# Final report on engagement and training

# D6.9

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# D6.9

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| Lead | RISE |
| Contributor(s) | DREEAM consortium |
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## Executive summary

The aim of this report D6.9, within the framework of Work Package 6.4 (WP 6.4), is to present and describe in detail how the engagement and training programme are prosecuted in context of the energy efficient renovations applied to multiple residential buildings.

The so-called 'demand side', the target group 1, namely the housing companies and cities and the 'supply side', the target group 2, comprising of energy experts, architects, contractors, skilled construction workers and quality control mangers are the identified target groups with in framework of engagement and training programme of this WP 6.4.

RISE, along with the experts involved in the DREEAM project have innovated and suggested a training programme for the above-mentioned target group.

With respect to target group 1, the following focal points have been identified and portrayed namely a) Awareness of associated benefits in applying energy renovation, b) Information of factors of importance of energy efficiency, c) Information of energy renovations solutions in integrated approaches, d) Comprehension of methods and its approaches and e) Information on quality assurance systems and function control programmes.

The diversity of the target group 2 creates an uphill task, in order to drastically increase the awareness with regards to the integrated approach of engagement and training processes for efficient and energy saving renovation in multiple residential buildings. The complex nature of the supply side has been identified in order to focus on the impact they have on successful deployment of procedures that lead to energy efficient renovation.

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# 1 Objective of the deliverable

## 1.1 Main objective of DREEAM - WP6 - Task 4

One of the objectives in the DREEAM project is to raise the ambition among project promoters and decision makers in their renovation programmes to further emphasize building energy performance as part of their agenda (DREEAM, 2015). In WP1, the approach for such methodology will be developed.

The aim of WP6 is to exploit and disseminate the DREEAM approach developed in WP1 and demonstrated in WP3. By applying this approach, the aim is to achieve reductions up to 75% in Net Energy Demand through renovation of residential buildings at a multi-building scale. The target groups intended for engagement and training are:

Housing companies and cities (demand side)
Contractors and skilled workers (supply side)

The overall purpose of WP6.4 is to develop specific engagement and training activities for the above-mentioned targeted groups.

## 1.2 Objective of deliverable D6.9

The objective of deliverable D6.9 within the WP6.4 (Engagement and training programme) is to present the execution of the engagement and training programme:

Training for:

- Municipality of Warsaw
- Property Managers in Warsaw
- Energy Efficiency Business Sector
- Energy Auditors

Raise awareness by:

- Workshop in the framework of the Eurhonet Sustainable Construction Topic Group meeting
- Eurhonet General Assembly 2017, 2018
- Housing for All - Affordable Housing in Growing Cities Conference
- DREEAM Workshops and field trips
- Eurhonet Annual Report 2016, 2017, 2018

Training material for skilled workers:

- Poster
- Brochures
- Workshops / Field trips

# 2 Key target groups

To address awareness of applying integrated approach for NZE renovation in residential multiple buildings by specific engagement activities and training, two target groups has been identified. As stated in the project (DREEAM, 2015) the target groups are (I) Project promoters in housing companies and cities, and (II) SME contractors and skilled workers.

RISE, with the support of DREEAM experts, have create a training programme for both target groups, which include both training materials and documentation on the DREEAM webpage. The training material has firstly been distributed by internal channels of participating organisations e.g. through Climate-KIC regions and its 34 members to their local contractors; to be included in the internal training programme at Exeleria, 3C-Pre and RISE.

## 2.1 Project promoters in housing companies and cities – Group I

The project promoters in housing companies and cities (target group I) accounts for the demand side of the market for energy efficient products and services in residential housing. The members of which can be found in large construction and housing companies, such as institutional building owners, and among policy makers, e.g. city officials.

The objectives are to convey the associated benefits of applying an integrated approach in the energy renovation programmes to the project promoters, but also to provide understanding for the possible methods and techniques of applying such approach. While also providing a guide in how to formulate functional requirements and control throughout the building process by the implementation of quality assurance systems and information on how to follow up processes and goals.

The DREEAM project, with the supporting partners, have produce a training programme and supporting materials (e.g. training brochures, presentations and webinars) targeting the first group – project promoters in housing companies and cities.

EURHONET has facilitate the execution of the training programme with the members of European Housing Network of 39 social and public housing. The training sessions has been organised on side of the EURHONET international events and workshops at least once a year. Training sessions targeting city officials has taken place on site of the annual events and workshops of the Energy Cities that has been organised at least twice in the second part of the project. In addition, the training materials are distributed to the project promoters by the internal network of EURHONET and Energy Cities.

The following aspects are conveyed in the engagement activities:

- Awareness of associated benefits in applying energy renovation
- Information on factors of importance for energy efficiency
- Information of energy renovation solutions in integrated approaches
- Comprehension of methods and approaches
- Information on quality assurance systems and function control programmes

## 2.2 SME contractors and skilled workers – Group II

The second target group, SME contractors and skilled workers, is responsible for the supply side of services associated with the integrated approach for the energy renovation in residential housing. They are a diverse group of people and can be identified as SME contractors, consultancies and skilled workers. Thereby, this group of actors is clearly quite diverse when it comes to educational level, training opportunities and challenges. The SME contractors and the skilled workers needs awareness of practical implications of the approach, associated benefits as well as the executions methods.

Identified professions and the process in which they can apply knowledge from the training materials are listed below. The complexity and diversity of the different occupations is shown here, with focus on the impact they can have on the success of the energy efficient renovation.

- *Energy experts* – in their work with energy audits in order to optimize the choice of energy efficiency measures and NZEB actions
- *Architects/constructors* – in their work integrating adequate NZEB technologies. In example good functions concerning airtightness, thermal bridges, thermal comfort and indoor air quality
- *Construction workers* – in their work with mounting equipment, materials, insulation, airtight membranes and performances etc. in order to achieve optimal professional performance
- *Quality personnel* – in their work as managers and in performing function checks before commissioning. These function checks may involve checking function of thermal comfort, airtight performances, window installations, operational features of systems for regulating ventilation, and cooling. These function controls may be performed as self-checks and third-party controls.

In the work towards lowering energy demand and reaching energy saving goals other factors could have a large impact. These include property maintenance and the behaviours of caretakers and users/residents.

# 3 Seminaries and training for group 1

Several seminars and training activities are completed for group 1. Totally the DREEM project partners have actively presented the project at 38 events and workshops. A few of them with a special focus on information and training are presented here. A summary of all communication activities is presented in D6.6 Updated Dissemination and Exploitation Plan

## 3.1 Training for Municipality of Warsaw, 23.11.2018

### 3.1.1 Event details

Training: "Deep energy renovations of Warsaw Municipality-owned buildings". There were 84 participants registered where 75 took part in the training. All participants were representatives from different Warsaw District Offices, Infrastructure office and other municipal-owned organizations. The subjects of the training were suited for public buildings – specially ways to save energy in those and how to finance energy efficiency investments from public budget. Training included lectures, Q&A time and personal consultation with participants.


*Image 1, closing image of presentation*

### 3.1.2 Agenda

1. Energy saving in public and residential buildings - why and how to do it? Examples from DREEAM project
2. Preparation of energy modernization of buildings in Warsaw
3. Possibilities to reduce heating costs of public buildings in Warsaw
4. Possibilities to reduce heating costs for residential buildings in Warsaw
5. Sources of financing energy-saving measures in Warsaw buildings
6. Assumptions for the implementation of the municipal energy management system based on the ISO 50001 standard

Knowledge presented during the training was possessed thanks to DREEAM project and NAPE own experiences.

### 3.1.3 Responses

Participants were interested in the topic and asked a lot of questions during Q&A time. In the end of training there was time to talk with each speaker (energy efficiency expert). Most of participants took this opportunity to explain their local challenges and talked about certain topics related to energy efficiency measures. All the materials were delivered to participants in order to enable usage of them in their institutions.

*Image 2, discussion*

## 3.2 Training for Property Managers in Warsaw, 10.04.2019

### 3.2.1 Event details

Training/Seminar: Deep Energy Renovations of Multi-family Buildings. There were 74 participants registered where 62 attended the training. Participants were representatives of different housing associations and communities, property managers and other organizations in housing sector.

At the seminar, we presented and tested with participants a new methodology of energy review of the building, talked about specific examples of completed deep energy renovations and a matched source of funding with the participation of European Union funds. The renewable energy sources solutions were shown as an example of good practices – from Poland and foreign countries (Paddiham).

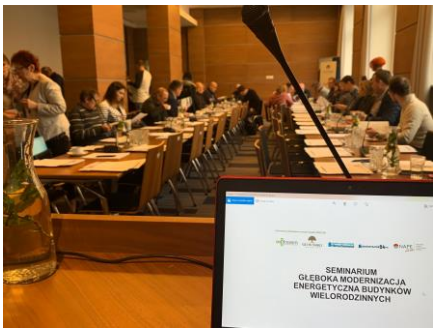


*Image 3, the participants arrive*

### 3.2.2 Agenda

1. Saving energy in residential buildings - why and how to do it? Examples from DREEAM project

2. Sources of financing energy-saving measures in multi-family buildings in Warsaw and Mazovia region - regional loans for thermo-modernization with EU support
3. Preparation of energy modernization of multi-family buildings. A new standard for the energy review of the building.
4. Additional possibilities to reduce heating costs for multi-family buildings after thermo-modernization
5. Effects of active management of energy consumption in multi-family residential buildings
6. Use of renewable energy sources in multi-family buildings – DREEAM demo site as an example of new approach

*Image 4, in the middle of the presentation*

Partners of the seminar were:

- Administrator and Property Manager together with the portal Administrator24.info
- PROMAR Sp. z o.o. who presented energy management systems
- GetIn Noble Bank who presented financing options for housing associations

### 3.2.3 Responses

Based on survey that was answered by participant training was review as a useful for approaching energy efficiency investments in multi-family houses. The overall opinion of presented topics was 4 in sale of 5. Participants took an opportunity to exchange information between each other about the current status of building stock and to talk with energy efficiency experts about their cases and possible solutions. Materials from the training are available on the Event website where participants downloaded them to use in their work.

## 3.3 Training for Efficiency Business Sector, 24.05.2019

### 3.3.1 Event details

Training: DREEAM project - preparation of a strategy for energy modernization of municipal housing stock.

Training was a part of yearly summit of SAPE association - Respect for Energy and the Environment". SAPE was established on the initiative of a group of people operating in Poland and internationally for the sake of respect for energy and the environment.

Participants in the meeting were representatives from energy agencies which core business is improvement of energy efficiency in Poland. They work as a contractors for municipalities and housing companies ( f.e. housing association) in matters of energy efficiency solutions. There were 18 participants.

Agenda covered different project that were talked trough as an example of good practices and opportunity for development among other participants in different regions of Poland.


*Image 5, opening image with collaboration partners*

### 3.3.2 Agenda

1. A renewable energy loan in the Pomorskie Voivodeship
2. Information on subsidies to OZC + thermo-modernization in the Kleszczów Commune
3. Information on the work / study for NIK
4. Financing works in SMEs resulting from the EE-Metal project
5. Strategy of operation of energy agencies in cooperation with domestic and foreign institutions financing energy efficiency projects in Poland
6. DREEAM project - preparation of a strategy for energy modernization of municipal housing stock
7. Project "More effective use of the 2021 - 2027 Cohesion Funds for energy security of the Visegrad"

### 3.3.3 Responses

All participants were familiar with the topic of deep modernization which gave us fruitful discussion on how to implement DREEAM approach in in their regions.

## 3.4 Training for Energy Auditors, 10.07.2019

### 3.4.1 Event details

Training: “Deep energy renovations of buildings”

There were 40 participants invited and 29 participated. All of them are energy efficiency experts working mostly in field of energy auditing and thermomodernization.

At the training, we presented and tested with participants a new methodology of energy review of the building and focused on implementing in in their daily work. The topics also cover sources of funding the modernization and usage of renewable energy sources.

### 3.4.2 Agenda

1. Saving energy in residential buildings - why and how to do it? Examples from DREEAM project
2. Sources of financing energy-saving measures in buildings
3. Preparation of energy modernization of multi-family buildings. A new standard for the energy review of the building.
4. Use of renewable energy sources in multi-family buildings – DREEAM demo site as an example of new approach
5. Knowledge presented during the training was possessed thanks to DREEAM project and NAPE own experiences.

### 3.4.3 Responses

All participants were involved in the discussion about DREEAM approach and its possible usage in their work.

## 3.5 EURHONET

EURHONET have facilitate the execution of the training programme with the members of European Housing Network of 39 social and public housing. A summary of all activities is listed in the event diagram below in “3.5.1 Events to raise awareness for the project by EURHONET”. At each event there have been different topic in order to fulfil the demands of the audience. At the first workshop in Potsdam October 2016 a small survey was made to investigate the audience need of knowledge. Topic that were raised were; renovation founding, policy and regulations, training needs and technological trends in renovation.

### 3.5.1 Events to raise awareness for the project by EURHONET

*Diagram, Events to raise awareness for the project by EURHONET*

| Event | Date | Location | Target group | Organizer | Activity | Note |
|---|---|---|---|---|---|---|
| Workshop in the framework of the Sustainable Construction Topic Group meeting | Oct-16 | Potsdam, Germany | building owners | EURHONET | workshop | Presentations by DREEAM partners |
| Sustainable Construction Topic Group meeting | Feb-17 | Bremen, Germany | building owners | EURHONET | working group | Presentation by Iza |
| Sustainable Construction Topic Group meeting | Jun-17 | Calais, France | building owners | EURHONET | working group | Presentation by Miguel Fontela and Héctor Martínez (Exeleria) |
| Sustainable Construction Topic Group meeting | Oct-17 | Brescia, Italy | building owners | EURHONET | working group | Updates by Eurhonet Secretariat |
| Eurhonet General Assembly 2017 | Jul-17 | Turin, Italy | building owners | EURHONET | conference | Presentation by Iza and Rolf and world café session |
| Sustainable Construction Topic Group meeting | Feb-18 | Västerås, Sweden | building owners | EURHONET | working group | Updates by Eurhonet Secretariat |
| Sustainable Construction Topic Group meeting | Jun-18 | Reggio Emilia, Italy | building owners | EURHONET | working group | Updates by Eurhonet Secretariat |
| Sustainable Construction Topic Group meeting | Sep-18 | Darmstadt, Germany | building owners | EURHONET | working group | Updates by Eurhonet Secretariat |
| Eurhonet General Assembly 2018 | Oct-18 | Birmingham, UK | building owners | EURHONET | working group | Distribution of DREEAM leaflet in conference Infopack |
| Housing for All - Affordable Housing in Growing Cities Conference | Dec-18 | Vienna, Austria | policy makers / building owners | EURHONET | conference | Distribution of DREEAM leaflet at the Eurhonet stand (exhibition adjacent to the conference room) |
| Sustainable Construction Topic Group meeting + DREEAM Workshop and Study Visit | Feb-19 | Manchester/Padiham, UK | building owners | EURHONET | working group | Presentation by Pilot Sites managers |
| Sustainable Construction Topic Group meeting + DREEAM Workshop and field trip | May-19 | Treviso, Italy | building owners | EURHONET | working group | Presentation by Pilot Sites managers |

### 3.5.2 Publications to raise awareness for the project

*Diagram 2, Publications to raise awareness for the project*

| Publication | Type | Date | Organizer | Link |
|---|---|---|---|---|
| Eurhonet Annual Report 2016 | article | Oct-17 | EURHONET | https://www.eurhonet.eu/wp-content/uploads/2017/11/Eurhonet-Annual-Report-2016_web.pdf |
| Eurhonet Annual Report 2017 | article | Oct-18 | EURHONET | https://www.eurhonet.eu/wp-content/uploads/2018/10/6625-Eurhonet-Annual-Report-2018-web.pdf |
| Eurhonet Annual Report 2018 | article | Oct-19 | EURHONET | To be published online and distributed once approved by the GA in October 2019 |

# 4 Training material for skilled workers, group 2

A suitable format of training material for the skilled workers was decided to be in the form of ten brochures on relevant topics and a poster to summarize the subjects and inform about the DREEAM project. The material is available for download from the project website (www.dreeam.eu). It is easily recognizable with a unique and uniform layout based on the project's graphic profile. It includes representative graphics and has high readability, making the information simple to take in.

## 4.1 Format

The format of the training material aims to be accessible and educational. With a broad target group and a great variety of settings in which the material is relevant, the chosen format intends to reflect that. The information is short enough to go through over a coffee break and can hopefully be a reminder of how and why things are done in a specific way. It can also be a way of learning something new and find out about future technologies.

### 4.1.1 Brochures

The brochure format is easy to use in that it is small, can be organized educationally and the user can individually select the topics that they find relevant or engaging. To cover as many subjects as possible, brochures have been made about *control systems, cooling systems, heat insulation, heating systems, installations, living green walls, moisture, solar thermal energy, sun shading,* and *windows* (see appendix).

On the project website, SMEs and skilled workers can find pdfs in A4 format that is effortlessly printed front to back (flipped along the short edge) and folded in three, as shown below (image 6). The material are available in English, Italian, German and Swedish.

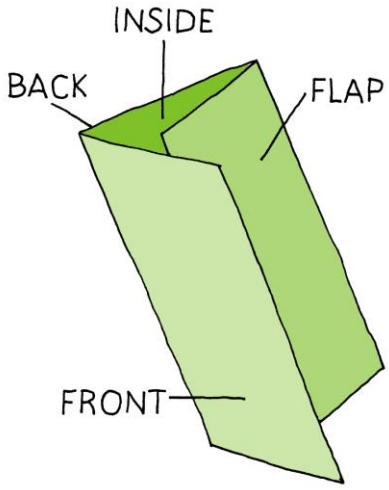


*Image 6, How to fold the brochures*

The brochures are illustrated using a coherent layout and organization. The front page is recognized by a straightforward title and graphic to depict the subject. Here, the importance of the topic is addressed. All of which is being framed by the city (at the bottom of the page).

Turning the page, the reader is faced with information that is directly connected to the front page to the left and the flap to the right. Depending on the subject, the flap holds different information, some display advice on the installation of e.g. windows, while others state and address misconceptions, etc. This is, not unlike the front page, is presented within the frame of the city.

Turning the page, the reader is faced with information that is directly connected to the front page to the left and the flap to the right. Depending on the subject, the flap holds different information, some display advice on the installation of e.g. windows, while others state and address misconceptions, etc. This is, not unlike the front page, is presented within the frame of the city.

The backside of the brochure is dedicated to DREEAM. On top of a black and white picture of a residential building, there is a concise text about the project. It focuses on the aims of the projects, its importance and briefly mentions the pilot sites. This page is the only one that is identical to all ten brochures.

### 4.1.2 Poster

As a complement to the brochures, the poster (see appendix) is made to be featured in the workplaces to inform and bring attention to the topics covered in the brochures. It features the same information about the project as the backside of the brochures with additional material concerning the goals set by the European Union (EU) for 2020 and 2030. A map The climate zones are illustrated to display the different climate zones within Europe and to show the sites of the three pilot sites.

## 4.2 Method

The methods used to collect the data needed to choose the best suited format of the training material and the information was through the research of previous reports on the topics. Both on the subject of producing training material and also the separate topics. In addition, a field trip was made to a renovation project in Gothenburg, Sweden where the material was discussed with skilled workers.

### 4.2.1 Research

Based on previous work made by RISE and on other energy efficiency refurbishment projects from European Commission (e.g. Build Up Skills and nZEB) reports were collected in an early stage of the project. At the time of the production of the brochures and the poster these reports made the foundation on further research. Two Swedish web-based educational platforms were used; *Energilyftet* and *Energibyggare* (a part of the Swedish Build Up Skills). Research on how to create an appealing education material made by the Build Up Skills project was taken under consideration in the formation of the education material.

### 4.2.2 Field trip

In the middle of July 2019, a field trip was made to a construction site in Gothenburg where skilled workers could discuss their view on the on the material and points that they would have wanted more information on. Topics discussed included our common goal of finding a wall solution that works in most, if not all of Europe, how countries in the warmer climate zones could greatly benefit from e.g. better and more heat insulation and windows with a lower U-value and the standardization of methods and materials to make collaboration between countries easier.

Nots from the field trip can be found in appendix.

# 5 Conclusion

Through seminars, workshops and other training activities more than 100 project promoters in housing companies and cities (target group I) were reached. The training and topics for discussion has been:

1. Saving energy in residential buildings - why and how to do it? Examples from DREEAM project
2. Renovation founding, policy and regulations. Sources of financing energy-saving measures in multi-family buildings - regional loans for thermo-modernization with EU support
3. Preparation of energy modernization of multi-family buildings. A new standard for the energy review of the building.
4. Additional possibilities to reduce heating costs for multi-family buildings after thermo-modernization
5. Effects of active management of energy consumption in multi-family residential buildings
6. Use of renewable energy sources in multi-family buildings – DREEAM demo site as an example of new approach
7. Training needs and technological trends in renovation.

For the SME contractors and skilled workers (target group II) a web-based training programme are developed. The materials are divided in 10 different areas, reported as easy-to -use brochures:

1. Control System
2. Cooling System
3. Heat Insulation
4. Heating System
5. Installations
6. Living Green Walls
7. Moisture
8. Solar Energy
9. Sun Shading
10. Windows

# 6 References


[1] Ambius (n.d.). *The Ultimate Guide to Living Green Walls*. [online] Ambius. Available at: https://www.ambius.com/green-walls/ultimate-guide-to-living-green-walls/#what-are-the-benefits-of-living-green-walls [Accessed 2 Aug. 2019].

[2] Andromeda District (n.d.). *The Benefits of Living Green Walls*. [online] Andromeda District. Available at: https://andromedadistrict.com/green-wall-benefits/ [Accessed 2 Aug. 2019].

[3] Basnet, A. (2012). *Architectural Integration of Photovoltaic and Solar Thermal Collector Systems into buildings*. [online] Trondheim: Norwegian University of Science and Technology. Available at: http://www.ntnu.no/wiki/download/attachments/48431699/Master-Basnet.pdf?version=1&modificationDate=1339765553175 [Accessed 1 Aug. 2019].

[4] Brownell, B. (2018). *Solar Activated Facade*. [online] Transmaterial. Available at: http://transmaterial.net/solar-activated-facade/ [Accessed 1 Aug. 2019].

[5] Capstick, A. (2019). *What are smart thermostats?*. [online] Money Saving Expert. Available at: https://www.moneysavingexpert.com/utilities/smart-thermostats-explained/#need-3 [Accessed 1 Aug. 2019].

[6] Cleffmann, L. (2019). *This is Art*. [image] Available at: https://unsplash.com/photos/FDlBbfyViR0 [Accessed 25 Jul. 2019]

[7] DREEAM (2015). *Grant Agreement Horizon 2020*. DREEAM No 680511 - Annex 1 (Part A and Part B). European Commission.

[8] DREEAM (2017). *D1.3 Assessment of innovative technologies of Climate-KIC*. Demonstration of an integrated Renovation approach for Energy Efficiency At the Multi building scale.

[9] ECOFYS (n.d.). *U-Values For Better Energy Performance Of Buildings. [online] ECOFYS*. Available at: https://www.eurima.org/uploads/F_EURIMA-ECOFYS_VII_report_p1-65.pdf [Accessed 25 Jul. 2019].

[10] Energikontoren Sverige, Sveriges Byggindustrier, SP Sveriges tekniska forskningsinstitut, WSP, Teknologiskt Institut, Passivhuscentrum, NCC and Installatörsföretagen (2017). *Energibyggare | Interaktiv utbildning i energieffektivt byggande*. [online] Energibyggare.se. Available at: http://www.energibyggare.se/ [Accessed 25 Jul. 2019].

[11] Efficient Window Collaborative (n.d.). *Low-E Coatings*. [online] Efficient Windows. Available at: https://www.efficientwindows.org/lowe.php [Accessed 25 Jul. 2019].

[12] Efficient Window Collaborative (n.d.). *Solar Heat Gain Coefficient (SHGC)*. [online] Efficient Windows. Available at: https://www.efficientwindows.org/shgc.php [Accessed 25 Jul. 2019].

[13] EndeF (n.d.). *Panel Solar Híbrido*. [pdf] Zaragoza: ENdeF. Available at: http://ecomesh.es/pdf/CTG-ecomesh.pdf [Accessed 1 Aug. 2019].

[14] Energimyndigheten (n.d.). *Energilyftet*. [online] Energilyftet. Available at: http://energilyftet.learnways.com/ [Accessed 25 Jul. 2019].

[15] Energy Saver (n.d.). *Dynamically Responsive Infrared Window Coatings*. [online] Energy.gov. Available at: https://www.energy.gov/eere/buildings/downloads/dynamically-responsive-infrared-window-coatings [Accessed 25 Jul. 2019].

[16] Energy Saver (n.d.). *Update or Replace Windows*. [online] Energy.gov. Available at: https://www.energy.gov/energysaver/design/windows-doors-and-skylights/update-or-replace-windows [Accessed 25 Jul. 2019].

[17] Energy Saver (n.d.). *Window Types and Technologies*. [online] Energy.gov. Available at: https://www.energy.gov/energysaver/window-types-and-technologies [Accessed 25 Jul. 2019].

[18] ERA-NET Eracobuild (n.d.). *Aerogel Glazing*. [online] One Stop Shop. Available at: http://www.one-stop-shop.org/sites/default/files/FORM_14_aerogel%20glazing.pdf [Accessed 25 Jul. 2019].

[19] Eurammon (n.d.). *Natural refrigerants*. [online] Eurammon. Available at: http://www.eurammon.com/natural-refrigerants [Accessed 1 Aug. 2019].

[20] European Commission (2016). *10 Things You Didn't Know About Heating & Cooling*. [online] European Commission. Available at: https://ec.europa.eu/energy/sites/ener/files/DG_Energy_Infographic_heatingandcolling2016.jpg [Accessed 1 Aug. 2019].

[21] European Commission (n.d.). *Heating and cooling*. [online] European Commission. Available at: https://ec.europa.eu/energy/en/topics/energy-efficiency/heating-and-cooling [Accessed 1 Aug. 2019].

[22] European Heating Industries (n.d.). *Surface heating and cooling*. [online] European Heating Industries. Available at: http://www.ehi.eu/heating-technologies/surface-heating-and-cooling/ [Accessed 1 Aug. 2019].

[23] Florin, R. (2018). [image] Available at: https://unsplash.com/photos/hKU5dmGfSKY [Accessed 1 Aug. 2019].

[24] Fortum (n.d.). *Solar energy - facts and advantages about solar power*. [online] Fortum. Available at: https://www.fortum.com/about-us/our-company/our-energy-production/solar-power-unlimited-source-energy [Accessed 1 Aug. 2019].

[25] Fraunhofer (2014). *Efficient thermal cooling and heating*. [online] Available at: https://www.fraunhofer.de/en/press/research-news/2014/june/efficient-thermal-cooling-and-heating.html [Accessed 1 Aug. 2019].

[26] Go Green (n.d.). *Why Solar Energy is Good?*. [online] Go Green. Available at: https://www.go-green.ae/greenstory_view.php?storyid=1044 [Accessed 1 Aug. 2019].

[27] Greenroofs.com (n.d.). *Musee du Quai Branly Greenwall*. [online] Greenroofs.com. Available at: https://www.greenroofs.com/projects/musee-du-quai-branly-greenwall/ [Accessed 2 Aug. 2019].

[28] Heliatek (n.d.). *Your Organic Solar Film Solution*. [online] Heliatek. Available at: https://www.heliatek.com/ [Accessed 1 Aug. 2019].

[29] Helmenstine, A. (2019). *Hygroscopic vs. Hydroscopic*. [online] ThoughtCo. Available at: https://www.thoughtco.com/definition-of-hygroscopic-605230 [Accessed 1 Aug. 2019].

[30] Hoyne, S. (2013). *Foundation Energy Skills Programme – General Principles Document*. QualiBuild. BUILD Up Skills QualiBuild.

[31] Huysmans, B. (2018). *Umbrellas*. [image] Available at: https://unsplash.com/photos/J7NCMCOTNG0 [Accessed 5 Aug. 2019].

[32] Jakob, U. (2016). *Adsorption Chiller*. [online] ScienceDirect. Available at: https://www.sciencedirect.com/topics/engineering/adsorption-chiller [Accessed 1 Aug. 2019].

[33] Kuhn, T. (2017). *State of the art of advanced solar control devices for buildings*. [online] Freiburg: Elsevier. Available at: https://reader.elsevier.com/reader/sd/pii/S0038092X1630648X?token=4EC894A1A81E21C711358ECD5FC4ACCEED179B4A3DE1D34E27CF53BF9AFEF4CBB4A39C7E7958953C95594728EC695CC7 [Accessed 5 Aug. 2019].

[34] Lab Partnering Service (n.d.). *Home Energy Management System - Stochastic Optimal Scheduling of Residential Appliances with Renewable Energy Sources*. [online] Lab Partnering. Available at: https://www.labpartnering.org/p/lab-technologies/97e32e2a-1586-41e7-b909-38cdd80c3f6d [Accessed 1 Aug. 2019].

[35] LeBlanc, R. (2018). *The Basics and the Promise of Green Walls for Cities*. [online] The Balance Small Business. Available at: https://www.thebalancesmb.com/the-basics-and-the-promise-of-green-walls-for-cities-4177948 [Accessed 2 Aug. 2019].

[36] Lightsource (2014). *Should I use a solar PV or solar thermal system?*. [online] Lightsource BP. Available at: https://www.lightsourcebp.com/uk/2014/09/should-i-use-a-solar-pv-or-solar-thermal-system/ [Accessed 1 Aug. 2019].

[37] Loominade (2017). *An Energy efficiency label highlighting the class B*. [image] Available at: https://upload.wikimedia.org/wikipedia/commons/9/91/Energy_efficiency_label_B.svg [Accessed 25 Jul. 2019].

[38] May, N. and Sanders, C. (n.d.). *Moisture in buildings: an integrated approach to risk assessment and guidance. white paper*. [online] bsi. Available at: https://sdfoundation.org.uk/downloads/BSI-White-Paper-Moisture-In-Buildings.PDF [Accessed 31 Jul. 2019].

[39] McQuerry, R. (n.d.). *Everything you need to know about living walls*. [online] Homes To Love. Available at: https://www.homestolove.co.nz/inspiration/everything-you-need-to-know-about-living-walls [Accessed 2 Aug. 2019].

[40] Meehan, C. (2018). *NREL Developing Improved Tech to Lower Costs for Multi-Junction Solar Cells*. [online] Solar Reviews. Available at: https://www.solarreviews.com/news/Nrel-developing-tech-lower-cost-multi-junction-solar-cells-071918/ [Accessed 1 Aug. 2019].

[41] Michael (2016). [image] Available at: https://unsplash.com/photos/48yI_ZyzuLo [Accessed 25 Jul. 2019].

[42] Militaru, E. (2016). [image] Available at: https://unsplash.com/photos/l29U993HB5A [Accessed 31 Jul. 2019].

[43] Morgan, T. (n.d.). *Air Source Heat Pumps Explained*. [online] Which?. Available at: https://www.which.co.uk/reviews/ground-and-air-source-heat-pumps/article/air-source-heat-pumps-explained [Accessed 1 Aug. 2019].

[44] Murmson, S. (2018). *What Is Solar Altitude?*. [online] Sciencing. Available at: https://sciencing.com/solar-altitude-23364.html [Accessed 5 Aug. 2019].

[45] NASA (2012). *Technology Readiness Level*. [online] NASA. Available at: https://www.nasa.gov/directorates/heo/scan/engineering/technology/txt_accordion1.html [Accessed 25 Jul. 2019].

[46] Nilsson, P. (n.d.). *Comfort Cooling. EFFEKTIV*. [online] Elforsk. Available at: https://www.sp.se/sv/index/research/effektiv/publikationer/Documents/Engelsk_version_konmfortkyla.pdf [Accessed 1 Aug. 2019].

[47] Ossila (n.d.). *Perovskites and Perovskite Solar Cells: An Introduction*. [online] Ossila. Available at: https://www.ossila.com/pages/perovskites-and-perovskite-solar-cells-an-introduction [Accessed 1 Aug. 2019].

[48] Permagard (n.d.). *Treat Dry Rot & Wet Rot - Identification And Treatment*. [online] Permagard. Available at: https://www.permagard.co.uk/advice/treating-dry-rot-wet-rot [Accessed 31 Jul. 2019].

[49] Petit, P. (n.d.). *"Windows as warm as a wall."*. [online] V-Glass - Vacuum-Insulating Glass. Available at: https://www.vg12.com/ [Accessed 25 Jul. 2019].

[50] PH, C. (2018). *Heat insulation*. [image] Available at: https://unsplash.com/photos/qJa6WDmRNwM [Accessed 25 Jul. 2019].

[51] Prowler, D. (2016). *Sun Control and Shading Devices*. [online] Whole Building Design Guide. Available at: https://www.wbdg.org/resources/sun-control-and-shading-devices [Accessed 5 Aug. 2019].

[52] SageGlass (2018). *What is Electrochromic Glass?*. [online] SageGlass. Available at: https://www.sageglass.com/en/article/what-electrochromic-glass [Accessed 25 Jul. 2019].

[53] Shannon, M. (2017). *Donegal Retreat*. [image] Available at: https://unsplash.com/photos/I47lLEgVlso [Accessed 2 Aug. 2019].

[54] Sharma, J. (2015). *Low--Cost Haziness-Free Transparent Insulation*. [online] U.S. Department of Energy. Available at: https://www.energy.gov/sites/prod/files/2016/04/f30/31396_Sharma_040616-1105.pdf [Accessed 25 Jul. 2019].

[55] SHARP (2013). *Sharp Develops Concentrator Solar Cell with World's Highest Conversion Efficiency of 44.4%*. [online] Available at: http://www.sharp-world.com/corporate/news/130614.html [Accessed 1 Aug. 2019].

[56] Sharp, R. (2007). *6 Things You Need to Know About Green Walls*. [online] Building Design + Construction. Available at: https://www.bdcnetwork.com/6-things-you-need-know-about-green-walls [Accessed 2 Aug. 2019].

[57] Sikkema, K. (2017). *selective focus photography of white water gauge*. [image] Available at: https://unsplash.com/search/photos/cold---temperature [Accessed 1 Aug. 2019].

[58] Smarter House (n.d.). *Types of Cooling Systems*. [online] Smarter House. Available at: https://smarterhouse.org/cooling-systems/types-cooling-systems [Accessed 1 Aug. 2019].

[59] Snoeziesterre (2008). *The Vertical Gardens by Patric Blanc*. [image] Available at: https://www.flickr.com/photos/3poezen/2643611492 [Accessed 2 Aug. 2019].

[60] SOLAIR. (n.d.). *Desiccant cooling systems*. [online] Available at: http://solair-project.eu/146.0.html [Accessed 1 Aug. 2019].

[61] SP Technical Research Institute of Sweden (n.d.). *Façade Products. Informing Design. SP Technical Research Institute of Sweden, Transparent Solar Cells.*

[62] Sustainable Design Assessment in the Planning Process (2015). *Sunshading - Building design for a sustainable future*. [pdf] Melbourne: Sustainable Design Assessment in the Planning Process. Available at: https://www.moreland.vic.gov.au/globalassets/areas/esd/imap-2-1-sunshading-v3c-moreland.pdf [Accessed 5 Aug. 2019].

[63] Technical University of Crete (TUC) (2013). *Assessment of the state of the art of existing technologies to support nZEB renovations*. [online] REHVA. Available at: http://www.nezeh.eu/assets/media/PDF/Assessment_of_existing_nZEB_technologies30.pdf [Accessed 25 Jul. 2019].

[64] Winter, T. (2012). *Air conditioning: we need to talk about indoor climate change*. [online] The Conversation. Available at: http://theconversation.com/air-conditioning-we-need-to-talk-about-indoor-climate-change-11286 [Accessed 1 Aug. 2019].

[65] Woodford, C. (2019). *Hydroponics*. [online] Explain that Stuff!. Available at: https://www.explainthatstuff.com/hydroponics.html [Accessed 2 Aug. 2019].

# 7 Appendix

## 7.1 Control systems

### Note:

- *Representative placement of sensors*
  - The placement of sensors is crucial for the system to function properly and collect useful data. We have all been to that one room in which you must jump around to get the sensors to notice you and turn on the light.
- *Follow the manufacturers' instructions*
  - Always follow the instructions from the manufacture. Although most control systems function similarly, the installation may be more or less complex.

### Sensor placement


### About DREEAM

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### CONTROL SYSTEMS

### Why do we need control systems?

Efficient control and regulating systems in our house favour energy-efficient solutions and safety. This can reduce energy waste, cost and assist to maintain a comfortable indoor climate. The currently available techniques allow to steer and regulate the effect of our installations as we please - based on our needs or what we are prepared to invest. The control be simple *(e.g.* timers) or sophisticated and based on measurements.

### Saving energy ≠ behavioural changes

When control systems are adapted in the house, energy can be saved without the need to change our behaviours. Examples of need-oriented installations are light fixtures that turn off in empty rooms, thermostats with the ability to shut on or off heating/cooling in a room, and ventilation that is regulated by the air quality. When some fluctuations in temperature is allowed, the thermal mass of the building can be used, and significantly reduce the energy needs.

### Optimal regulation

All the control systems in a house must cooperate to be as energy efficient as possible, and there are already today systems available on the market that can communicate with one another.

### Measurements are knowledge

To obtain optimal regulation of a building, we need to know about the operations of different appliances and installations.

*What should we measure?*

Multiple readers can measure parameters like temperature, airflow, and air quality. To gain optimal energy efficiency it is essential to asses all parameters. It is desirable to have separate readers for the energy use of different appliances.

*Why should we measure?*

Readers are monitored for regulation purposes. They may be used as proof of energy savings, or as a base for future modifications made to the system. Based on the measurements the installations can be adjusted and maintained and the building will become more intelligent.

*How should we measure?*

Readers can be either built into an appliance or detached. It is important to install the sensors in places that are representative of the space.

STATE OF THE ART

### Smart Heating Control TRL 7*

The system uses sensors and Wi-Fi connection to communicate and regulate the heating in different rooms. The smart heating control system can assist in the optimization of energy and reduce energy costs.

A feature in using smart thermostats is the ability to change the heating from anywhere there are an internet connection. Other features may vary but often include multi-room control, draught detection and 'geofencing' to keep track of when you enter or leave your home. There are several types of smart heating controls, but the general function is the same.

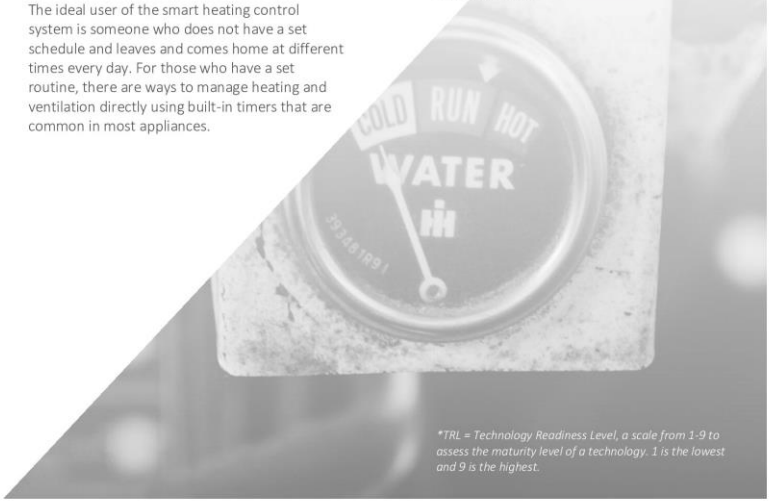
The ideal user of the smart heating control system is someone who does not have a set schedule and leaves and comes home at different times every day. For those who have a set routine, there are ways to manage heating and ventilation directly using built-in timers that are common in most appliances.

### Stochastic Optimal Scheduling TRL 5*

The stochastic optimal scheduling system uses a software-based algorithm to schedule residential appliance usage. This By doing so, we can minimize the weighted sum of occupant discomfort, energy cost and carbon footprint.

The stochastic scheduling system regulates the stochasticity, using simulations, to account for uncertainties. These can range from electricity price to outdoor temperature and water usage.

The technique reduces the consumers' needs to directly manage their installations while also providing them with the benefits of time-of-use rate structures.




**TRL = Technology Readiness Level, a scale from 1-9 to assess the maturity level of a technology. 1 is the lowest and 9 is the highest.*

## 7.2 Cooling systems

### Note:

- *All-water systems are more space efficient*
  - In renovation projects, the space can be limited and making the all-water systems better suited.
- *All-air systems utilize 'free cooling' more efficiently*
  - The utilization of 'free cooling' (cooling from the surroundings) in all-air systems do not require any additional equipment. Whereas all-air systems, in most cases, do.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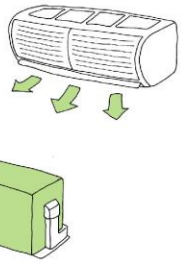
### COOLING SYSTEMS



### Our cooling needs are increasing

With the rising temperatures, cooling our homes are becoming a greater issue than ever before. Not only are our cities experiencing higher temperatures each year but in less than a generation, air-conditioning has allowed life on the edge of the desert to become far more comfortable.

By the year 2020 the number of air coolers and conditioners is thought to have doubled. Let us plan for a sustainable future by using efficient and renewable technologies.

Buildings may be supplied with cooling from a great variety of sources e.g. district cooling, free-cooling or using refrigerating machines.

### Traditional cooling systems

To maintain the indoor temperature below some a predetermined maximum (cooling requirement) surplus must to be removed. To put simply, the cooling requirement is the same as its heat surplus. This is most commonly achieved using one of the following traditional systems:

*All-air cooling systems*

It can be both difficult and expensive to install an all-air cooling system in an existing building as it may require the replacement of the ventilation duct system. For this system, the rate of airflow is determined by the cooling requirements of the building.

*All-water cooling systems*

The all-water system supplies cooling from the water to the individual rooms using the ventilation system. They are prevalent in renovation projects as there is usually space in the ceiling for the installation of the water pipes.

*Combined systems*

All-air and all-water systems can be combined in many ways. One reason for doing so is in cases where the all-air cooling system alone is uncapable of supplying enough cooling. Another being the use of the different systems is parts of a building (e.g. one new and one older).

To generally say that one type of cooling systems should be chosen or not is close to impossible. In most cases, a range of systems could work satisfactory from a technical viewpoint. Thus, the general decisive factor will be the initial cost as well as the cost of running the system.

STATE OF THE ART

### Surface Based Cooling System TRL 7*

The surface-based cooling system operates using ceiling, floor or wall panels with chilled surfaces. The system can fill two functions in one using hot water to heat in the winter.

In renovations, it can be problematic to integrate floor heating/cooling into the floor as it may increase the floor level or pose a problem to the load-bearing structures. Thereby, the use of special surface structures enables this without the need for thorough intervention. They range from wet (e.g. screed or plaster) to dry to thin-film systems.

### Adsorption Cooling TRL 5

Adsorption refrigerators adsorb the cooling water on a solid sorbent like silica gel or zeolite during the disposal of latent heat on the surface. In this specific technique, a metal-organic framework (MOF) has been developed to be well suited to adsorb water vapour, which has previously been lacking. With the MOF, water vapour absorption increase from 0,4 to 1,4, resulting in a refrigerant capacity three times greater compared to standard chillers.

### Green refrigerants TRL 5

The green refrigerants have been around for over a century. But until recently, it has mainly been used within the field of food production and storage. The technological evolution and innovation have led to the implementation of green refrigerants within residential and commercial buildings.

Because of their non-global warming potential, they are said to be a future-oriented technical solution. The natural refrigerants ammonia, $CO_2$ and more are well proven and economically significant.

### Ground Coupled Solid Desiccant Cooling TRL 5

The desiccant cooling systems use water, in direct contact with air, as a refrigerant in an open cycle system. The cooling cycle employs a combination of evaporative cooling and air dehumidification using a desiccant (e.g. a hygroscopic material — a material that can absorb or adsorb water from its surroundings). For this use, liquid or solid materials can be utilized.

This method of cooling utilizes a combination of ground-coupled fluid systems and solid desiccants. In the first stage, the supply air is dried using a solid desiccant wheel, and in the second, it is sensibly cooled by a ground-coupled fluid loop. The use of this technique can result in up to 43% energy savings and increase energy efficiency.

### Liquid Desiccant Cooling TRL 5

The liquid desiccant cooling is a reasonably new technology that uses liquid water-lithium chloride solution as sorption material. Advantages to using this technique include higher air dehumidification at the same driving temperature range as solid desiccant cooling systems and the possibility of high energy storage. The application of this technique is a promising option for the increasing exploitation of solar thermal systems for air cooling.

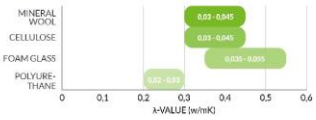
**TRL = Technology Readiness Level, a scale from 1-9 to assess the maturity level of a technology. 1 is the lowest and 9 is the highest.*

## 7.3 Heat insulation

### Note:

- *Keep materials dry and clean*
  - The heat insulation capacity of all materials will decrease if exposed to water
  - Dirty materials increase the risk of mould, even more so if the materials are wet
- *Insulate sufficiently, don't leave gaps*
  - Areas with no or insufficient insulation will give thermal bridges and significantly increase the energy emissions
  - Difficult areas may be filled using loose fill insulation
- *Control the fibre direction*
  - Some materials are dependent on its fibre direction to decrease the heat conductivity
- *Prevent air leakages*
  - Stationary air makes for great

### Insulation capacity of conventional materials (λ-value)

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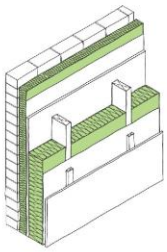
# HEAT INSULATION



### Why do we need insulation?

A well-insulated building is a basic condition for efficient regulation of the climate inside. A good insulation stabilizes the inside temperature all year round as it protects the cold during the winter and excess heat in the summer.

Insulation will also improve building standards by e.g.

- decrease of energy emissions
- decrease of the energy needs of the building
- decrease the risk of mould
- increasing fire safety

### Insulation capacity (λ, W/mK)

Heat is transferred by radiation, conduction and convection. All materials have their characteristics in heat transfer and insulation capacity, measured in terms of lambda (λ). A low λ value implies that the material transfers little energy, hence has a high insulation capability.

### Mineral wool

There are two different types of mineral wool; rock and glass wool. They differ in the base material used in the production. Both types of mineral wool are not very flammable and easier to compress compared to e.g. cellular plastic.

If mineral wool is placed incorrectly, not parallel to each other and perpendicular to the direction of heat emissions that is, the insulation capacity is reduced by up to 10 %.

Area of application: walls, roofs, the framing of joists and installations.

### Cellulose

As cellulose absorbs moisture from its surroundings it can absorb moisture in the construction and decrease the risk of mould and improve fire safety. This feature also makes it important to be observant of dry surroundings.

The cellulose is usually soft and frequently caves in after a while. This make it common practice to fill in gaps and package the insulation using foam.

Area of application: walls, roofs and the framing of joists above ground.

### Foam glass

Foam glass is a non-organic material produced by expanding glass. It is heat resistant, non-sensitive to moist and is easy to process.

The foam glass boards are easy to cut and install but need to be handled carefully as they are sensitive and can't handle too many bumps.

Area of application: walls, roofs and foundation. Works good as part of the construction.

### Polyurethane

The polyurethane is available both as boards and foam. The foam is expansive and is a good filling material.

Polyurethane foam is produced from two components that are mixed together at the nozzle during application. The two components are sensitive to UV-light and should thereby not be stored in direct sunlight. They need to be mixed correctly and precision is needed when applied due to the expansion.

Area of application: used as boards in sandwich elements and in panels, and as foam in the building's construction (walls, roof and ground).

### STATE OF THE ART

### Enhanced foam insulation TRL 7*

Enhanced foam insulation is a graphite enhanced *polystyrene foam* for insulation boards with hydrophobic properties. It can be used in various remodelling applications-

The material works in the very same way as traditional insulation, with one primary difference - the high-purity graphite particles gives the insulation a reflective property. This increase the energy efficiency of the material, and enhanced foam insulation has 20 % better performance than expanded polystyrene and low thermal conductivity.

### Bio-based insulation TRL 5

Bio-based insulation is a *phenolic foam* derived from biomass lignocelluloses from common low -cost bio-based waste products with low acidity.

Bio-based insulation has improved mechanical characteristics through micro reinforcement and offers high insulation and compressive strength that is 20 % better than that of polyurethane. It is an environmentally friendly alternative that can replace conventional materials in many cases without any loss in thermal performance.

**TRL = Technology Readiness Level, a scale from 1-9 to assess the maturity level of a technology. 1 is the lowest and 9 is the highest.*

## 7.4 Heating systems

### Note:

When the heating system in a building is replaced or modified, the building must be considered as a whole. The change may affect other parameters or features of the building.

- *Adjust the heating system*
  - After renovations, the heating system requires inspection and adjustments to fit with the new conditions.
- *Review the building's ventilation*
  - Changes made to the heating system can alter the ventilation, e.g. removal of a chimney may cause moist in the basement and attic.
- *Review the buildings electrical effect*
  - The current in the main fuses may be reduced as the electrical effect used by different heating systems may vary.

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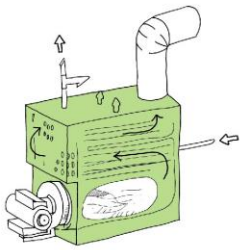
### HEATING SYSTEMS



### Temperature control and energy

Half of the energy consumed by the countries of the European Union is used to heat and cool buildings. In 2016, only 16 % of heating and cooling were produced by renewable energy sources. To fulfil the EU's climate and energy goals, the heating and cooling sector must considerably improve and shift to renewable energy sources (EU, 2016).

The energy consumption can be reduced through renovation processes, where the airtightness of the building fabric is improved, and intelligent thermostats and/or upgrade heating and cooling systems are installed. The change to renewable energy sources and local energy production can significantly decrease the need for fossil fuels.

### Different kinds of heating systems

The heating system is one of several installations in buildings. Below, some of the most common heating systems are listed. Either one can assist in the reduction of carbon footprint. The reduction depends on the type of fuel that is replaced e.g. the saving is larger for electrical heating compared to natural gas.

*District heating*
District heating facilities distribute the heat using subcentres and is most common in larger communities and cities. The source of energy in district heating is often renewable.

*Heat pump*
Heat pumps employ energy in the surroundings e.g. from the ground, air or water. Excess energy from ventilation and water may also be used. An electrical supply is needed to power the pump.

*Electrical heating*
Electric boilers generate heat from an internal immersion heater, electrical radiators, floor heating or batteries in supply air channels.

*Bio boilers and water-jacketed stoves*
The combination of bio boilers or water-jacket stoves with solar thermal energy is eminent in the heating of accumulator tanks and/or boilers. This combination reduces fuel use and maintenance during the summer. In contrast to other stoves, this method allows for storage of energy that could be used as either heat and/or hot water.

*Solar thermal energy*
Solar thermal energy may be combined with a bio boiler or a water-jacketed stove. The bio boiler or water-jacketed stove will produce enough energy to make up for the decreased energy production from the solar panels in the winter.

STATE OF THE ART

### Micro Combined Heat and Power TRL 5-7

Combined heat and power (CHP) systems, also known as cogeneration, recovers the heat generated in the electricity production to be used in the heating of buildings. Micro CHPs in homes have a small fuel cell or heat engine that are commonly fuelled by natural gas. A generator in the device provides electric power, while the excess heat is used for heating, ventilation and air conditioning of the building.

Depending on the used technology, the CHPs can be based on the reciprocating engine (TRL 7), Stirling engine (TRL 6) or fuel cells (TRL 5). The Micro CHPs takes advantage of wasted energy (heat) to provide an energy-efficiency of 95 %.

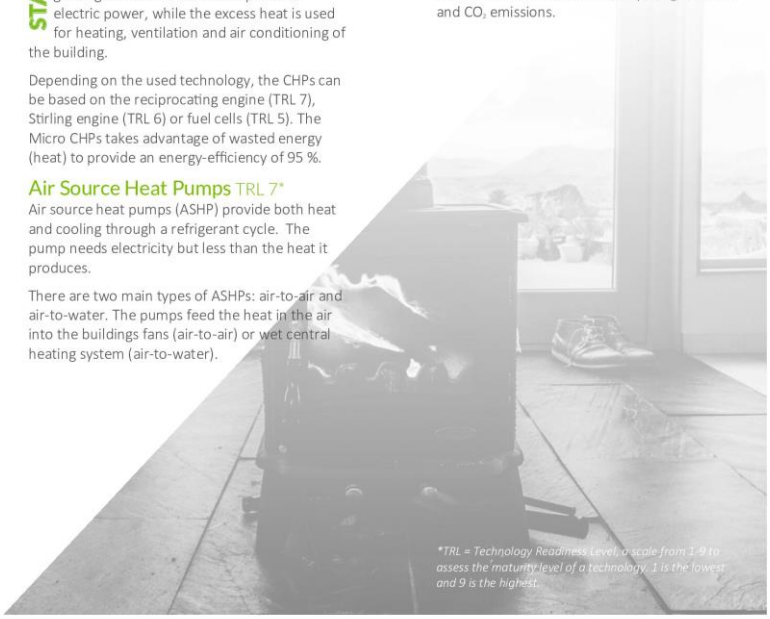
### Air Source Heat Pumps TRL 7*

Air source heat pumps (ASHP) provide both heat and cooling through a refrigerant cycle. The pump needs electricity but less than the heat it produces.

There are two main types of ASHPs: air-to-air and air-to-water. The pumps feed the heat in the air into the buildings fans (air-to-air) or wet central heating system (air-to-water).

### Server-based Heating TRL 6

The excess heat from computer servers can be used to heat buildings. If the servers are placed in residential buildings, otherwise wasted heat can be employed as free heating and the need for cooling of data centres be reduced. This will both cuts the cost of cloud computing services and $CO_2$ emissions.



**TRL = Technology Readiness Level, a scale from 1-9 to assess the maturity level of a technology. 1 is the lowest and 9 is the highest.*

## 7.5 Installations

### Advice:

- *Minimize perforations*
  - Perforations through the airtight layer significantly increase the risk of thermal bridges. Try to perforations with the use of installation layers in the construction.
  - In some cases multiple penetrations are more beneficial by enabling better air tightening, analyse the situation to assess what is ideal.
- *Make it airtight and insulated*
  - The airtightness of the building fabric is a qualification for an energy-efficient building. Any opening must be properly insulated.
- *Review and give feedback*
  - Adjustment of the installations may greatly influence the energy-efficiency and internal climate.
  - Follow the instructions given from the supplier.
- *Use a thermal camera to check for thermal bridges before any renovation work*

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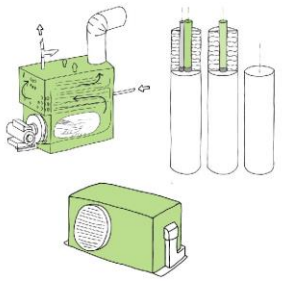
### INSTALLATIONS



### What are installations?

The term *installations* refer to the systems used to produce, transform and distribute electricity, heat and water. Installations are used to distribute the air in the ventilation, but also to take care of sewage and surface water.

To reduce the number of energy losses in a building, the energy-efficient installations needs to be optimized and supply the right amount of energy at the right time. The difference in energy usage between a conventional and energy-efficient building can be more than 10 kWh/m2/year (20 kWh/m2/year and less than 10 kWh/m2/year respectively).

### Indoor climate and energy efficiency

The installations help create a good indoor climate. To reach ideal results, the installations need cooperate with each other, the building and the inhabitants. The right choices and installations from start enables optimal usage.

1. *Energy efficiency* — components that are energy efficient and are correctly dimensioned
2. *Choice* — although pumps, fans and aggregates may have the same capacity their efficiency may vary
3. *Execution* — non-airtight, disproportioned and/or damaged insulation may cause pressure drops and thermal losses. Follow manufacturing instructions for optimal performance
4. *Installation* — choices made during the planning and construction phases of a building is of utter importance. A lack of oversight, in either of these phases, may result in short-circuiting of the ventilation and increased volume levels.

*Eco-design requirements* — a product needs to reach certain energy and resource efficiency conditions to be used within the EU. Leading to major energy and financial savings for the consumer.

**Energy labels* — light fixtures, heat pumps and appliances are some of the products that should be supplied with energy labels displaying their energy consumption.

### The building as a whole

Throughout any building process, it is essential to view the building as a whole and choose solutions that recognize this. A renovation may affect the whole building and result in a need to adjust other elements.

The EU has requirements on the *energy labelling** and efficiency via *eco-design requirements*** . To make the replacements of existing components more efficient and cost-effective it is beneficial to do so in combination with other renovations.

To optimize the energy optimization the components are to be chosen based on individual needs for each building. By use of demand-driven installations the energy needs could be reduced further and decrease the risk of e.g. electromagnetic disturbance.

Notable is the exchange of light fixtures. This may result in decreased heat transmission and lower temperatures, and thus increasing the need for heating from external sources or improved building fabric.

### Insulating installations

Often one might be good to insulate the building fabric, but it is just as important, if not more so, to insulate the installations. The installations are constantly exposed to differences in temperature as opposed to the building fabric.

The insulation of installations is important also from a health perspective. Insulation is used to reduce heat losses from the hot water, but also to prevent the heating of cold water which can cause the growth of legionella.

The difference in energy losses between an insulated and non-insulated installation is illustrated below. The insulation prevents about 90 % of energy losses.

It is particularly important to insulate installations of dissimilar temperatures. In addition, both energy, money and insulation can be saved when pipes of similar temperatures are insulated together.

### Insulation and seal of penetrations

Where a wall or framing of joints needs to be penetrated, the insulation must be uninterrupted. In case of breakages, condensation and/or heat emissions may occur in the structure.

## 7.6 Living Green Walls

### The three types of green walls

The three main types of green walls are as following:

- Panel systems - the plants in this structure is pre-grown into the construction. They are suited for both in- or outdoor use.
- Tray systems - pre-grown plants are installed into trays, that allows for a great variety of plants to be inserted into the wall. They are used mostly indoors.
- Freestanding walls - the location and type of plants in this structure is easily interchangeable, and allows for large variety of appearance and use of the wall.

*Interior green living walls*

The implementation of vertical gardens indoors is often made to create a unique and decorative environment, but it has also several other benefits, that ranges from improvements of our mental and physical health to positive effects on the air quality. In offices, restaurants and receptions, the living walls create a unique element that is shown to help boost creativity and workplace morale.

### Benefits of green living walls

The reintroduction of green structures into urban areas has proved to have considerable positive impacts on the environment, public health and economy. The most significant benefits are:

*Reduction of noise levels*

The plants block high-frequency sounds, while the supporting structure reduces the low-frequency noise. Therefore, green structures are used to reduce noise levels on freeways. The implementation of green structures in urban areas will reduce the noise that has become a part of our everyday life.

*Improvement of air quality*

The plants actively remove carbon dioxide and other toxic pollutants from the air and emits oxygen. Studies have shown that the introduction of green structures improves the air quality in urban areas up to 40 %.

*Reduction of energy consumption*

One effect of the increased urbanization is that cities have become significantly warmer compared to rural areas. The higher temperature demands a higher energy consumption for cooling that adds to emissions and air pollution. The green walls act to reduce these problems as they provide shade and cools the air, and reflects rather than store solar energy. During the winter, the plants insulate and reduce the need for heating.

*Improvement of appearance*

As our cities are grows denser, we become and more deprived of the beauty of nature. The implementation of a green wall adds colour and texture that significantly improve the appearance of a building in a way that will never grow out of style.

### Example: Musée du Quai Branly

One famous example of a green living wall is that of Musée du Quai Branly (MQB), in Paris. The museum features indigenous art, cultures, and civilizations from all around the world, yet its most noticeable feature is the 200 m long by 12 m tall vertical garden.

The Eco wall presents a range of species from the world's main temperature zones — mainly from the northern hemisphere, but also from Chile and South Africa.

### Misconceptions about green walls

*"Green walls damage the facade"*

In the construction of green walls is the wall structure protected from moisture and root penetration. Only when climbing plants rest directly on brick walls they can cause damage.

*"Green walls need extensive maintenance"*

When a green wall is introduced the system initially needs frequent adjustments to irrigation and lighting. After the first six months, the plants are likely to have adapted to the new environment. By then, upkeep may be scaled down to be monthly, bi-monthly or even three months apart.

*"They are only implemented for aesthetics"*

The building fabric is greatly influenced by fluctuating temperatures, which causes the materials to expand and contract and results with cracks and deterioration. By the implementing of green exterior walls, the building is protected against changes in the temperature but also from heavy rain and UV radiation.

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### The impacts of green structures

Plants effects both us and the environment. They improve our mental and physical health, and air quality. Less well known is the effects of plants on the building fabric. The green living walls reduce the heating and cooling loads, and improves the thermal comfort of the building.

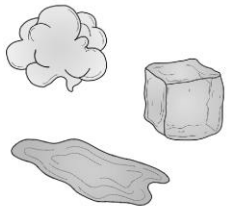
### What is a living green wall?

Based on the recent gain in popularity of green walls, it's easy to think that the concept is new. However, green walls have been around for close to a century. The term *living green walls* refers to panels of plants, vertically grown without the use of soil, on structures that are either attached to walls or free-standing. The wall structure is also referred to as vertical gardens, green walls, living walls or Eco walls.

## 7.7 Moisture

### Advice:

- *Control building material*
  - Make sure that the building material is of good quality, dry and well wrapped when delivered
- *Handle the material carefully*
  - Store it in a place that is waterproof, airy and protected from solar radiation and dirt
  - Use weather protection during construction
- *Control the airtightness of the finished construction*
  - Give time to dry out building moist
  - Do moisture measurements



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### MOISTURE

### Why is moisture bad?

Moisture in a building can lead to severe structural damages and serious health risks. Thereby, it is essential to keep the construction dry during the renovation process, especially when the goal is to improve its energy efficiency.

Water damage is one of the most common mistakes to occur during construction, and as moist is easily spread these damages are one of the most expensive to repair. In energy-efficient buildings, moist takes longer time to dry out and increase the risks of long-term problems.

### Sources of moisture

Moisture damages are caused by water liquid or vapour. Water vapour is slower in the process compared to liquid. The most common sources of moisture in buildings are:

*Weather*
All buildings experience precipitation (e.g. rain and snow). The types, amount and intensity along with temperature varies depending on location.

*Ground moisture*
The amount of moisture in the ground depends on the groundwater level and the properties of the soil. To reduce damage, the groundwater level can be assumed to be high and the terrain should be inclined down, away from the foundation.

*Humidity*
Air always carries some amount of water vapour. The amount is increased as everyday tasks are carried out e.g. taking a shower and preparing a meal, but also through breathing.

*Building moisture*
Moist can occur during the construction of a building. Moist can be contained within the materials, obtained from precipitation, or from processes that involve water (e.g. concrete). This kind of moisture often dries out, but as the drying process is slower in well-insulated buildings this may increase the risk of water damage.

### Moisture transport

Moisture has three main ways of transport, by *moist convection*, *liquid diffusion* and *capillary flow*.

*Convection*
When two volumes with different air pressures are connected, higher air pressure (warmer air), moves towards lower air pressure (colder air). Since the air carries its humidity, the water vapour will condensate if the temperature is lowered to saturation conditions. This can cause decay problems if the condensed water gets trapped inside the construction. Convection occurs quickly and can create damage relatively fast.

A vapour barrier can be installed to prevent condensation in the construction. The barrier must be within the condensation limit of the wall, but not too close to the interior to avoid perforations later in the building process. Any damage to the vapour barrier will defeat the purpose.

*Diffusion*
Diffusion is the transfer of water from an area of high concentration to one of lower concentration. Unlike convection, diffusion is a slow process. Building material dries out by diffusion.

*Capillarity*
Capillary motion is the ability of a liquid to flow in narrow spaces without the external forces. Moisture transport in thus takes place when a sufficiently small porous material gets in contact with liquid water. The smaller the pores, the better the water transport.

### Types of water damage

Water damage appears in different shapes and forms, e.g. mould and dry rot.

Mould growth is not always visible and can take time to discover. These problems can be avoided by keeping the material dry during construction. When fungi growth is evident, significant sanitations often is required, potentially leading to the need for reconstruction of the complete composite construction.

Unlike mould, dry rot gradually breaks down the material and reduce the density. Dry rot exists in the atmosphere as spores and germinate in the right condition, i.e. a place with about 20 % humidity and free access to air.

### The drying of building moist

Water is generally removed from a construction either by heating or dehumidification. Warming in combination with ventilation will enable the moisture to evaporate. This technique is more used in colder climates. Higher temperature makes the process faster but may damage the material.

Dehumidifiers are more prevalent in warmer climates. Moisture is then transferred from the material to the air by diffusion. However, any breaks in the building fabric will significantly reduce the effectiveness of dehumidifiers.

## 7.8 Solar energy

### Advice:

- *Safety first*
  - The PV cells produce electricity using the smallest of light sources. The setup is therefore difficult to make voltage free and should be treated accordingly.
- *Consider the weight*
  - Solar panels may be heavy and add weight to the roof. They can also make it more difficult to remove snow from the roof.
- *Reduce damage to the building fabric*
  - One need to be careful not to damage the building fabric and insulate potential ruptures in the air-tight layer.

### Misconceptions about solar energy

*"It is better to wait to invest in solar energy, the technique is under development"*
It is like with smartphones, you could wait however long you want, but the differences between the models are so small. There is no need to wait.

*"Solar energy is expensive"*
In the last couple of years, the prices have dropped with about 75-80 %. Yes, it may take up to 14 years before payback, but that with a lifetime of 30 years there is still 16 years of profit.

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### SOLAR ENERGY

### An unlimited source of energy

The Sun provides us daily with far more energy than needed to power everything on Earth. Solar power comes at no cost and supplies energy infinitely in contrast to the fossil fuels.

As we gradually implement solar energy on a larger scale, to replace fossil fuels as the foremost source of energy, the cost of electricity, heat and maintenance will be reduced, new jobs will be formed - and we will save the planet.

### Solar thermal and photovoltaic

The two types of solar panels - solar photovoltaic (PV) and solar thermal - both absorb raw energy from the Sun and converts it into useable energy. Either in the form of electricity (PV) or heat (solar thermal).

The PV has an advantage that the form of energy generated is more versatile. Any excess electricity can be sold back to the grid and generate a second income for PV owners.

### Solar energy at northern latitudes

The interest for solar energy grows, but a lack of basic knowledge and uncertainty about solar panels hinder the expansion. One such misconception is the usefulness at northern latitudes.

A south-facing surface in Sweden receives about 1000 kWh per $m^2$ and year, 15-20 % of which can be transformed into electricity using PV modules. This is close to other countries, e.g. parts of Germany, where PV is advancing at a tremendous rate.

Although solar panels in northern Europe are effective, the output doubles south, e.g. from Germany to Spain. This would imply to build solar power plants in sunny countries rather than cloudy ones. But until recently, the movement has been the opposite.

If the price of electricity and heating continues to rise, the utilization of solar power to residential buildings is set to be an even more profitable investment for the future.

### STATE OF THE ART

### Solar Activated Facade TRL 7*

The construction of a Solar Activated Facade (SAF) includes horizontal panels of solid wood with a back-vented glass curtain wall. The exterior glass protects the wood from the elements and preserves the thermal heat in the construction for a delayed release.

The wood absorbs the heat during the day wintertime and prevent heat loss during the night. In summertime when the sun strikes at a steeper angle, the slated panel is self-shading and absorbs less heat.

### Solar Thermal Balcony Railing TRL 7

As balconies are usually oriented toward the south or west, their railings are ideal for multifunctional use. Solar energy can be absorbed and used to heat air or water by implementation of tubular vacuum collectors and replace conventional balcony railings.

### Integrated Solar Thermal Roof TRL 7

The ECOMESH hybrid solar panel is an integrated solar thermal roof that produces both electricity and hot water. The combination of both systems can generate more energy per surface area than both technologies separately, as the cooling effect from the water circuit improves the PV performance by up to 15 % compared to traditional PV panels.

### Organic PV TRL 7

The organic PV (BioPV) are based on biotic electronics and makes use of organic molecules or small modules in the cell to absorb the light. This principle allows the BioPVs to be recyclable and produce a minimal carbon footprint. The panels are ultra-light, ultra-thin and flexible to suit a greater range of buildings.

### Perovskite Solar Cells TRL 6

The Perovskite Solar Cells technique utilizes a perovskite structured compound to harvest energy from the light. Most common is a hybrid organic-inorganic lead or tin halide-based material. Since its discovery in 2012, the Perovskite Solar Cells has exceeded all other thin-film, non-concentrator technologies on the market when it comes to power conversion efficiency.

### Concentrator-Triple Junction PV TRL 6

The concentrator triple-junction PV technology is a lens-based concentrator system where cells focus sunlight on the solar cells to generate electricity. The three layers of the cells are then used to capture a broader range of wavelengths and energy from the sunlight.

Not too long ago, the implementation of this technique came with a massive price tag, but a recent renewal to the technologies made it more economically competitive.

### Transparent Solar Cells TRL 5

There are currently three transparent solar cell technologies on the market: silicon-based, thin-film and the Grätzel cells. Out of which, the silicon-based is the most developed.

**TRL = Technology Readiness Level, a scale from 1-9 to assess the maturity level of a technology. 1 is the lowest and 9 is the highest.*

## 7.9 Sun shading

### Advice:

- *Consider the location and cardinal direction*
  - Use a fixed sun shading on the south façade and removable/flexible devices on the east and west façade
- *The further out in the construction the better*
  - A sun shading device on the inside is not as efficient as one on the outside. To reduce the solar heat gain, shading is effectively installed externally
- *Acknowledge the solar altitude*
  - To optimize the effect of the sun shading, it needs to be regulated based on the height of the sun

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### SUN SHADING

### Benefits of sun shading devices

The implementation of sun shading devices can considerably benefit both residents and owners. Ideal solar shading can reduce solar heat gain by up to 80 to 90 per cent. Thus, reducing cooling energy consumption and significantly improve thermal comfort.

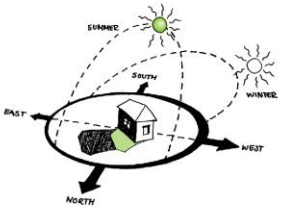
Additional benefits include improved visual comfort and, using solar control systems, reduced needs for artificial light as well as greater use of natural light. Newer, state of the art technologies, has made it possible to integrate solar energy technologies into the sun shading, generating electricity or heat.

### Solar heat gain (g-value)

Solar heat gain coefficient (g-value) is a measurement used to describe how much solar radiation the building fabric lets in. The g-value ranges from zero to one. If g is equal to 0,3, it implies that 30 per cent of the solar radiation enters through the building fabric. Thereby, a lower value is more desirable, especially in the summer.

### Solar altitude

To choose the optimal solar shading device for a building, we need to know the elevation of the sun. The solar altitude is the angle of the sun relative to the horizon. Three parameters decide the angel; time, date and latitude. In Europe, in the northern hemisphere, the sun stands the highest in July and lowest in December. Whereas in the in the Sothern Hemisphere, it is the opposite.

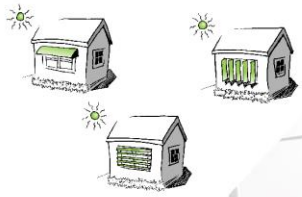



### Different cardinal directions

Depending on the direction a façade is facing, the amount of sunlight experienced throughout the day will differ. Generally, the southern façades are most exposed to sunlight, making a fixed sun shading device suitable. The western and eastern façades experience less sunlight, making a removable device optimal. In most of Europe, northern façades are rarely exposed to the sun and often do not need any sun shading.

### Different ways to shade

There are a variety of ways in which we can shade our buildings. These can be categorized based on their position relative to the window as; external, integrated or internal.



*External sun shading*

External sun shading devices are generally the most efficient shading method used to reduce energy consumption and improve thermal comfort. The external shades are great for the reduction of solar heat gain by preventing solar radiation from entering. Awnings, slats and overhangs are common examples of external sun shading devices.

The climate heavily influences the durability and performance of a solar shading device and should be considered when choosing the type of shade. Alternative include elements like a deciduous tree, in southwest or southeast of a building.

*Integrated sun shading*

The integrated solar shading is part of the window solution. They appear as Venetian or roller blinds between panes of glass, or as in the form of special glazing (see the window pamphlet). For improved efficiency, the window requires an insulating glass pane on the inside.

*Internal sun shading*

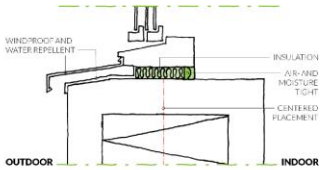
The internal solar shades include Venetian and roller blinds, curtain panels etc. that, unlike the integrated shading is fitted inside the building fabric. Since the solar radiation already has entered through the window, most of it remains on the inside leading to a higher solar heat gain. However, some internal sun shading devices contain sun radiation reflectors, which can reduce heat gain. Thus, the central purpose of internal solar shadings is to increase visual comfort.

## 7.10 Windows

### Advice:

There are several factors during the installation that can affect the insulation ability of the window:

- *Centred placement*
  - Thermal bridges can be reduced if the window is placed depth-wise centred to the insulation in the wall
- *Insulation around the window*
  - The space between the frame and the window must be carefully insulated
- *Air and moisture tightness*
  - The space between the frame and the window must also be air- and moisture tight from the inside, as well as windproof and water repellent from the outside

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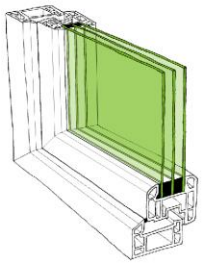
### WINDOWS



### Benefits of window improvements

The savings in renovation projects can be substantial and the energy emissions can be decreased by up to 40 % by the improvements of old windows. Older windows have a high heat transfer coefficient (U-value) that creates heating loads in cold climate and cooling loads in warm climate. Newer windows have a higher insulation ability, leaks less air and reduce the solar heat gain, which all affects the energy use negatively.

Additional benefits associated with window updating are the increase in thermal and acoustic comfort. A downside is the high investment cost.

### Thermal transmittance (U-value, W/m$^2$K)

The heat transmission through a building part, e.g. a wall or a window, can be compared using their U-value. The U-value expresses how much energy a material emits per unit area and temperature difference (°K/C) between the in- and outside. However, what is included in the calculations varies from country to country, some include only the glass while others take the complete window into consideration.

### Solar heat gain

Solar heat gain occurs when solar radiation perpetuates the window. The effects of which can be either positive or negative, depending on the external climate.

### Different kinds of windows

When it comes to windows there are lots of different kinds, they vary in appearance and characteristics e.g. when it comes to thermal transmittance. Three of the most significant features when it comes to energy efficiency are the frame, the filling between the panes (e.g. gas) and its operating type (e.g. fixed, sliding or casement).

### Adaptations

To optimize a window there are several parameters to take under consideration:

- *Location*: The climate and weather condition in which the building is located effects the demands on the window.
- *Facing direction*: A window which is frequently exposed to sunlight (facing south) should not let much solar heat in. In contrast, a window facing north should have a higher U-value to prevent heat emissions.

### STATE OF THE ART

### Low emissivity coatings TRL 9*

The low emissivity (low-e) coating can be applied to any window with insulated glazing. The coating lowers the emissivity *i.e.* a materials ability to radiate, so that less heat can enter through the window.

A normal window emits about 84 % of the long-waved (infrared) light and only reflects 16 %. With a low-e coating, the emittance can be as low as 4 % and reflect up to 96 % of long-waved light. The emittance rating is usually not listed in the product information for windows since the effect is incorporated into the U-value.

### Electrochromic glazing TRL 7

Electrochromic glazing, also known as smart or dynamic glass, shuts the heat out by tinting the glass. The window reduces cooling needs and glare but is still transparent.

The tinting of the electrochromic glazing can be controlled automatically or manually to all or sections of the glass.

### Vacuum insulated windows TRL6

A vacuum insulated window is comparable with a flat and transparent thermos bottle. When two sealed airtight panes of glass are separated with small spacers, it is possible to create a vacuum in between. The vacuum will eliminate the heat loss by conduction and convection make the window surface almost as warm as the wall. To achieve the highest possible result, the technology takes advantage of the low-e technique to prevent heat loss through radiation.

### Aerogel glazing TRL 6

Aerogels are among the lightest solid materials in the world with a density 1000 times less than glass. Most aerogels are based on *silicon dioxide* and consists of up to 99.8% air.

The aerogel glazing has a high insulation ability and diffuses the light without glare. It can be used as a filling between the panes in the window and is suitable in both hot and cold climate zones to prevent heat transmissions.

### Dynamically responsive infrared coatings TRL 5

The dynamically responsive infrared (IR) window coating has two states. In the first state, the window coating is transparent. As the temperature rises, it changes into the second state, which reflects the IR light.

### Hierarchical porous silica insulation TRL 4

This technique involves insulating windows using a layer of a newly produced material called Hierarchical Porous Silica, that has a low U-value. It is also free from haziness and has improved mechanical strengths. Compared to aerogel, hierarchical porous silica is predicted to be both cheaper and more transparent.

**TRL = Technology Readiness Level, a scale from 1-9 to assess the maturity level of a technology. 1 is the lowest and 9 is the highest.*

## 7.11 Poster

# ENERGY EFFICIENT RENOVATION

Guidance and information promoting energy efficient renovations

This project has received funding from the European Union's Horizon 2020 research and innovation programme under the Grant Agreement no 680511. This document does not represent the opinion of the European Union, and the European Union is not responsible for any use that might be made of its content.

## About DREEAM

DREEAM (Demonstration of an integrated Renovation approach for Energy Efficiency At the Multi building scale) aims to show that renovating at a larger scale opens the opportunity for better integration of renewable energy and is generally more cost-effective. The project demonstrates a multi-building and single owner renovation approach that can achieve a 75% reduction of total energy demand.

The DREEAM approach is implemented on pilot sites in the *UK*, *Germany* and *Italy*. These demonstration sites are to validate the DREEAM method in different climate, cultural and institutional configurations.


## Energy goals in European Union

The goals set by the European Union is to, in comparison with 1990:

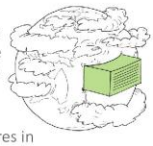
- Reduce the green house emissions with 20 % by 2020 and 40 % by 2030
- Reduce the energy usage with 20 % by 2020 and 27 % by 2030
- Increase the renewable energy sources with 20 % by 2020 and 27 % by 2030

## CONTROL SYSTEMS

Efficient control and regulating systems in our house favour energy-efficient solutions and safety. This can reduce energy waste, cost and assist to maintain a comfortable indoor climate.

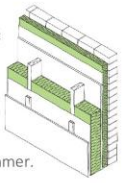
## COOLING SYSTEMS

With the rise in temperatures that we experience today, the cooling of our homes become a greater issue than ever before. Not only do we experience higher temperatures in the each year, but in less than a generation, air-conditioning has allowed life on the edge of the desert to become far more comfortable.



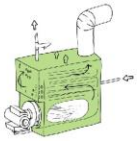
## HEAT INSULATION

A well-insulated building is a basic condition for efficient regulation of the climate inside. A good insulation stabilizes the inside temperature all year round as it protects the cold during the winter and excess heat in the summer.



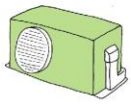
## HEATING SYSTEMS

Half of the energy consumed by the countries of the European Union is used to heat and cool buildings. The energy consumption can be reduced through renovation processes, where the airtightness of the building fabric is improved, and intelligent thermostats and/or upgrade heating and cooling systems are installed.



## INSTALLATIONS

To reduce the number of energy losses in a building, the energy-efficient installations needs to be optimized and supply the right amount of energy at the right time. The difference in energy usage between a conventional and energy-efficient building can be more than 10 kWh/m2/year.



## LIVING GREEN WALLS

Plants effects both us and the environment. They improve our mental and physical health, and air quality. Less well known is the effects of plants on the building fabric. The green living walls reduce the heating and cooling loads, and improves the thermal comfort of the building.

## MOSITURE

Water damage is one of the most common mistakes to occur during construction, and as moist is easily spread these damages are one of the most expensive to repair. In energy-efficient buildings, moist takes longer time to dry out and increase the risks of long-term problems.

## SOLAR ENERGY

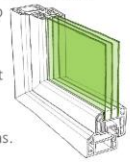
As we gradually implement solar energy on a larger scale, to replace fossil fuels as the foremost source of energy, the cost of electricity, heat and maintenance will be reduced, new jobs will be formed - and we will save the planet.

## SUN SHADING

The implementation of sun shading devices can considerably benefit both residents and owners. Ideal solar shading can reduce solar heat gain by up to 80 to 90 %. Thus, reducing cooling energy consumption and significantly improve thermal comfort.

## WINDOWS

Energy savings in renovation projects can be substantial. Window improvements alone can decrease energy emissions by up to 40 %. Modern windows have a higher insulation ability, leaks less air and reduce the solar heat gain, which allows for a more comfortable indoor climate and significantly less energy emissions.



*To find out more and print your own brochures on the subjects above go to www.dreeam.eu.*

## 7.12 Notes from field trip

### Comments from skilled workers 2019-08-09

#### Take care of different building technique in the different countries.

In Sweden we follow most of the EU-norms, which results in buildings being able to withstand to some extent earthquakes, while in Southern Europe there is very little care for that, we think.

#### Roofs in Sweden vs. in Spain

In Sweden, the optimal thickness of the roof insulation is 430mm, while at southern latitudes it is reduced to a half, provided that the roof is insulated of course. The shingles are often single cupped instead for double cupped like here in Sweden, which causes problems.

#### Waterproofing

In Southern Europe waterproofing is not common. It is not possible to add it on the inside during renovation, so what can be done? An example is about a basement where studs were installed at a distance from the wall with a ventilated floor and ceiling to allow for the moisture to dry. A better waterproofing in the other parts of Europe would have been great to reduce energy losses, moisture problems and so on.

#### Heating

Which parts of the building are to be heated? Since in Sweden we have very tight and energy efficient windows we can install floor heating instead of radiators under the windows, but it cannot be done with inefficient windows.

Our goal: a wall construction that works in the whole of Europe

- It is not possible to build it in wooden because it will be degraded in Spain and so on

- Concrete and bricks work better and can be used everywhere

- Fiber cement is used in Hammarkullen (Göteborg) as additional isolation for houses of the 60s and 70s

- Cembrit: façade material made in a glassfiber-armed board of concrete that can be done in different shapes and is easy to install

- Concrete blocks: sandwich elements

### Reduction of energy use

It would be ideal with three-glass windows in the whole of EU, even though a double pane or 1+1 windows are common today. Electricity is very expensive in South Europe but they do not exploit and harvest the solar energy provided by a generous amount of irradiation.

### Standardisation

In the rest of Europe there are many different building styles and in different sizes due to the fact that people were shorter in the past with the result that many components such as doors and so on have to be custom made.

### Thomas Betong

A good company to contact to get technical advice about drying of buildings. They are in most of the European countries, are experts and interested into helping the client with the projects