IEA SHC Task 56 –

Building Integrated Solar Envelope Systems for HVAC and Lighting

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Task 56 – Scope

TASK 56

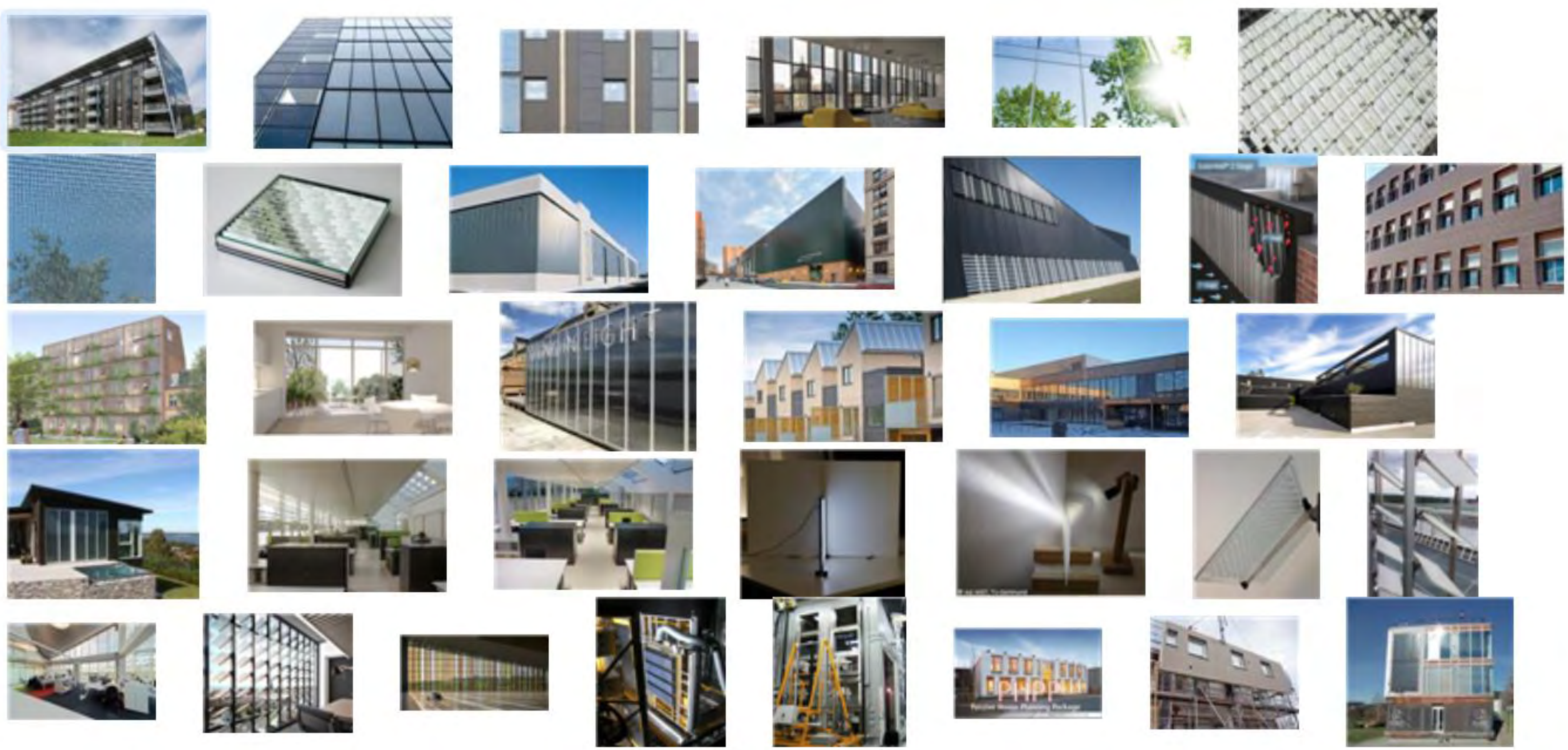
Definition and focus

- A solar integrated envelope system is a **multifunctional** envelope
- that uses and/or controls **solar energy**
- influencing thermal and electric energy demand of the building as well as IAQ and thermal (and visual) comfort

As such the IEA SHC **Task 56** focuses on both
- integrated solar thermal and photovoltaic solution
and on
- daylight control

Solar integrated envelope system

http://task56.iea-shc.org



Task 56 – Scope

Sector analysis

- To gather relevant information on market available and "under-development" solar envelope systems
- To structure information and to develop simulation models to characterise performance of solar envelope elements
- To structure information on test methods for the performance characterisation of solar envelope elements
- To analyse monitoring data from real installations

Task 56 – Scope

Technical development

- To assess and develop value propositions for solar envelope systems

- To develop design and installation guidelines for industrialised solar envelope systems, accounting for technological, architectural, economic, financial and customer acceptance viewpoints

- To include generated information into a market available pre-design tools

Task 56 – Activities

TASK 56

Solar envelope solutions information and SWOT analysis – market overview (SubT A)

Report on barriers for new solar envelope systems (final draft ready and sent to review committee)

- Technical barriers
- Regulatory barriers
- Architectural and planning barriers
- Economic barriers
- Social barriers

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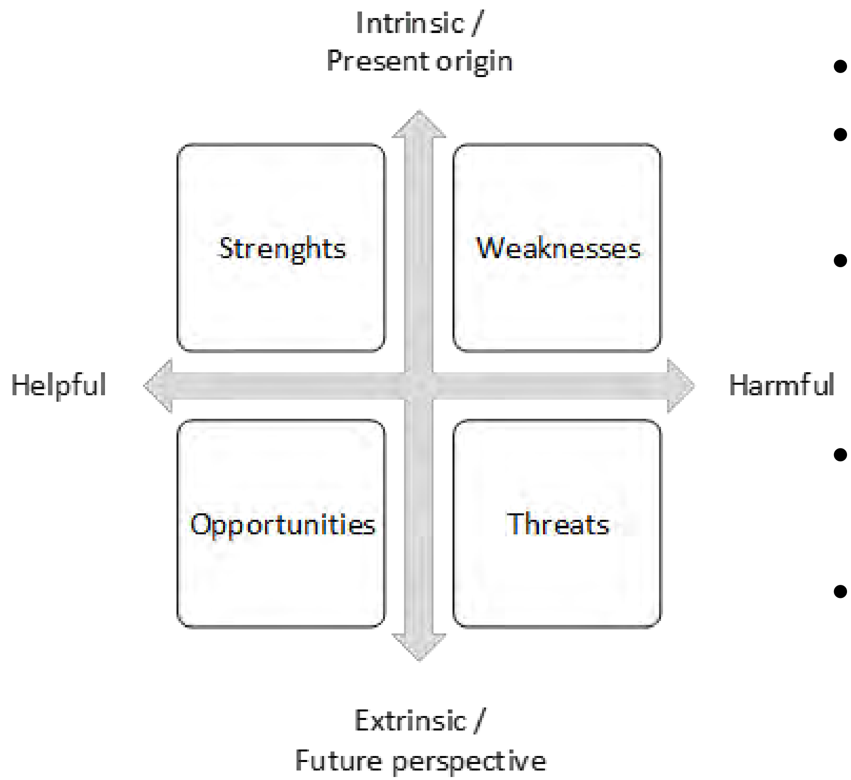
Task 56 – Activities

Solar envelope solutions information and SWOT analysis (SubT A)



- Brief concept description
- Architectural and technological integration into the façade
- Integration into the building: system and comfort

- SWOT analysis

- Lessons learned

Task 56 – Activities

Solar envelope solutions information and SWOT analysis – specific products (SubT A)

Source: Solarwall

Source: Aventa Solar

Task 56 – Activities

Solar envelope solutions information and SWOT analysis – specific products (SubT A)

Source: Cenergia a part of Kuben Management

Source: Merck

Task 56 – Activities

TASK 56

BI Solar Envelope systems forms (SubT A, Aventa)

3 OKALUX OKA*SOLAR* 3D

by David Geisler-Moroder, Bartenbach GmbH, Austria, and Johannes Franz, OKALUX GmbH, Germany

3.1 Product description

3.1.1 Brief concept description

OKA*SOLAR* 3D is a sun protection and daylight management system with a three-dimensional, highly reflective sun protection grid in the cavity between the glass panes. The geometry of the sun protection grid has been optimised for roof applications. The direct solar transmission is blocked at all times, irrespective of the height of the sun. Thus, the heat gain into the interior of the building is reduced considerably. However, a large part of diffuse daylight from the northern hemisphere gets into the interior. This results in even light distribution in the interior and significantly less fluctuation in brightness than with direct sunlight.

The main louvre of the system is made of aluminium with a reflection (solar and visual) of about 95 %. The cross bars are concave in shape, so also at low solar altitude, the sunlight is always reflected to the outside. They are made of plastic with a highly reflective surface with a reflection (solar and visual) of over 80 %. The sun protection grid, which is open to the north, enables partial transparency and allows diffuse irradiation. The thin cross section of the louvres enables a transparency of the grid itself of up to 85 %, depending on the direction of sight, and a diffuse light transmission of 60-70 % in the area of transmission.

In roof applications, OKASOLAR 3D has two different functional areas:

1. Lock-out area (general direction on northern hemisphere: south):
   - thermal sun protection with g-values ≥ 7 %
   - reduced glare
2. Area of transmission (general direction on northern hemisphere: north):
   - diffused irradiation of daylight
   - partial view through

3.1.2 Architectural and technological integration into the façade

The special feature of OKA*SOLAR* 3D is that the sun protection grid is integrated into the cavity of the insulated glazing system, so there are no special requirements with regards to installation, maintenance or repair, and the entire system can be treated just like standard insulated glazing. The thickness and type of glass depend on structural and building requirements. However, for structural reasons the bending radius is to be limited to 12 *m* under deformation. The system can be used in a 2-pane make-up with a space between the panes of 24 mm as well as in a 3-pane make-up where the system is mounted in the outer cavity.

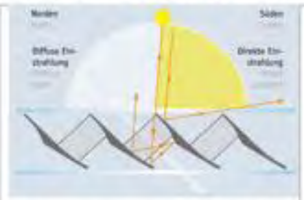


Figure 6: Functional principle of OKASOLAR 3D for installation at northern hemisphere

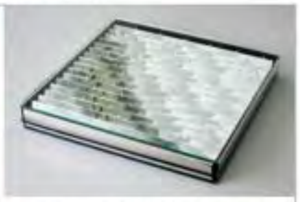


Figure 7: Sample of OKASOLAR 3D in a 3-pane insulating glazing unit, appearance as seen from outside

6 Blinds

by Carolin Hubschneider, Fraunhofer IBP, Stuttgart, Germany

6.1 Product description

6.1.1 Brief concept description

Blinds are solar shadings consisting of multiple horizontal or vertical slats that can be fixed or movable. They are used to control the solar incident radiation and protect against glare. Blinds are build-up of lamellas blocking and/or redirecting the direct sunshine, in function of their slope. The dimensions, colour and gloss of the lamellas determine the properties of blinds.

6.1.2 Architectural and technological integration into the façade

Blinds perform best when they are placed on the exterior of the façade. Due to their limited resistance to wind, blinds are best applied on low height buildings. Exterior blinds placed in front of windows can reduce the solar gains significantly (direct and secondary heat transfer) providing a limitation to the risk of overheating of the building (lower g value of the complex fenestration system: window + blinds). Placed at the interior of the building, they can achieve good daylight control but they do not contribute significantly to the reduction of the heat gains. The majority of redirecting blinds are designed to be installed between two panes of glass or in double skin façades to reduce exposure to dust (interior) or dirt and snow (exterior).

6.1.3 Integration into the building: system and comfort

To enable the functionality of the system, the blinds have to be connected to the power supply of the building. In modern buildings automatic control of blinds is recommended. The automatic control works with sensors (photo sensor, temperature sensor and presence sensor), that are also necessary for other components of the technical building equipment like the electric lighting. Blinds are used in a dynamic way to control daylight, provide a protection against glare and increase visual comfort.

Figure 14: Example of blinds

6.1.4 Further reading

The description of blinds is mainly adopted from "T50 B.6 Daylighting and electric lighting retrofit solutions - A source book of IEA SHC Task 50 (Task 50 Subtask B Report B6)". Websites: http://task50.iea-shc.org/publications, https://depositonce.tu-berlin.de/handle/11303/5494

13 Semi-Transparent Luminescent BIPV Windows

by James Walshe and Philippe Lemarchand, Dublin Institute of Technology, Ireland

13.1 Product description

13.1.1 Brief concept description

The integration of photovoltaics (PV's) into building facades offers the increasing possibility of making the structures in our society play a more active role in our transition towards a sustainable economy. Luminescent building integrated photovoltaic (L-BIPV) windows are solid-state and semi-transparent systems based on luminescent down-shifting (LDS) species that are combined with photovoltaic (PV) solar cells. A system combining a semi-transparent PV cell directly underneath the LDS layer forms a LDS-PV system. In the case of a luminescent solar concentrator (LSC) system, light is captured and re-emitted by the LDS species and concentrated by total internal reflection to small and highly efficient PV cells located within a window edge cell. The use of thin strip silicon within the window edge provides the advantage to lower cost of large semi-transparent photovoltaic cells that would cover the glazing surface and increase the glazing transmission as well as the overall light to power conversion efficiency of the system.

LDS materials absorb diffused and direct light within the ultraviolet region (200 nm – 400 nm) and re-radiate it to a tuned wavelength band within the 500nm-700nm light range where the PV cell can more effectively convert the energy. The capability to tune the optical characteristics of the luminescent species considered to a region of the spectrum (650 nm -700 nm) where the underlying cells responsivity is higher in conjunction with the human eyes responsivity being low would allow the semi-transparent hybrid device to provide some of the indoor lighting requirements and enhance the energy conversion from the photoluminescence. L-BIPV systems potentially can replace or be added to conventional window to produce electricity, therefore reducing the building energy consumption and carbon emission, improve indoor light and thermal comfort and provide colourful architectural designs.

The current PV market consists primarily (~80%) of first generation technology (silicon based) with a small percentage (~10%) occupied by second generation alternatives such as CdTe, CIGS or dye synthesized cells (A. A. Hossam-Eldin 2015; International-Renewable-Energy-Agency 2012). As more design-flexible and building integrating technologies (perovskite and organic based cells) become commercially viable with recent developments, the energy loss mechanisms inherent in each technology become more controllable. This aspect is represented in the differences reported in the enhancement in the power conversion efficiency of LDS devices when fitted to different generations of technology. LDS devices based on first generation, second generation (thin film) and organic PV technologies have resulted in efficiency enhancements of 0.5% - 1%, 1% -3% and 0.5% - 2% respectively (Klampaftis et al. 2009; McKenna and Evans 2017).

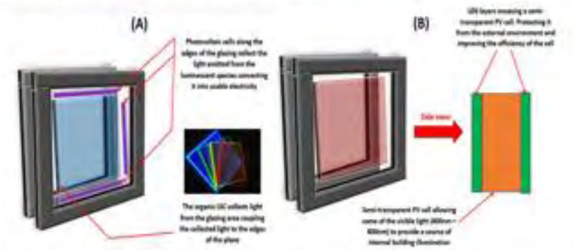


Figure 28: Two different L-BIPV design options (A) building integrated LSC window and (B) building integrated LDS-PV window

more on: http://task56.iea-shc.org

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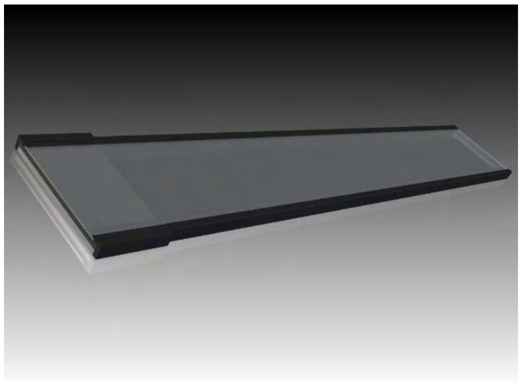
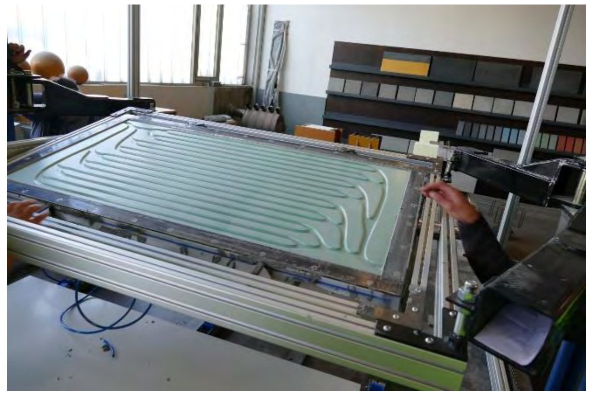
Task 56 – Activities

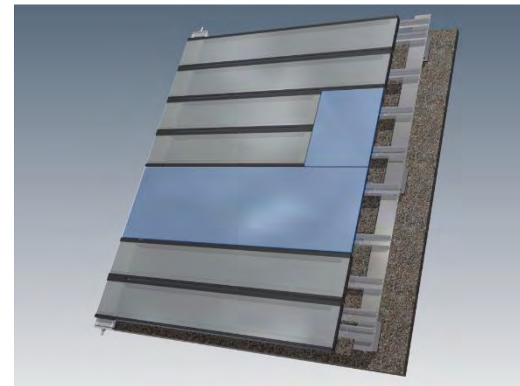
TASK 56

Component Level (Characterisation, Lab and Component Models)
Sub T B (FHG ISE)

Fraunhofer ISE





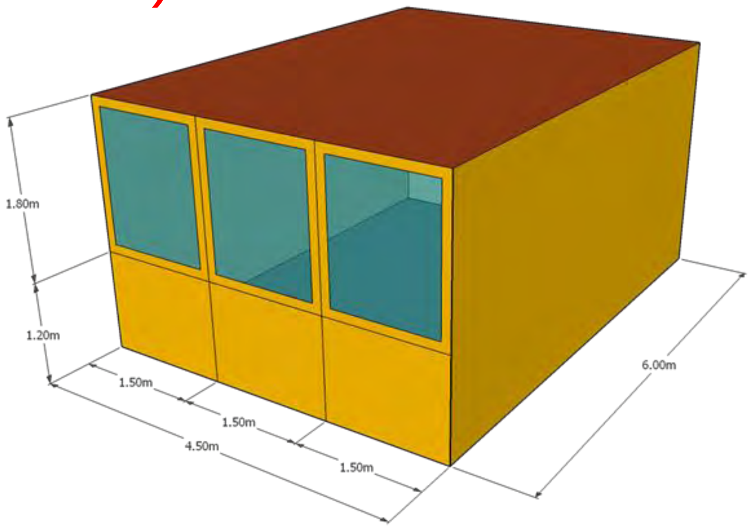


Task 56 – Activities

TASK 56

Evaluation of solar envelope solutions on building level:

Building and system simulation (SubT C)



- General methodology
  - Residential buildings
  - Office buildings
- Monitoring
- Design Tools / Decision support tools

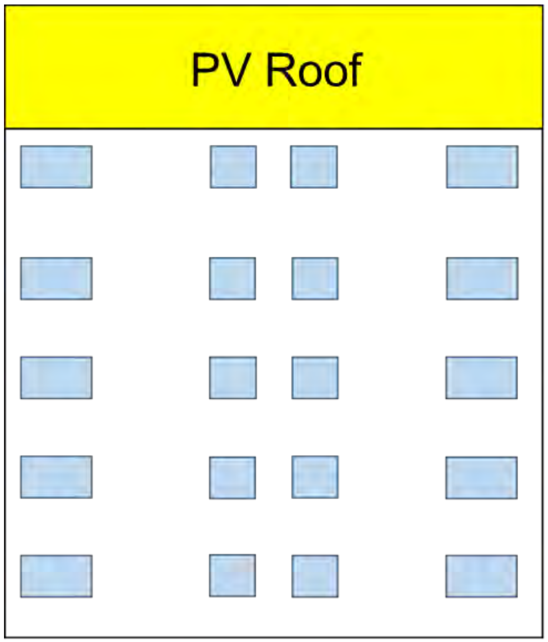
Task 56 – Activities

Evaluation of solar envelope solutions on building level:

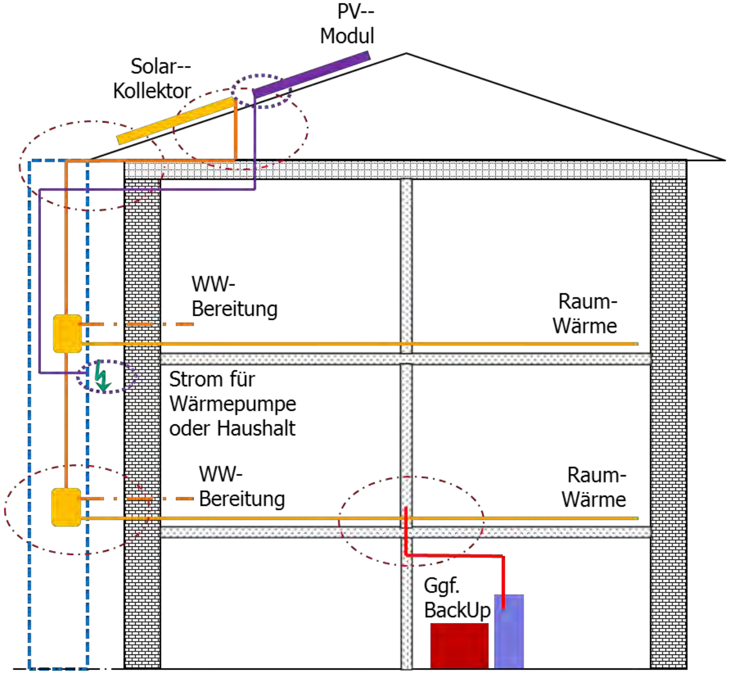
Building and system simulation (SubT C)

Residential Buildings

Project SaLüH! (UIBK)



Project HVACviaFacade (AEE INTEC)



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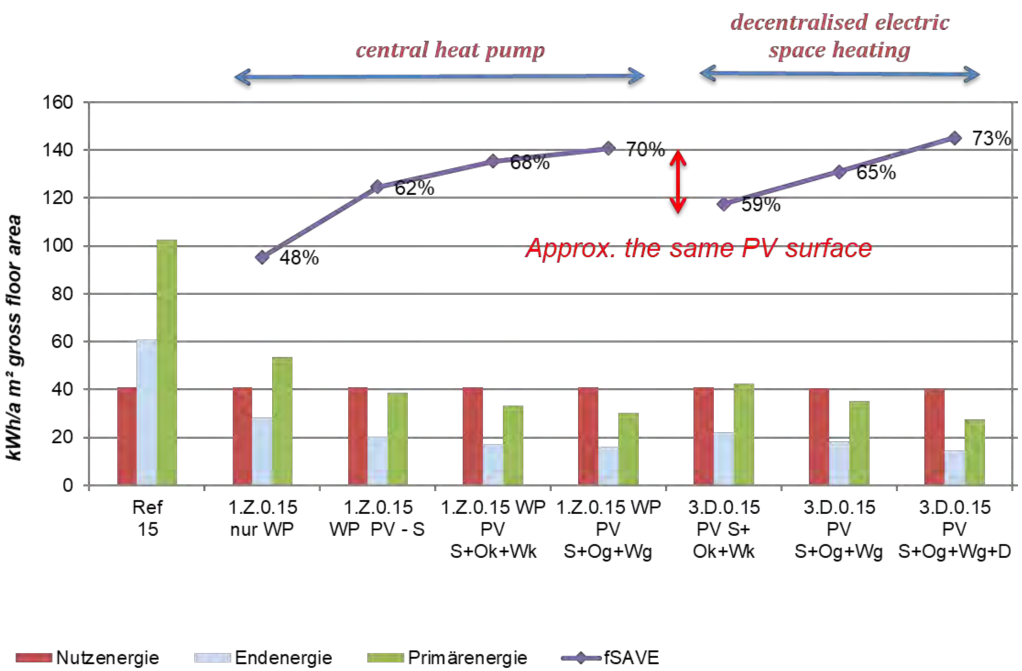
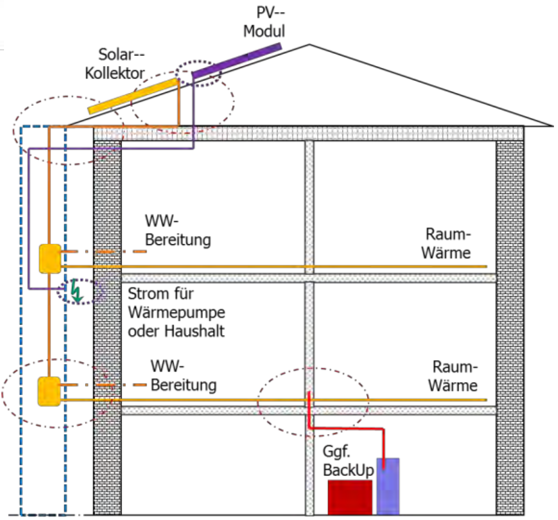
FFG project HVACviaFacade (AEE INTEC)



Useful energy *final energy* *primary energy* *PE savings*

f_{save}: Primary energy savings compared to reference retrofit

Source: Kulmer Holzbau GmbH



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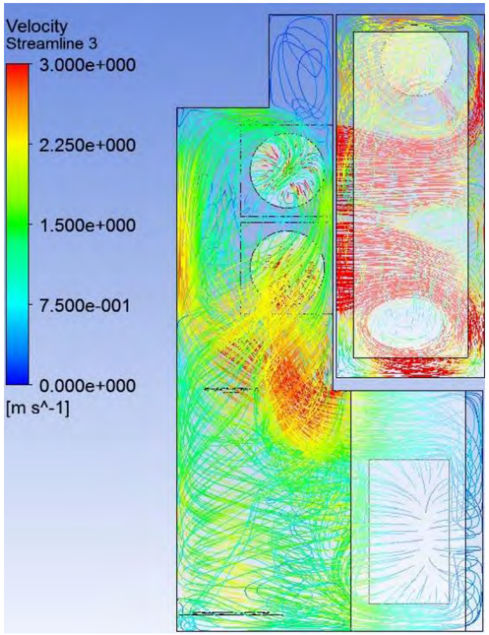
FFG project SaLüH! (UIBK)

Facade Integrated Heat pump Outdoor Unit



Functional model of outdoor unit with evaporator and CFD simulation

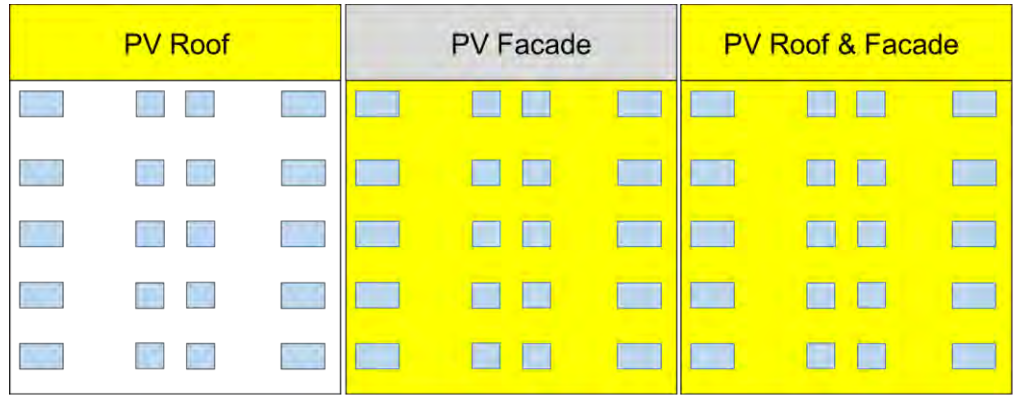
Outside view of the outdoor unit integrated into the prefabricated timber frame facade in the Passys test cell at UIBK

Task 56 – Activities

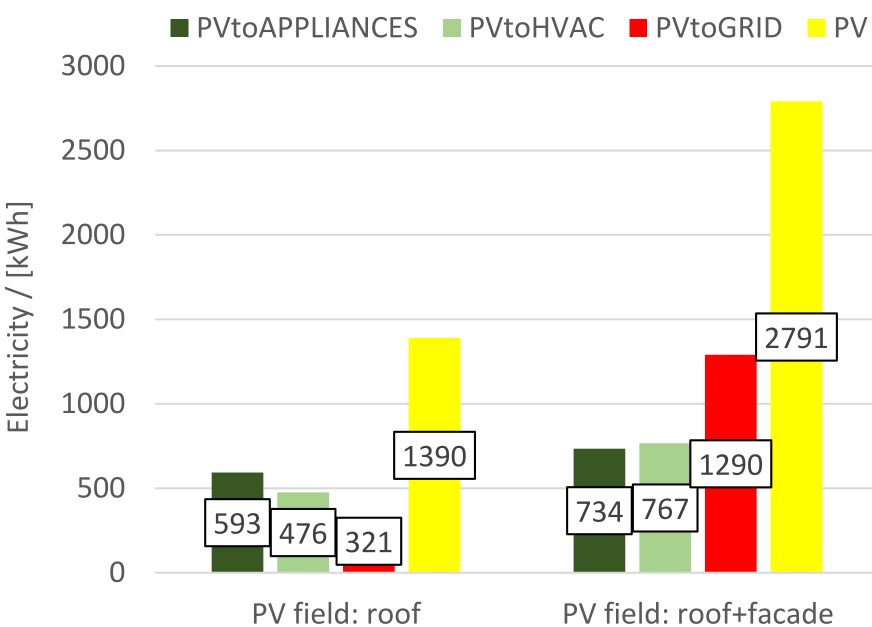
Sanierungsansätze für Lüftung, Heizung und Warmwasser

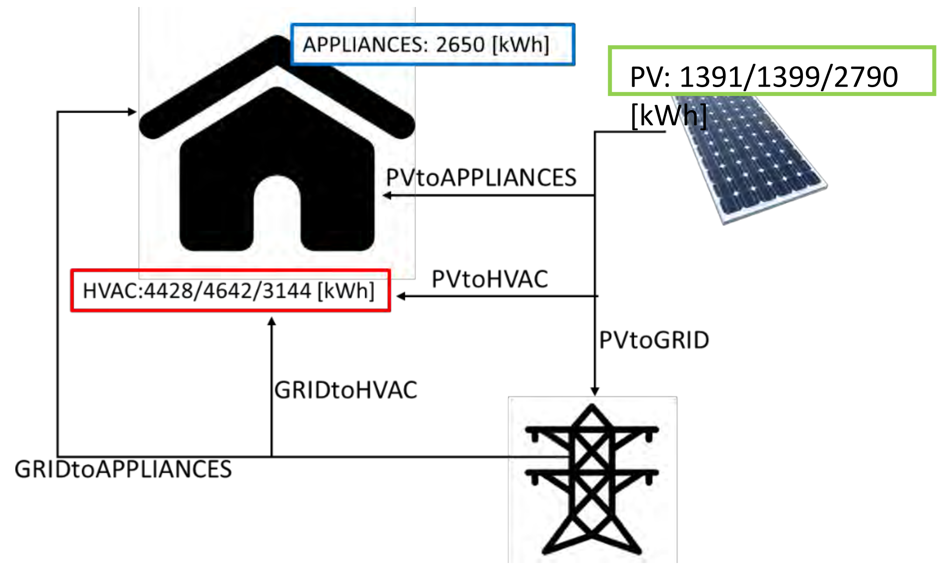
FFG project SaLüH! (UIBK)

PV own-consumption



Use of PV electricity – **no** storage

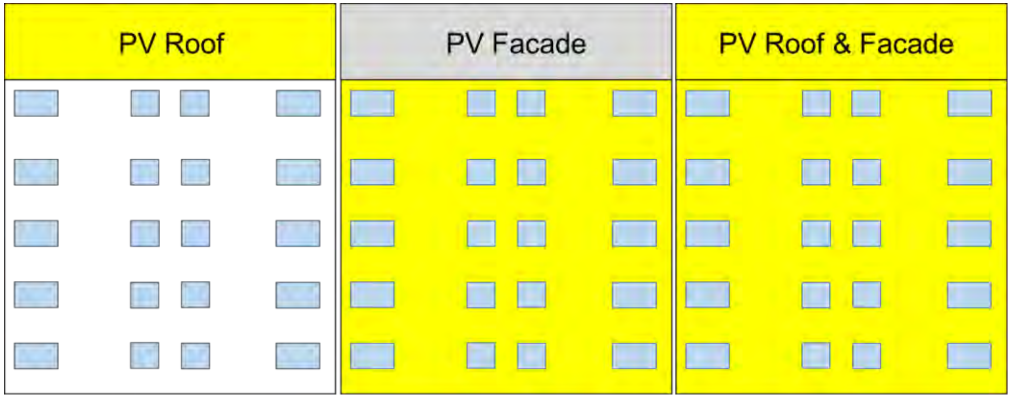




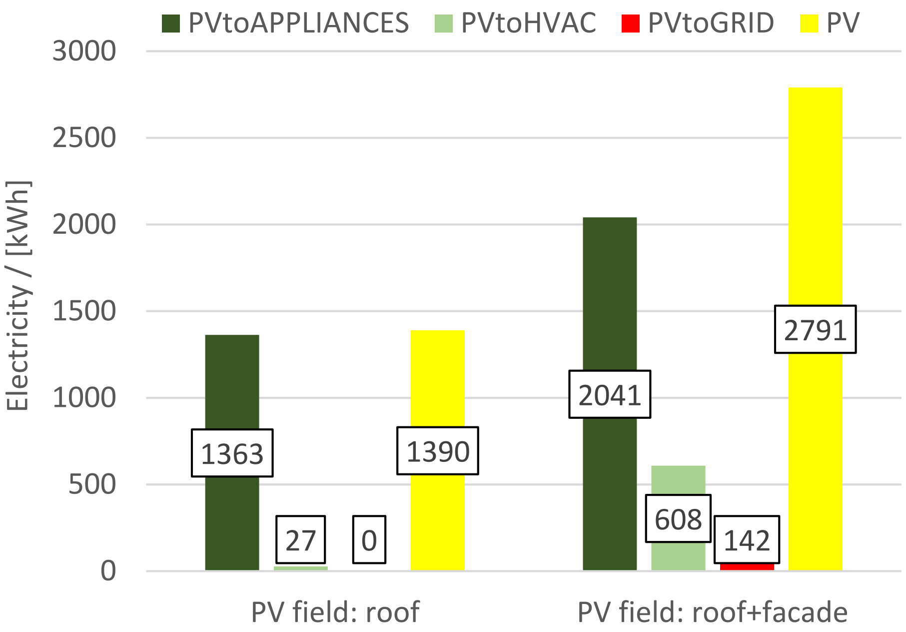
Task 56 – Activities

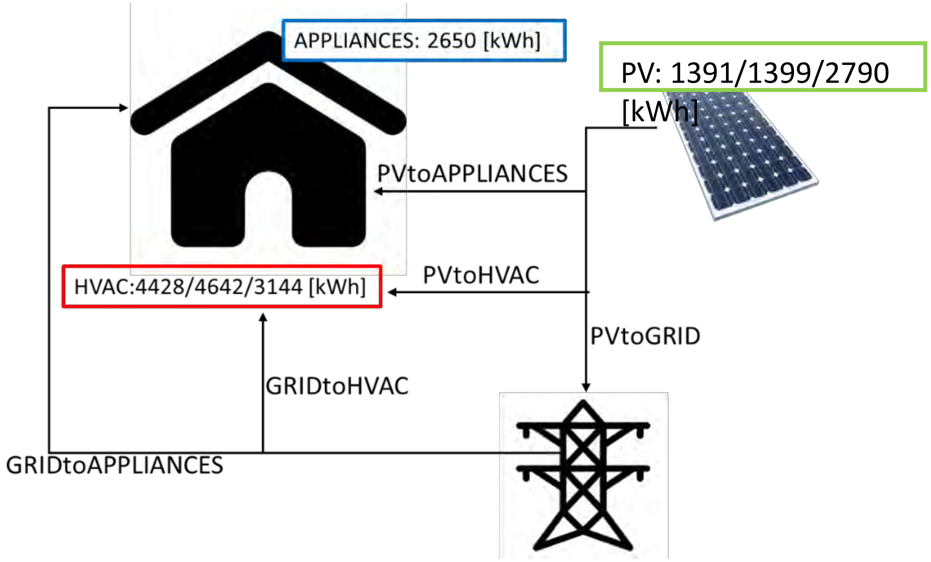
FFG project SaLüH! (UIBK)

PV own-consumption



Use of PV electricity – **Daily** storage





Task 56 – Activities

TASK 56

Evaluation of solar envelope solutions: Building and system simulation (SubT C)

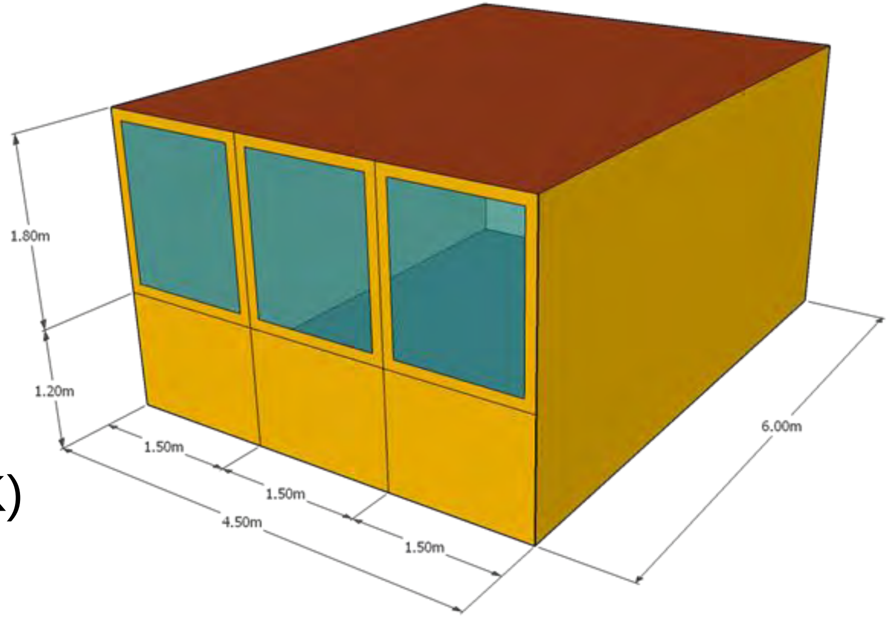
Reference office building

Simulation Tools/Paltforms

- TRNSYS
- Matlab/Simulink
- Modellica/Dymola
- E+
- IDA ICE

Planning Tools

- Dalec (Bartenbach, Zumtobel, UIBK)
- PHPP (PHI, UIBK)



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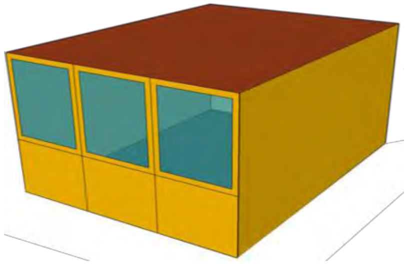
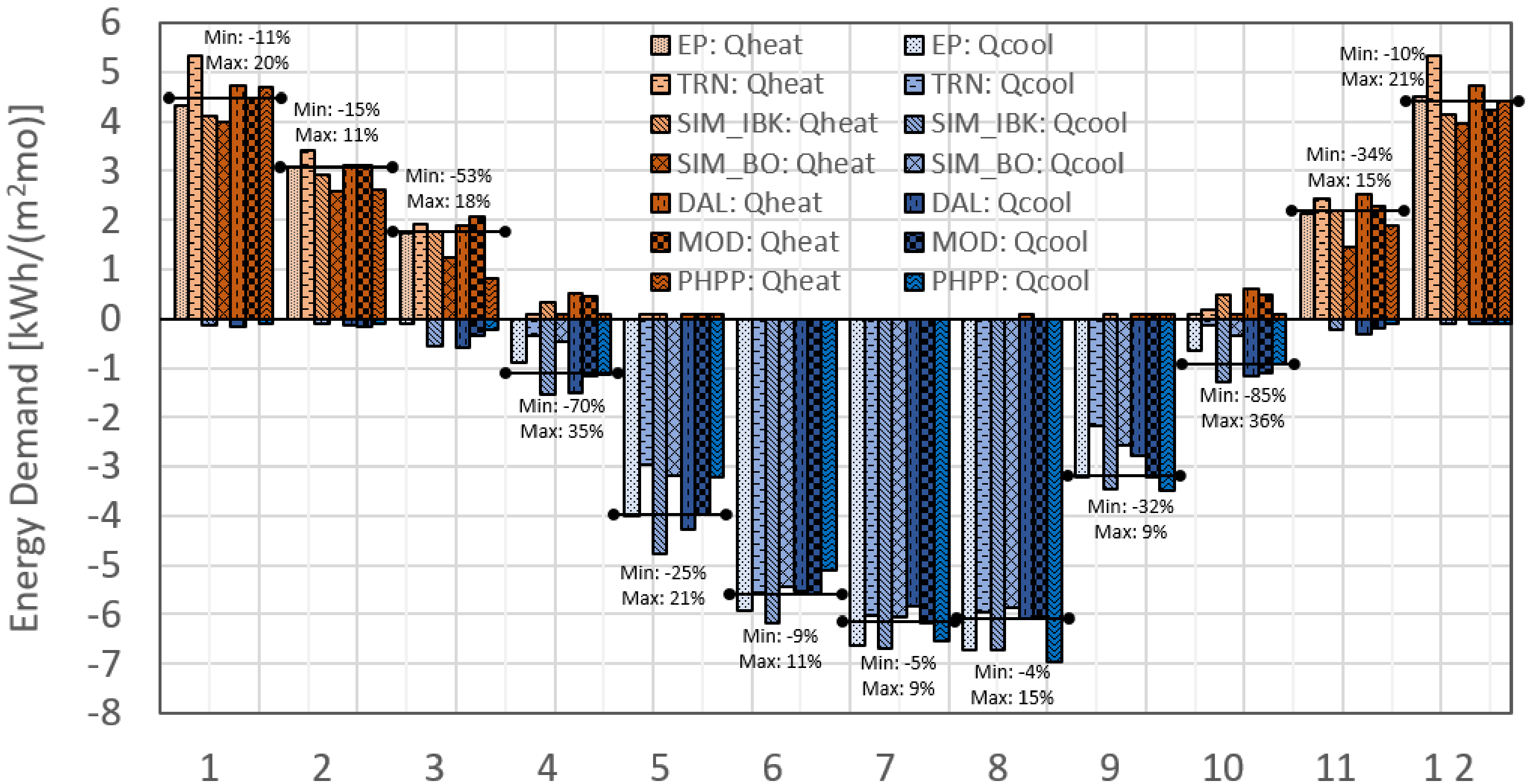
Task 56 – Activities

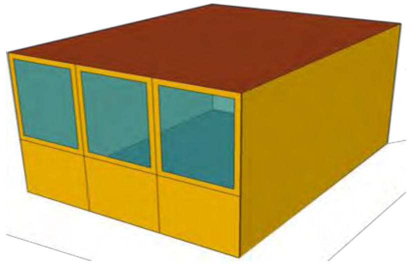


Mara Magni et al. **Comparison Of Simulation Results For A Reference Office Building – Analysis Of Deviations For Different BES Tools**, BS 2019, IBPSA Confeence 2019, Rome

STUTTGART: Monthly Heating and Cooling demands

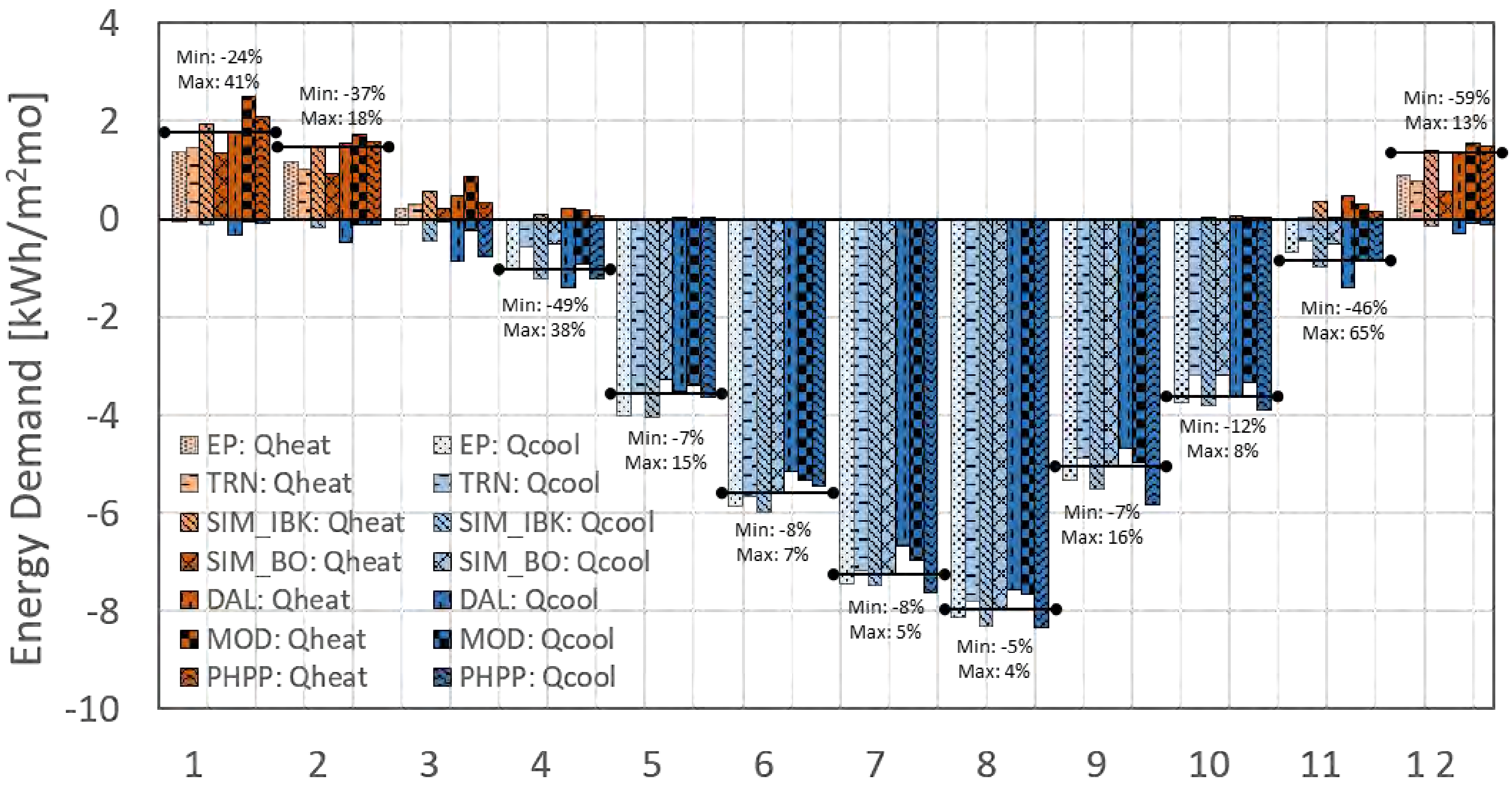


Task 56 – Activities



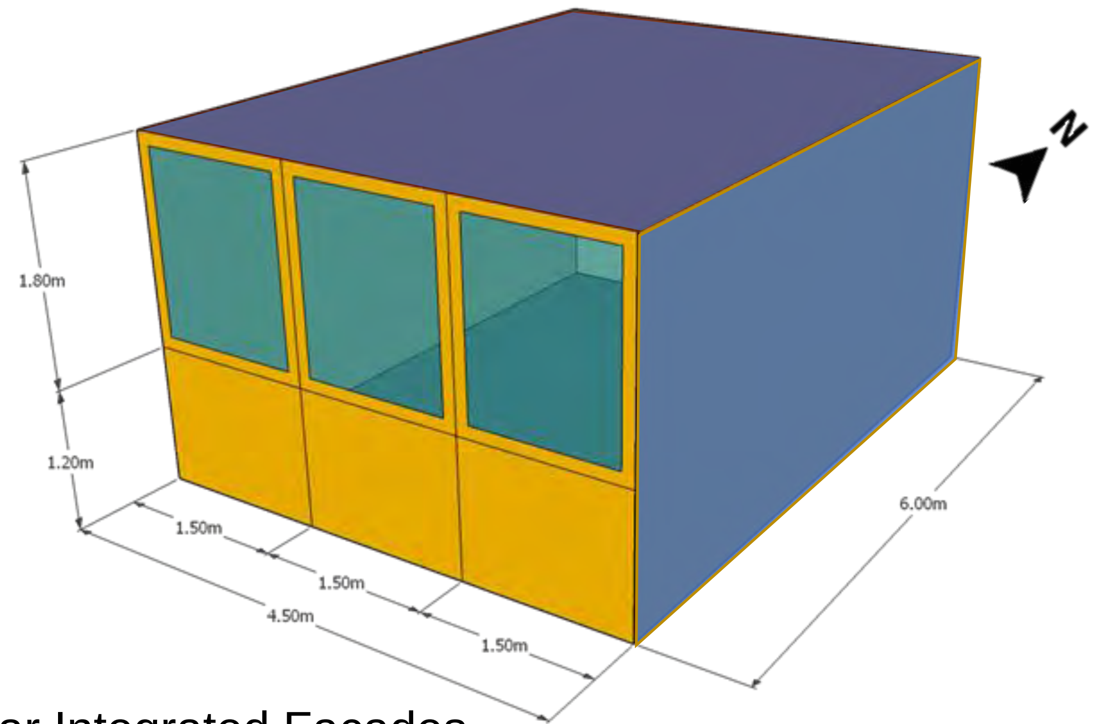
Mara Magni et al. **Comparison Of Simulation Results For A Reference Office Building – Analysis Of Deviations For Different BES Tools**, BS 2019, IBPSA Confeence 2019, Rome

Rome: Monthly Heating and Cooling demands



Task 56 – Activities

» EURAC
» UIBK
» TUe
» Bartenbach
» SBI
» NTNU



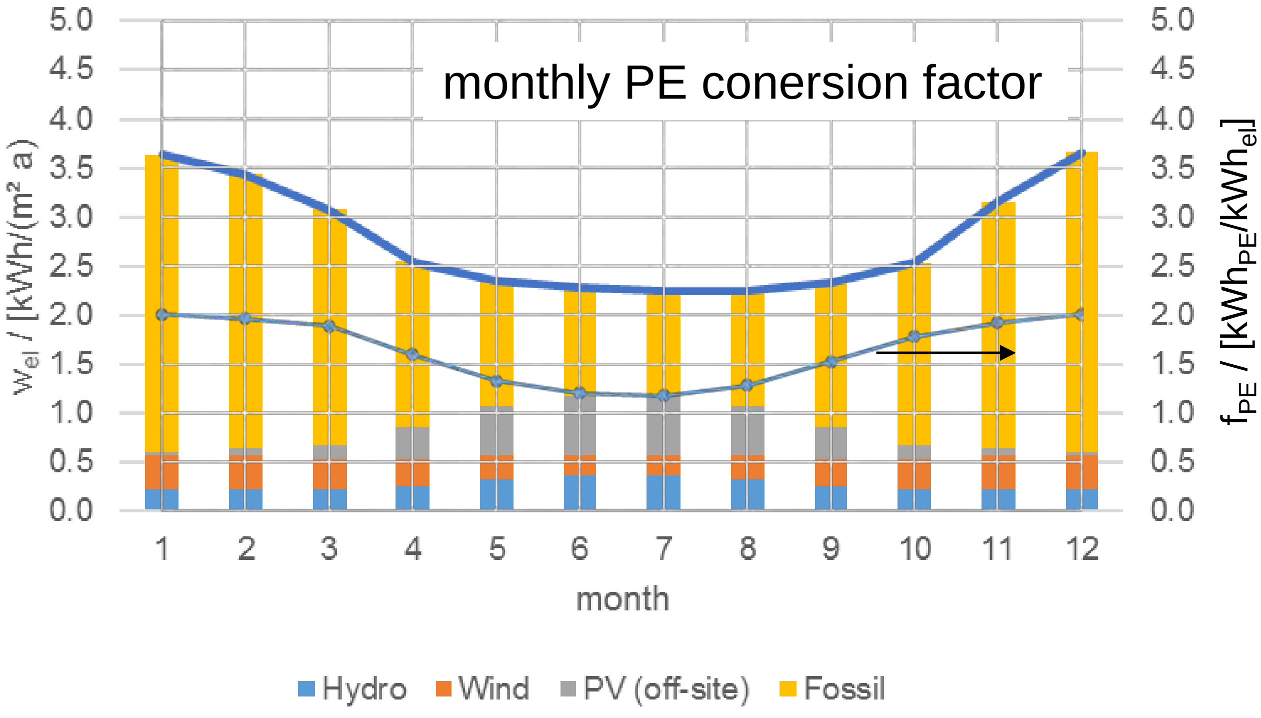
Simulation and Evaluation of Solar Integrated Facades

- BIPV with/without thermal/electric storage
- BIST
- Shading/Dayligthing
- Heat Pump + PV (Heating and Cooling)

Evaluation of Primary Energy Savings

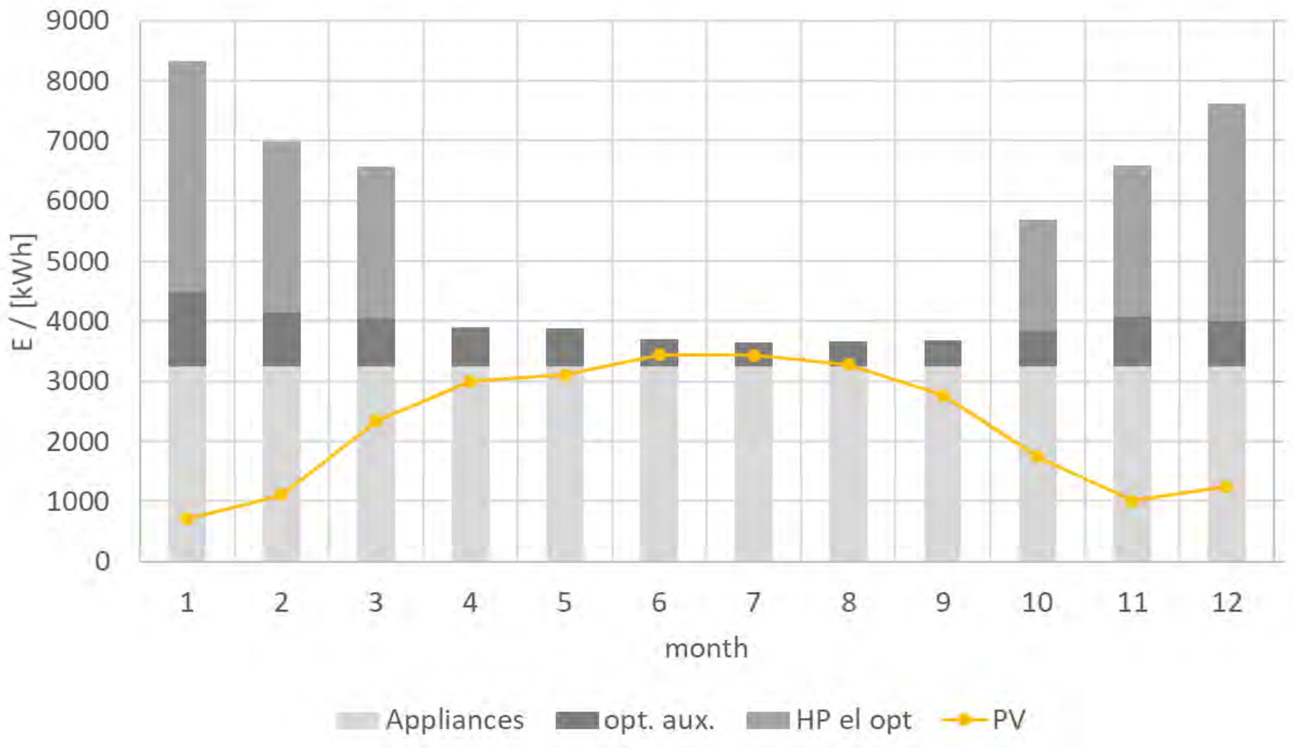
Task 56 – Activities

Monthly primary energy conversion factors (UIBK)



Task 56 – Activities

Heat Pump and PV – Reduction of Primary Energy Demand – monthly balance



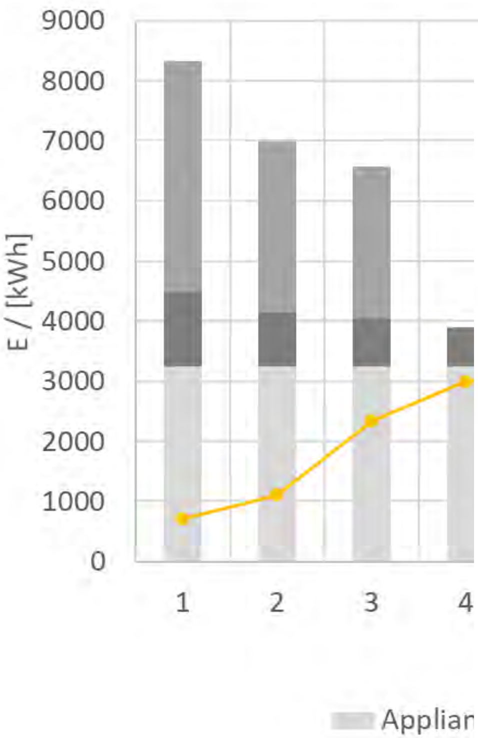
PV on roof

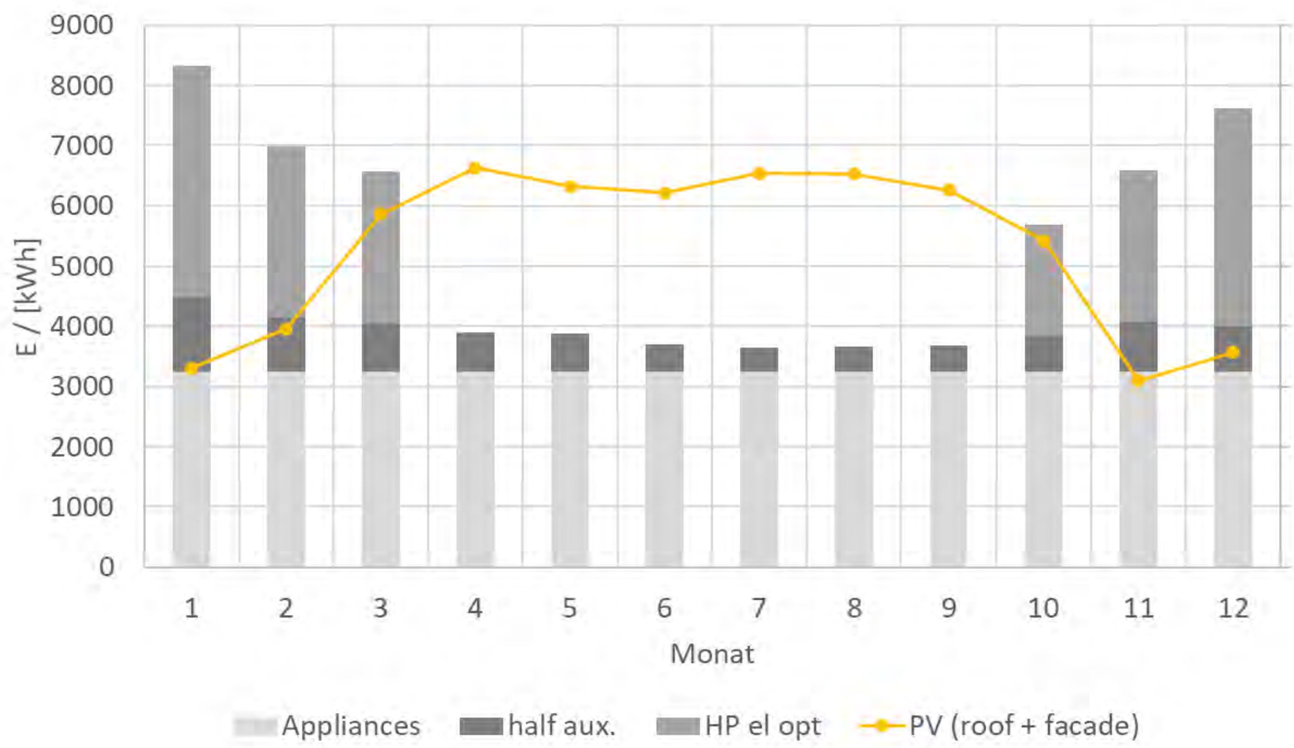
University Innsbruck (Project Innsbruck Vögelebichl)

Task 56 – Activities

Heat Pump and PV – Reduction of Primary Energy Demand – monthly balance

PV on roof and façade





PV on roof

University Innsbruck (Project Innsbruck Vögelebichl)

DALEC Online Tool

Day- and Artificial Light with Energy Calculation

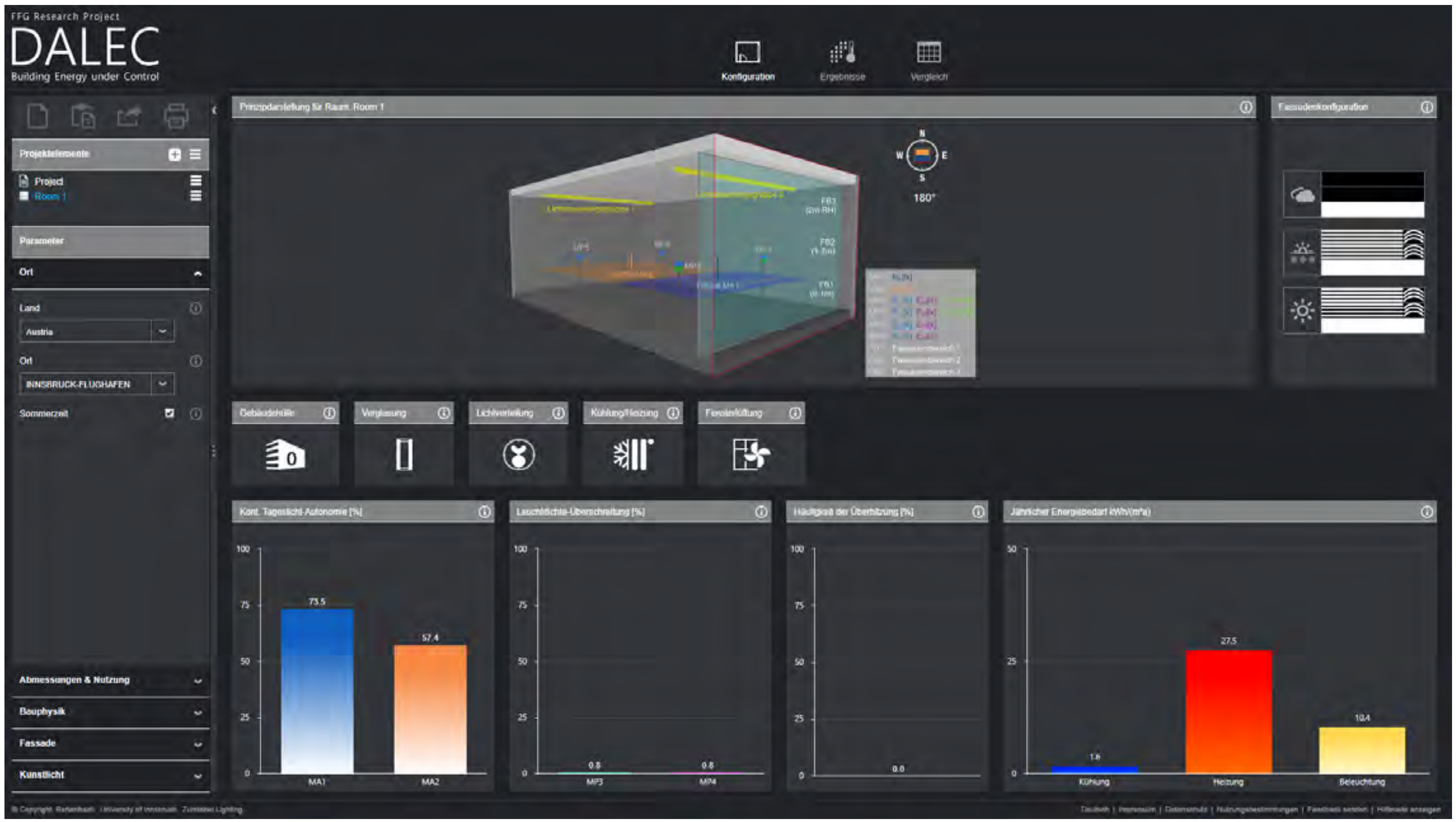
Design and Decision support tools

www.dalec.net

Bartenbach

universität innsbruck

ZUMTOBEL



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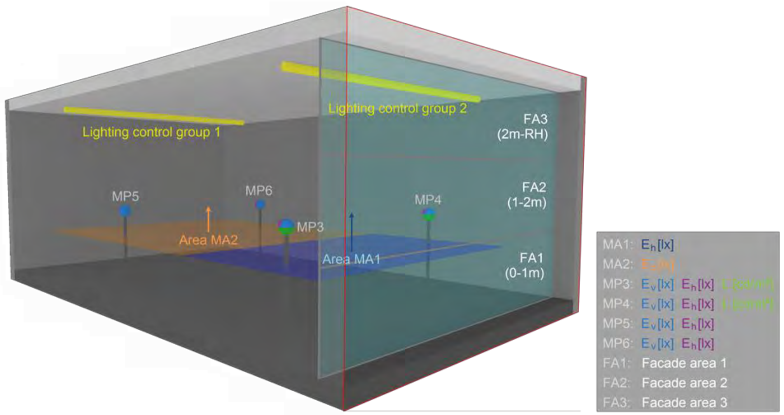
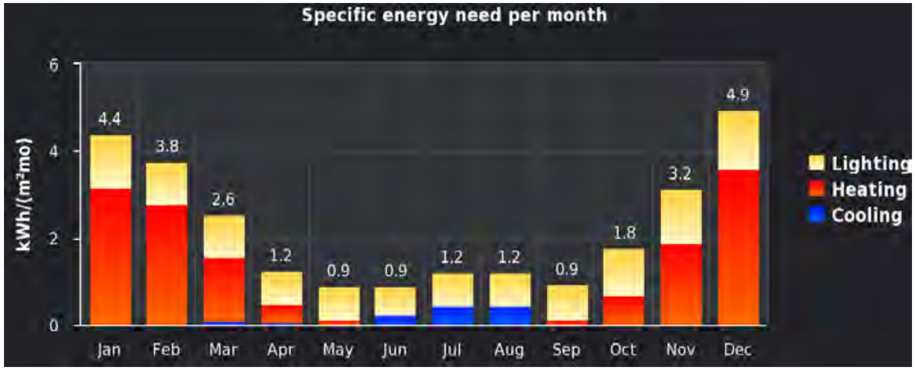
TASK 56

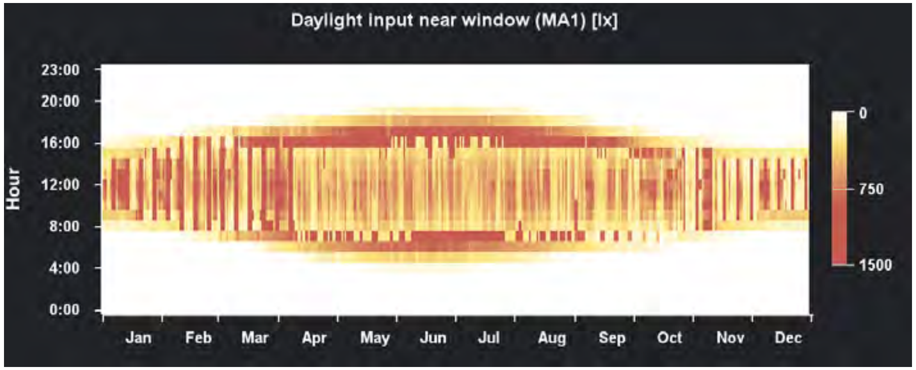
Task 56 – Activities

Design and Decision support tools



- Online tool for realistic evaluation of facade systems and artificial lighting solutions
- Integrated lighting and thermal calculation





Source: Bartenbach – DALEC software

Task 56 – Activities

https://passiv.de/

Design and Decision support tools

PHPP

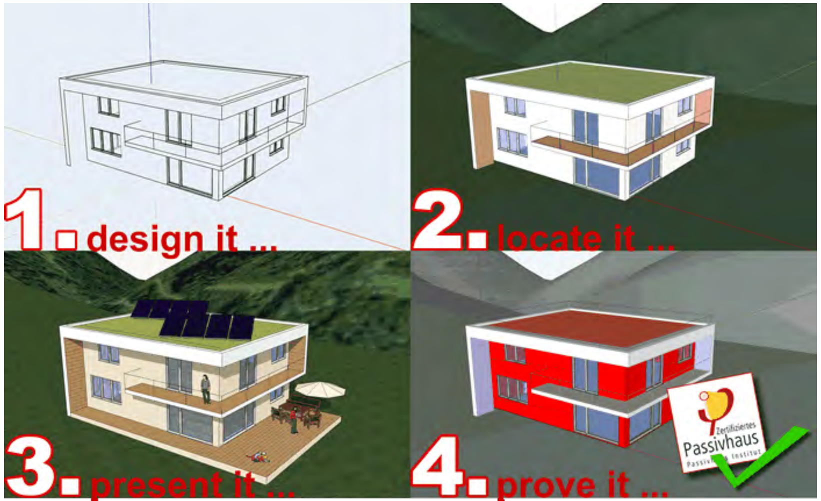
- Monthly Energy Balance (EN 13790)
- PH Design (worldwide)
- Passive Solutions
- HVAC

Ongoing work in the field of …

Prediction of Performance of HPs

PV own consumptions

Primary energy



https://designph.org/

Demo

Copenhagen International School (Cenergia / Kuben Management, Copenhagen, DK)

Demo

TASK 56

An der Lan (IIG, UIBK, Innsbruck, At)

- Passive House
- Innsbruck
- $Area_{tot}$: 1053 m^2
- PV on South facade
- 14 studio apartments
- Common areas
- Electric heating
- Electric DHW

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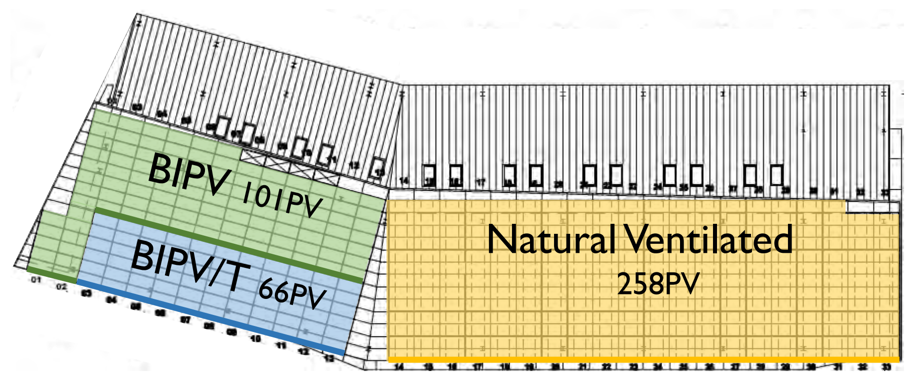
Task 56 – Activities

Demo

Concordia University – Varennes Library (Concordia University, Montreal)

Canada's first institutional solar NZEB

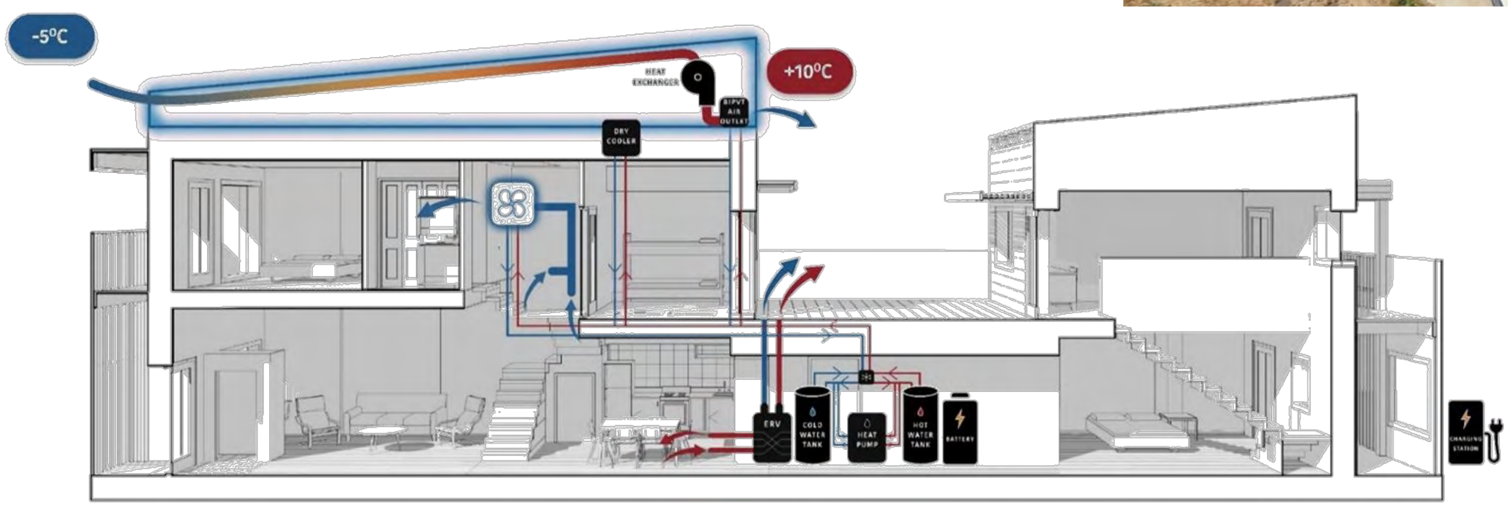


Task 56 – Activities

TASK 56

Demo

Concordia University – Solar Decathlon house



Conclusions

TASK 56

- Solar Active Facades = Multifunctional Facades
  - Office (**daylighting,** PV, etc.)
    Heating
    Cooling
    Electricity
    Daylighting
  - Residential (**HP, MVHR,** PV, ST, storage, etc.)
    Heating
    Cooling
    Electricity
- Market overview, State of the Art: broad range of products but not sufficiently established (market barriers, standards, knowledge, …)
- Component Level: Development, Characterization, Modelling
- Building Level: Evaluation on Building and system level
  - **Simulation**
  - **Monitoring**
- **Design Tools** to foster market penetration

Thanks …

Partner Meeting at Concordia University in Montreal

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