AUTARKIC COOLING VIA BUILDING SKINS - RESULTS FROM COOLSKIN-PROJECT

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

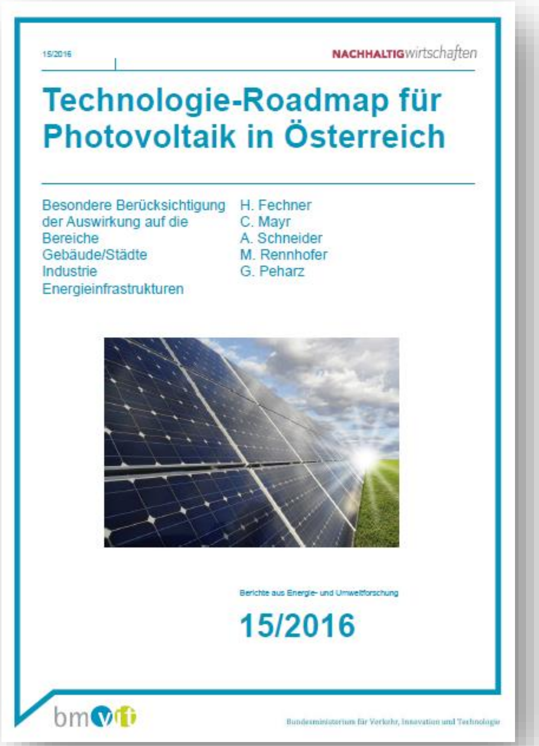
Tim Selke

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


15/2016
NACHHALTIGwirtschaften
Technologie-Roadmap für Photovoltaik in Österreich
Besondere Berücksichtigung der Auswirkung auf die Bereiche Gebäude/Städte Industrie Energieinfrastrukturen
H. Fechner
C. Mayr
A. Schneider
M. Rennhofer
G. Peharz
Berichte aus Energie- und Umweltforschung
15/2016
bmvit
Bundesministerium für Verkehr, Innovation und Technologie

Austrian Energy Targets

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

Dimension of Implementation

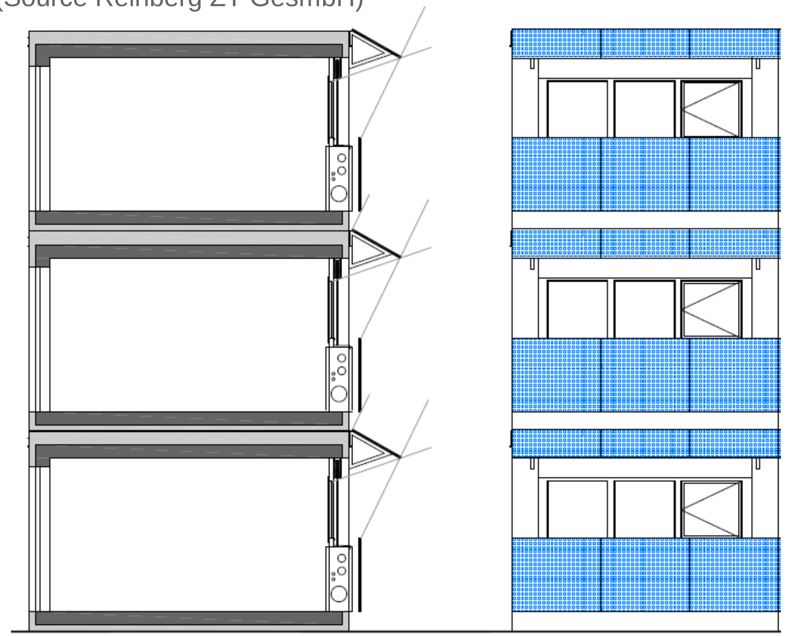
For achieving a 100 percentage energy delivery by using renewable energy sources in 2050 requires an annual solar electricity generation by photovoltaics of approx. 29,9 TWh. This corresponds to 26 MWpeak installed. An annual new installation capacity of 600 MWpeak and starting with 2030 820 MWpeak have 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

(Source Reinberg ZT GesmbH)



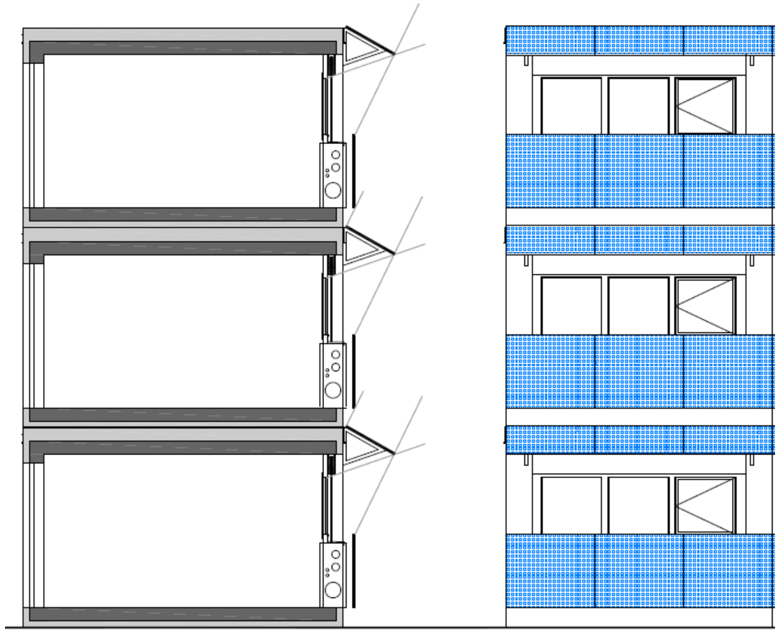
General idea:

- *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

AUTARKIC COOLING VIA BUILDING SKINS



(Source Reinberg ZT GesmbH)

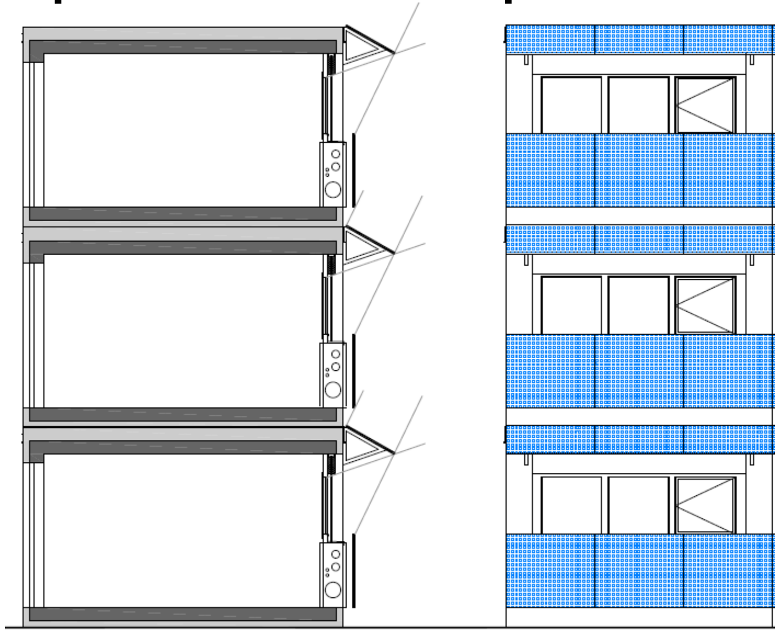
Focus of the development:

- ***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.*

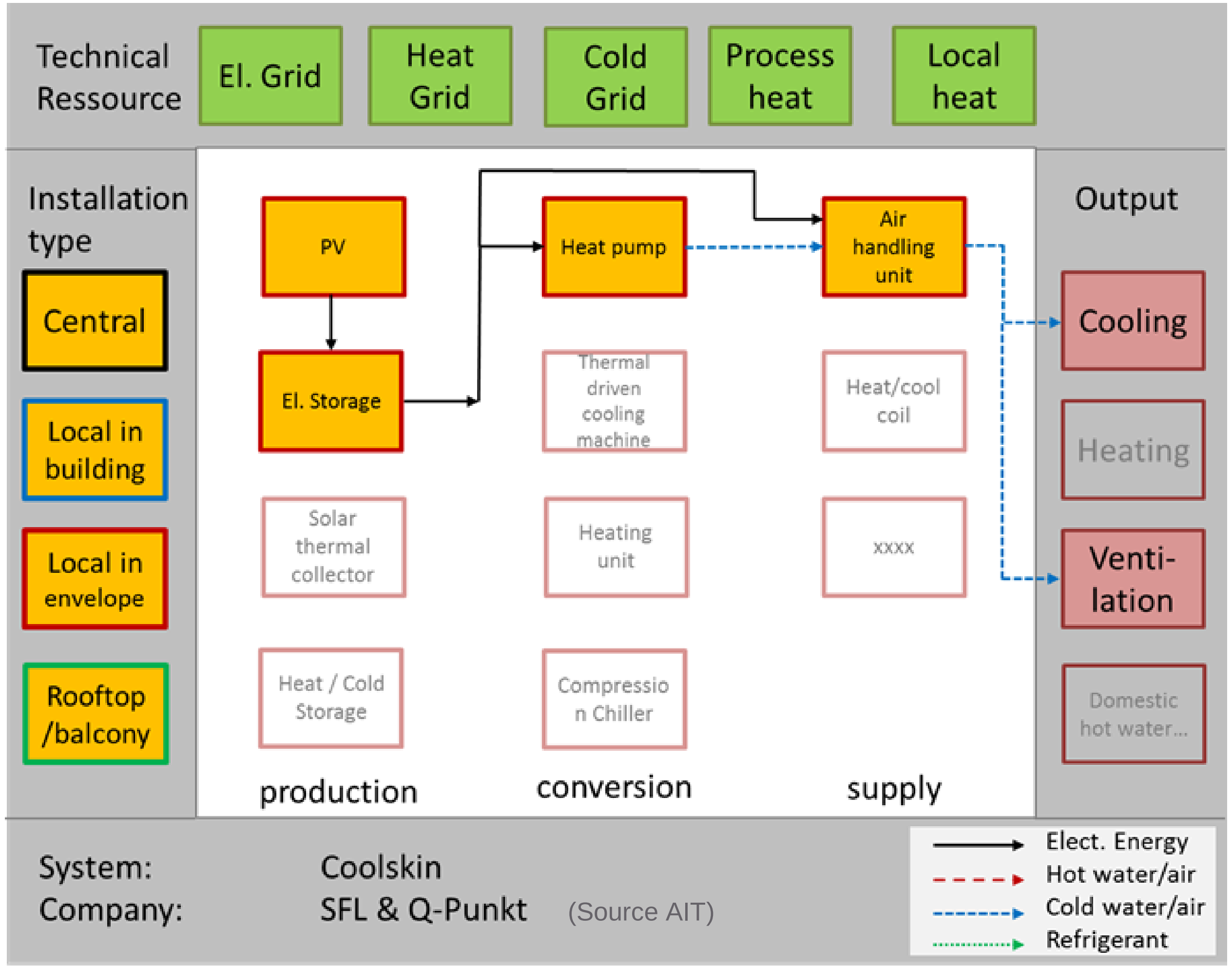
AUSTRIAN INSTITUTE OF TECHNOLOGY

COOLSKIN – ENERGY MODELLING OF THE REFERENCE ROOMS

Square View of the implemented COOLSKIN system

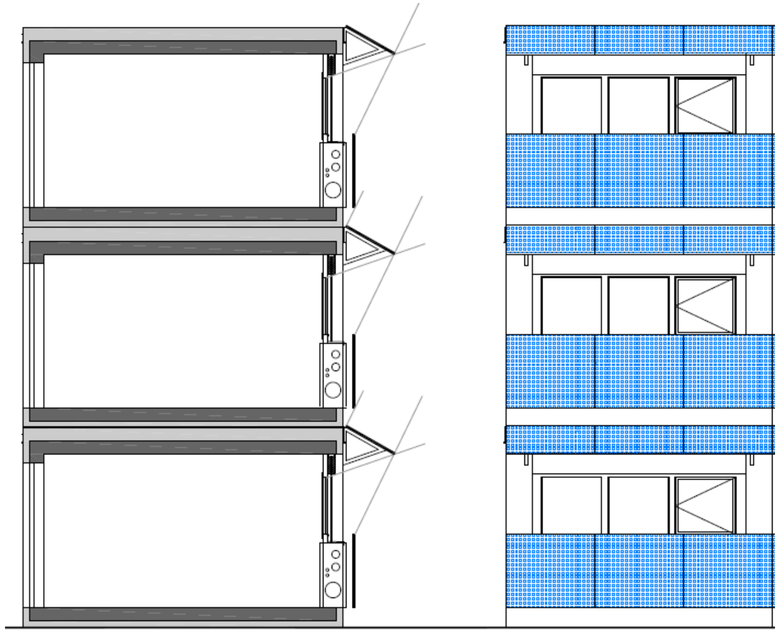


(Source Reinberg ZT GesmbH)



Task 53
SHC
SOLAR HEATING & COOLING PROGRAMME
INTERNATIONAL ENERGY AGENCY

AUTARKIC COOLING VIA BUILDING SKINS



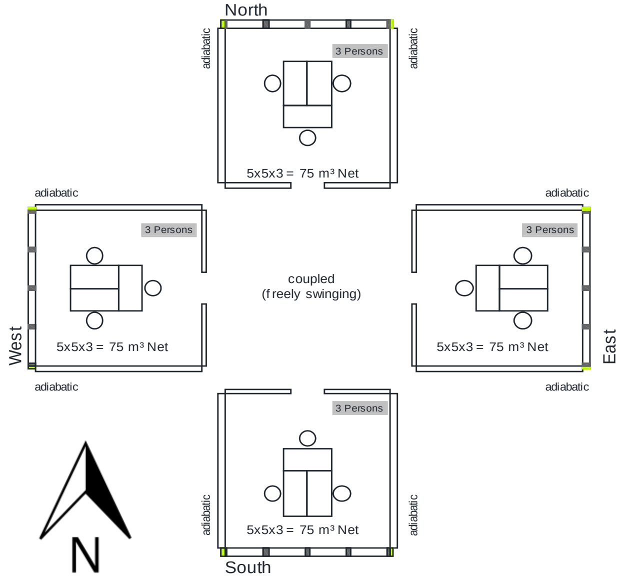
(Source Reinberg ZT GesmbH)

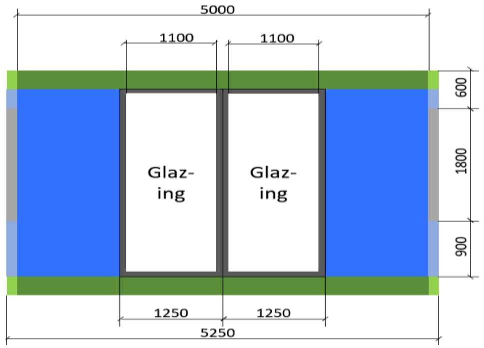
For achieving the COOLSKIN target the research project is sub-divided into three development steps:

- 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





	Area m²	Fraction %
PV	11.22	59.9
Frame	1.31	7.0
Glazing	6.19	33.1
Sum	18.72	100

Approach

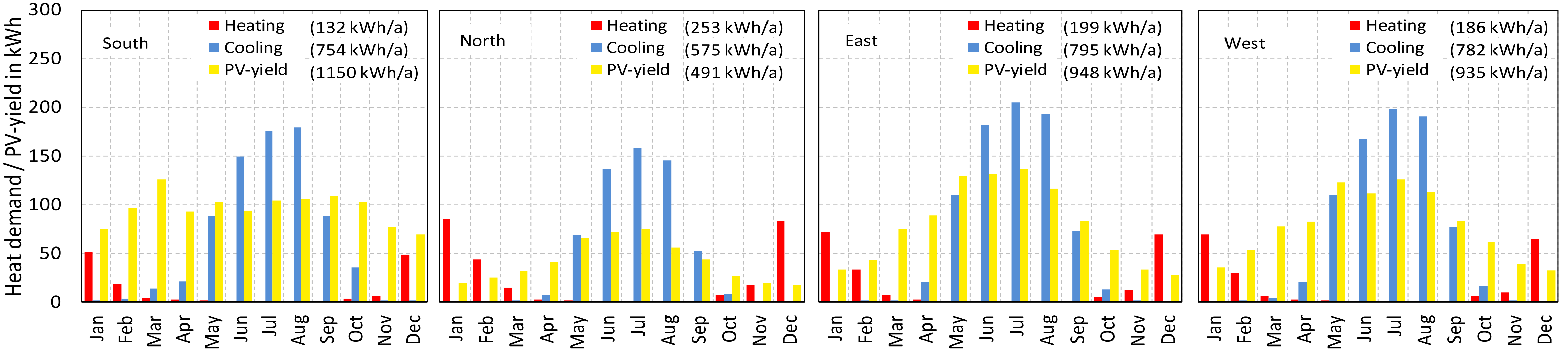
- *Thermal building model created in the simulation environment (TRNSYS, 2011)*
- *10-year average climate taken from Meteonorm software (Meteotest 2009) for Helsinki (cold), Ljubljana (moderate) and Madrid (warm)*

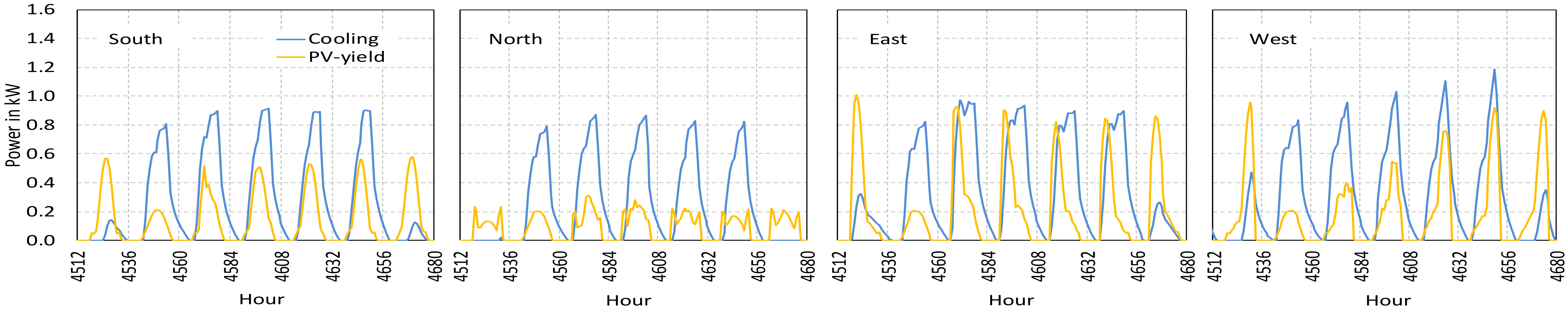
Modelled building parameter

- *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

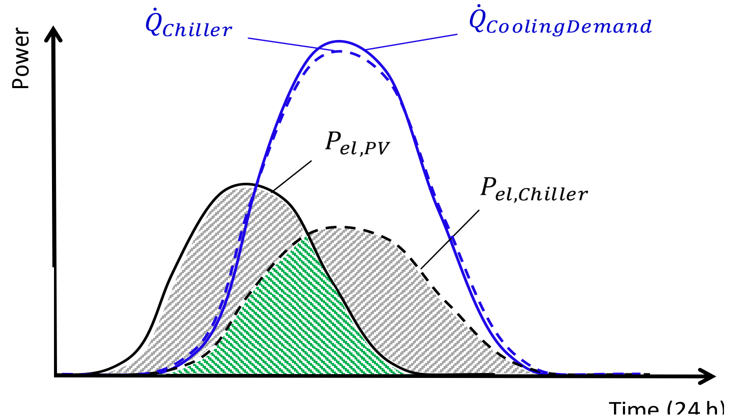
Investigated location of Ljubljana (moderate European climate)





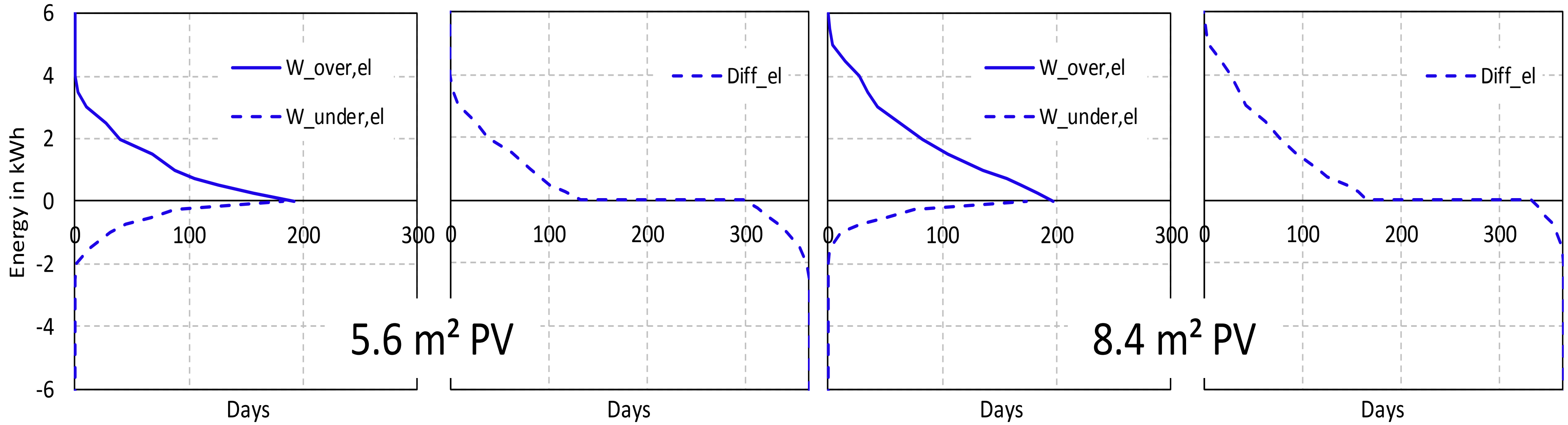
Source TU Graz

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$_{thermal}$ cooling capacity*
- *Daily energy balances*
- *Ljubljana climate/ south-oriented façade integrated PV*



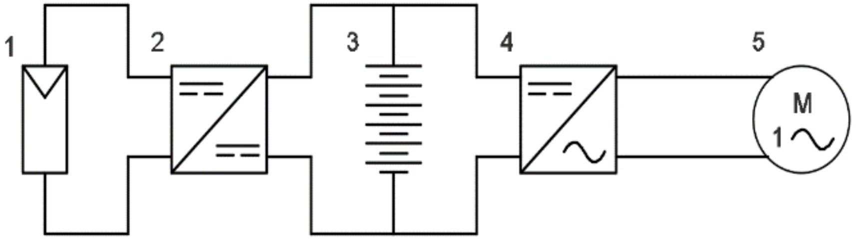
Source TU Graz

COOLSKIN – EXPERIMENTAL COMPONENTS AND SYSTEM TESTS

TEST PHOTOVOLTAIC MODULES

Digital print

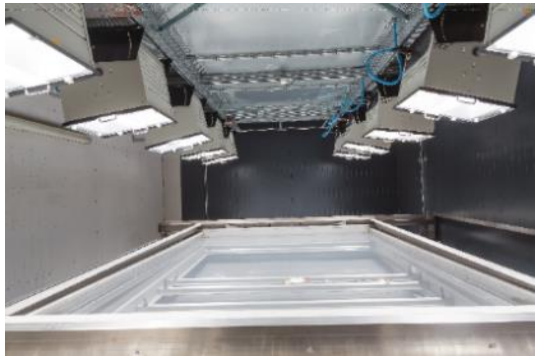
Black line



Experimental components		
Number	Name	Value
1	Photovoltaics modules	1167 W
2	MPP-Tracker	1680 W
3	LiFePo Battery	2300 Wh
4	Inverter	1600 W
5	AC Compressor	500 W

Source AIT

$$\underset{98\%}{\eta_{MPP}} \times \underset{92\%}{\eta_{Bat}} \times \underset{94\%}{\eta_{Inv}} = \underset{85\%}{\eta_{Con}}$$



Source AIT

Stat. Sun Simulator 9 m^2

Source AIT

Flasher 9 m^2 A+A+A+

Type	Number of Cells	V_{OC} [V]	V_{MPP} [V]	I_{SC} [A]	I_{MPP}[A]	P_{MPP} [W]	η [%]
Digital print	60	39.05	31.90	6.69	6.34	202.17	11.56
Digital print	60	38.99	32.80	6.65	6.05	198.51	11.35
Digital print	84	54.60	46.23	6.73	6.02	278.28	11.61
Digital print	84	54.41	46.08	6.71	5.93	273.38	11.41
Black line	60	39.45	33.32	7.93	7.11	236.95	13.55
Black line	60	39.34	32.52	8.03	7.53	244.82	14.00
Black line	84	55.05	46.60	8.07	7.15	333.11	13.90
Black line	84	55.20	45.08	8.26	7.81	352.09	14.70

DI Tim Selke | Center for Energy
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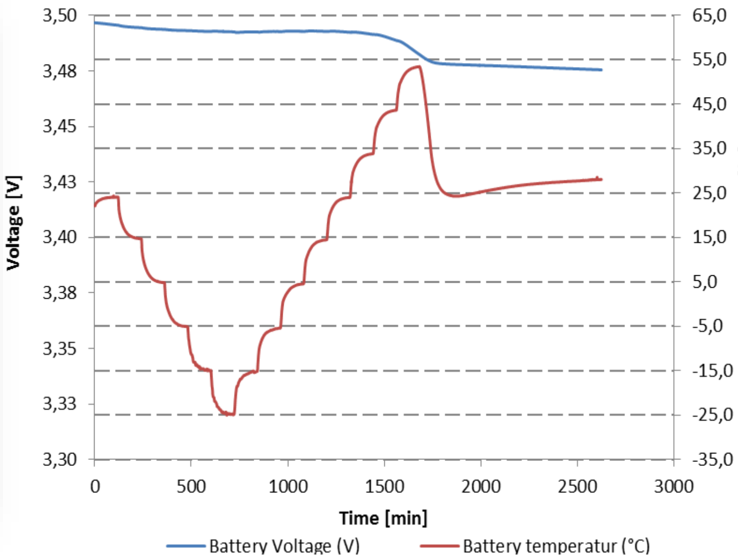
COOLSKIN – EXPERIMENTAL COMPONENTS AND SYSTEM TESTS

TEST BATTERIES

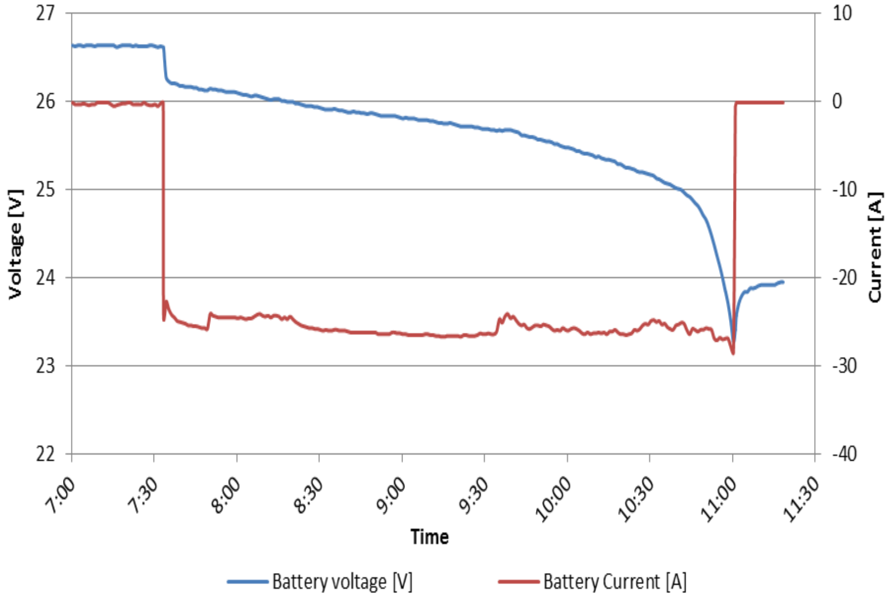
Source AIT

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.

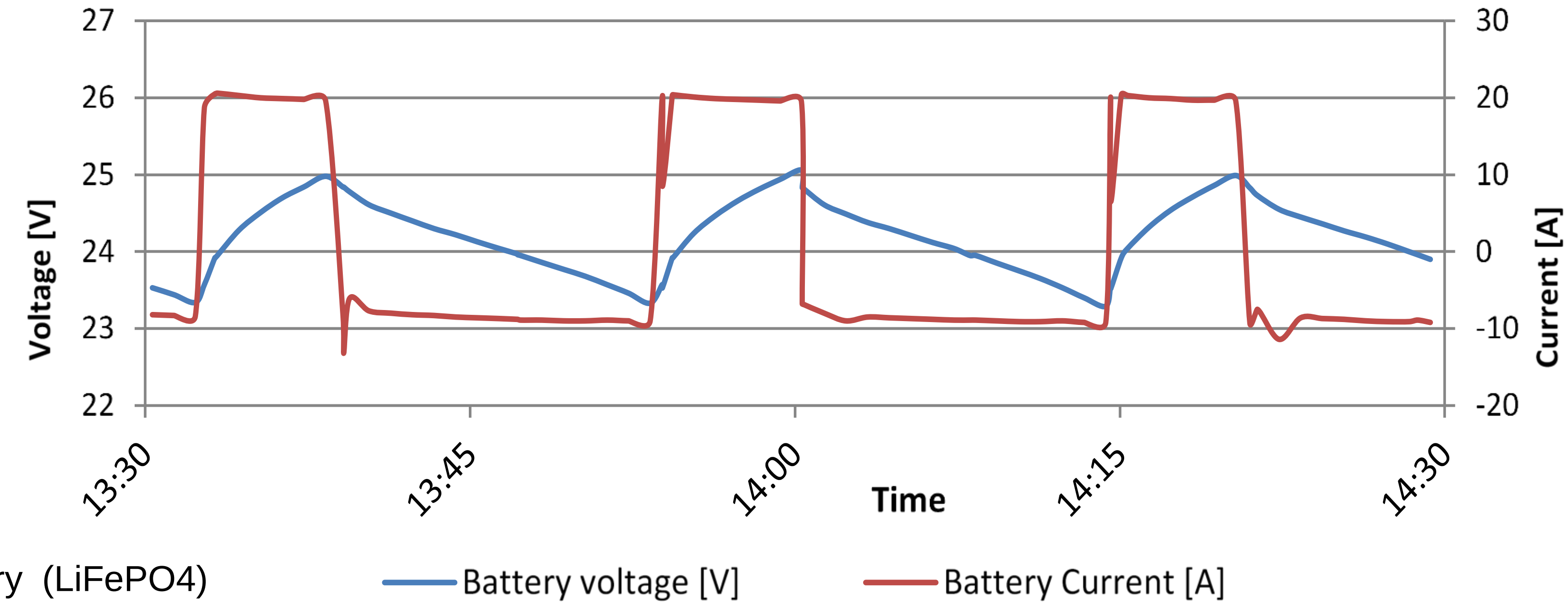


Battery discharge process with a 500 Watt load of the compressor unit of **the two batteries**

COOLSKIN – EXPERIMENTAL COMPONENTS AND SYSTEM TESTS

TEST BATTERIES

Source AIT



2 Lithium iron phosphate battery (LiFePO4)

Each 12.8 Volt / 90Ah / 1152 Wh

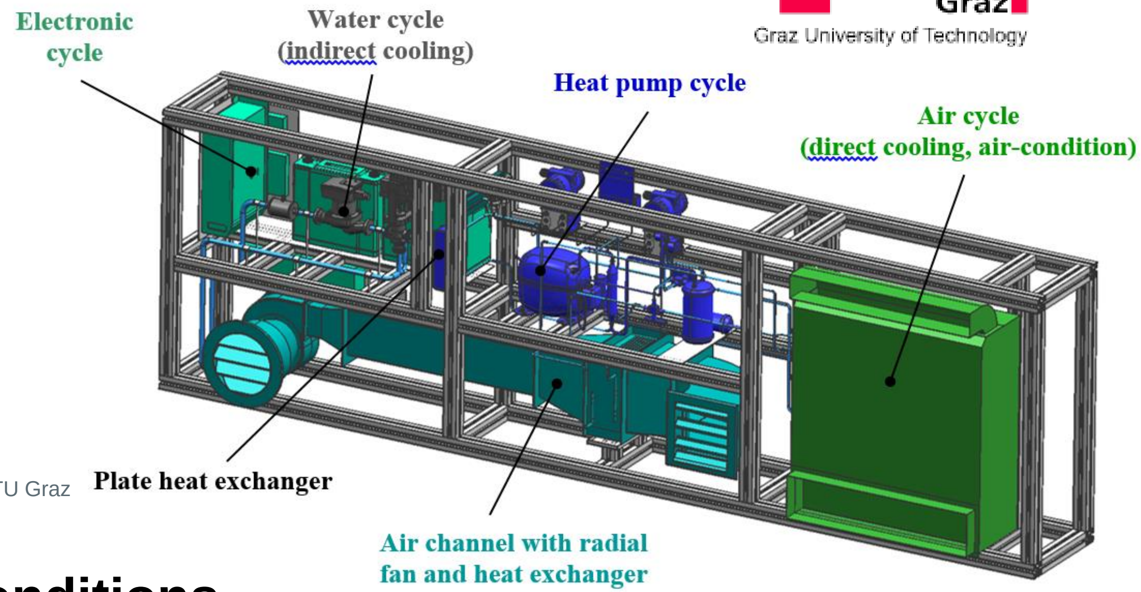
Flickering

- Start and stop performance when the load is higher than the photovoltaic yield

COOLSKIN – EXPERIMENTAL COMPONENTS AND SYSTEM TESTS

OUTLOOK

Source TU Graz



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*

AUTARKIC COOLING VIA BUILDING SKINS

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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