AUTARKIC COOLING VIA BUILDING SKINS - RESULTS FROM COOSKIN-PROJECT

COOSKIN This project is funded by the Austrian ‘Klima- und Energiefonds’ within the programme ,e!MISSION’ 1st Call 2014

Tim Selke

Solar Cooling Workshop
in conjunction with the 9th expert meeting of IEA SHC Task 53

April, 12th 2018, Dresden, Germany
PHOTOVOLTAICS IN AUSTRIA TECHNOLOGIE ROADMAP

Austrian Energy Targets
- 2030 - 100% Electricity from renewables
- 2050 - 100% Energy from renewables in the entire energy system:

Dimension of Implementation
For achieving a 100 percentage energy delivery by using renewable energy sources in 2050 requires an annual solar electricity generation by photovoltaics of approx. 29.9 TWh. This corresponds to 26 MWpeak installed. An annual new installation capacity of 600 MWpeak and starting with 2030 820 MWpeak have to be put into operation annually.

Finding
Using all areas with high solar irradiation potential → Building integrated is one good option
AUTARKIC COOLING VIA BUILDING SKINS

General idea:

• Development, assessment and testing of different façade concepts
• Technical integration of both photovoltaics (PV) and air-conditioning or cooling system into the façade element
• High grades of energy autarky in system operation
• Plug and play character of the façade construction
• High level of pre-fabrication of the technical façade solution

Project Partner

• Institut für Wärmetechnik – Technische Universität Graz
• AIT Austrian Institute of Technology GmbH (AIT-Energy)
• SFL technologies GmbH
• qpunkt GMBH
• Architekturbüro Reinberg ZT GesmbH

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Focus of the development:

- **Office buildings** offers a greater potential for decentralized cooling system solutions compared to residential buildings.

- **Europe** is the primary target market – Increasing demand for cooling and air-conditioning in the building sector and the climate change will lead to additional markets.

- Primarily technical solution for covering the cooling demand in buildings; **all-year operation**; other energy demands like heating and electricity for other appliances are going to be investigated as well.
COOLSKIN – ENERGY MODELLING OF THE REFERENCE ROOMS

Square View of the implemented COOLSKIN system


Installation type:
- Central
- Local in building
- Local in envelope
- Rooftop/balcony

Output:
- Cooling
- Heating
- Ventilation
- Domestic hot water...

System: Coolskin
Company: SFL & Q-Punkt
(Source AIT)

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For achieving the COOLSKIN target the research project is subdivided into three development steps:

- Elaborated system simulations
- Experimental tests with a functional model of the system
- Field tests under real operating conditions.
COOLSKIN
ENERGY MODELLING OF THE REFERENCE ROOMS

Source TU Graz

Approach

- Thermal building model created in the simulation environment (TRNSYS, 2011)
- 10-year average climate taken from Meteonorm software (Meteotest 2009) for Helsinki (cold), Ljubljana (moderate) and Madrid (warm)

Modelled building parameter

- 25 m² net floor space / 75 m³ volume
- Set temperatures: 21°C (heating), 26°C (cooling)
- Fresh air supply per room: 108 m³/h; Air change rate 1.44 [1/h]
- Facade opaque: U-value total 1.004 W/m²K
- Facade transparent
  - U-value glazing 0.59 W/m²K
  - U-Value frame 2.08 W/m²K
- g-value 0.59
- External Shading factor 0.75
COOLSKIN – RESULTS OF ENERGY MODELLING

Investigated location of Ljubljana (moderate European climate)

- South: Heating (132 kWh/a), Cooling (754 kWh/a), PV-yield (1150 kWh/a)
- North: Heating (253 kWh/a), Cooling (575 kWh/a), PV-yield (491 kWh/a)
- East: Heating (199 kWh/a), Cooling (795 kWh/a), PV-yield (948 kWh/a)
- West: Heating (186 kWh/a), Cooling (782 kWh/a), PV-yield (935 kWh/a)

Source TU Graz
COOLSKIN – ENERGY MODELLING OF THE BUILDING

Indication of storage capacity

• Using the previous presented simulation results
• Simple model of a compression chiller, operated only when a cooling load occurs, \(0.85\ kW_{\text{thermal}}\) cooling capacity
• Daily energy balances
• Ljubljana climate/ south-oriented façade integrated PV

\[\text{Energy in kWh} \times 100 \times 200 \times 300\]

\[\text{Days} \times \text{Diff}_\text{el} \times 5.6 \text{ m}^2 \text{ PV} \times 8.4 \text{ m}^2 \text{ PV}\]

Source TU Graz
COOLSKIN – EXPERIMENTAL COMPONENTS AND SYSTEM TESTS

TEST PHOTOVOLTAIC MODULES

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COOLSKIN – EXPERIMENTAL COMPONENTS AND SYSTEM TESTS

TEST BATTERIES

Source AIT

2 Lithium iron phosphate battery (LiFePO4)
Each 12.8 Volt / 90Ah / 1152 Wh

Voltage curve of a LiFePO4 cell in a temperature range from -25 °C to 55 °C.

Battery discharge process with a 500 Watt load of the compressor unit of the two batteries.
COOLSKIN – EXPERIMENTAL COMPONENTS AND SYSTEM TESTS

TEST BATTERIES

2 Lithium iron phosphate battery (LiFePO4)
Each 12.8 Volt / 90Ah / 1152 Wh

Flickering
• Start and stop performance when the load is higher than the photovoltaic yield
Scientific long-term Monitoring under real conditions

- Two test boxes at the campus of TU Graz (nearly same thermal performance)
- One reference box with PV modules (digital print) without air-conditioning
- Assembled PV modules (Black line & Digital print)
- Development and implementation in façade of the rack containing HVAC system
- Planned experimental cases i) Continuous loading while load is connected, ii) Continuous de-charging while load is connected, iii) Voltage all day between 23 V and 28 V and iv) Flickering
Findings

Simulation

- Solar electricity generation by PV modules differs more than the indicated cooling demand as a function of façade orientation

- South, West and East façades are suitable for PV driven decentralized cooling systems

- North facades require energy storages

- The daily profiles for cooling demand and solar electricity production depend very much on the different façade orientation

- Approximately a 2 kWh battery compensates the gap between PV-Yield and electricity consumption
AUTARKIC COOLING VIA BUILDING SKINS

Findings

Component tests

• Not more than 85% of energy harvested by the photovoltaic modules can be used to operate the compressor motor;

• Average battery power output of 640 W; compressor motor consumes 500 W electric power, 140 W can be assigned to conversion losses and standby energy consumptions. i.e. technical solution for heat rejection matters

• Direct coupling of the battery and the load in series does not allow to bypass the battery; PV electricity charges the battery; the bypass is essential

• Start and stop performance when the load is higher than the photovoltaic yield, which leads to a discharge of the battery and hand in hand with that to a negative battery current.
THANK YOU!

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