consumption and, hence, costs. In other words, since most respondents already reach the desired temperatures in their houses by help of their thermostats, any new system should be able to create extra benefits beyond the temperature levels as such. However, in any such scenario, any new system working through automatic control must have functions to intervene manually so that the end users are able to keep control personally when needed or desired. Generally speaking, the interviewees highly appreciate their own control of the system. Their personal mentation and action, in their view, should be promoted rather than relieved. The acceptance of additional technology is much higher though, when asked about possible situations with impairments such as bedriddenness, high fragility or moderate to severe dementia.

Considering that the established heating solutions are perceived by the target group as rather satisfactory and of low-maintenance, the interviewees hardly accept extra effort for the organization of their heating. Some of them would be sensitive to suggestions for adapted heating behaviour, if costs or ecological effects (real time) can be made transparent by a heating system. Still, the system needed to be simple and keep their additional effort to a minimum.

As mentioned earlier, there is no experience with remote controls in the context of heating. Remote controls, however, are considered a useful tool for situations with strong impairments or handicaps. As long as people retain their physical mobility, the participants believe that remote controls would hardly be used. Elderly people were driven by the motivation to stay as agile as possible and as independent as possible

in their own households. Control from remote places, yet, would be appreciated during holidays.

In cases where remote controls were used, most of the interviewees do not have privacy concerns as long as control was given only to persons of trust. Instead, concerns were raised regarding the reliability, avoidable technical complexity, rays, loss of personal control and the need for maintenance. Moreover, there are concerns about 'learning systems' in situations in which different persons in one apartment have dissimilar preferences and schedules. Any learning system was therefore required to recognise different persons in order to adjust to their specific preferences. There is a concern that without such recognition, any system learning preferences, schedules etc. might rely on average numbers which might be undesirable on both sides. Moreover, in conflictual situations an automatically controlled system might not take into consideration any possible compromise and find ad hoc solutions as people could do bilaterally.

5.1.2.3 Acceptance of Technology

As specific technological devices will be applied in the SmartHeat system and as the end users will be required to interact with specific appliances, their overall affinity to specific technological devices was discussed in the personal interviews and group sessions.

Generally speaking, most respondents refuse the use of additional technology as this latter is in the first place considered as creating avoidable complexity rather than simplification. The system and all required installations should therefore be kept simple. Moreover, some respondents consider the management of the heating through additional technology no use in small premises. They rather see a point in using such systems in larger facilities or offices where no one feels responsible for regulation of the heating. Accordingly, the cost-benefit-ratio as well as ration between effort and benefit of installing a SmartHeat system should be clearly recognizable.

The use of wearables for the sake of improving the heating performance was totally rejected by the majority. Few participants would accept the tracking of motion as long as the functions are implemented in existing portable devices (smart watches; not Smartphone, as the latter is not constantly carried around inside the apartments). The preferred devices for receiving instructions and information would be devices that are already used and that fit into daily routines, such as smartphones and / or smart TVs (with touch functions). Fixed screens would be an additional option. Informative sounds or voicemails, in contrast, would be considered annoying for most respondents.

5.1.2.4 Heating Costs

The impact of heating costs on heating behaviour was further analysed in order to find out how attractive solutions reducing the consumption would be to them. As noted earlier, the personal well-being is considered more important than heating costs. And temperature preferences are not negotiable. Nevertheless, there is a basic sensitivity for costs and the environmental impact of heating activities. The visibility of costs
could have an impact on heating behaviour as long as the overall comfort of the end-user does not suffer. The visibility of real time costs for heating of specific rooms and the calculation of different heating scenarios in relation to costs would be appreciable assets of an innovative heating system.

Currently, the active monitoring of heating costs and the performance of their heating is widely neglected. Energy saving is widely limited to conventional methods such as sporadic ventilation, closing of doors and the lowering of temperatures in rooms without frequent use.

5.1.2.5 Empowerment of secondary users

In order to shed light on the target group's attitude regarding external steering and monitoring of their heating systems, topics regarding the empowerment of secondary users on the basis of remote control functions were discussed with the invitees. However, no coherent preferences regarding the acceptance of steering through third persons could be identified among them. Some participants consider such functions helpful in the event of high dependency, others highlight their concern to become infantilised in the event where such features become operational.

Likewise, there is no common view about the types of information that the end users would be willing to share with potential secondary users. Any such system should comprise different options for different levels of trust and intimacy to the persons who are entitled to receive information (e.g. only alarm in emergency cases, information about state of the heating or full information about behaviour). Possible addressees of such information could be family members, neighbours and professional caregivers.

The potential primary end users interviewed in the context of the present discussions expect major benefits of remote functions on the part of secondary end users, in the first place, through time benefits for both for professionals and beloved ones. There is no expectation, however, that caregivers would use time-savings to visit the end-users less frequently. Rather, they expect them to use the time-savings for more effective care, i.e. through focusing on the most important issues of care when dropping in. On the part caregivers with special emotional attachment to the persons

they care for, there is an expectation of a greater feeling of security / peace of mind, particularly in cases in which the person in need of care suffers from dementia.

5.2 Results interviews secondary users in Austria and Switzerland

As findings from the preliminary group discussions and personal interviews with individuals from the primary target group suggested benefits of a SmartHeat system on the side of secondary users, additional information was sought from their side. Complementary interviews were therefore held with professional caregivers in Austria and Switzerland. This target group was divided into home care services on the one hand and retirement homes on the other hand. A total of seven institutions was interrogated in this phase.

5.2.1 Findings from retirement homes

5.2.1.1 Engagement with heating activities of the primary end-users

According to the interviewees, the care personnel in retirement homes is only marginally concerned with heating activities of the residents. Individual rooms are often heated through centralised systems which are monitored by the respective facility management. Specific action is only required in the event of complaints.

Complaints are not counted, yet, there is a common understanding that topics related to the heating are rather seldom compared to other issues raised throughout ordinary visits. The changing of radiators' valves, the opening of windows and performance checks of the heating are the most common measures in the event of complaints. As technological affinity can be rather low among some of the residents, technical features need to be explained time and again. For example, complaints about broken radiators are rather common when these latter are cold, yet only in response to the reaching of the desired room temperatures.

5.2.1.2 Heating habits and specific problems of elderly people

Among the houses considered, common heating policies are defined on the basis of defined temperature levels held up by thermostats. Temperature levels tend to be comparably high (23-24 °C), since elderly people often feel colder as a result of reduced physical activities (lower blood circulation) and lower fat tissues. Temperature preferences tend to be rather stable, according to the caregivers.

5.2.1.3 Benefits of a smart heating system

The interviewees do not see specific benefits of a smart heating system on the side of the residents, as these latter do not have to care for the heating settings under the

status quo. Complaints about room temperatures are rather rare and once they occur, rather simple to solve. Issues related to air ventilation (noise and draught) are considered more important. There is some sensibility for energy issues on the part of the interviewees. However, direct benefits were expected on the part of the (facility) management (cost reductions) rather than on the side of the care personnel.

5.2.1.4 Benefits of remote monitoring and control

None of the interviews would be willing to change their monitoring activities in the event where remote controls were available to them. Any alarm function would not motive to change settings remotely, but engender the same reactions as the residents` conventional (manual) alarm applications would provoke. Daily routines, i.e. room visits, would not be changed either, considering that subjects related to heating are only a marginal part thereof and hardly time consuming. Alarm functions and remote information about the heating performance would rather contribute to the work of the facility management.

5.2.2 Findings from mobile care institutions

2 interviews were carried out with employees of the “Hilfswerk”. “Hilfswerk” is a major austrian wide institution which provides nursing services and care at home.
Health and nursing staff provide expert assistance for the elderly, sick and persons who are in need of care at home. The aim of these complementary offers is to support elderly, sick and persons in need of care to be able to remain as long as possible in their own homes.

5.2.2.1 Engagement with heating activities of the primary end-users

Employees of Hilfswerk look after people in various walks of life; from running errands for the elderly to the care of bedridden people.
Depending on the cognitive constitution of the older person the desired temperature is denied with the clients. If the client is unable to regulate the room temperature himself, this will be done by the carer. Overheated rooms should be avoided by the carer when leaving the client.

5.2.2.2 Heating habits and specific problems of elderly people

Due to financial reasons, older people often stay in chilly rooms and this circumstance may lead to an adverse effect on their state of health. In this case the nursing staff tries to find a solution with the client to overcome this problem. There are possibilities like getting a grant for heating from the public hand. But in general it was mentioned that heating is not a real issue for the nursing stuff except if apartments are heated with wood or coal – the task of the nursing staff then includes the acquisition of heating material, heating the oven, dealing with the increased pollution from soot in living rooms etc.

5.2.2.3 Benefits of a smart heating system

Depending on the cognitive constitution some people would probably welcome such a system - especially if these systems would be energy efficient and cost saving.

5.2.2.4 Benefits of remote monitoring and control

Since the clients are not always supported by the one and the same caregiver, the interviewees do see a hazard in terms of lack of knowledge in dealing with the remote control which can cause problems for the clients. However, alarm systems could be very helpful if the heater does not work, then the nursing staff gets informed and could immediately take action.

5.3 Results primary users survey in Austria and Switzerland

The common survey among elderlies in Austria and Switzerland was carried out in the period December 15, 2015, until January 13, 2016 by use of the online survey tool LimeSurvey, hosted by terzStiftung. The target groups were addressed through e-mailings with cover letter and explanations by use of the given databases of EURAG and terzStiftung. Reminders to the same target groups were sent out after the first half of the operational period. Selected individuals with limited access to online resources were given the possibility to fill out the questionnaire in paper form. All participants were informed about the background of the survey, use of the data and the underlying privacy policies.

By January 13, 2016, LimeSurvey registered 297 file counts in the questionnaire, 167 of which were completed. Among the remaining 130 files, a total of 43 dropouts was counted, the majority of them within the first third of the survey. 87 counts relate to the mere external opening of the hosting webpage. For the underlying evaluation, the sample of 167 completed questionnaires has been further considered as the data base for the results published in this paper.

Considering the goals of the underlying research questions, the survey was divided into the following parts.

- **General Information about the sample:** All participants were asked to fill out specific questions to identify the characteristics of the respondents, none of which allow direct identification of specific individuals in adherence to the underlying privacy policies. Factors such as the age, structure, gender, country were collected. Moreover, the participants were asked to respond voluntarily to questions about their health status, level of independence and living environment, including care services.

- **Overall heating behaviour and requirements:** Through this parameter, it was investigated how elderly people organise their heating at home and where there are possible deficiencies in terms of comfort, effectiveness and efficiency. As the SmartHeat Project seeks to gauge the heating to specific factors such as personal preferences, heating environment, body parameters and use of rooms, questions were asked to shed light on the current situation and areas with need for improvement. The potential use of specific features of the SmartHeat systems were evaluated.
- **Smart Heating:** The demand for specific features offered by the envisaged SmartHeat system was analysed. Major interest was focused on required modes of assistance and conditions / situations in which specific features would be used and perceived as beneficial.
- **Acceptance of technology:** As the SmartHeat project aims to deploy innovative technology, including the use of different sensors, in the target groups`premises, the acceptance of specific devices was investigated by reference to past experience and feeling of comfort with such devices. Moreover, the participants were called upon to signal their preferences regarding possible steering devices, modes of communication.
- **Impact of heating costs:** Specific questions were asked about the role of heating costs, especially regarding cost sensitivity and monitoring activities. The overall affinity to efficient energy consumption and inclination to adjust personal habits to more efficient heating was investigated in order to shed light on the benefits elderly people perceive through SmartHeating.
- **Empowerment of secondary users:** Finding out information about the inclination of elderly people to hand over information and control about their heating system at home to potential caregivers was the objective of this parameter. Questions were asked regarding preferences regarding features allowing full automation and remote control of the domestic heating system, including situational context where such features can be extra benefits to the primary user group.

5.3.1 General information about the sample

A total of 167 questionnaires, that were filled out by the target group between mid of December 2105 and mid of January 2016, are the basis for a next step of evaluation of requirements. (53% participants from Switzerland, 42% from Austria, 5% Germany, 30 % of them are female, 66 % male).

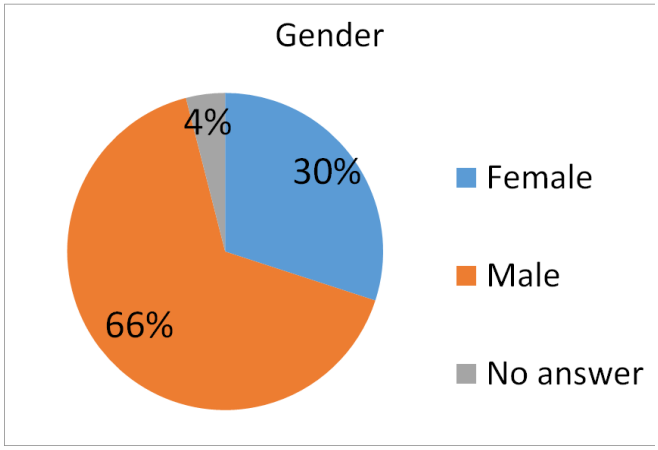

Chart 3

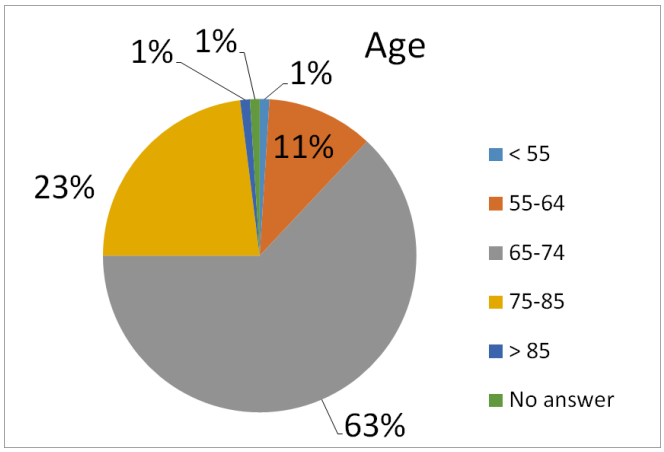

Chart 4

Half of the participants of the survey reside in private houses, the other half in apartments, only one percent lives in retirement homes.

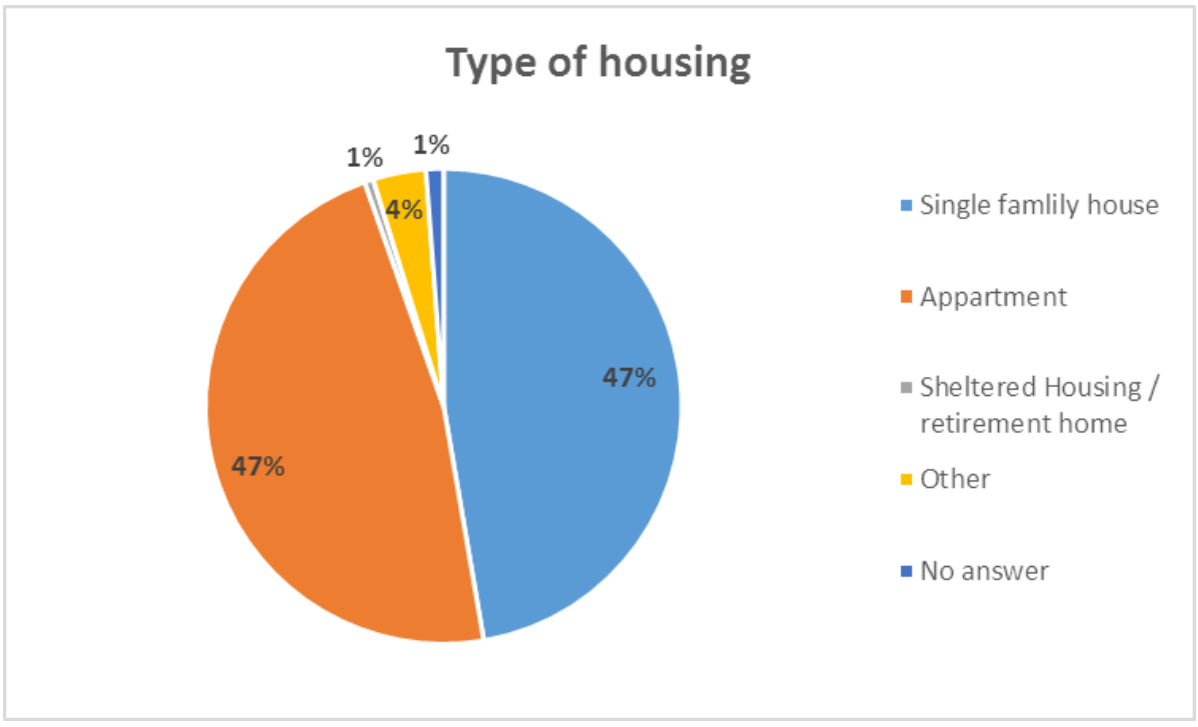

Chart 5

The way to heat their premises is mostly done by radiators (59%) and underfloor heating (30%) In some premises a coexistence of both heating systems is given. 69 % of the radiators are equipped with Thermostatic Radiator Valves (TRV).

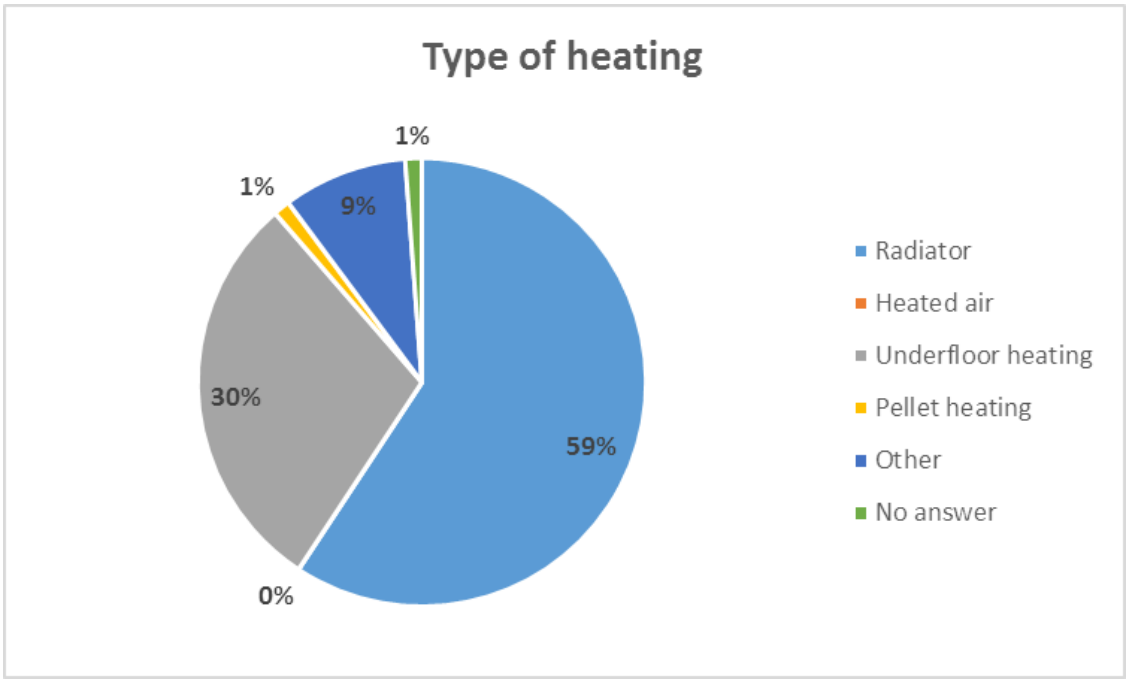

Chart 6

The health status and personal body conditions of the surveyed group seems to be a rather good one: 35 % do not have any health related problems, 59% mentioned that they are suffering from minor health related problems and only 4 % struggle with real

strong problems.96 % are living completely independent, only 3 % require regular assistance by caregivers. 7 % of the respondents care for an elderly person on a regular basis.

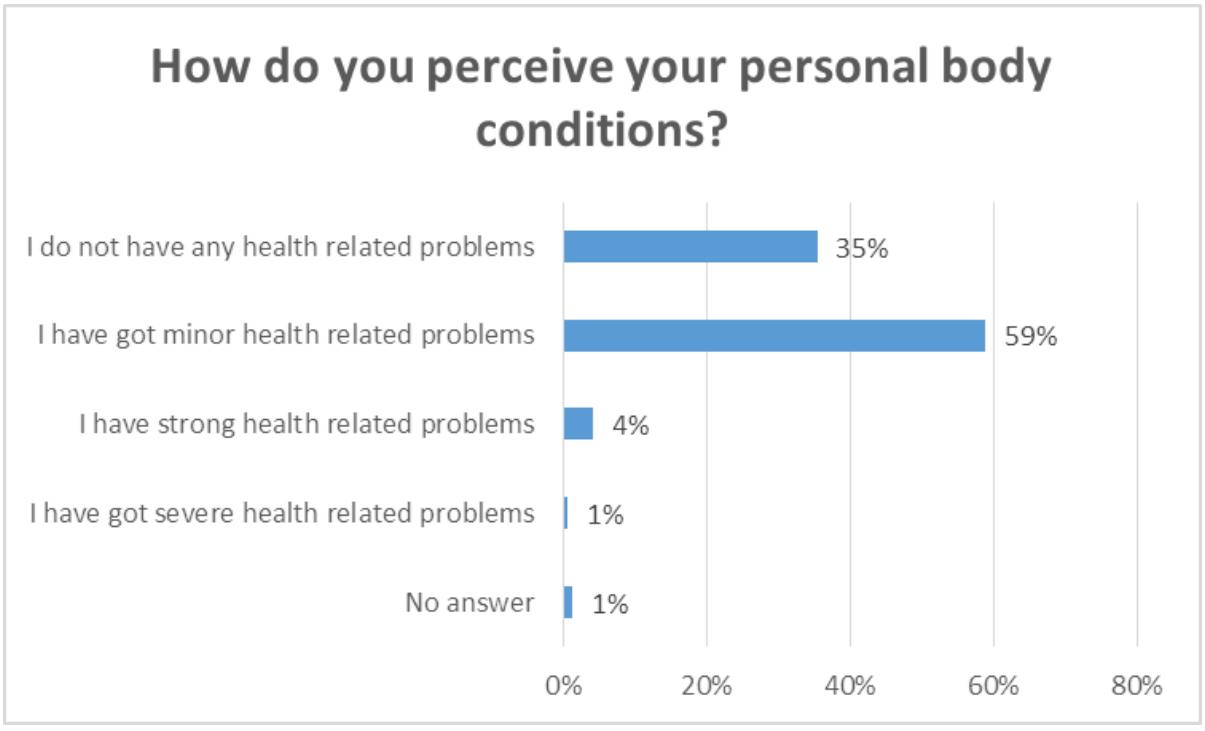

Chart 7

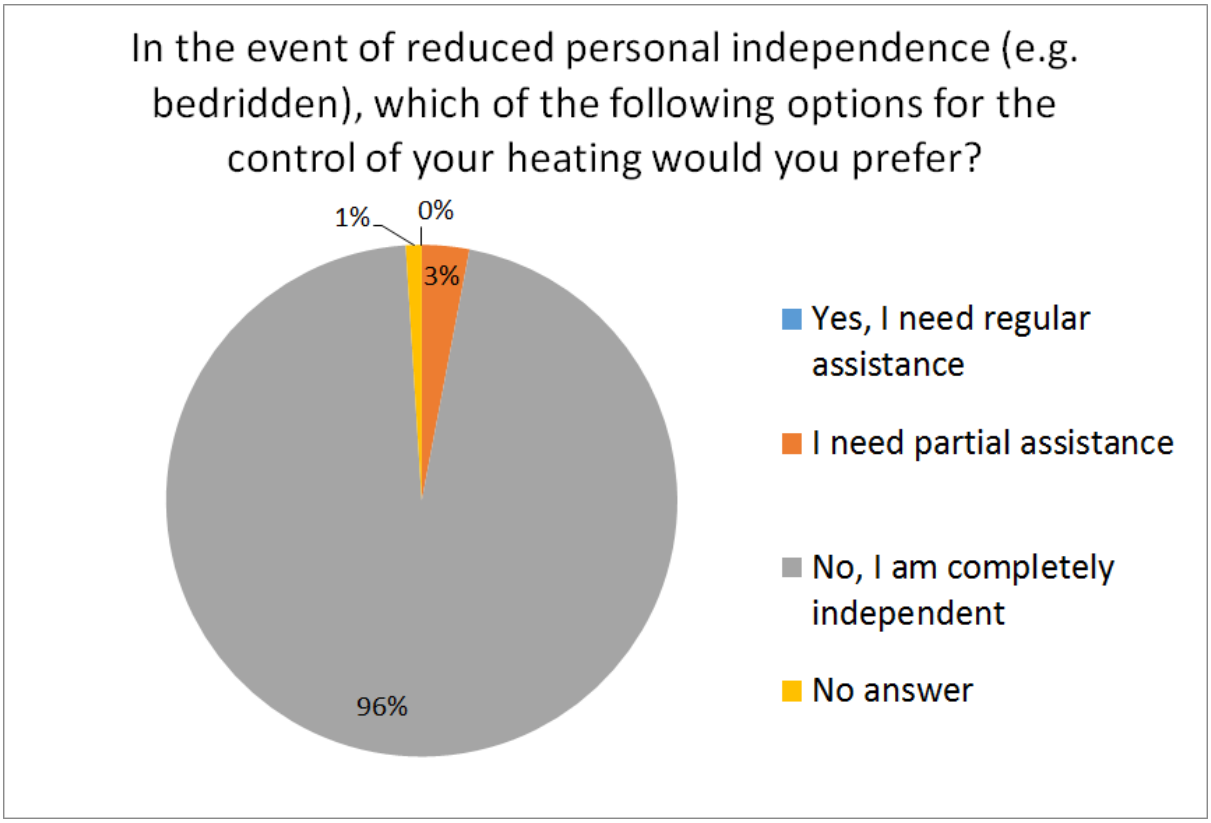

Chart 8

When it comes to health problems related to heating the following statements were given – see Chart 9.

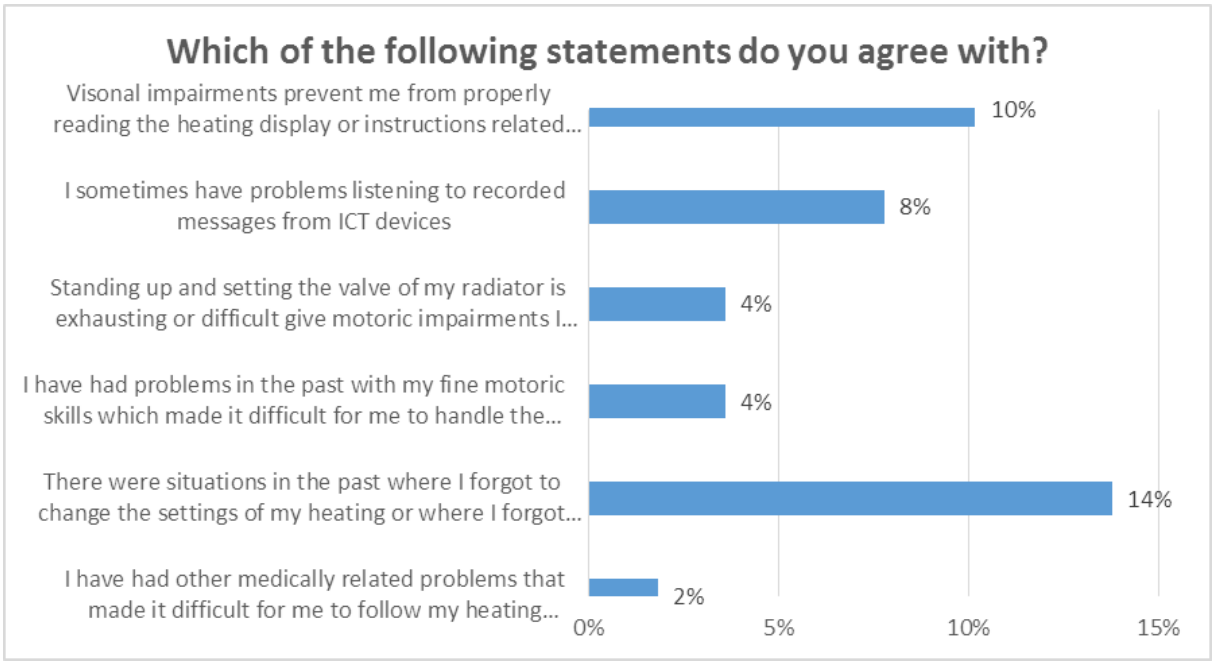

Chart 9

Forgetfulness to change the settings, visual impairments that prevent from properly reading the display and problems with the fine motoric to handle the setting of the valve of the radiator are the most mentioned factors in coherence to heating that cause sometimes problems for the target group.

5.3.2 Overall heating behaviour and requirements

In order to understand the overall heating habits and overall dealing of the interviewees with their domestic heating, these latter were questioned about their personal way of organizing their heating at home. Chart 10 illustrates that more than half of the respondents does not have fixed criteria for their heating. 43% stated that they use to act spontaneously, considering their subjective feeling. 29% align their heating to specific temperature preferences regulated by their thermostats, whereas only 10% look after the settings of their valves. The item ‘Other’ mainly reflects respondents without influence on their heating (e.g. central steering).

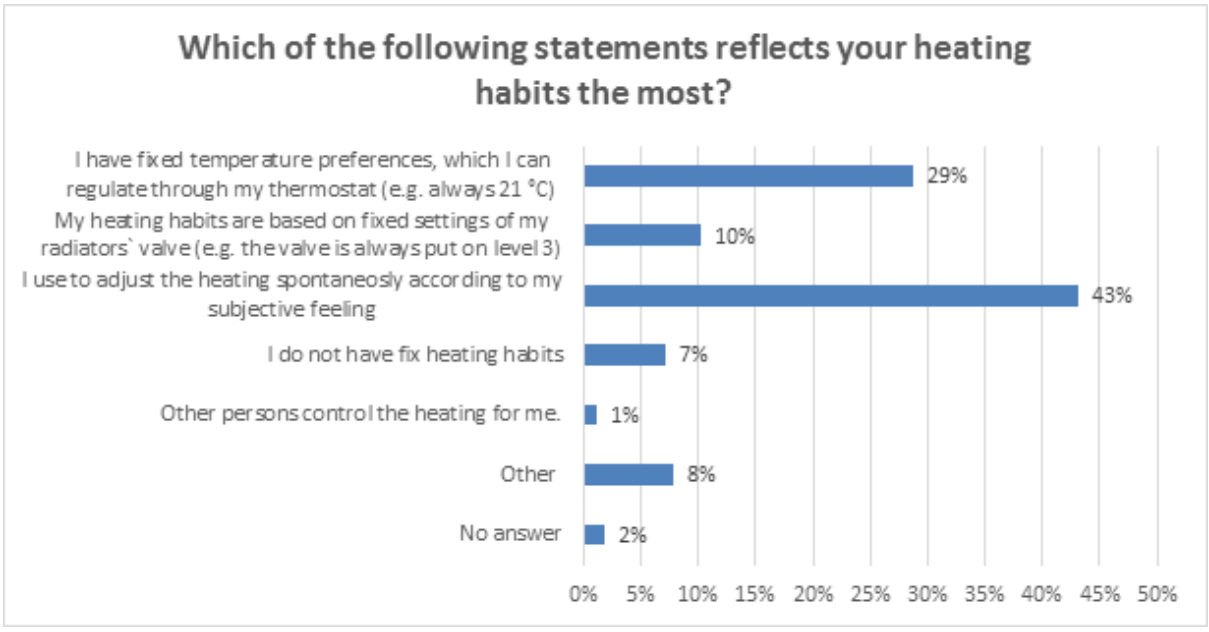

Chart 10

More than half of the respondents does not handle their heating throughout the cold season. As illustrated in Chart 11, only 20% report to personally act upon their heating at least once a day. These numbers, however, should be read in conjunction with the big amount of respondents equipped with TRV (69%), by use of which predefined settings automatically control the desired temperature level. Out of the 48 respondents who align their heating preferences to predefined temperature levels, only seven indicate that they change the setting once a week or more often. Conversely, out of those 86 persons who change their settings never or only once the season starts, 31 respondents align their heating according to fixed temperature preferences.

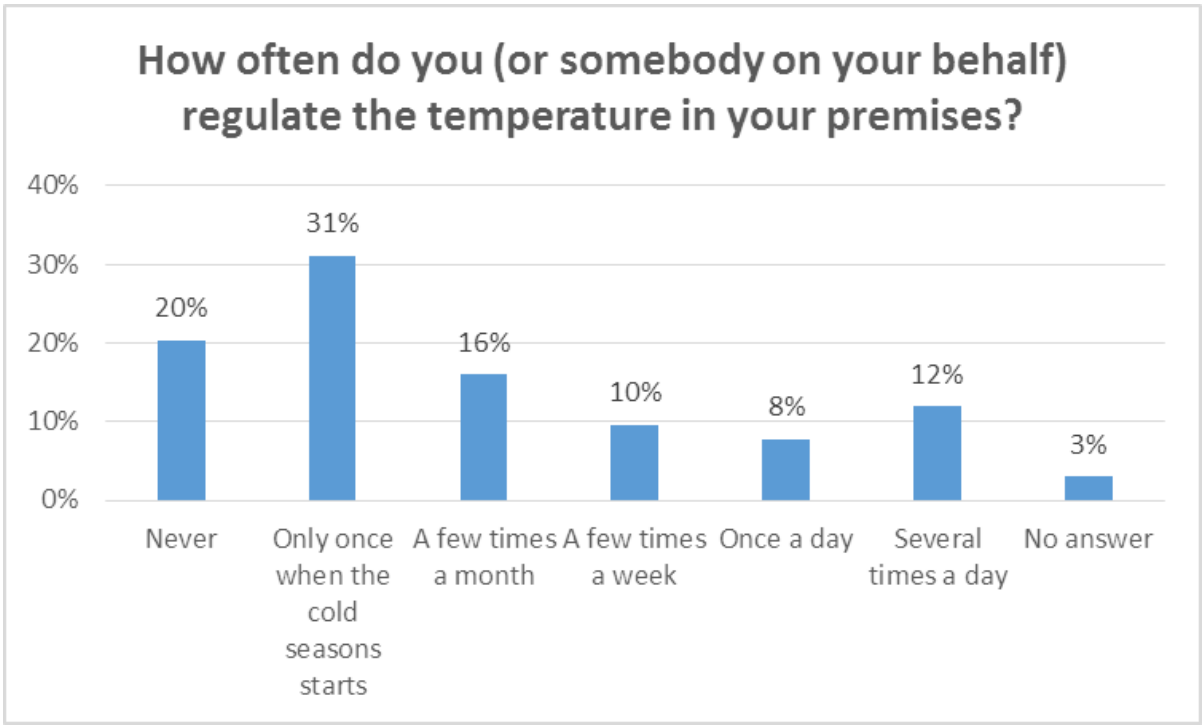

Chart 11

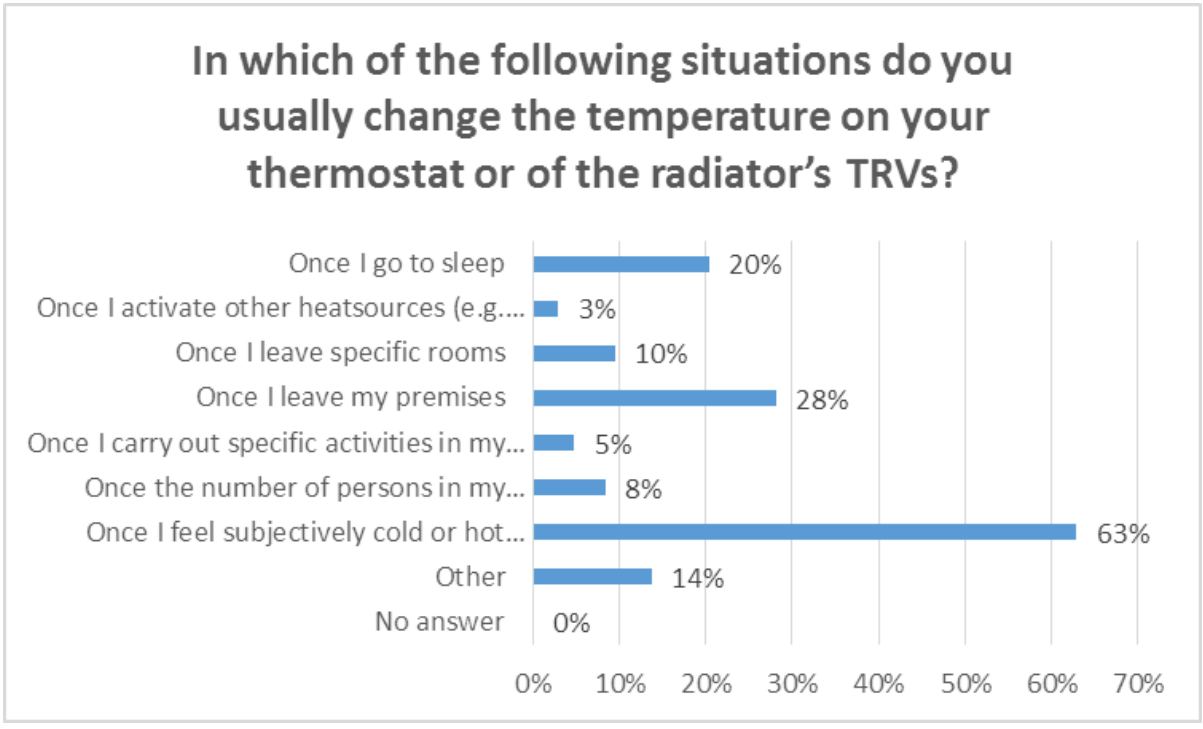

Chart 12

Subjective feeling is the most common situation where changes to the heating settings are made (63%), followed by going out of the house (28%) and going to sleep (20%). Very few of the respondents considered the switching on of additional heat sources (3%), their own physical activities (5%) or the number of present persons in their heating policy (8%).

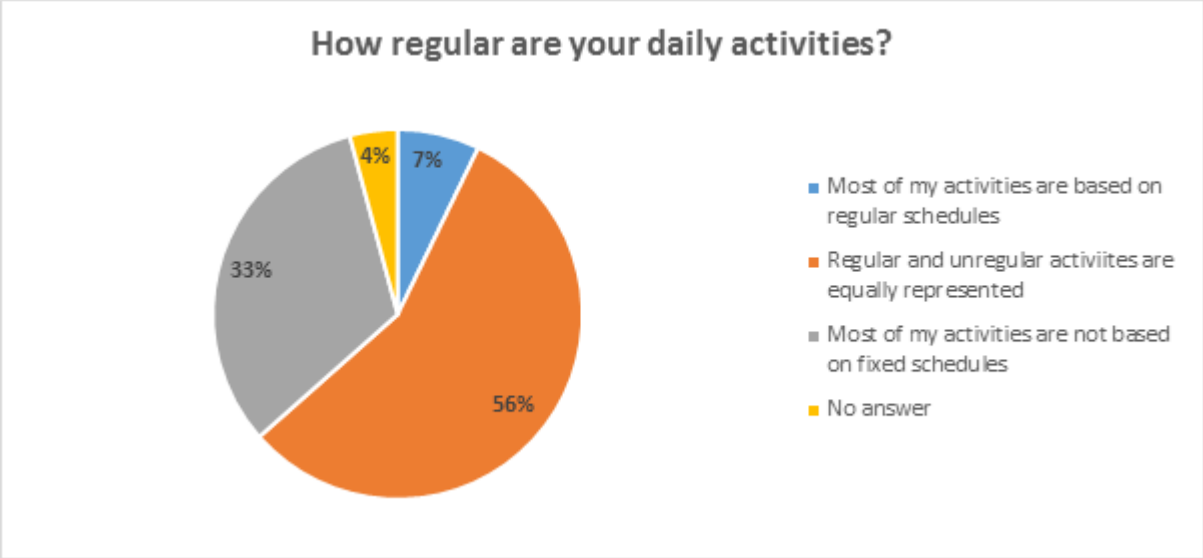

Chart 13

As we see can see on Chart 13, 89% of the interviewees indicate that at least half of their activities are irregular (flexible times and types), which suggests that specific patterns of behaviour in their premises and the use of specific rooms are barely predictable. Only 7% indicate that they have regular schedules such as regular daily hours for groceries, meetings, etc.

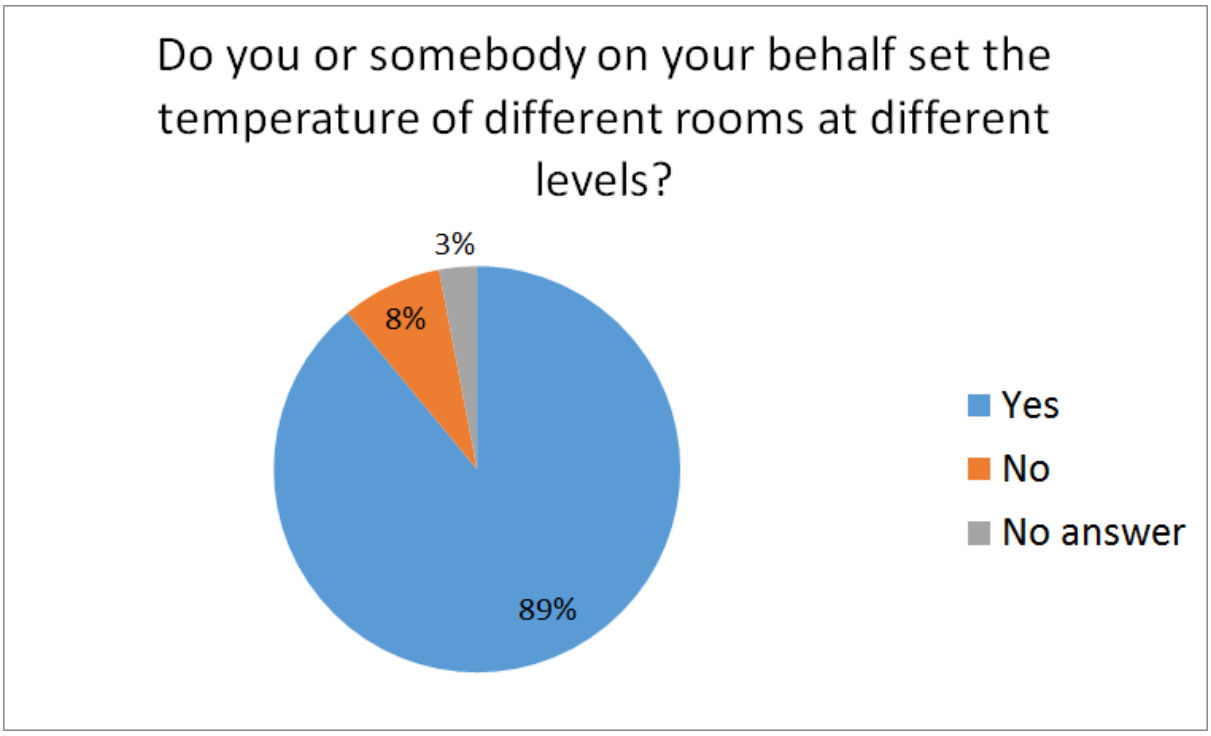

Chart 14

A large majority of the elderlies interviewed considers the use of different rooms in their heating policies. 89% set the temperature level of different rooms at dissimilar levels (Chart 14), which may be an indication of costs or environmental sensitivity on their part.

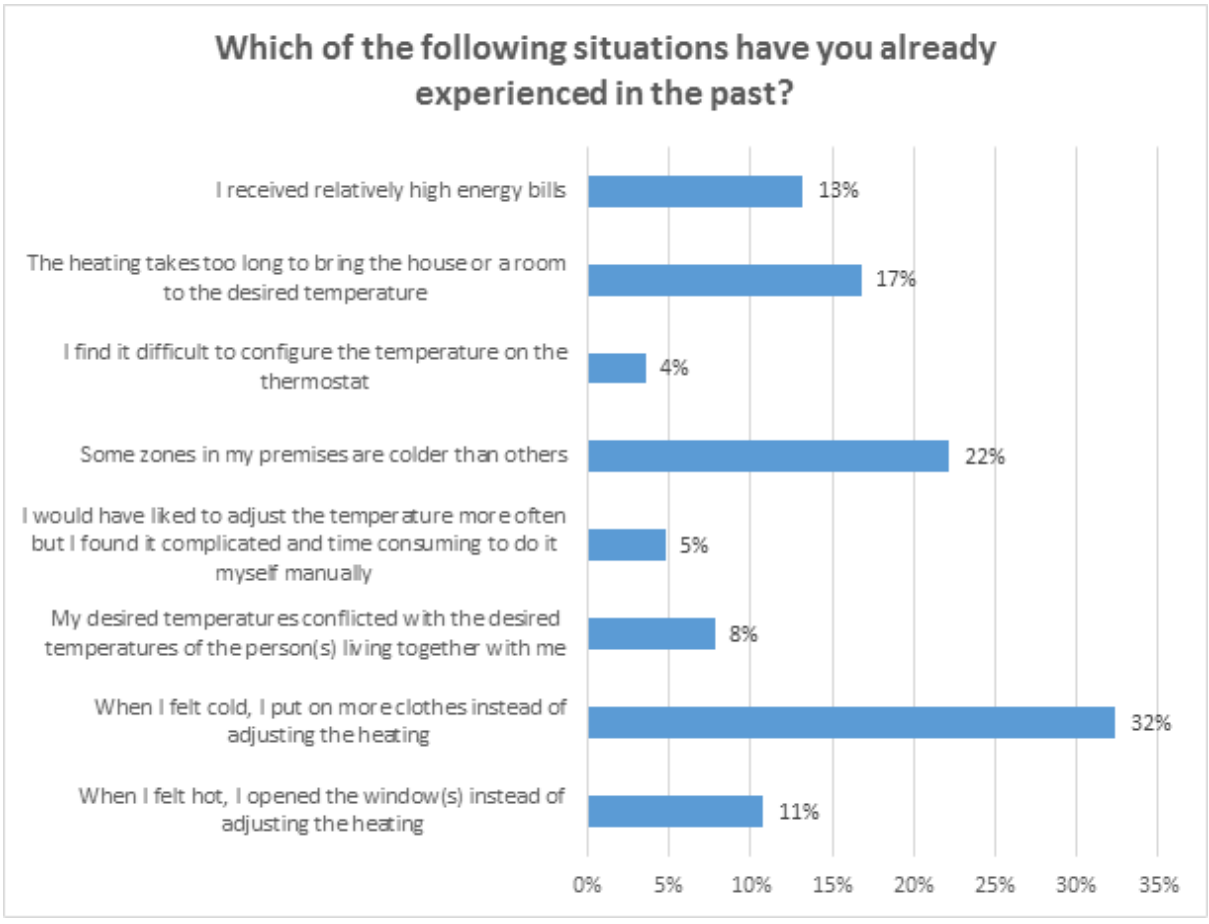

Chart 15

In order to find out what extra benefits a smart heating system might contribute to the current situation, the questionnaire asked whether or not specific problems or situations occurred in the past (Chart 15), that could be resolved by the envisaged SmartHeat system. Only few respondents indicated that they have had usability issues, i.e. difficulties with configurations (4%) and manual settings (5%). A considerable number, in contrast, indicated behavioural changes at home as a result of imperfect heating conditions: 32% compensated heating deficiencies through additional clothes and 11% regulated overheated rooms through cold air instead of taking direct measures at the heat source itself. Almost every fifths interviewee reported unbalanced dispersion of the heat in his / her premises as well as heating delays. Energy bills were an issue for every tenth respondent.

5.3.3 Smart Heating

The overall interest in a smart heating system is relatively high, considering the appreciation by the system description by more than 70% of the participants. Yet, more than 70% among these latter indicate that possibilities for manual intervention should not be replaced (Chart 16). 20% would not feel comfortable with an intelligent heating system.

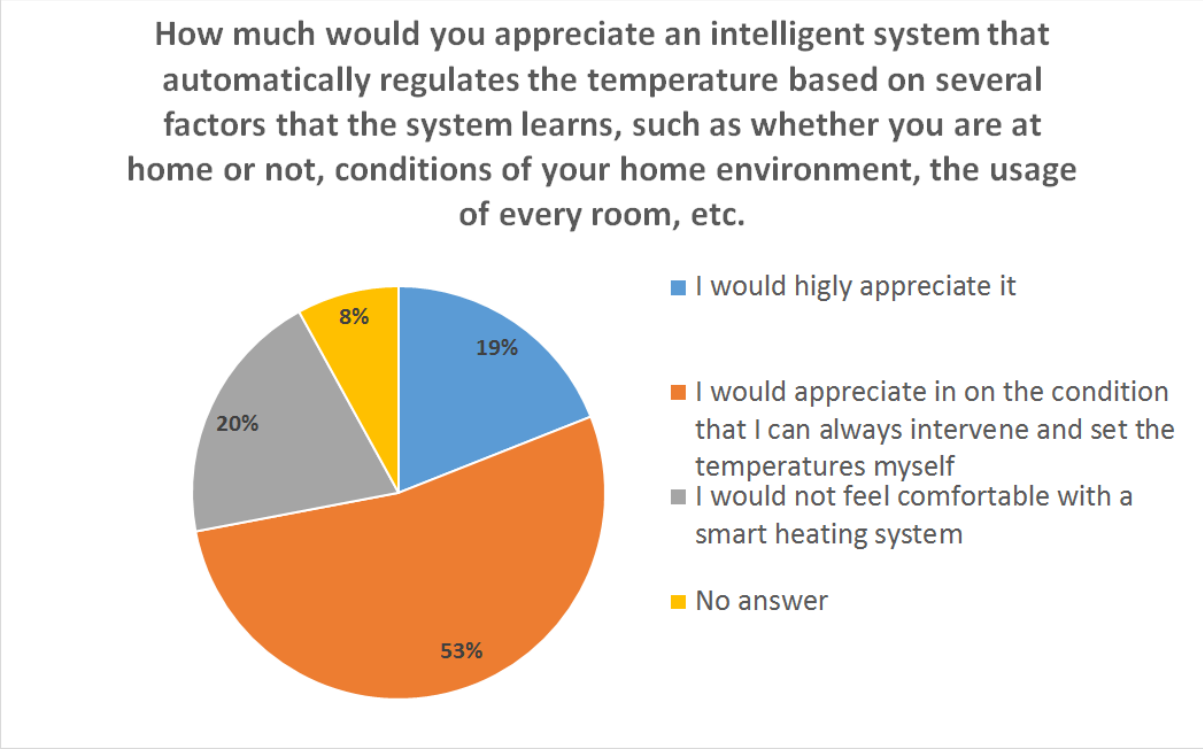

Chart 16

Described as a system with manual intervention, yet linked to direct benefits, namely increased comfort and reductions in energy expenses, there is slightly less enthusiasm for the depicted heating, with 16% of little and 14% of no appreciation (Chart 17). This could indicate that automated heating is preferred over manual intervention, while manual intervention should be a possibility rather than a required effort.

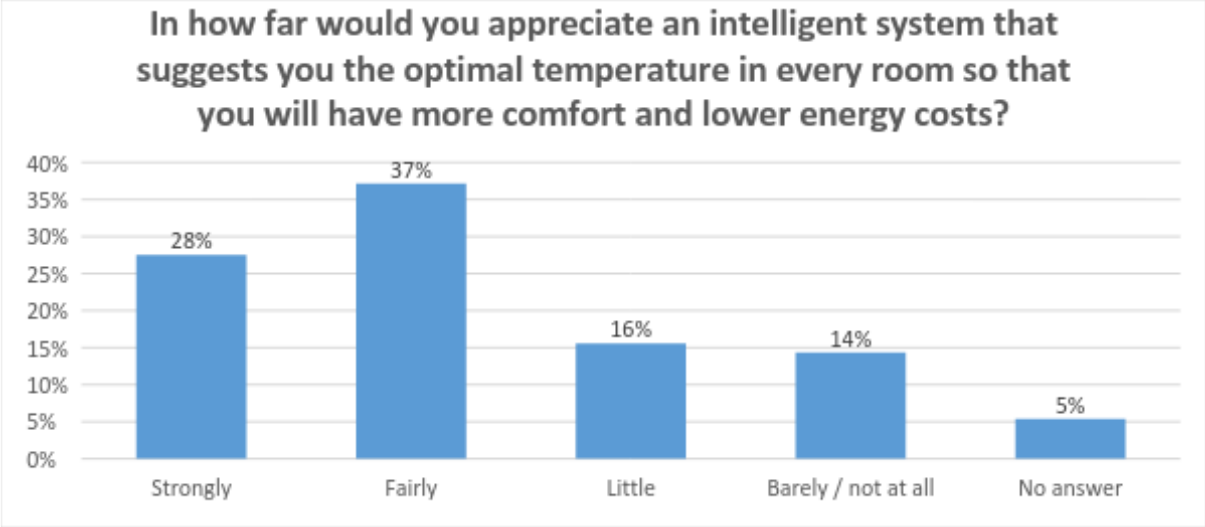

Chart 17

In order to further specify potential target groups for the smart heating system, the interviewees were asked to state specific situations in which a) full automatic control and b) remote control were perceived as beneficial to them (Chart 18). Among the given criteria, long-term absences from home (63/65%), followed by strong mobility problems (52/43%) and dementia (40/28%) were ranked the highest in both categories. Considerably less respondents indicated both system components to be wanted in cases of third-party-use, for short-term absences from home or in situations of reduced sense of touch. The item 'other' was predominantly clicked as a substitute for 'none of the abovementioned', among persons where the question is not applicable (incompatible heating system such as fireplace) and as a substitute for 'always'.

In summary, Chart 18 shows that compared to each other, both features of the envisaged SmartHeat system would be desired in the same situations with roughly similar values. Full automatic control is wanted by slightly more participants in the event of strong mobility problems, in cases of problems with tactility skills and for short-term absences from home. The value is considerably higher regarding a potential suffering from dementia.

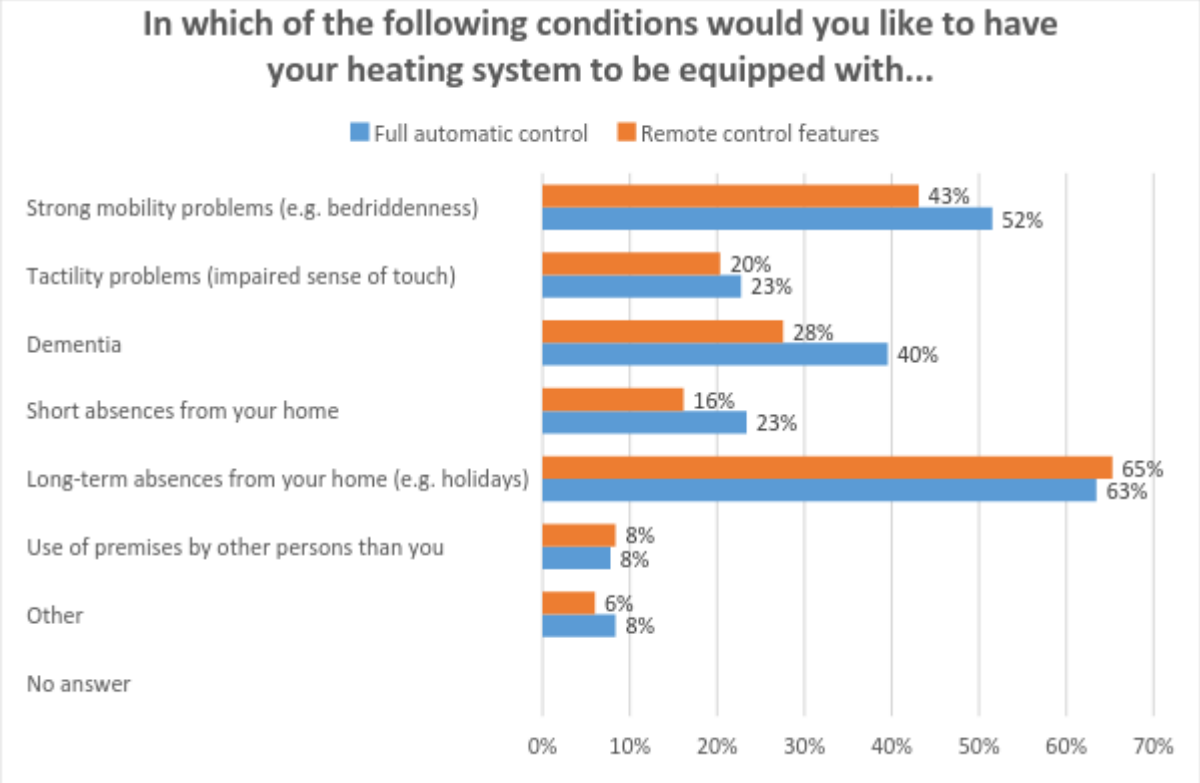

Chart 18

The survey set the objective to find out more about elderly people's intrinsic motivations to use heating systems with automatic control. As illustrated in Chart 19, a reduction of heating costs is considered the predominant benefit of automated control, with 78% considering this factor at least important of which 55% even very important. The second and third ranking benefits are the optimization of temperature levels at home and the promotion of independence, with 37 / 31% considering the factors very important and 25 / 27% considering these benefits important. 'Personal guidance', the feeling of 'security / peace of mind' and the 'reduction of personal effort' are still considered important motivations by almost every third and every fourth and every fifths respondent (27 / 23 / 21%). About 60% of the respondent consider these three factors at least moderately important.

Between 11% (reduction of heating costs) and 30% (reduction of personal effort) consider the listed benefits of a smart heating system as little important or unimportant.

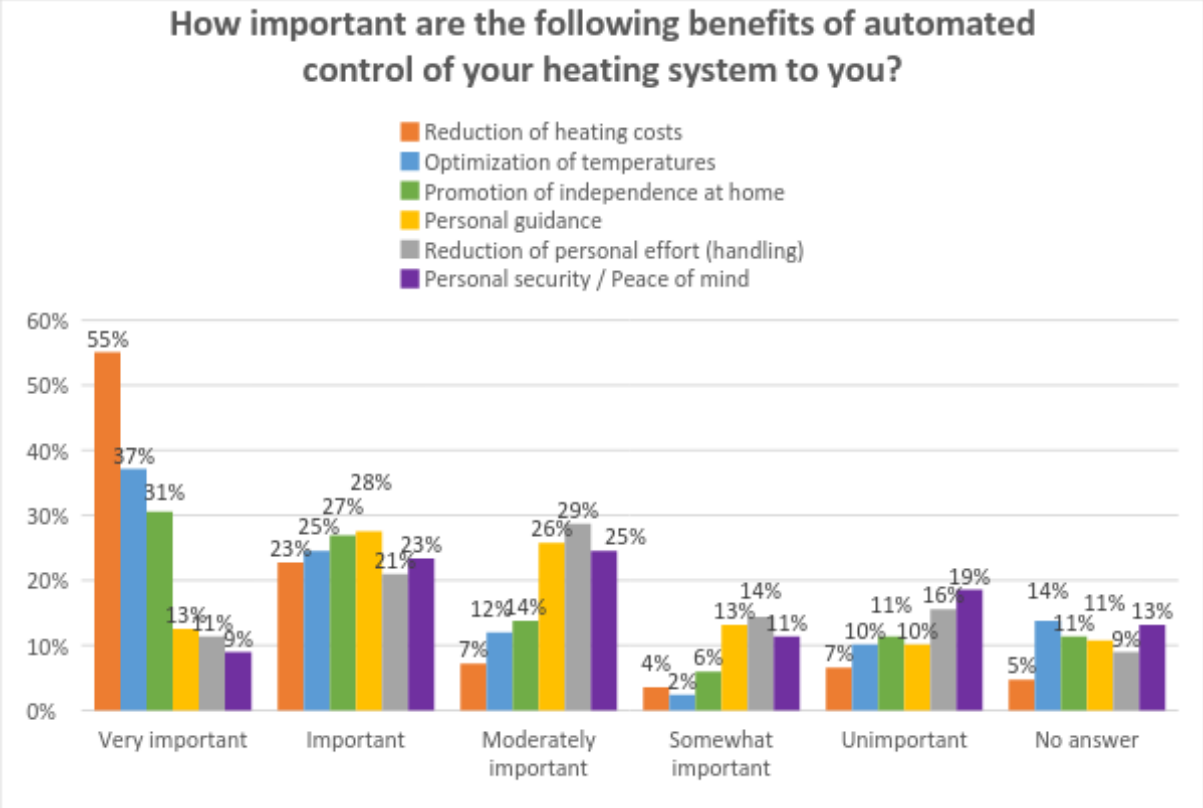

Chart 19

The reduction of personal effort merits further attention. Assuming that most elderly people are not willing to put additional work into their heating at home and that they are therefore not ready to invest into new technology that required them to act more often, their propensity for potential changes in the heating behaviour were queried.

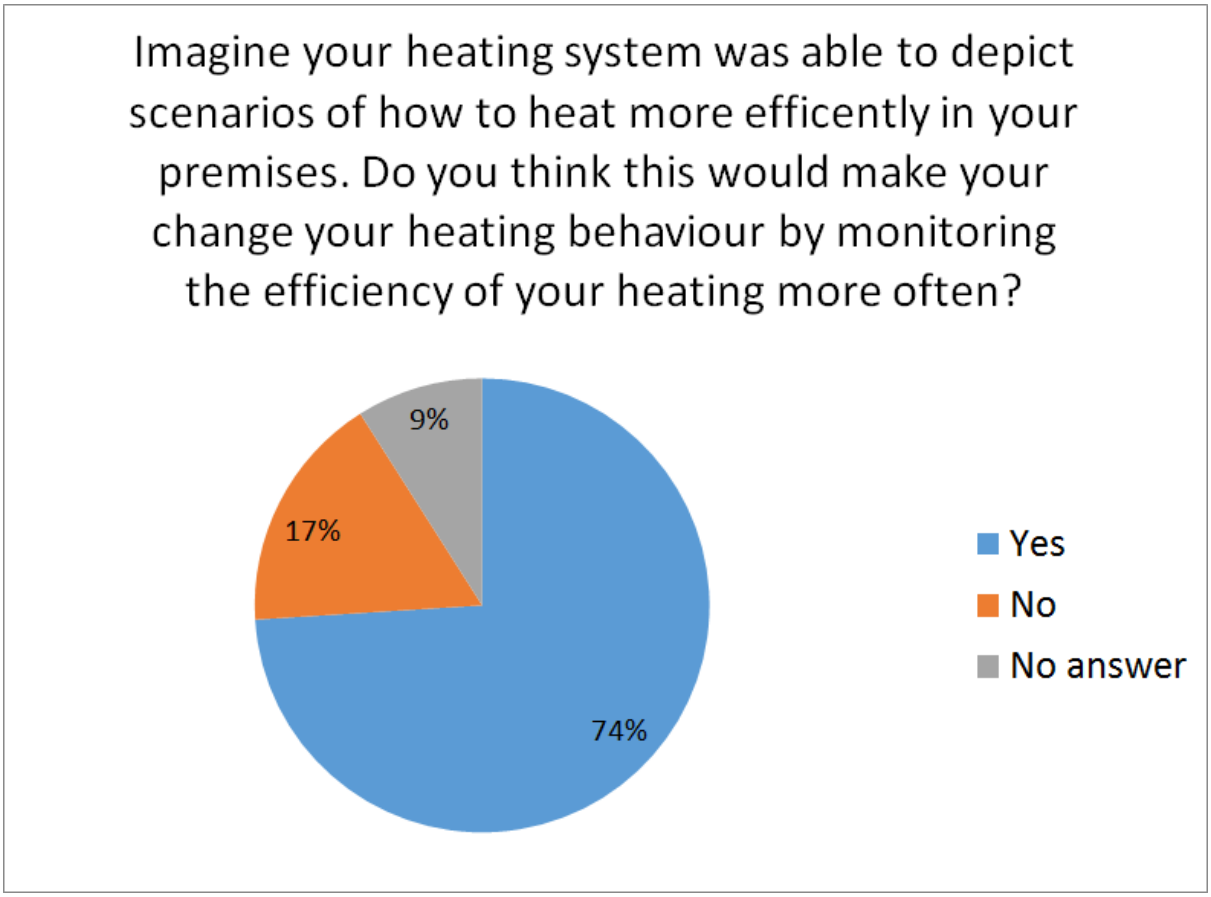

Chart 20

Contrary to prior assumptions, more than 74% indicated their readiness to change heating behaviour even if it requires additional effort, i.e. additional monitoring (Chart 20).

5.3.4 Acceptance of Technology

In order to learn more about the most suitable devices and platforms for the SmartHeat System to be used, the interviewee's experiences with and acceptance of different technology was investigated.

As different sensors will be applied, it was examined which types of sensors will be accepted for installation in the target group's premises or be accepted for monitoring activities, respectively. As shown in Chart 21, only a small minority has prior experience with smart watches (7%) and fall detection devices (1%, a total of 1 person). In contrast, about two thirds have experience with clock timers (79%) and environmental sensors (74%). After all, 62 % know about position tracking and 24%

have already used body sensors in their lives. 11 out of 167 participants (7%) did not check any option.[11]

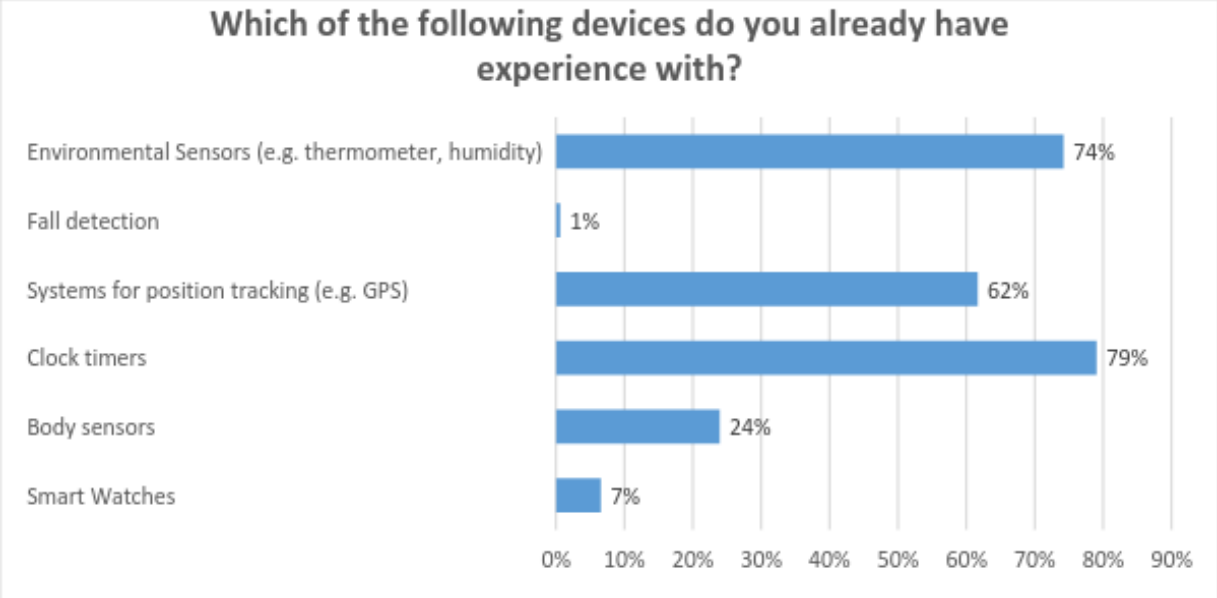

Chart 21

The findings here should be taken with care. As individual respondents might not be familiar with some of the items or their names, they may be reluctant to check the relevant boxes, even though experience is given. Moreover, the findings do not give information about the intensity of experience which might have prevented individual respondents to check the boxes, e.g. when experience is only low. Accordingly, the values from the Chart could be read as minimum values.

Insights about the respondent's' experience with individual devices should help to interpret the following statistics. In order to shed light on the circumstance that specific configurations of the SmartHeat System could be rejected by the target group due to specific sensors used, the questionnaire asked for the personal feeling with these items.

As can be retrieved from Chart 22, the general refusal of the listed items in terms of comfort is rather low. 11% indicate that they did not feel comfortable with body sensors, 7% with smart watches. Discomfort with the remaining items was stated by 2 to 6% of the interviewees.

[11] This could mean that they either do not have experience with any of the devices or that they did not answer the question. In case of the latter The percentage points of the other items will be slightly higher considering the smaller sample.

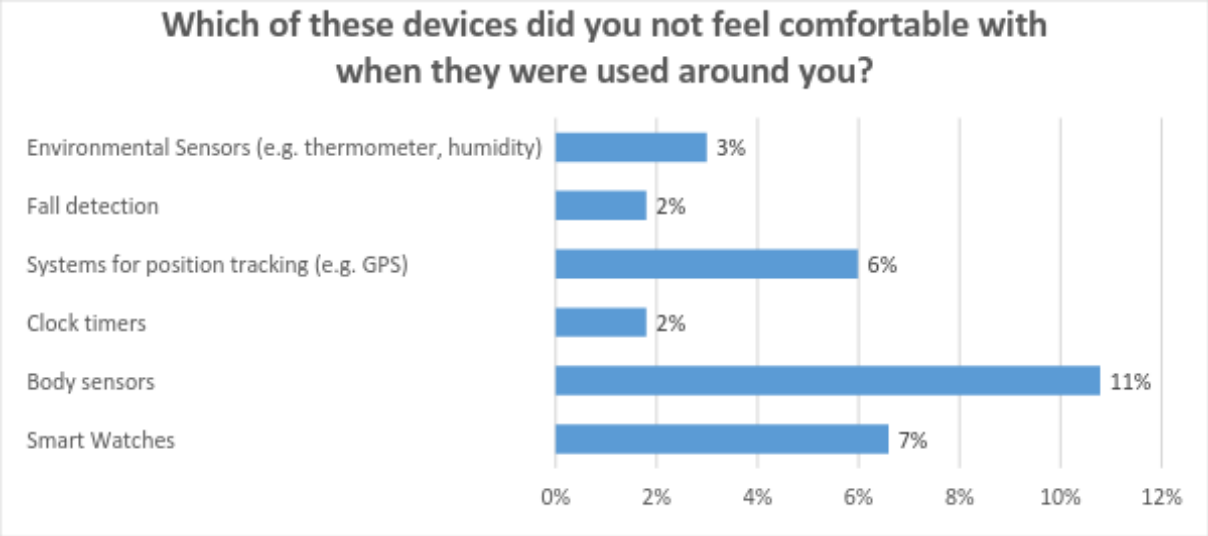

Chart 22

It should be noted that validity of the findings of Chart 22 are subject to high uncertainty. The given numbers show percentage points based on the total sample and do not refer to those who have experience with the items. Out of the 167 respondents, 132 (79%) did not check a single box, which could mean that they omitted the question totally, that they do not have experience with the item or that they do have experience but do not feel uncomfortable with the items at hand. Accordingly, whereas the total numbers are true for those who responded, conclusions about those who did not respond could be misleading. For example, it is true to conclude that 3% out of 167 interviewees did not feel comfortable with environmental sensors. However, there is not sufficient information to conclude that the remaining 97% do feel comfortable with these sensors.

In order to get more valid information, the following values take as the sample size the number of those who stated to have experience with the respective devices.[12] As can be derived from the following chart, the level of refusal is still rather low. From this perspective, the rejection of body sensors is reported by almost every fifth of those who have experience with such sensors. For the remaining items, the values are still rather low, with 7% for clock timers, 4% for locational tracking and 2% for environmental sensors. The lower sample sizes between 40 (body sensors) and 132 (clock timers) should be taken into account when assessing the validity of these numbers. Yet, there are valuable indications for further tests in the SmartHeat project.

[12] The values for fall detection and smart watches were cancelled out here because of the low number of respondents with experience on these items.

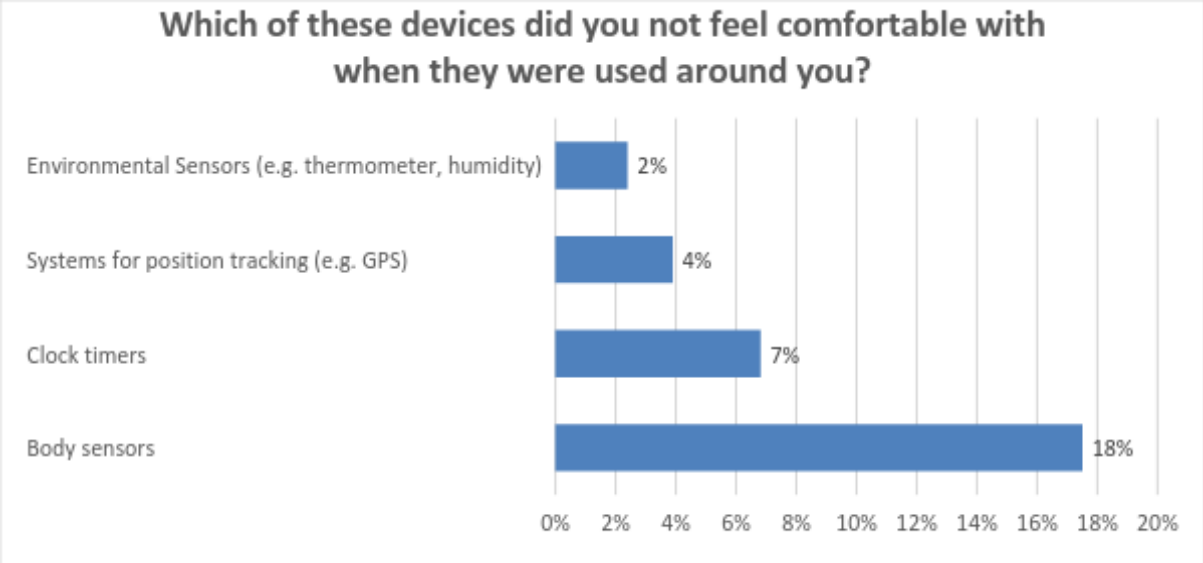

Chart 23

In order to get information about the communicative features of the SmartHeat system, the questionnaire was interested in the ways people prefer to receive instructions from their heating. Text messages were considered at least helpful by 57% of the respondents, iconographic instructions by 47%. Voice messages and sounds are much less appreciated as a tool for the heating to communicate need for action. 32% actively reject such features as uncomfortable and only 8% consider this mode very helpful.

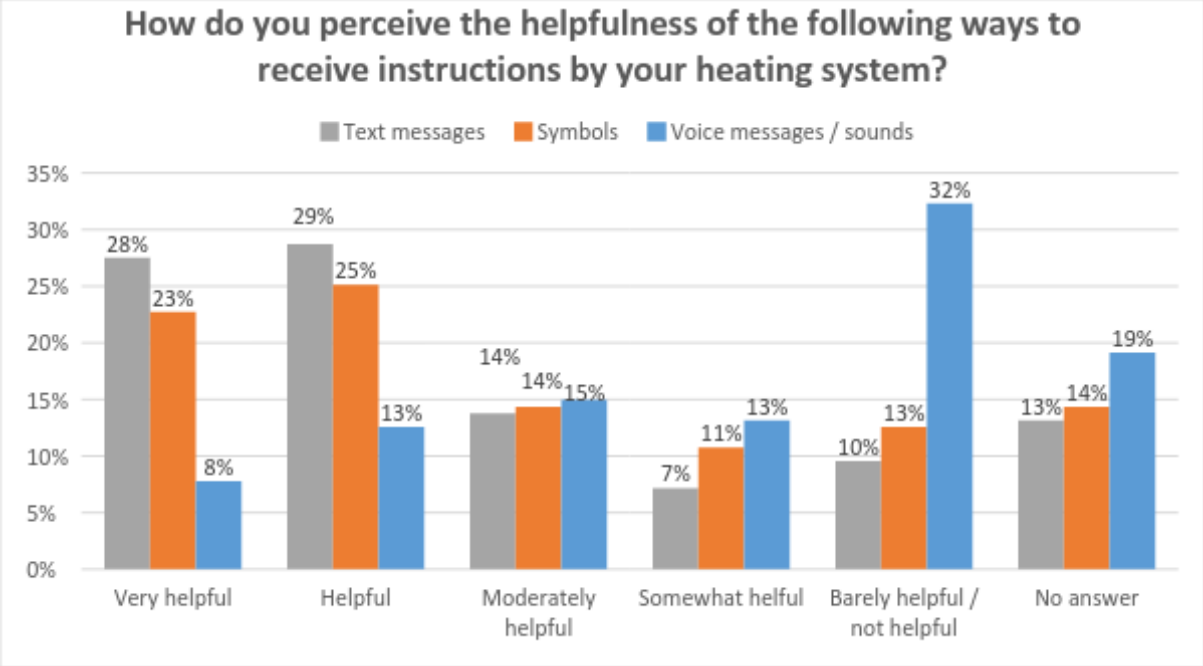

Chart 24

Regarding the integration of suitable communication devices in the envisaged SmartHeat system, the survey was interested in elderly people's current practices, comfort and preferences in the context of existing technologies.

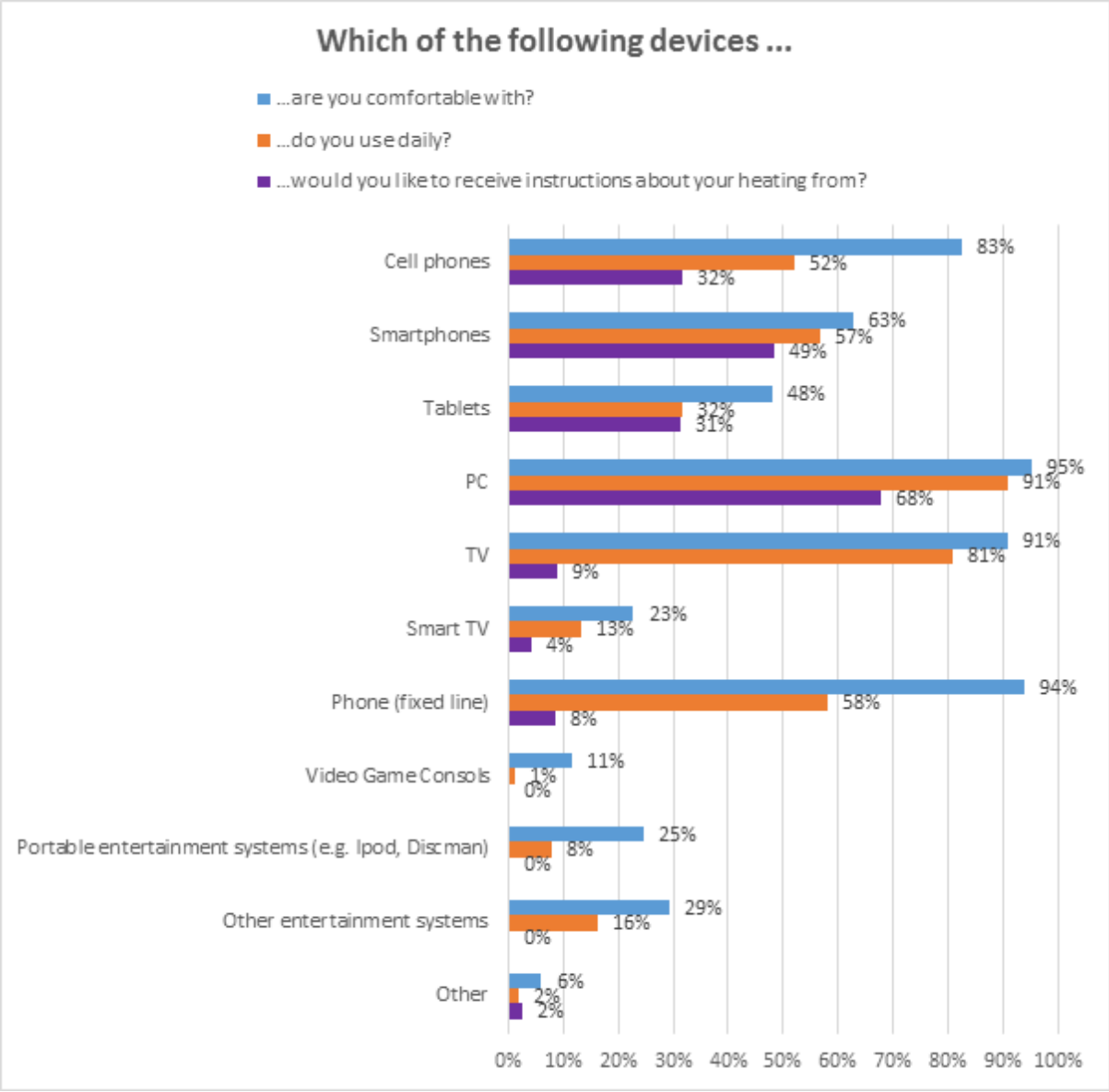

Chart 25

As can be derived from Chart 25, a large majority of the target group feels generally at ease with the handling of fixed line (94%), cell (83%) and more importantly with smartphones (63%), TV (91%) and PC (95%). After all, 48% report comfortableness with tablets. Other items (29 %), portable entertainment devices (25%) and smart TV (23%) are connected with positive associations by about every fourth respondent, whereas video game consoles (11%) and other devices (6%) are reported by a minority.[13]

Regarding the daily use of such devices, the values are significantly lower. Yet, the same categories prevail. PC (91%), TV (81%), fixed lines (58%), smart (57%) and

[13] DVD players, e-book-readers, fax machines, GPS systems, cameras and household appliances were listed as 'other'.

cell phones (52%) are used on a daily basis by the majority of the respondents. About every third respondent uses their tablets every day (32%).

As for their preference for receiving instructions through the heating system, however, the dominant categories shift. Although used every day by a large majority, only 9% prefer messages about their heating to be reported through this appliance. The highest popularity was recorded for PC (68%), followed by smartphones (49%), cell phones (32%) and tablets (31%).

As some of the abovementioned preferences could be distorted by insufficient imagination or experience with solutions using the devices listed, further questions were asked about the reasons why specific communication devices are not being used (Chart 26). The most dominant factor mentioned in this regard was the lack of personal need, as stated by 42% of the respondents. Unwillingness to try new things was stated by a minority of 5%, whereas the remaining factors were checked by only every sixth to eighth participant.

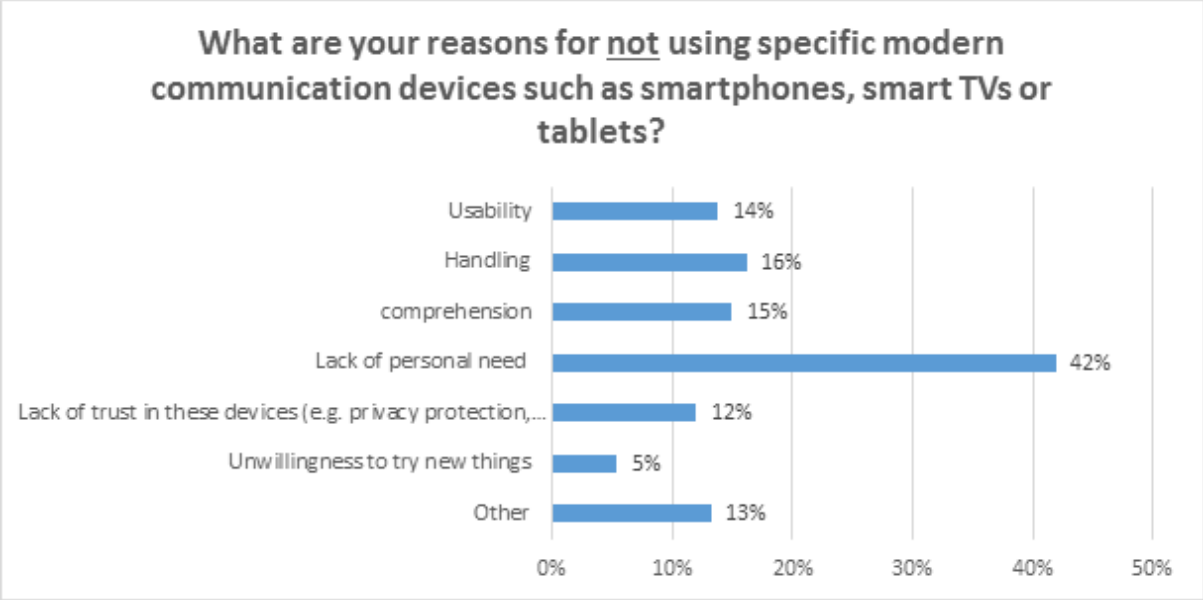

Chart 26

5.3.5 Impact of heating costs

It was found above that heating costs are a major factor that potential customers from the target group would consider in the context of a smart heating system. Moreover, it was found that a large majority would be willing to accept additional effort if more efficient heating could be made transparent to them.

Being questioned about heating behaviour in direct relation to costs (Chart 27), almost similar numbers report a willingness for behavioural changes in cases where potential saving were made transparent by the system. In other words, they would be willing to take additional action if they received additional information about their heating's cost-effectiveness.

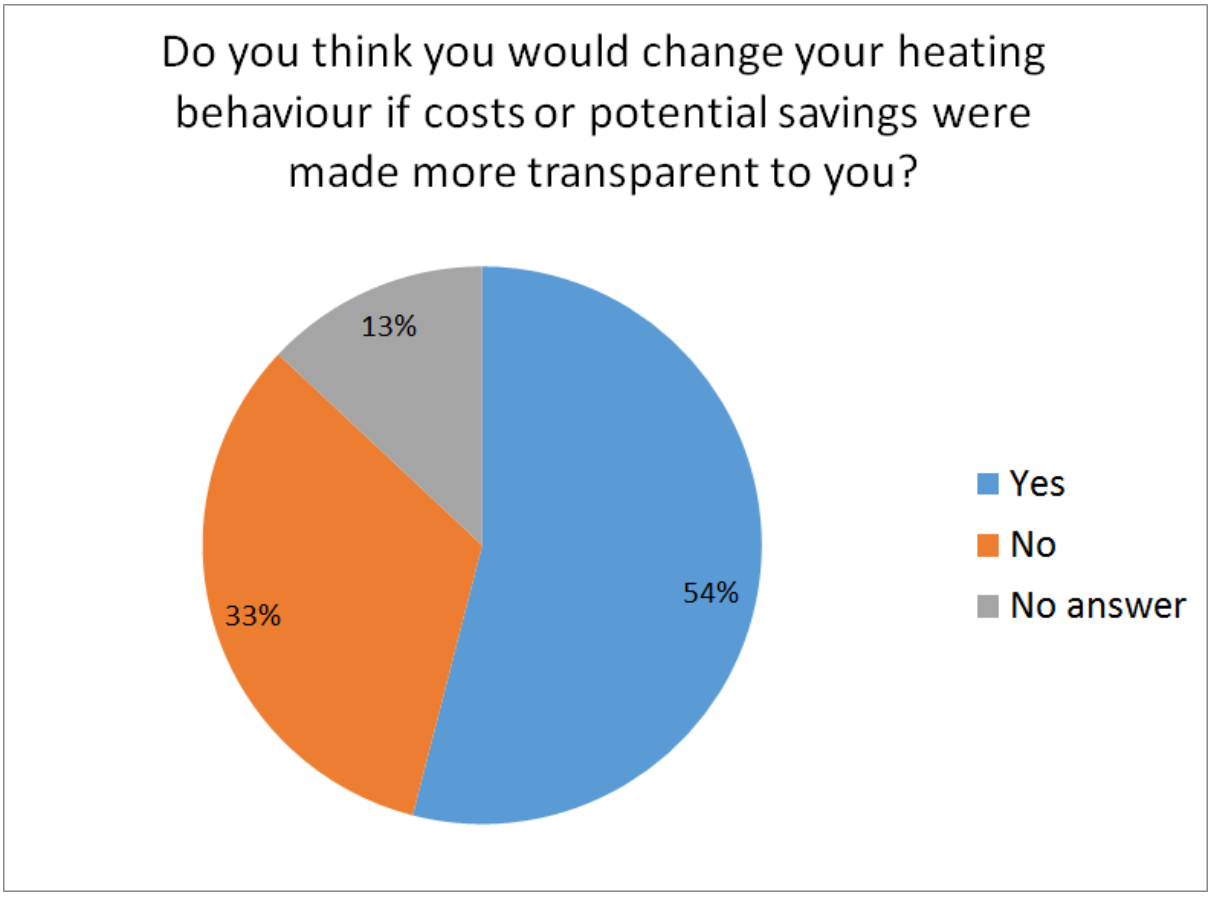

Chart 27

The following chart (n° 28) partly supports the claim that many of the respondents are sensitised for energy costs. Interviewed about their status quo, it turns out that more than half of them already tries to save energy through efficient heating. 32% try to adapt the heating to their schedules at home and 19% even compromise their well-being in order to reduce their energy bills. 32% in contrast, acknowledge that heating habits are not driven by consideration of costs.

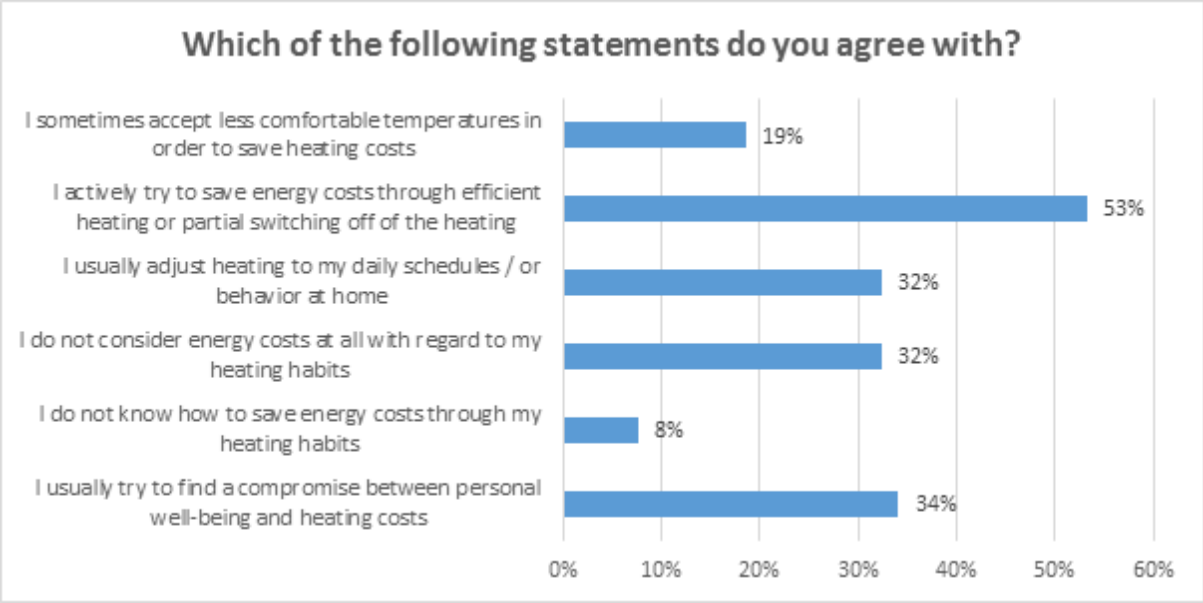

Chart 28

5.3.6 Empowerment of secondary users

Considering that the envisaged SmartHeat system shall promote features for secondary users to relieve and monitor elderly people, these latter were asked about their preferences for access of caring persons to their heating.

First, light was shed on the conditions for interventions by people other than the primary users (Chart 29). Among these latter, a majority considers temperature regulations by third parties appreciable in cases of strong mobility problems (60%), dementia (58%) and long-term absences from their houses (53%). 28% consider tactility problems to be sufficient reason to hand over control to third parties, whereas minorities consider the use of premises by other persons (8%) or short-term absences (7%) as conditions qualified for doing so.

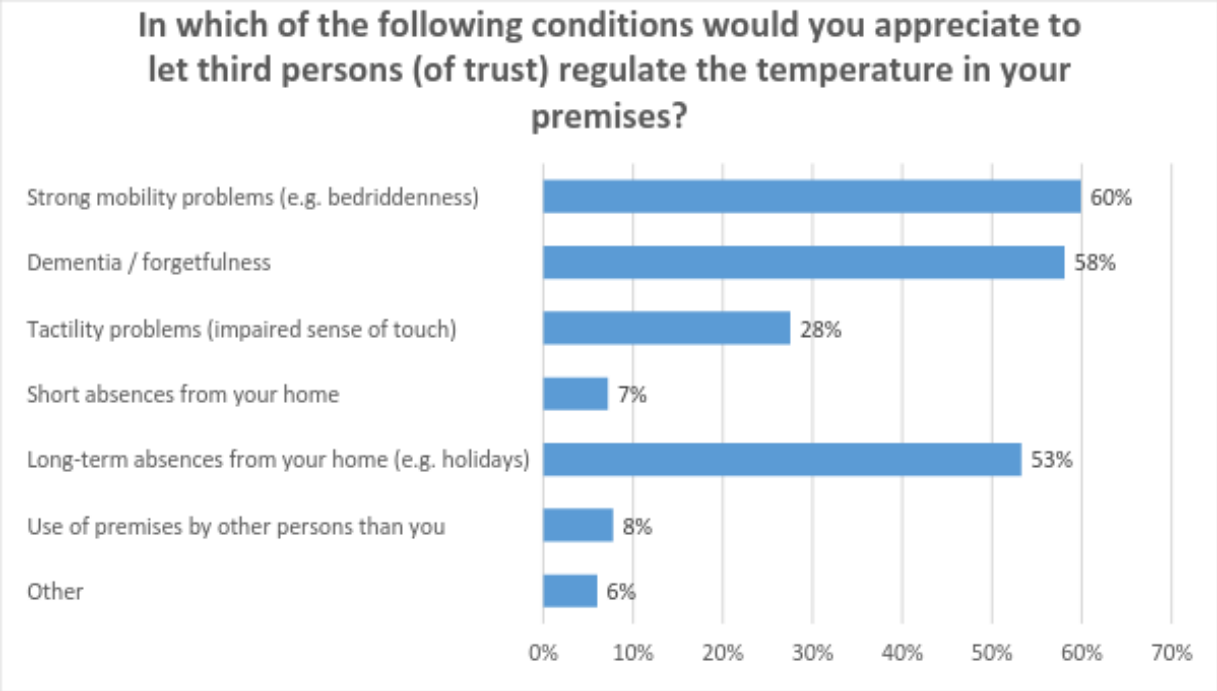

Chart 29

Although strong mobility problems are mentioned as reasons where third persons shall have access to the heating by a majority, there is reluctance to grant too much independence to them. This is illustrated in the following question. Being asked for alternative features to be used in the event of reduced personal independence full automation (46%) and own remote control (41%) are clearly preferred over remote control by secondary users (8%).

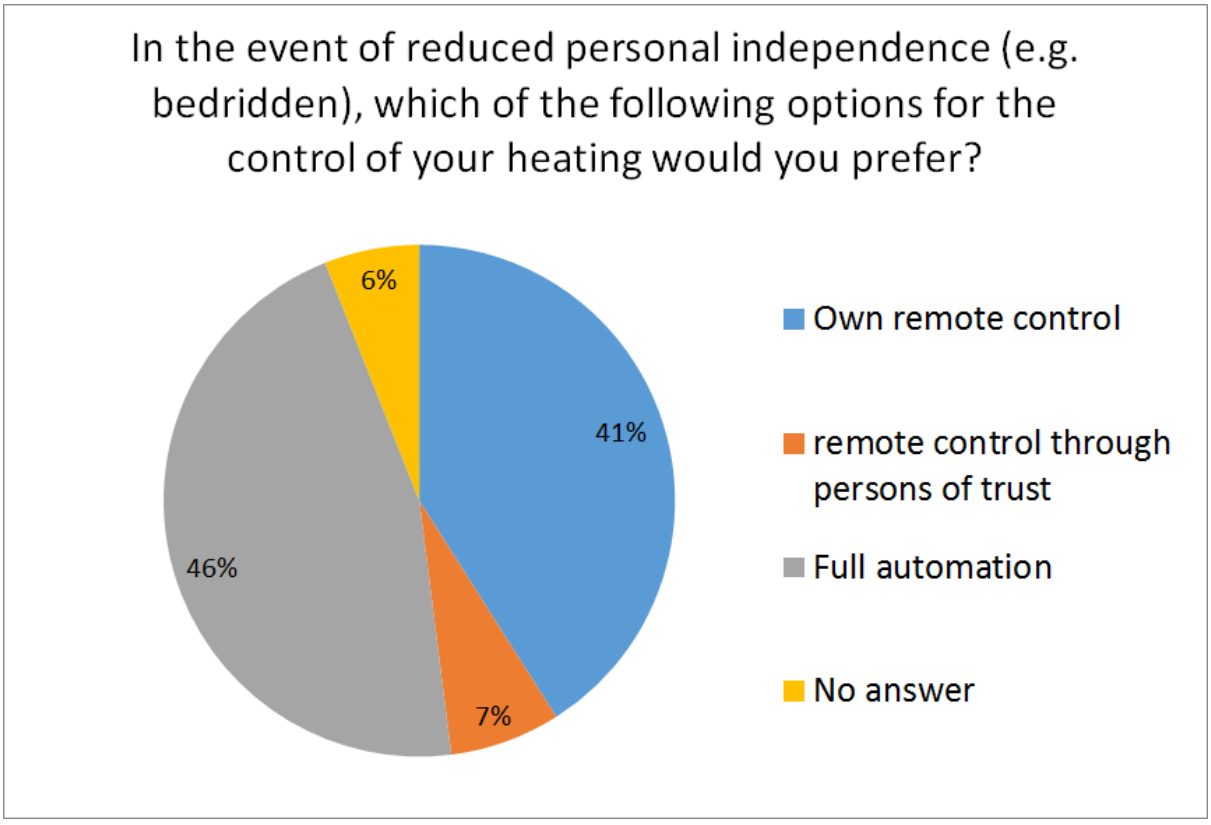
In the event of reduced personal independence (e.g. bedridden), which of the following options for the control of your heating would you prefer?
6%
41%
46%
7%
Own remote control
remote control through persons of trust
Full automation
No answer

Chart 30

In order to learn more about the willingness of the target group to concede remote control to potential secondary users, the release of different types of information was investigated by considering different target groups, namely family/friends, professional caregivers (home care services) and neighbours.

As can be derived from Chart 31, the propensity to communicate heating relevant information is highly dependent on the involved target group. It is the highest with regard to the group family/friends, followed by professional caregivers. It is the lowest for neighbours.

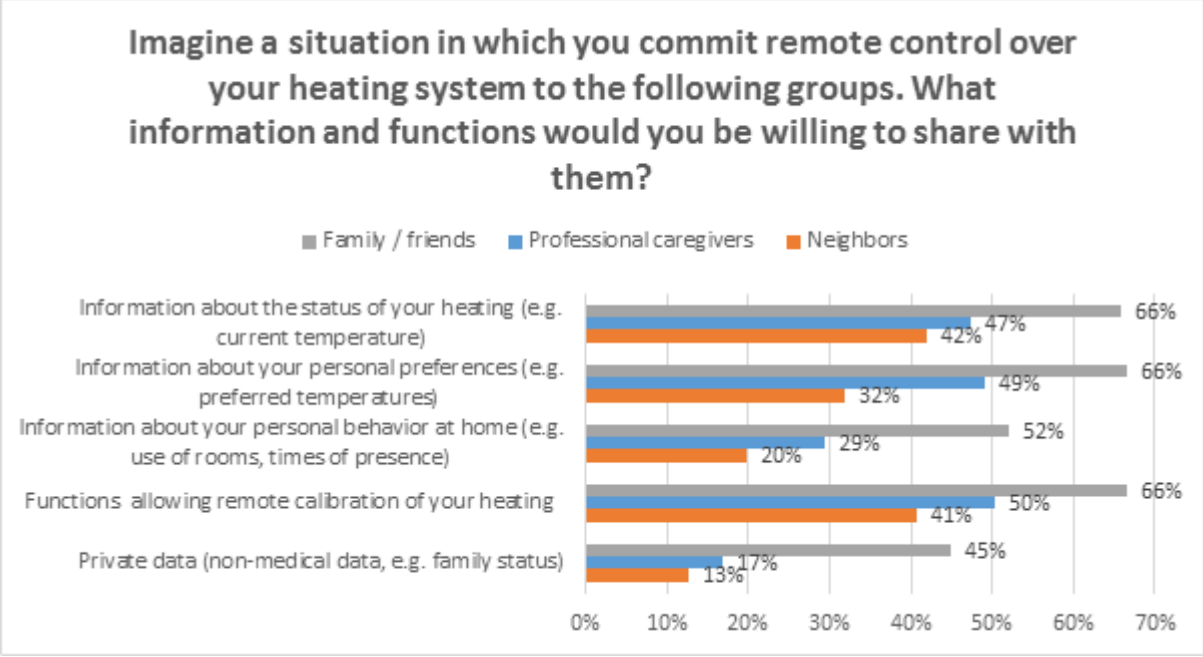

Chart 31

The respondents are especially sensitive to private data, which only 13/17% of the people interviewed were willing to release to neighbours and professional caregivers. Low values were also reported for information about domestic behaviour (20/29 %). Almost half of the respondents would be willing to give information about the heating status (47%) and personal heating preferences (49%) as well as functions to remotely calibrate the heating (50%) to professional caregivers. Two thirds would be willing to make these information / functions available to the group family / friends. Information about domestic behaviour and personal heating preferences would be communicated to this latter group by about half of the survey participants.

6 Conclusions and recommendations

This document analysed the needs of the target user groups of the SmartHeat project. The project considers two main user groups: the primary users, who are the older adults, and the secondary users, who are informal and formal caregivers.

In order to work with valid data, the user profiles were selected based on the CURE-Elderly-Personas. For the primary users, two personas were used: an older, active user without major restrictions and an older, inactive user with restrictions.

The analysis has been executed by means of a mix of qualitative and quantitative methods. As qualitative instrument, focus groups and interviews were selected. As quantitative instrument an online survey was applied focusing on heating habits and usage and acceptance of new technologies.

The scope of the user need analysis is to give inputs to the system specifications which will be included in deliverable D2.3. The findings of the analysis of the primary users, as well as preliminary recommendations for the requirement engineering phase, are summarized in Tables 1, 2 and 3. The three tables include findings and recommendations for the SmartHeat functionalities, benefits and technologies.

Table 1. Findings and recommendations for the SmartHeat system functionalities.

Functionalities	Findings	Recommendations
Automation and learning	Highly desired as long as reduce the user's effort. Highly desired in case of reduced personal independence.	The system's automation mode will have to completely reduce the human intervention.
	Current systems are rarely adapted, except for night or long term absence.	The system should adapt the temperature on a more regular basis.
	Most users express the need for quicker reaction of the system when the heating settings are changed.	The adaptation functionality should be intelligent enough to anticipate the user's need. When it is not possible to predict the user's behaviour, a "fast-reaction" response should be available.
	Users express the need for a heating system able to interact with other heat sources.	The system will have to be able to recognize whether there is another heat source

		around and adjust the temperature accordingly.
	Users show concern for multi user homes.	The intelligent algorithms will have to consider that there might be more than one person living at home.
	Most of the users keep the TRV's temperature always to a fixed value.	The system will have to be able to change the temperature of every room independently from each other.
Manual and remote control	The users want to be able to manually control the system when needed or desired.	The system should have a manual mode which has priority over the automatic mode.
	Remote control is highly desired in case of reduced personal independence.	The system should implement remote control functionality in case of need.
Remote control from caregivers	Highly desired in case of dependency, such as strong mobility problems or dementia.	The system should implement remote control functionalities.
	The users are rather confident in sharing heating status and preference information with family, friends and professional caregivers, while they are slightly less confident with neighbours.	The user should be able to decide to whom grant access to the system.
	The user showed concern when private data need to be shared.	The user should have control on the type of data to be shared.
	The user don't have expectation that caregivers would use this functionality to visit the end-users less frequently.	The control from third parties should be implemented only as a security system and not as a functionality which can be used by caregivers on a regular daily basis.

Table 2. Findings and recommendations for the SmartHeat system benefits.

Benefits	Findings	Recommendations
Efficiency and cost reduction	Most users heat rooms depending on the use.	This shows the need for a system which improves the

		efficiency and reduces costs. The SmartHeat system should facilitate this function in an automatic way.
	Rooms more used are heated equally.	This is prevented by the fact that manual adaptations are annoying. The SmartHeat system should improve the efficiency without requiring human intervention.
	The visibility of real time costs for heating of specific rooms and the calculation of different heating scenarios in relation to costs would be appreciable assets.	The system should provide the user with information on the real-time heating expenses of every single radiator.
	Most users are willing to change their heating behaviours if costs or potential savings are made transparent.	The system should provide recommendations on possible scenarios which would improve the efficiency.
	Many users currently improve the efficiency by using traditional way, such as putting on or off more clothes.	The system should improve the efficiency by means of intelligent technologies without forcing the user to use alternative way which might reduce comfort.
Comfort	The users show the need for comfort and they clearly state that this is inviolable.	The system should increase the efficiency always considering the comfort as priority.
Simplicity	The users have clear that simplicity and solving of actual problems rather than “nice-to-have-applications” is of extreme importance.	The system should be user friendly by design, both when working in automation, manual or remote control mode.

Table 3. Findings and recommendations for the SmartHeat system technologies.

Technologies	Findings	Recommendations
Reliability and acceptance	The users are firmly convinced that an intelligent system need to be reliable otherwise it is useless.	Reliability should be one of the main specifications of the system.
Receiving notifications	The preferred devices for receiving instructions and information would be	The system should be flexible enough to use

	devices that are already used and that fit into daily routines, such as smartphones, tablets and PC. Fixed screens would be an additional option.	different devices able to receive notifications. These devices should be those currently used by the users.
	Informative sounds or voicemails would be considered annoying for most respondents. Text messages and symbols are more appreciated.	The system should not be equipped with a voice based communication system. Messages should be based on messages and symbols.
Use of sensors	Most users declared to have experience with environmental sensors and location based systems. They also showed that they felt rather comfortable with these systems,	The system can be equipped with different environmental sensors (e.g. temperature, humidity, presence, etc.) and location based technologies.
	The users show slightly less comfort when have used body sensors in the past.	The use of external wearable devices such as wristbands should be considered only in case these devices are non-invasive and do not imply discomfort for the user.

While priority has been given to the requirement of the primary end user, the analysis has also collected preliminary requirements of the secondary end users. Complementary interviews were carried out and two main groups were analysed: retirement homes and home care services.

The preliminary analysis shows that professionals working in the retirement homes do not show particular problems in their current heating systems and do not see particular advantage in using an intelligent and automated system. This is due to the fact that every person lives in one single room which is usually sufficiently heated. This implies that the professional personnel does not usually have control on the user's room temperature. However, they see potential benefit from the point of view of the management of the overall facility. An intelligent decentralized system would be able to lower the energy costs of the overall facility.

The analysis show different results for the mobile care institutions. In this case, the mobile workers often take over the heating regulation when the older person is not able to do it independently. As a consequence, the professionals show more appreciation for a system which allow them to remotely monitor the heating conditions (e.g. avoid overheated or underheated rooms). Also, they would find of high utility an alert system which indicates whether there are problems with the heating and they can take action accordingly.

These preliminary indications show that the SmartHeat system would also provide benefits to secondary users, mainly those responsible to take care of people at their places and not in retirement homes. This also indicates that informal caregivers would also find the system highly beneficial.

The recommendations for the requirement engineering phase is to consider the remote control from third parties and the alert system in the functional specifications of SmartHeat but to implement it with basic functionalities. In the second iteration of the user need analysis, the secondary user group will be analysed more in detail, including also informal caregivers, so that to fine tune the functionalities for the secondary user group in the second iteration of the prototype development.

7 Annex

- Smart Heat End-User Questionnaire Online Survey