Lightweight switchable smart solutions for energy saving glass facades

On-line
12 December 2022

AGENDA

10:00 - 10:05 **Welcome, Introduction**
Aranzazu Galan Gonzalez, BuildUp

10:05 - 10:30 **Switch2Save project overview**
Matthias Fahland, Fraunhofer FEP, Switch2Save coordinator

10:30 - 10:50 **Switch2Save technical achievements and Demo-sites**
Greger Gregards, ChromoGenics

10:50 - 11:00 **Switch2Save Architectural Design Competition**
Sara Van Rompaey, E2ARC

11:00 - 11:15 **Switch2Save impact**
Matthias Fahland, Fraunhofer FEP, Switch2Save coordinator

11:15 - 11:30 **Q&A session**
moderated by Lenka Bajarová, AMIRES

REGISTER NOW!

@Switch2Save_EU

Switch2Save

www.switch2save.eu

BUILD UP Workshop, 12th December 2022

Switch2Save - Project Overview

M. Fahland[1], [1]Fraunhofer FEP (Dresden, Germany)

Switch2Save: Motivation

Reducing primary energy consumption in the building sector

The building sector accounts for 40% of total energy consumption in the European Union

https://www.irbnet.de/daten/iconda/CIB_DC26383.pdf

Windows are an essential component in the building envelope, regulating the flow of energy into and out of the building

M. Cassini ; Renewable Energy 119 (2018)

Improving the energy efficiency of existing buildings could reduce the EU's total energy consumption by 5-6%

https://ec.europa.eu/info/news/focus-energy-efficiency-buildings-2020-lut-17_en>

Fraunhofer FEP

Switch2Save Aim

Lightweight switchable smart solutions for energy saving large windows and glass facades

Switch2Save Objectives:

- Low weight of components for retrofitting existing buildings
- Improved insulation properties
- direct integration to windows and glass facades
- Reasonable costs

Switch2Save Facts:

- Call: H2020-NMBP-ST-IND-2018-2020
- Topic: LC-EEB-01-2019: Integration of energy smart materials in non-residential buildings
- Innovation Action (IA)
- Project duration: 48 months
- Now: month 38

Grant No: 869929

Switch2Save Consortium

Lightweight switchable smart solutions for energy saving large windows and glass facades

UNIVERSITY OF WEST BOHEMIA

AGL Technologies

VASAKRONAN

Pilkington Glass

ΓΕΝΙΚΟ ΝΟΣΟΚΟΜΕΙΟ ΝΙΚΑΙΑΣ ΠΕΙΡΑΙΑ
"ΑΓΙΟΣ ΠΑΝΤΕΛΕΗΜΩΝ"
2η Υ.ΠΕ. ΠΕΙΡΑΙΩΣ & ΑΙΓΑΙΟΥ

Fraunhofer ISC

Fraunhofer FEP

ChromoGenics

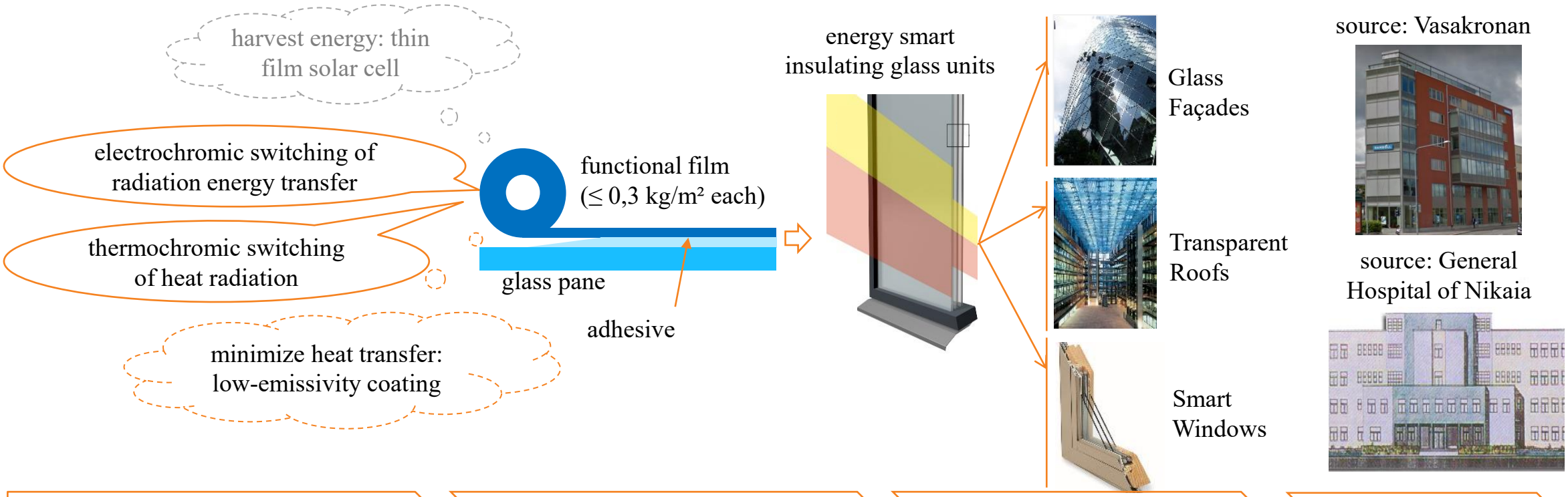
R&D → Materials → Components → Building Integration → Building Demonstration

AMIRES

E²ARC
Energy Efficient Architecture Renovation Cities

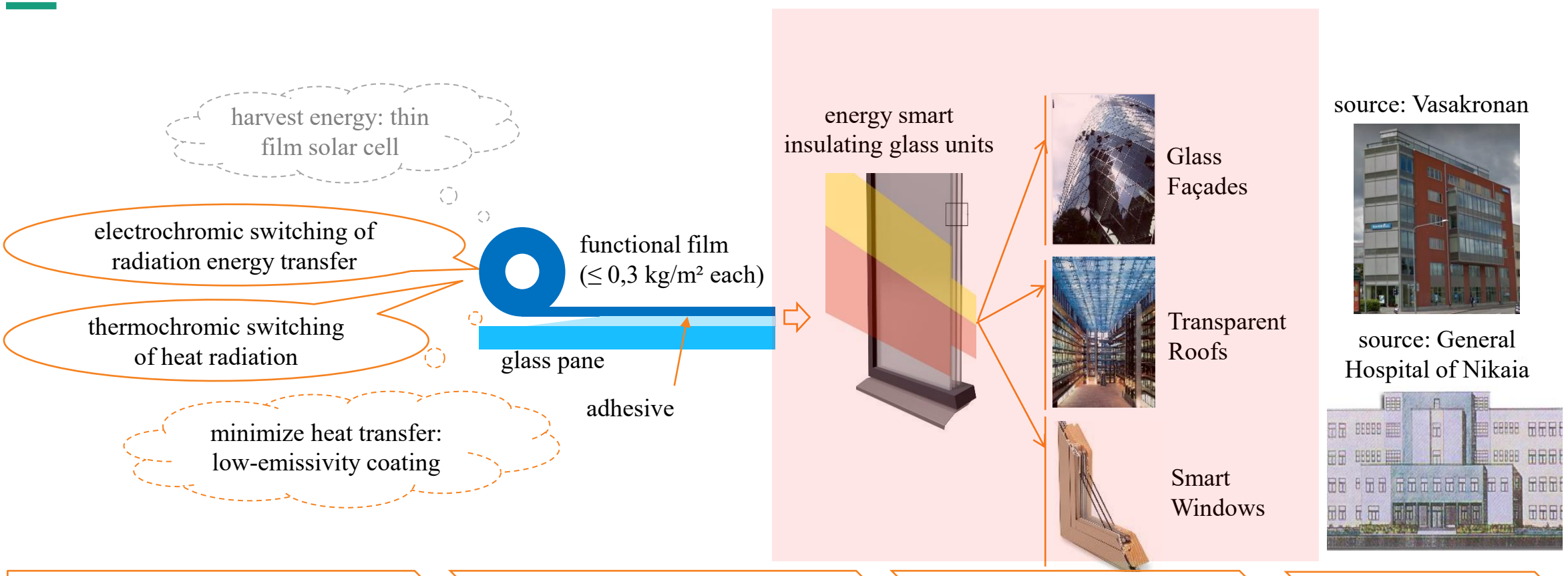
Grant No: 869929

Switch2Save project flow



Fraunhofer FEP

Switch2Save project flow

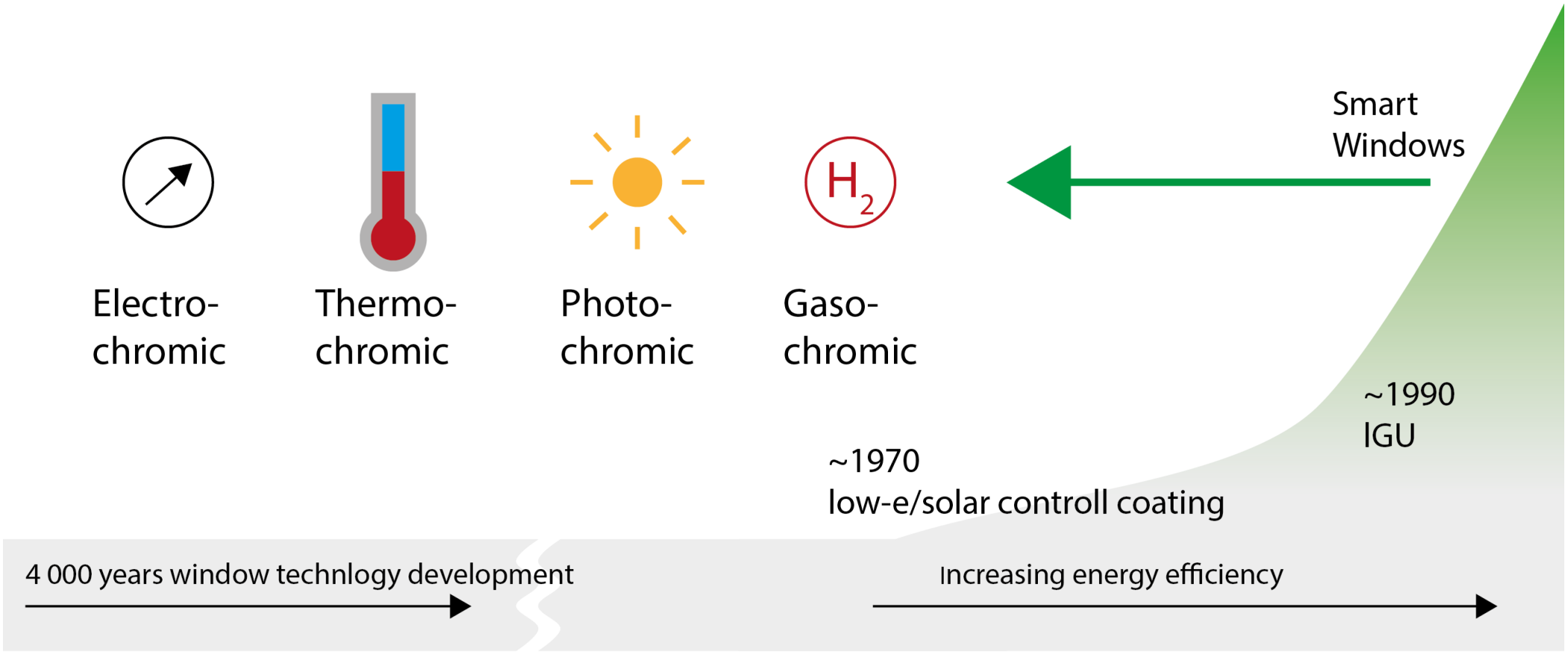


Energy Smart Material → Functional film and Integration technology → Building Components → Low-Carbon Zero Energy Buildings

Fraunhofer FEP

Smart Window Technologies

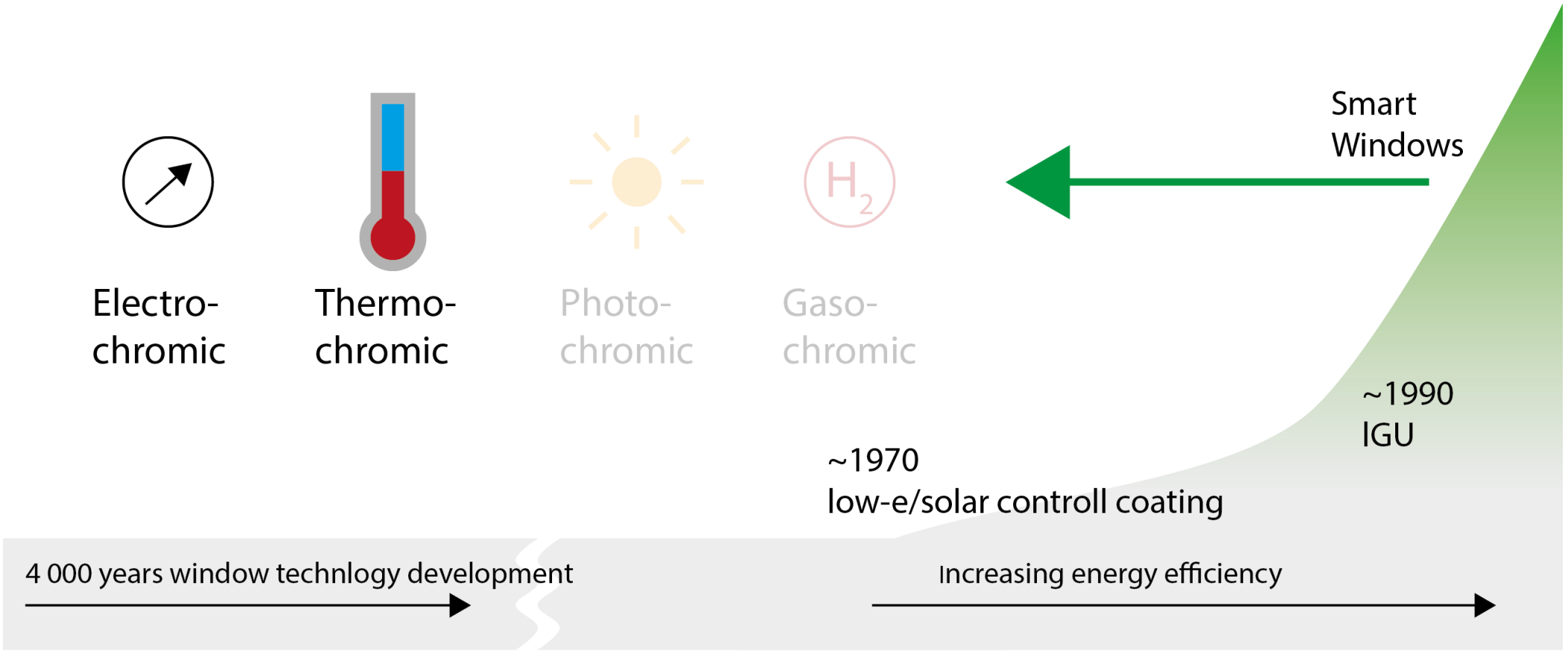
Smart Windows: Adapting optical properties to external stimulus



Grant No: 869929

Smart Window Technologies

Smart Windows: Adapting optical properties to external stimulus



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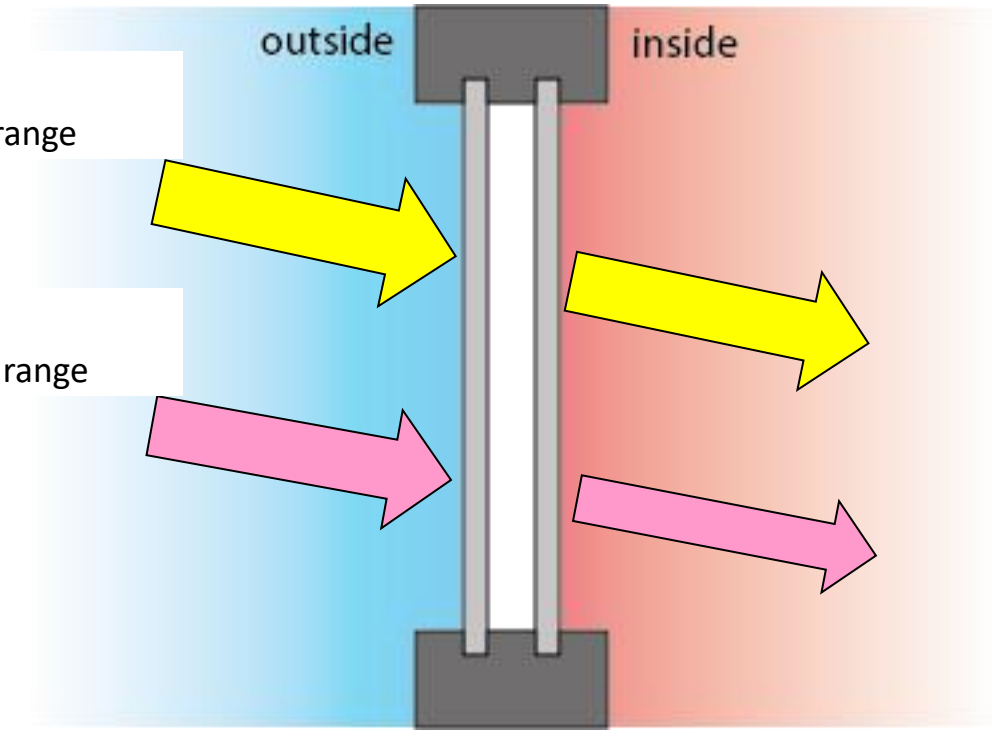
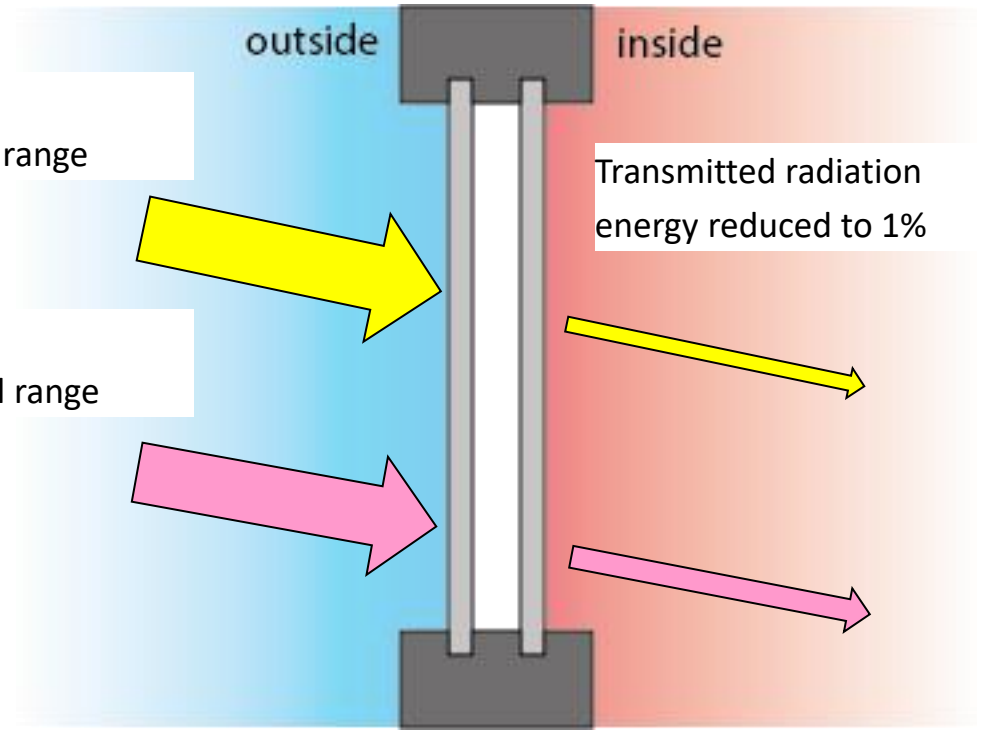
Smart Window Technologies of Switch2Save (1)

Electrochromic Windows: Reacting to human-decided electrical control signal

Window with electrochromic coating:
BRIGHT state



Window with electrochromic coating:
DARK state



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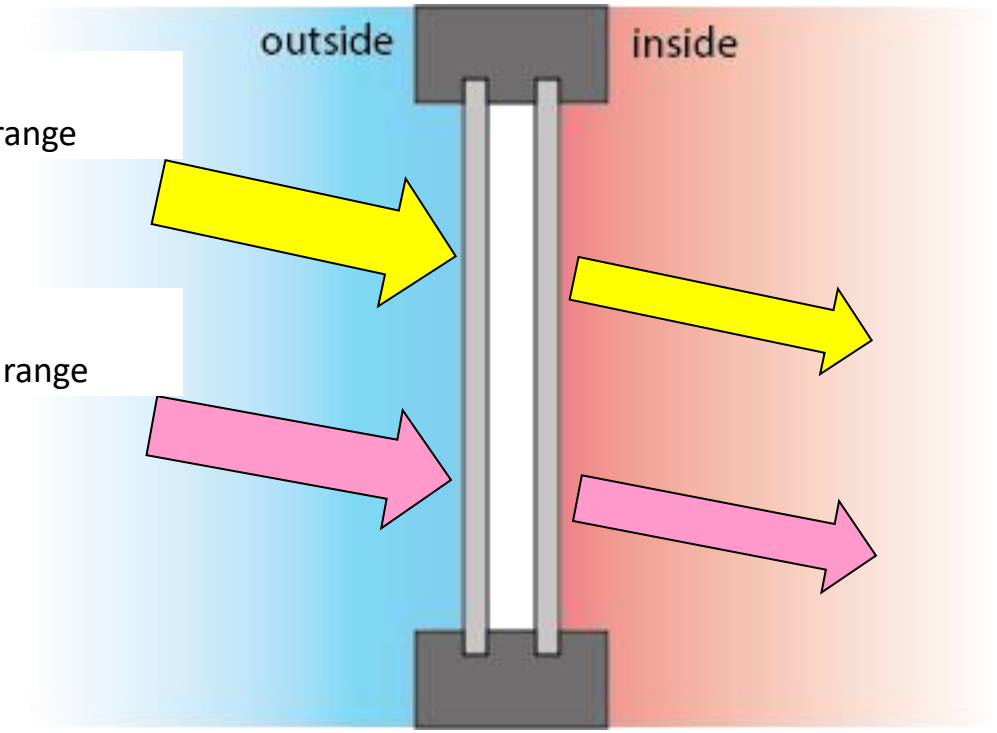
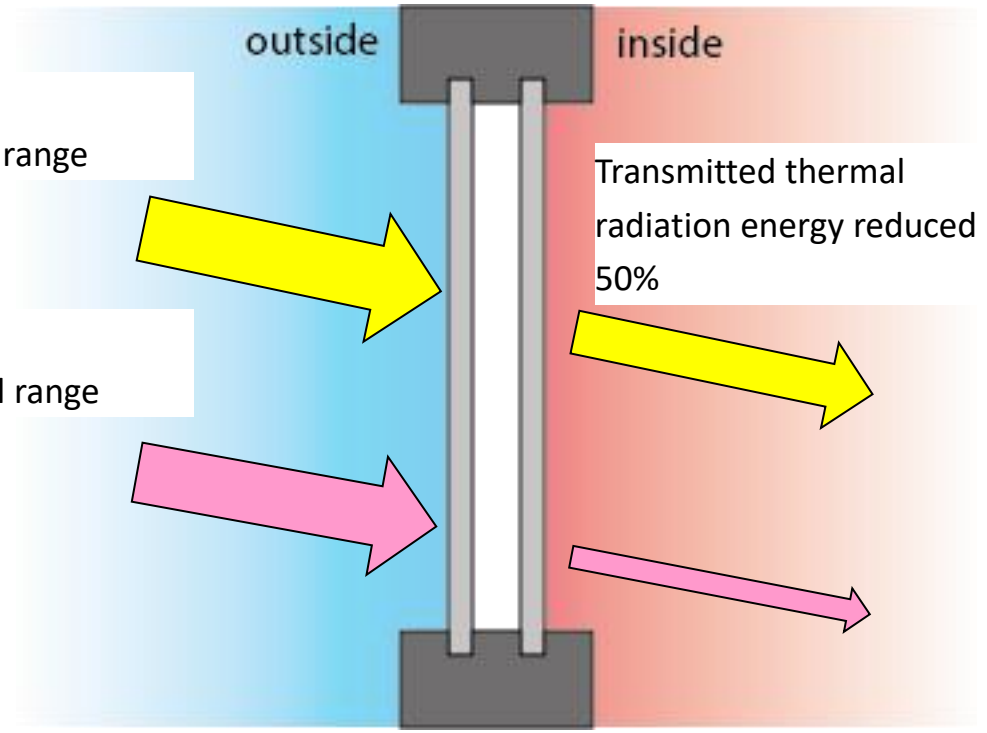
Smart Window Technologies of Switch2Save (2)

Thermochromic Windows: Reacting to external temperature

Window with thermochromic coating:
COLD state



Window with thermochromic coating:
WARM state



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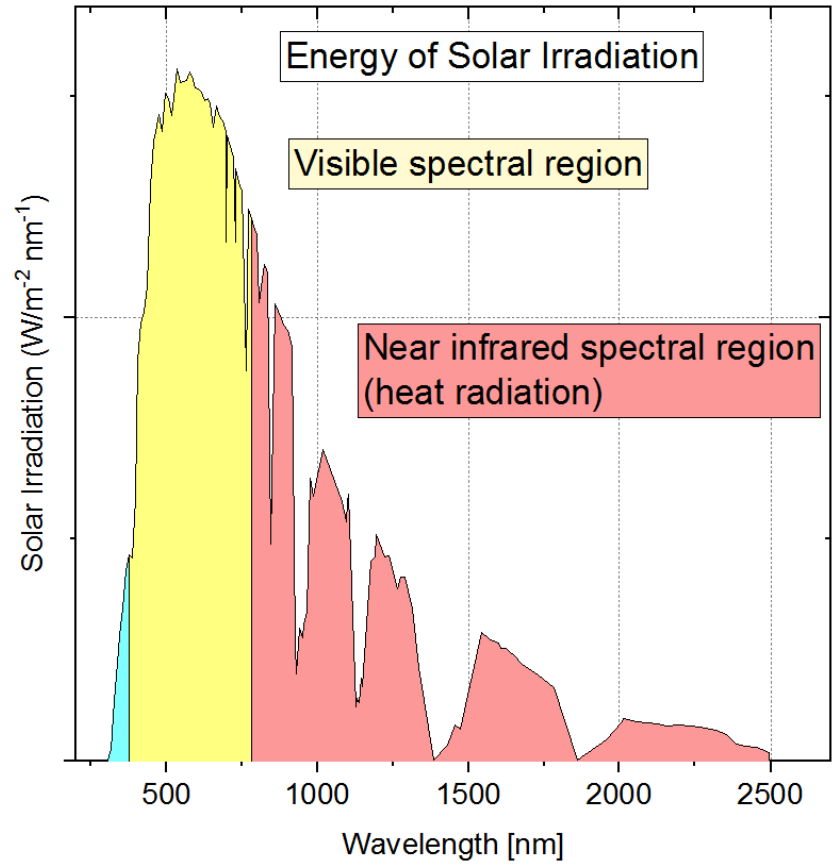
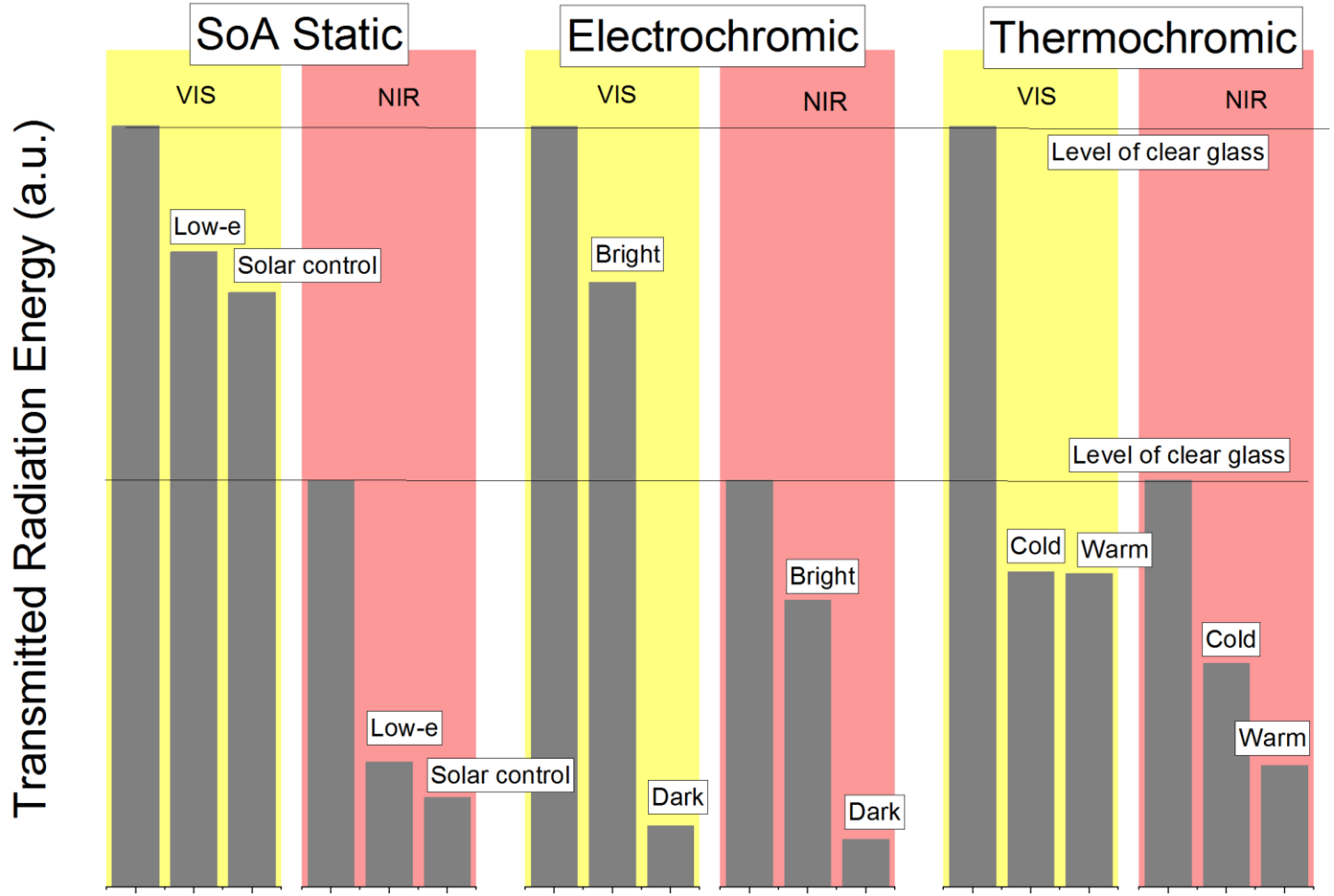
Smart Window Technologies of Switch2Save (3)

Achievements on material level compared to state-of-the art static solution





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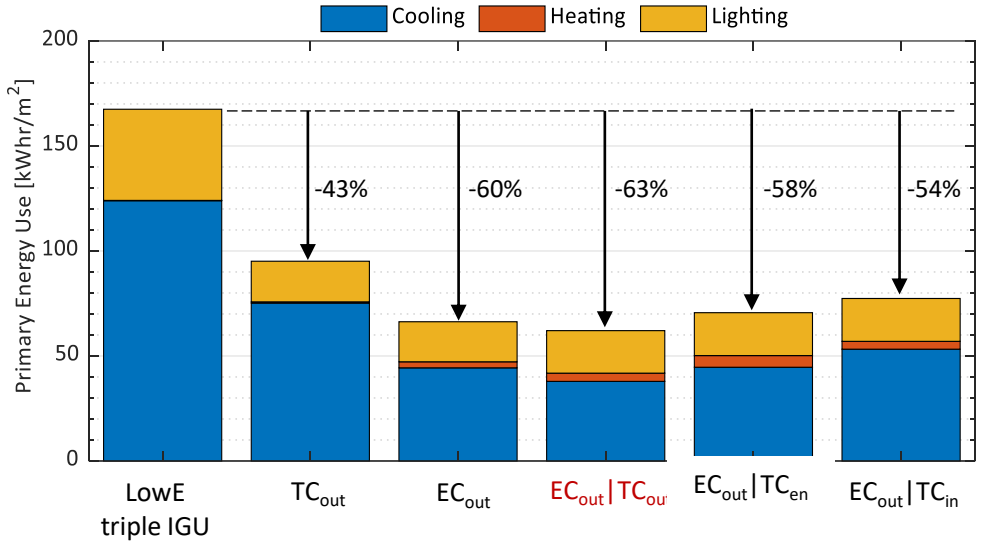
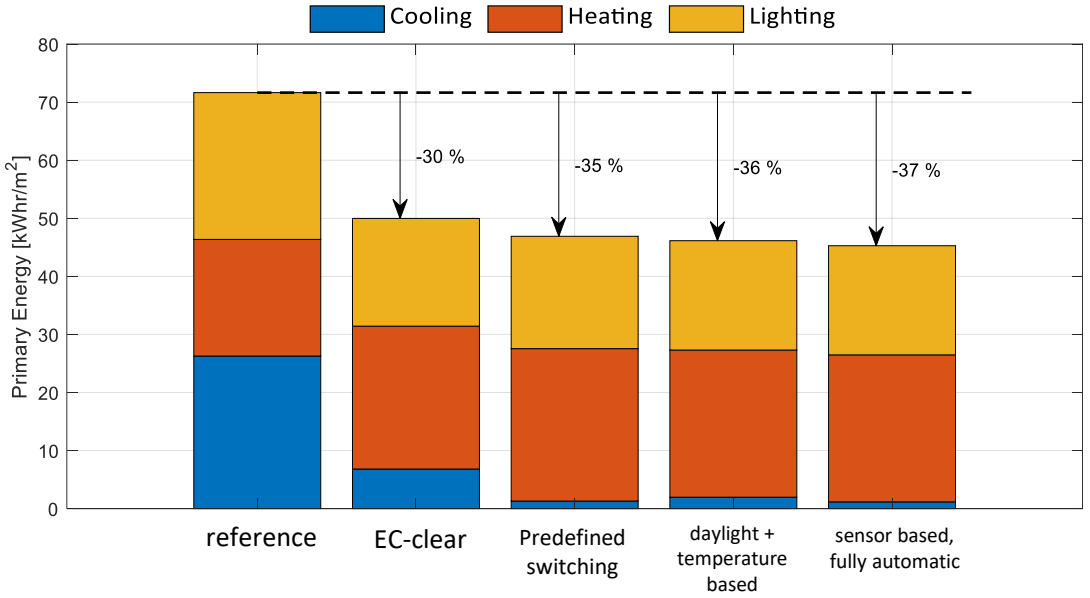
Smart Window Demonstration strategy of Switch2Save

Modelling of window performance



Single floor 12 × 12 m^2 in an office building in Athens



5 floor office building in Stockholm

- Saving Potential of EC and TC in Athens and Stockholm: Best performer: EC + TC inner side of outer pane
- Maximum saving potential: 30 – 55% due to smart IGU + 5 – 15% due to automatic switching protocol

M. Detsi et al., Energies 13, 3020 (2020)

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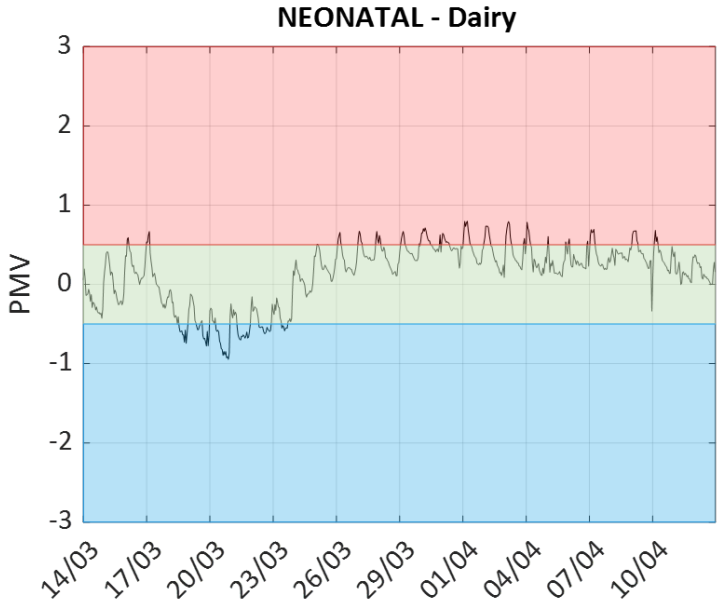
Smart Window Demonstration strategy of Switch2Save

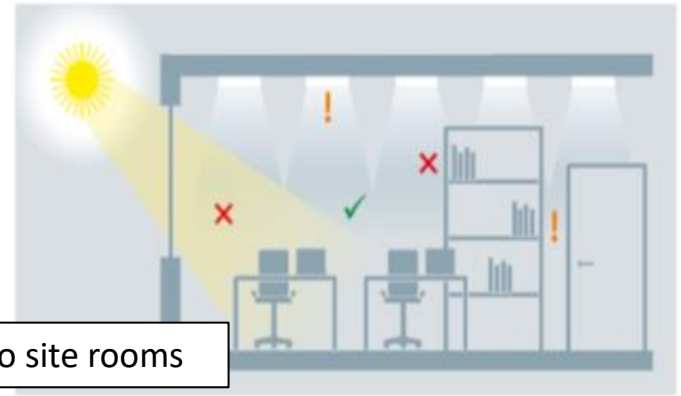
Methodology of indoor measurements

Live monitoring of thermal comfort variables (e.g. temperature, humidity etc.) at both Athens and Stockholm demo sites

- Thermal comfort
  - Air temperature,
  - air velocity,
  - floor temperature,
  - humidity ….
- Indoor Air Quality
  - VOC concentration
- Energy consumption measurement



Predicted mean vote (PMV)



Widely distributed sensor locations in the demo site rooms

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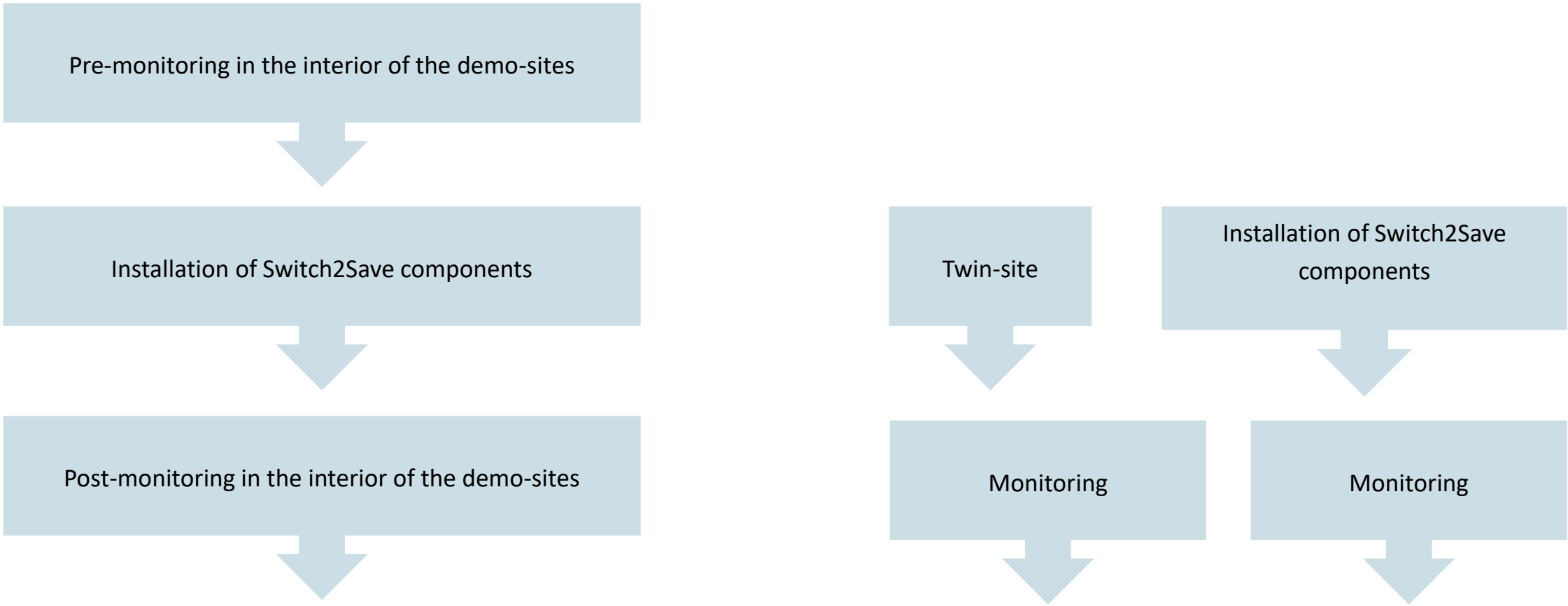
Smart Window Demonstration strategy of Switch2Save

Pre-monitoring and parallel monitoring of demo sites



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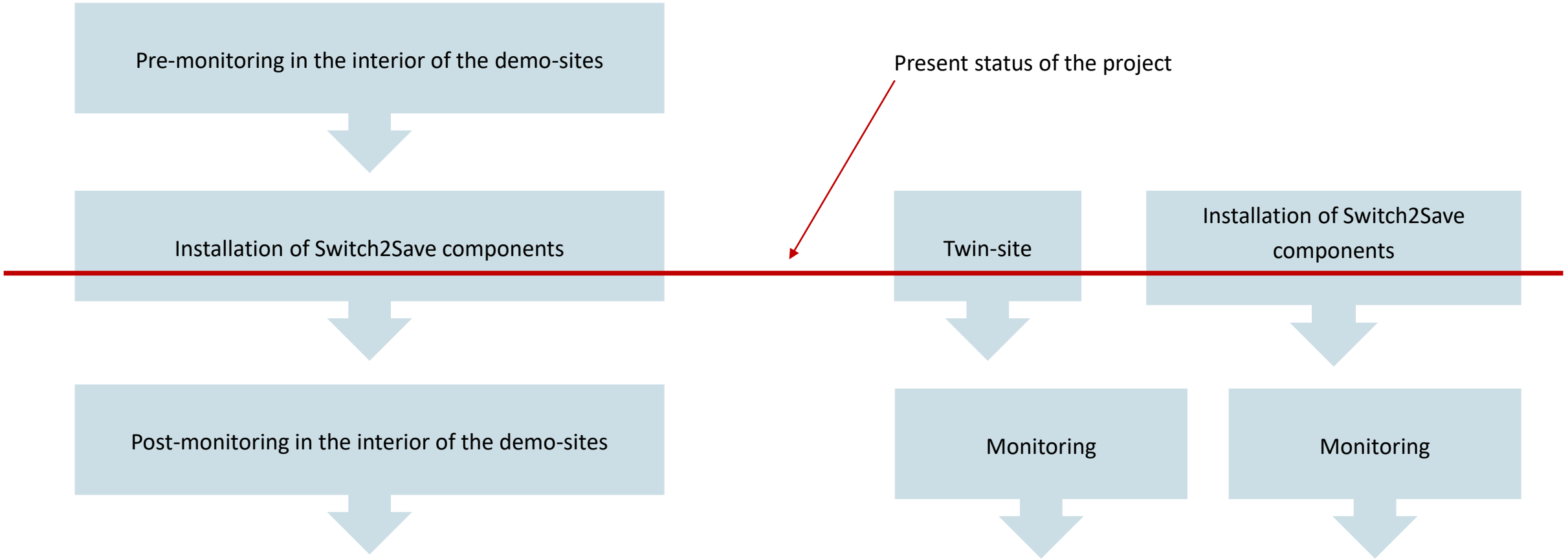
Smart Window Demonstration strategy of Switch2Save

Pre-monitoring and parallel monitoring of demo sites



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Smart Window DemoSites of Switch2Save

Uppsala (SWE)
Vasakronan Building

Athens (GRE)
Nikaia Hospital

Athens (GRE)
Mockup Buildings NTUA

Dresden (GER)
Mockup for thermochromic roof test

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Fraunhofer FEP

Thank you for your Attention

BUILD UP Workshop, 12th December 2022

Demo installation in Uppsala

Greger Gregard, ChromoGenics AB

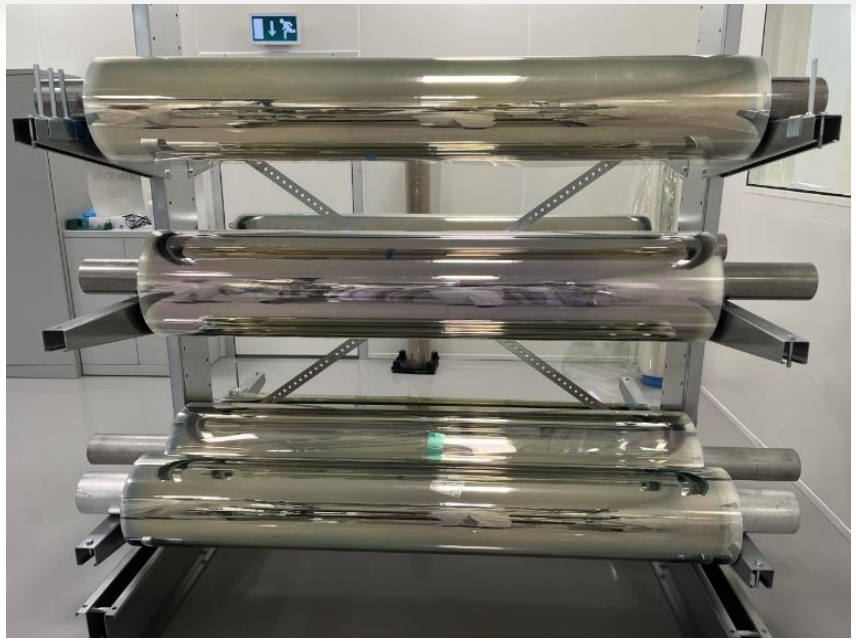
This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement n°869929, project Switch2Save

Demo installation in Uppsala

- Technical achievements
- Pre-monitoring
- Installation
- Follow-up monitoring

Technical achievements
Large scale process development

- Upscaling – Industrial processes have been developed for large area coatings



Technical achievements
Large scale IGU

- EC glass with increased light transmittance in clear state. VLT >70%
- Large scale IGUs
  - U-value 0.4 W/(m²K)
  - 30% less weight than SoA IGU

Technical achievement
Control system

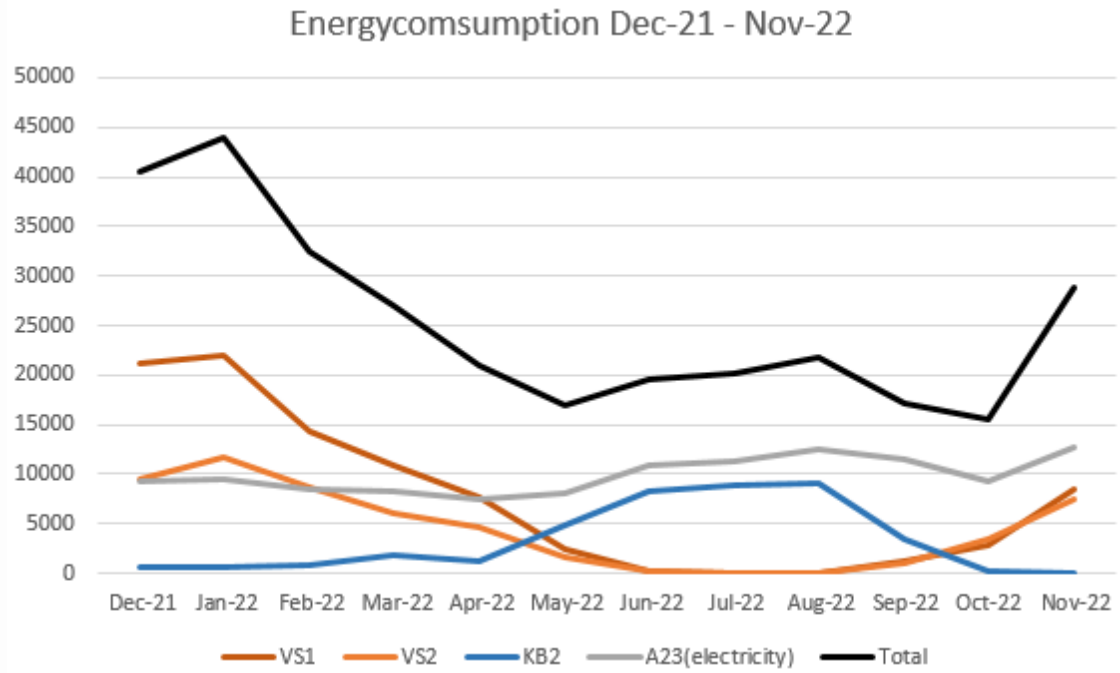
- A wireless control system has been developed
  - Powered by a battery and charged by a small solar cell
  - Wireless communication (LoRa, Z-wave or Wi-Fi)

Technical achievements
Manufacturing of smart IGUs

- 157 sqm of smart IGUs produced for demo building in Uppsala

Uppsala Demo Building
Pre-monitoring

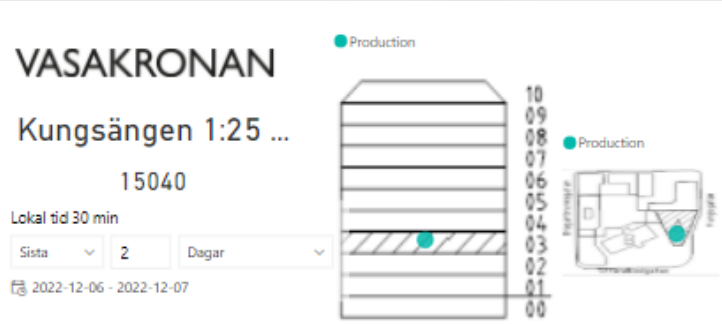
- Data from energy consumption for heating, cooling and electricity has been collected for one year prior to the installation.
- The building consumes 76,7 kWh /m² year.

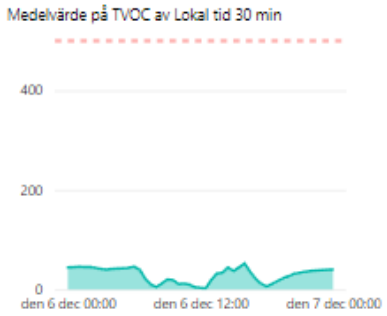


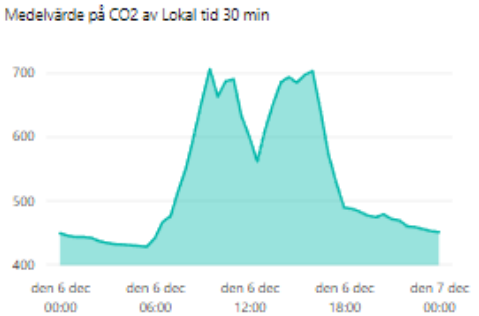
Uppsala Demo Building Pre-monitoring

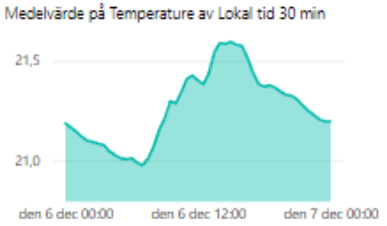
Data has been collected for one year prior to the installation:

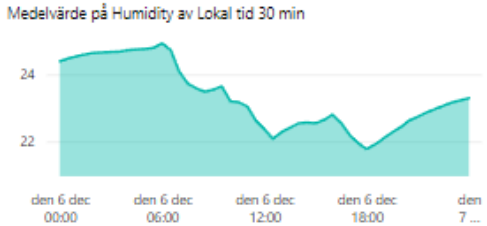
- VOC
- CO2
- Temp
- RH
- Illuminance
- Presence

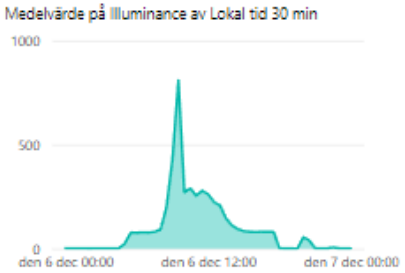


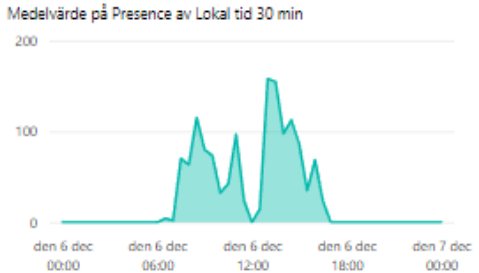








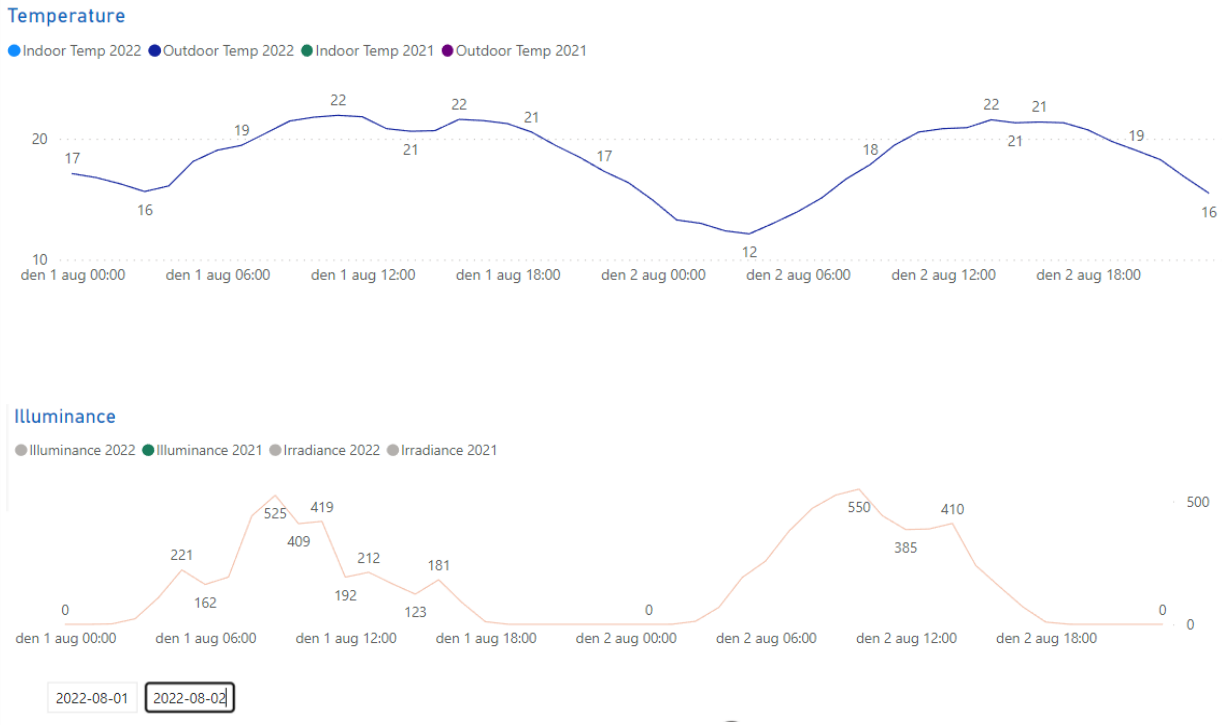




Plan	Rum	Description	Littera	IoT Device
2	1119	Matsal - PropTechOS Littera: 1119 Room Type:	15040-A1119-IOT01-GQ01	Decentlab-DL-IAM-1
3	1223	Öppet landskap - PropTechOS Littera: 1223 Room Type:	15040-A1223-IOT01-GQ01	Decentlab-DL-IAM-1
4	1327	Öppet landskap - PropTechOS Littera: 1327 Room Type:	15040-A1327-IOT01-GQ01	Decentlab-DL-IAM-1
5	1420	Öppet landskap - PropTechOS Littera: 1420 Room Type:	15040-A1420-IOT01-GQ01	Decentlab-DL-IAM-1
6	1521	Tidigare: A05-1521 - PropTechOS Littera: 1521 Room Type: OfficeLandscape	15040-A1521-IOT01-GQ03	Decentlab-DL-IAM-1
7	1621	Öppet landskap - PropTechOS	15040-A1621-IOT01-GQ01	Decentlab-DL-IAM-1

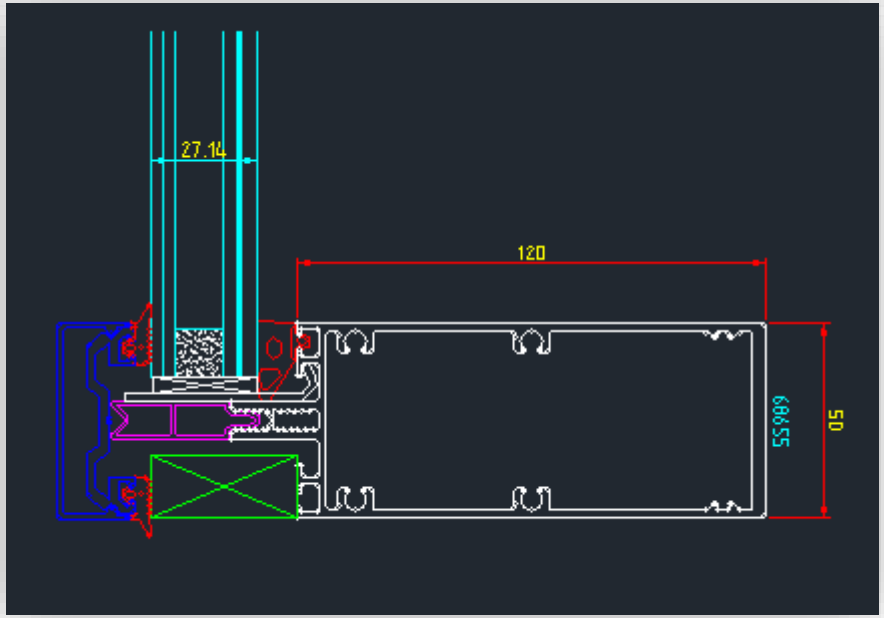
Uppsala Demo Building Pre-monitoring

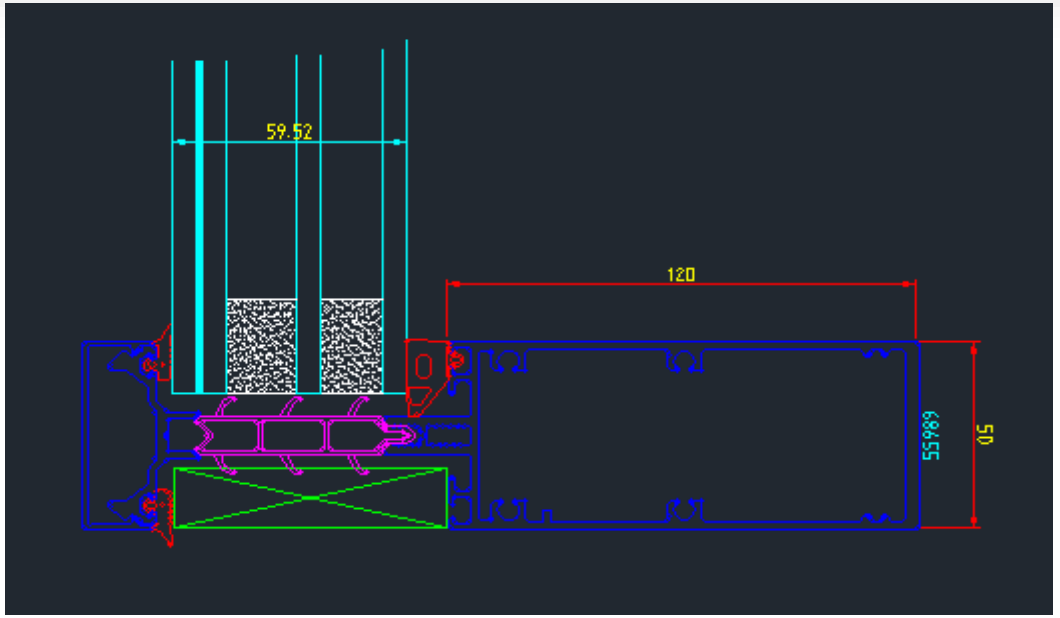
- All collected data can be extracted and presented visually in various forms for easy comparison, i.e. between different rooms, floors, time periods, etc.



Uppsala Demo Building Installation

- The facade system had to be modified to accommodate smart IGUs with increased thickness.





Uppsala Demo Building Installation

Uppsala Demo Building
Follow-up monitoring

- The follow-up in Lummelunda and Vitec, will be transferred to ProptechOS, monitoring the smart IGU impact on:
  - Energy consumption
  - Indoor temperatures
  - Illuminance
  - Presence

Registration deadline: 31st January 2023

Submission deadline: 31st March 2023

ARCHITECTURAL DESIGN COMPETITION

COMPETITION LAUNCH

OCTOBER

2022

SWITCH 2 SAVE

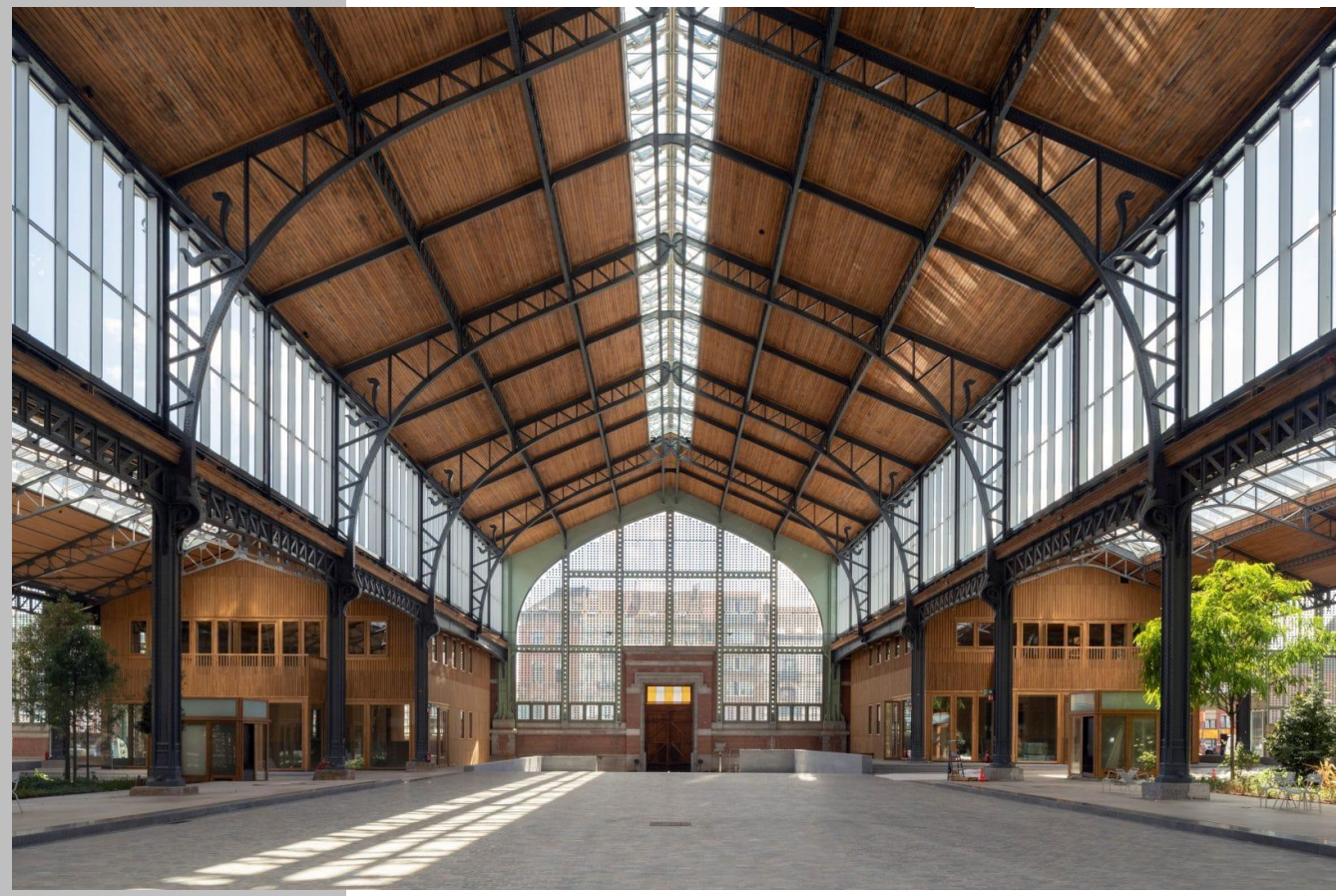
Architect Sara Van Rompaey

E²ARC

Architects for future cities

Webinar - Lightweight switchable smart solutions for energy saving glass facades, 12th December 2022

Smart Glazing in architecture: existing buildings



Gare Maritime Brussels / Neutelings Riedijk architecten

Smart Glazing in architecture: new buildings

Heydar Aliyev centre, Baku, Azerbaijan. Photograph: Zaha Hadid architects

Portico Milan, Bjarke Ingels BIG architects

Key role of glazing selection

Hamburg opera house / Herzog & de Meuron

Antwerp Port house / Zaha Hadid architects

Energy Saving Strategy

Ghent Library Krook /COUSSEE & GORIS in partnership with the Spanish-Catalan firm of RCR Arquitectes

Answer to challenges

High performance glazing can contribute to the insulation of a building and deliver energy savings, while ensuring comfort conditions for users and without losing sight and **architectural freedom**.

Residential building KNÄCKEPILEN, UPPSALA, SWEDEN / where Åke Sundvall Byggnads AB chose to install ConverLight® Dynamic (Chromogenics)

Answer to challenges: Example

GT5 (Gullhaug Torg 5, Oslo) with ConverLight® from ChromoGenics

Why use smart & switchable glazing?

Answer to challenges: Example

© Halio International – Gare Maritime, Extensa. Gare Maritime project at Tour & Taxis in Brussels (Belgium), rendering in clear and tinted.

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How does it work?

The state-of-the-art **daylight management system** will be installed as part of the renovation of the historic warehouses in the **former Gare Maritime freight station** in Brussels.

Switch2Save opportunity:
A new smart & switchable window

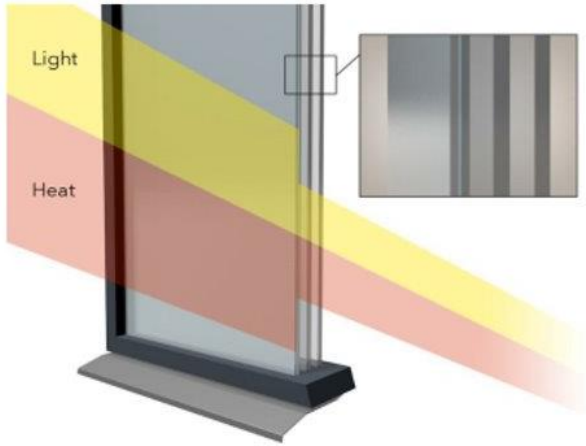
By applying low d.c. voltages to the transparent electrodes, the light transmittance of the devices can be changed

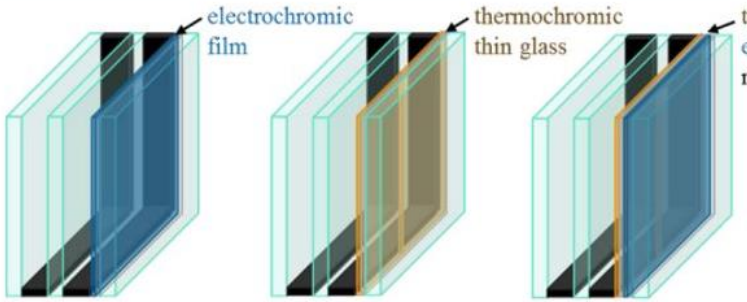
Switch2Save project proposes advanced, low-weight solutions suitable for direct integration to windows and glass facades for the control of radiation energy transfer, without any impact on the building structure, while enhancing occupants' comfort.

Switch2Save: A new smart & switchable window

The Switch2save System

- Combination of EC and TC film and integration in an Insulated Glazing Unit (IGU)
- EC switching reduces both visible and infrared light transmission
- TC switching affects only infrared light transmission





Color in transmission (clear state)

Color in reflection from the street (clear state)

Color in transmission (dark state)

Color in reflection from the street (dark state)

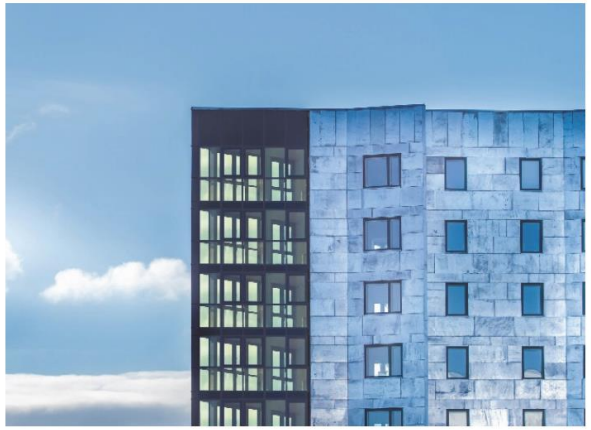
"Smart and switchable windows: How do they contribute in energy efficiency and comfort?" Switch2Save online Training Event, 28th February 2022

E²ARC Architects for future cities

Webinar - Lightweight switchable smart solutions for energy saving glass facades, 12th December 2022

Switch2Save: specification sheet dynamic glass

ConverLight® Dynamic Glass, Technical Specification



OVERVIEW CONVERLIGHT DYNAMIC GLASS

ConverLight® Dynamic Glass gives the optimal sun shading when you need it:

- **Electrochromic Smart Glass**
  Controllabel tint of glass
- **High-Tech Alternative**
  To traditional automated blinds
- **Low Climate Impact**
  Low carbon footprint and no toxic material
- **Energy Efficient**
  Excellent solar-control and thermal insulation
- **High Visible Comfort**
  Always free access to daylight and views
- **Cost Efficient**
  Low operating and maintenance costs
- **Architectural Freedom**
  Shape, function and apearence
- **Flexible Control**
  Automated system to autonomous window

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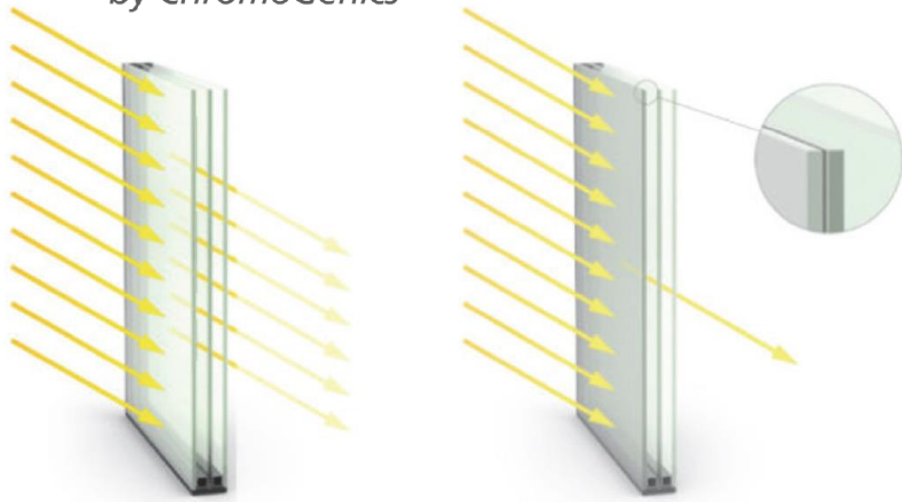
CONVERLIGHT DYNAMIC GLASS
by ChromoGenics



Webinar - Lightweight switchable smart solutions for energy saving glass facades, 12th December 2022

Switch2Save Architectural Design Competition

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Aiming to collect design concepts of **non-residential buildings** (new or renovation projects), featuring **glass facades, roofs, or large window to wall areas**, in any climatic context.

Switch2Save Architectural Design Competition

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DESIGN CONCEPT: Building use and site selection

- **Non-residential use**
- **No other restriction** regarding the size, location or use of the proposed building concept
- Project designs can be set within **any hypothetical site** of any size
- in either a city or countryside location **anywhere in Europe and in any climate**

Switch2Save Architectural Design Competition

E²ARC
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ELIGIBILITY:

- Competition is open to **young architects/ students** (up to 10 years after graduation) and/or multi-disciplinary teams (including building physicists, engineers) led by academic program (bachelor, master etc.) from an accredited educational institution.
- There is a limit of 3 members per team.
- Open to all nationalities. Team members should be based in EU or associated countries

Switch2Save Architectural Design Competition

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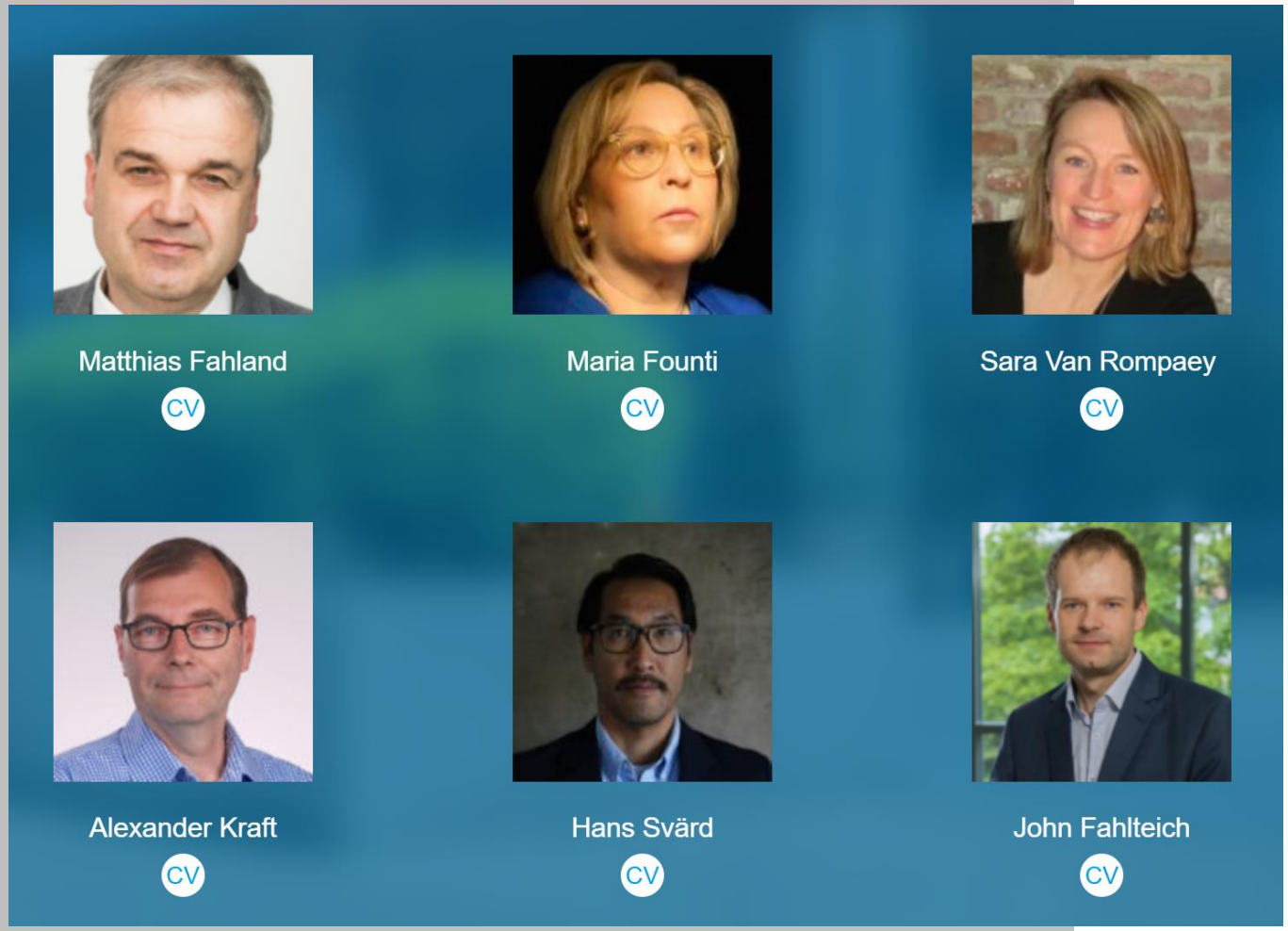
EVALUATION CRITERIA:

- Concept & Level of innovation
- Energy Saving Concept
- Exploitation of Switch2Save EC/TC smart functionalities & Replicability of the approach
- User comfort

Switch2Save Architectural Design Competition

JURY:



E²ARC
Architects for future cities

Switch2Save Architectural Design Competition

E²ARC
Architects for future cities

PRIZES:

1st prize: 1000 EUR

2nd prize: 500 EUR

\+ - demo kit of a fully functional energy smart EC/TC window
- Possibility to present the winning projects during Prize ceremony (travel expenses covered)
- Offer of internship at NTUA HMCS
- Publication at EU wide channels

All the participants will receive a digital participation certificate.

Switch2Save Architectural Design Competition

WHAT TO SUBMIT?

One pdf file (max. 30 MB) with:

- Brief description (see Competition Brief Template)
- Infographic (presenting the proposed design in response to the competition brief)
- Other visual material
- Declaration of Authorship and Acceptance of Competition regulations

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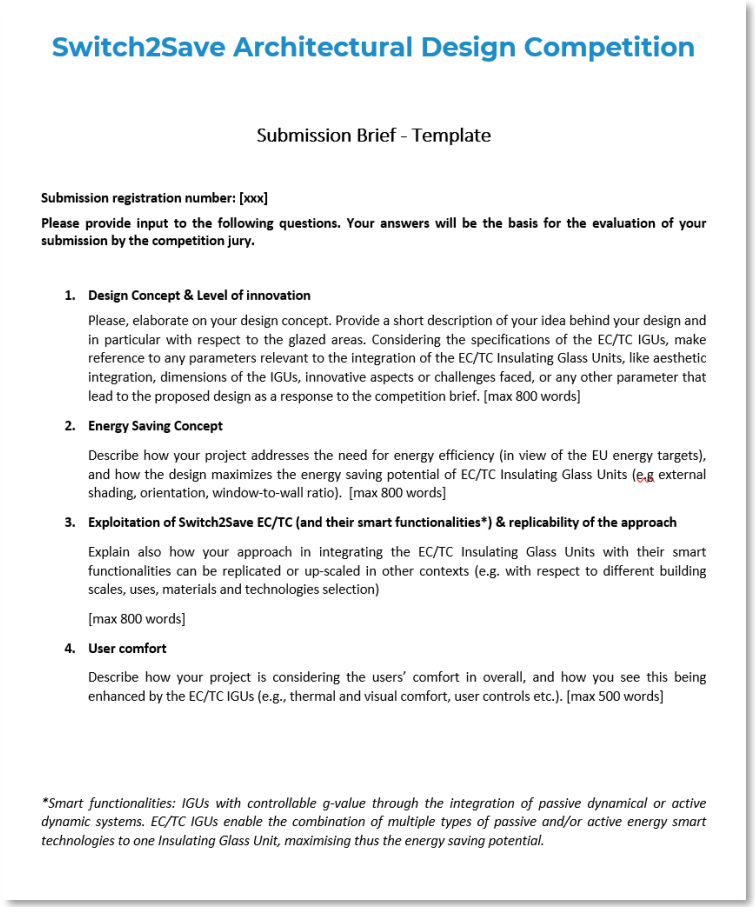


Switch2Save Architectural Design Competition

Submission Brief - Template

Submission registration number: [xxx]

Please provide input to the following questions. Your answers will be the basis for the evaluation of your submission by the competition jury.

1. **Design Concept & Level of innovation**

   Please, elaborate on your design concept. Provide a short description of your idea behind your design and in particular with respect to the glazed areas. Considering the specifications of the EC/TC IGUs, make reference to any parameters relevant to the integration of the EC/TC Insulating Glass Units, like aesthetic integration, dimensions of the IGUs, innovative aspects or challenges faced, or any other parameter that lead to the proposed design as a response to the competition brief. [max 800 words]

2. **Energy Saving Concept**

   Describe how your project addresses the need for energy efficiency (in view of the EU energy targets), and how the design maximizes the energy saving potential of EC/TC Insulating Glass Units (e.g external shading, orientation, window-to-wall ratio). [max 800 words]

3. **Exploitation of Switch2Save EC/TC (and their smart functionalities*) & replicability of the approach**

   Explain also how your approach in integrating the EC/TC Insulating Glass Units with their smart functionalities can be replicated or up-scaled in other contexts (e.g. with respect to different building scales, uses, materials and technologies selection)

   [max 800 words]

4. **User comfort**

   Describe how your project is considering the users' comfort in overall, and how you see this being enhanced by the EC/TC IGUs (e.g., thermal and visual comfort, user controls etc.). [max 500 words]

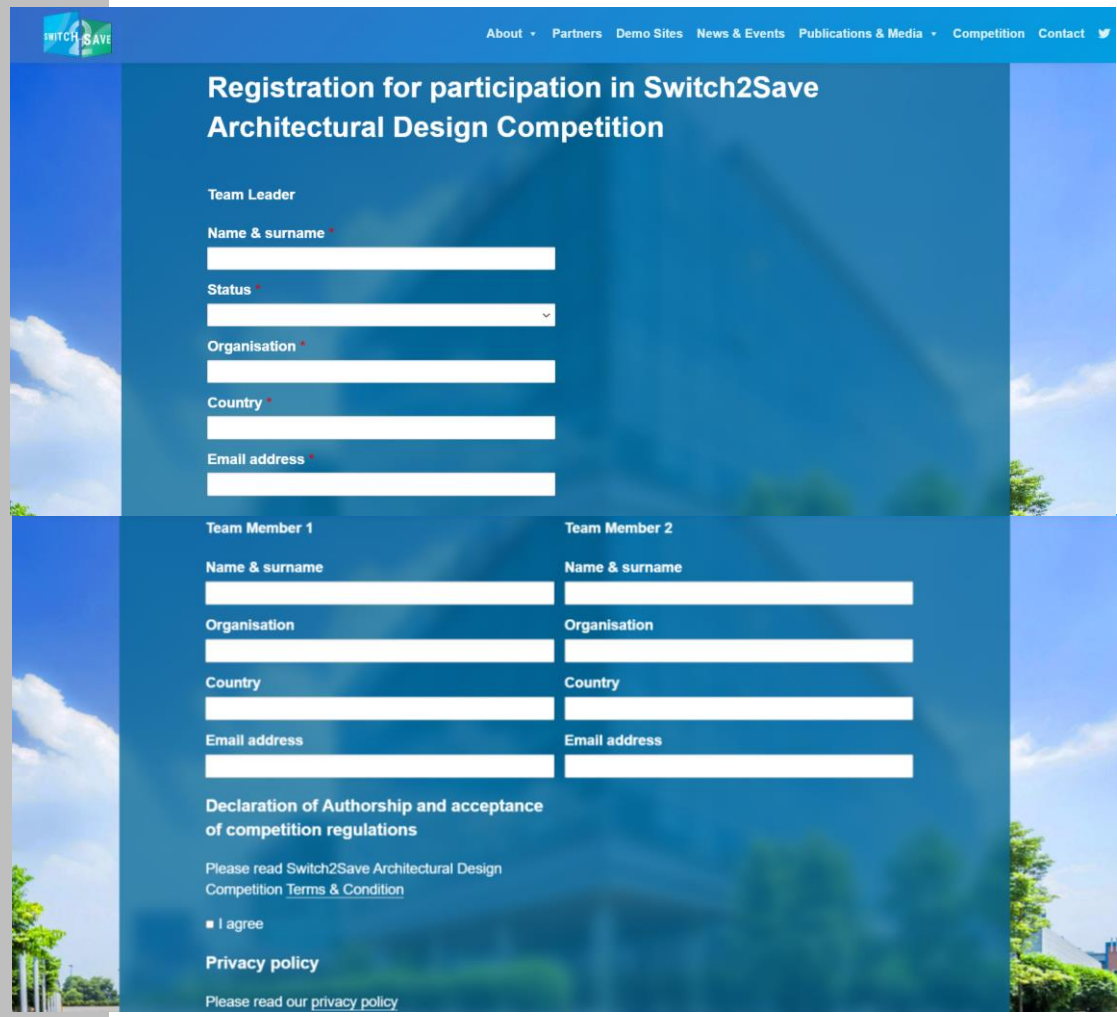
**Smart functionalities: IGUs with controllable g-value through the integration of passive dynamical or active dynamic systems. EC/TC IGUs enable the combination of multiple types of passive and/or active energy smart technologies to one Insulating Glass Unit, maximising thus the energy saving potential.*

Switch2Save Architectural Design Competition

HOW TO SUBMIT?

1. registration through link
2. confirmation of registration by email to Team leader including information on username & login & link to ownCloud folder
3. submission of proposal to ownCloud
4. confirmation of submission by email
5. information on final results by email

https://switch2save.eu/registration-for-participation-in-switch2save-architectural-design-competition/



Switch2Save Architectural Design Competition

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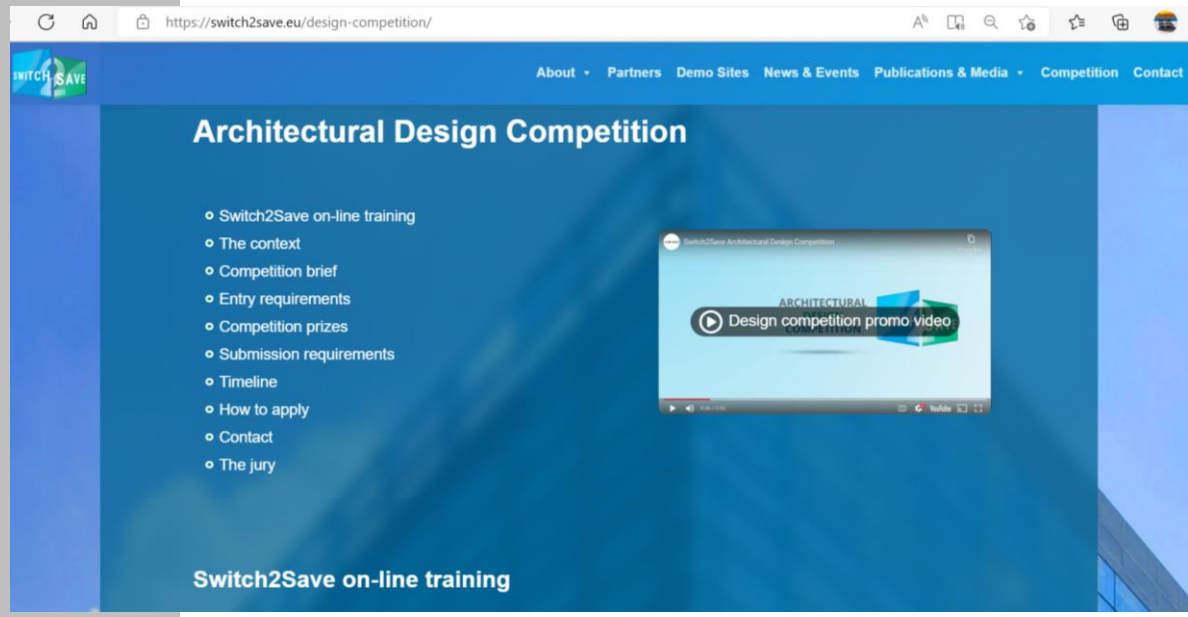
SCHEDULE:

- Competition launch: **20th October 2022**
- Registration deadline: **31st January 2023**
- Questions by: **28th February 2023**
- Submission: **31st March 2023**
- Winners Announcement: **16st May 2023**

https://switch2save.eu/design-competition/



Webinar - Lightweight switchable smart solutions for energy saving glass facades, 12th December 2022

Thank you!

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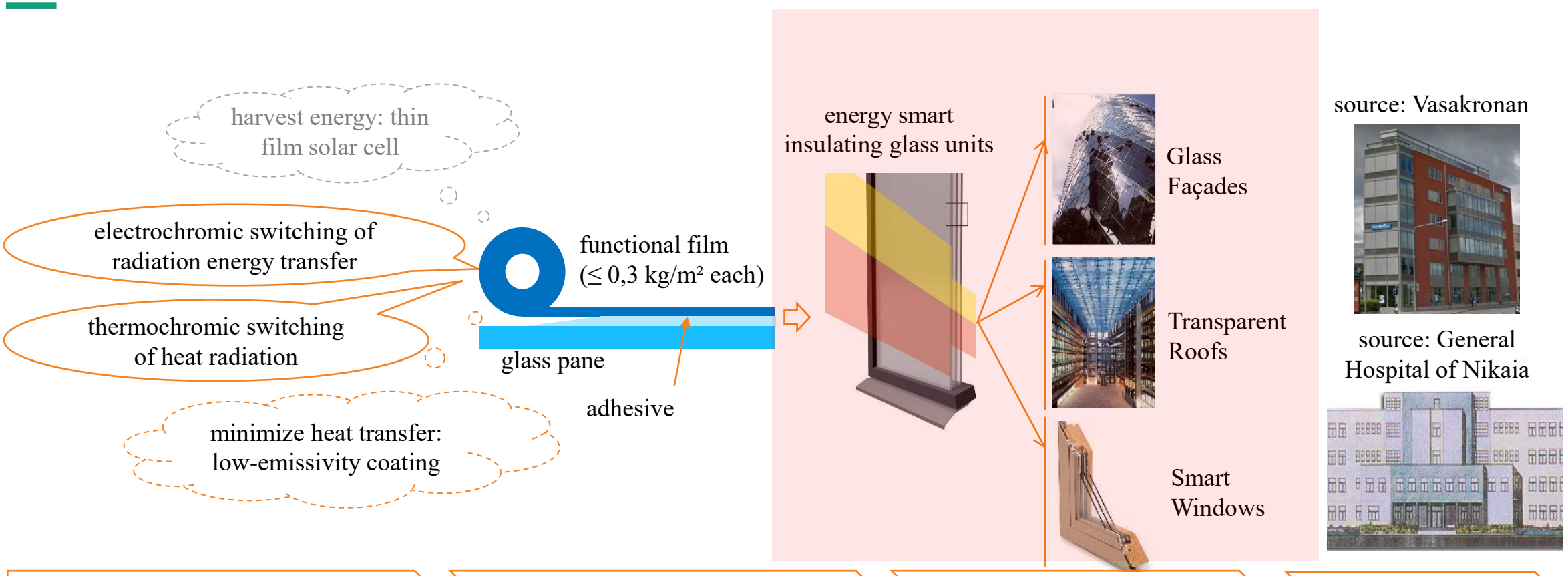
BUILD UP Workshop, 12th December 2022

Switch2Save - Project Impact Revisited

M. Fahland[1], [1]Fraunhofer FEP (Dresden, Germany)

Switch2Save project flow

Where are we now?



Fraunhofer FEP

Switch2Save impacts

Main catch-words of the impact section in the proposal

The Switch2Save Insulating Glass Units, with EC and TC technologies

- Prevent glare, fading and overheating:
- Eliminate the need for shades, blinds
- Improve the insulation on component level
- Will be cost effective (cost increase less than 15 %)
- Show that the use of Switch2Save windows with TC and/or EC films can reduce the energy demands for heating, cooling and lighting by up to 38%
- Improve of energy storage capacity
- Increase water and air tightness
- Allow retrofit in existing buildings

Mainly the goals are either met or to be proven in the remaining project time

Key Results of Switch2Save

Status after M36

World‘s first roll-to-roll made, lightweight thermochromic system

High-performance hybrid electrochromic system > 75% VLT;

Fully wireless controllable, lightweight smart IGU

Novel testing procedures for photometric performance, indoor comfort, and window durability

Grant No: 869929

Key performance parameters

Comparison of results (present status) with the objectives of the proposal

KPI	Remark / Condition		Objective	Result
Energy saving potential	Building w. large glass facade; in Athens & Stockholm		> 20%	**30 … 63%**
EC / TC weight	Single EC (2x PET) + 100 µm coated thin glass		0,6 kg/m^2	**0,65 kg/m^2**
EC VLT modulation	Blue: hybrid PB / WO_3; red: improved NiO/WO_3		10 … 70%	**8 … 78%** **17 … 70%**
Thermochromic Cells	ZrO_2 / VO_2 / ZrO_2 on 100 µm NEG glass Made in roll-to-roll process	VLT	> 65%	**~60%**
		T_{switch}	< 30°C	**21°C**
		dimensions	> 4 x 0.3 m	**20 x 0.3 m**
Energy Smart Insulating Glass Unit	Switch2Save GEN1 IGU as to be integrated to demonstrator buildings (including improved EC cell); 3.6 x 1,2 m^2 demonstrator!	VLT bright	> 50%	**50%**
		weight	< 75 kg/m^2	**55.4 kg/m^2**
		cost est.	< 300 €/m^2	**295 €**
Sustainability / life-cycle / durability	*25 yrs service life; LCA acc. to ILCD handbook; fire-safety; CE pre-certification*		*3rd RP*	***3rd RP***

Grant No: 869929

Revisiting the concerns

Pro‘s and con‘s of smart windows are widely discussed in the public

Concern	Response of Switch2Save
Electrochromic windows are too expensive	?
Installation of electrochromic windows are too expensive	?
Thermochromic windows have a low light transmittance	?
Thermochromic windows have an unbeneficial colour	?
Thermochromic windows have an unbeneficial transition temperature	?
Thermochromic windows have a large hysteresis	?

Grant No: 869929

Revisiting the concerns

“Electrochromic windows are too expensive”

Switch2Save answer:

Improved performance of electrochromic coating

- Objective: modulation of visual light transmittance:

10 % (dark state) 70% (bright state)

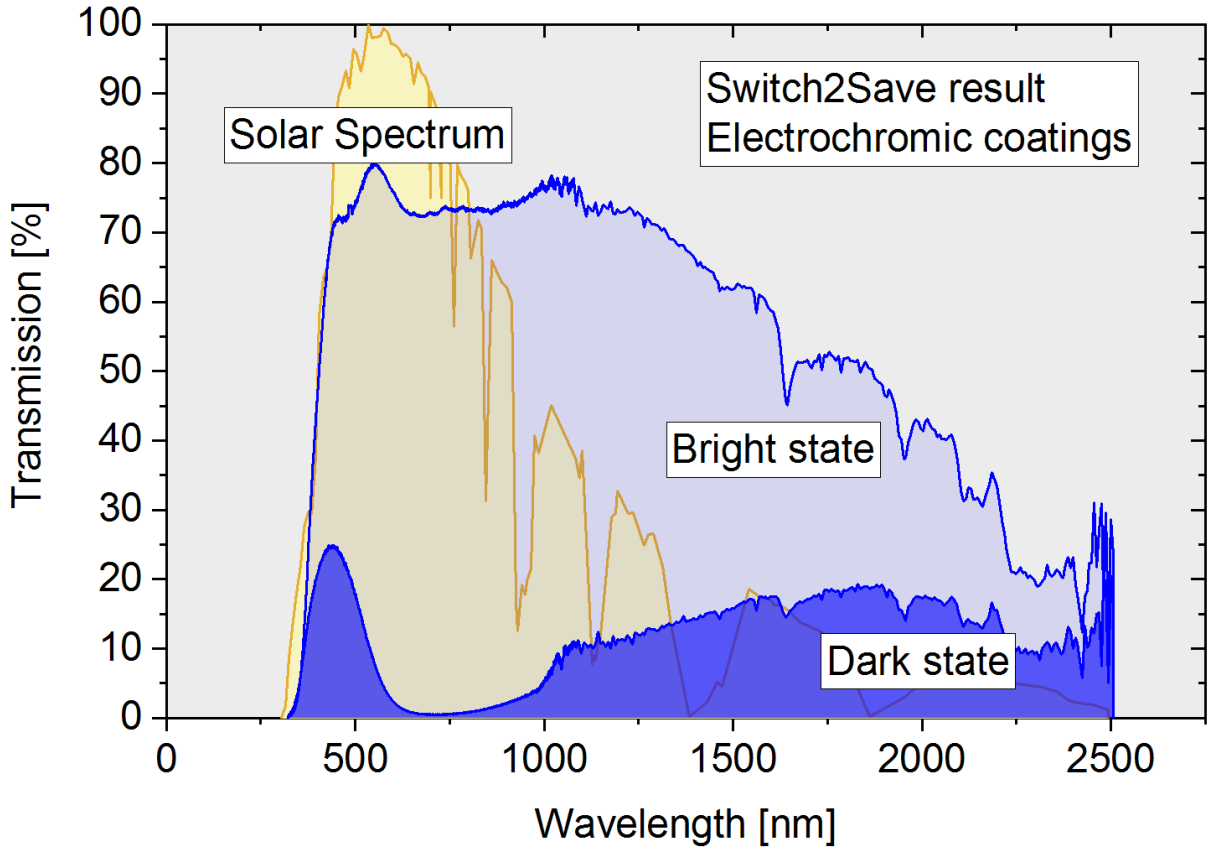
- Achieved for the modulation of the visual light transmission

10 % (dark state) 70% (bright state)

By improvement of established technology at the partner Chromogenics

8 % (dark state) 78% (bright state)

By combining the technologies of Chromogenics and Fraunhofer ISC



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Revisiting the concerns

Pro‘s and con‘s of smart windows are widely discussed in the public

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Thermochromic windows have a large hysteresis	?

Grant No: 869929

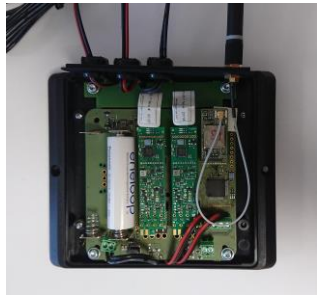
Revisiting the concerns

“Installation of electrochromic windows are too expensive”

Switch2Save answer:

Wireless control / energy harvesting

- Incorporation of photovoltaic modules in the frame of the window
- Incorporation of energy storage in the frame of the window
- Self sufficient control unit can wirelessly be connected to SMARTHome and SMARTCommercial systems



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Revisiting the concerns

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Thermochromic windows have an unbeneficial transition temperature	?
Thermochromic windows have a large hysteresis	?

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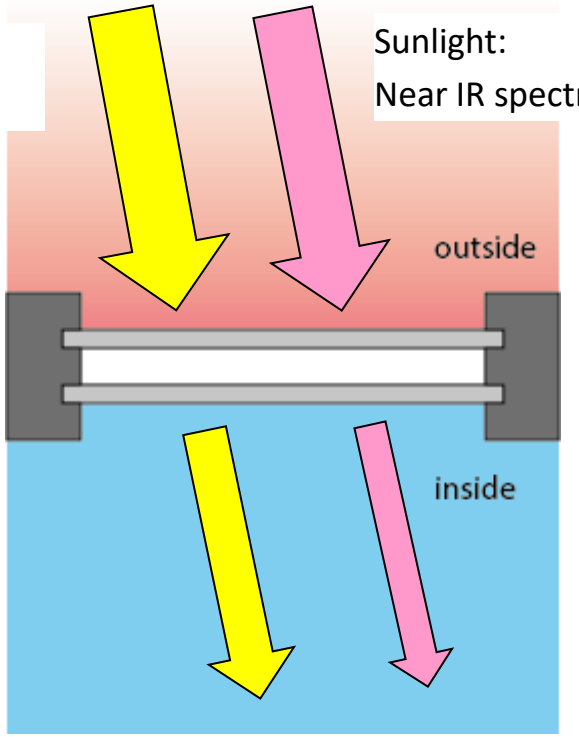
Revisiting the concerns

“Thermochromic windows have a low light transmittance/ unbeneficial colour”

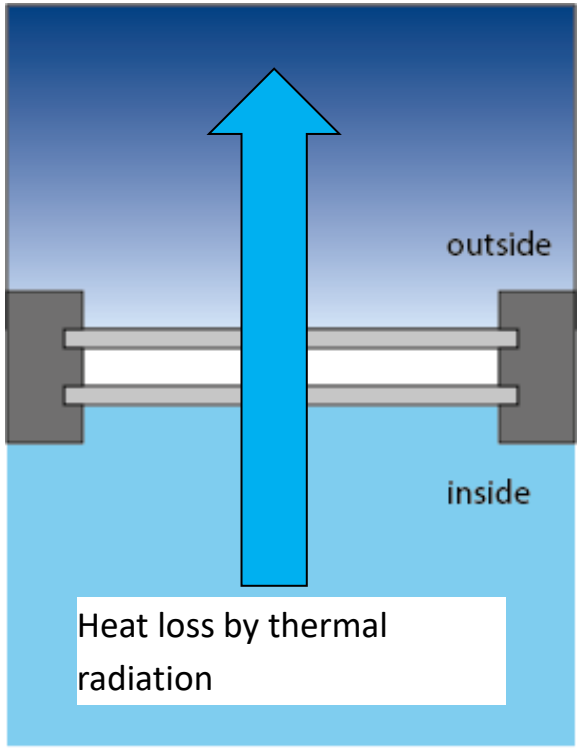
Switch2Save answer:

Consider use case of transparent roofs over cold rooms

Sunlight:
Visible spectral range



Window with thermochromic coating: WARM state



Window with thermochromic coating: COLD state

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Revisiting the concerns

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Installation of electrochromic windows are too expensive	Wireless control / energy harvesting
Thermochromic windows have a low light transmittance	Consider use case of transparent roofs over cold rooms
Thermochromic windows have an unbeneficial colour	
Thermochromic windows have an unbeneficial transition temperature	?
Thermochromic windows have a large hysteresis	?

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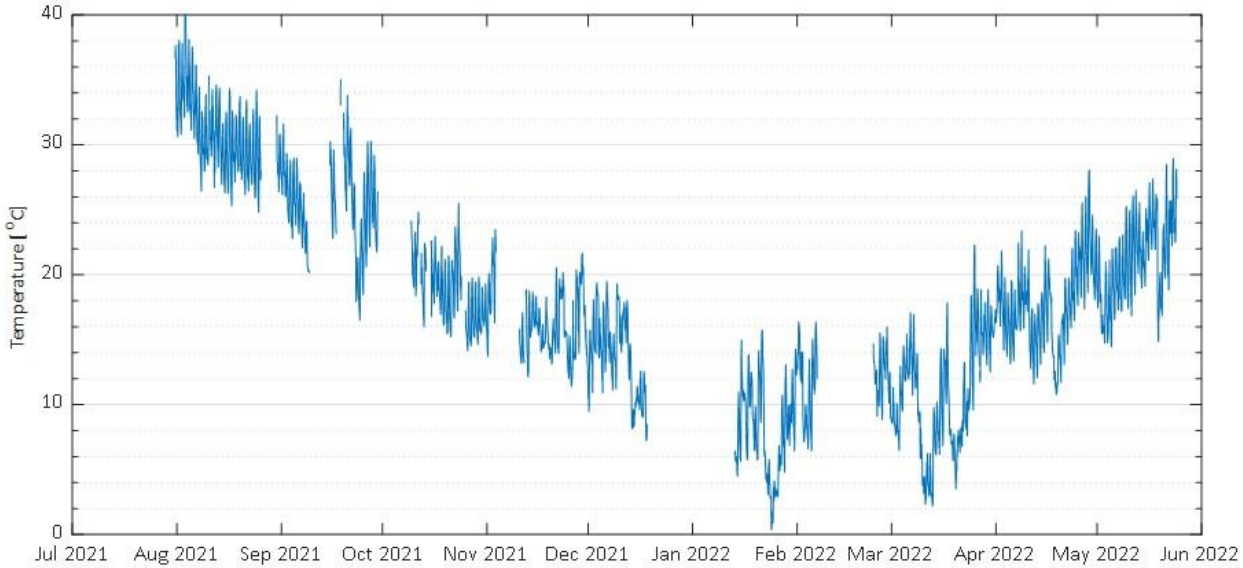
Revisiting the concerns

“Thermochromic windows have a unbeneficial transition temperature and large hysteresis”

Temperature variation at geographic location

Example: Athens

Day-night modulation roughly constant at 10 K over the entire year, but on different levels

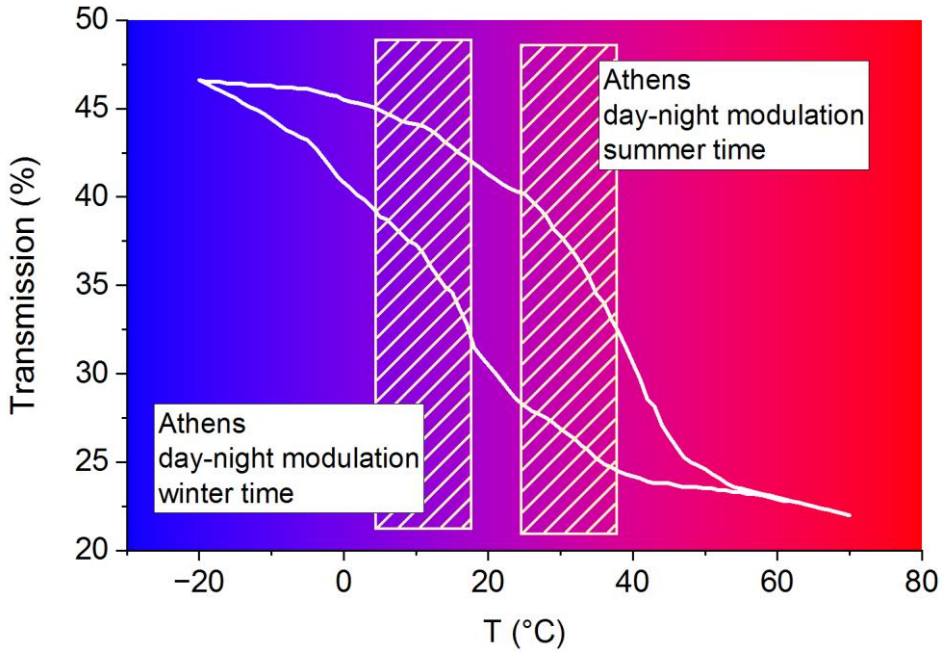


Adaptation of geographic location

Increases the effectiveness of the material

Essential for exploitation of day-night modulation

Requirement for research: property-on-demand approach



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TRL levels

Electrochromic coating improved layer stack

Electrochromic coating standard layer stack

Electrochromic coating layer stack, combined CMG/FhG

Thermochromic coating

Fraunhofer FEP

Beyond Europe (1)

What is more important: Cooling of Heating?

Geographic location	Impact of heating	Impact of cooling	Importance EC coatings	Importance TC coatings
Predominantly cold climate	Very High	Moderate	Topic of Switch2Save	Low
Moderate climate with a majority of cold days (Mid Europe)	High	Moderate		Low
Moderate climate with a majority of warm days (South Europe)	Low	Very high	Topic of Switch2Save	Moderate
Predominantly warm climate	Not existing	Very high		High

Beyond today, beyond Europe (2)

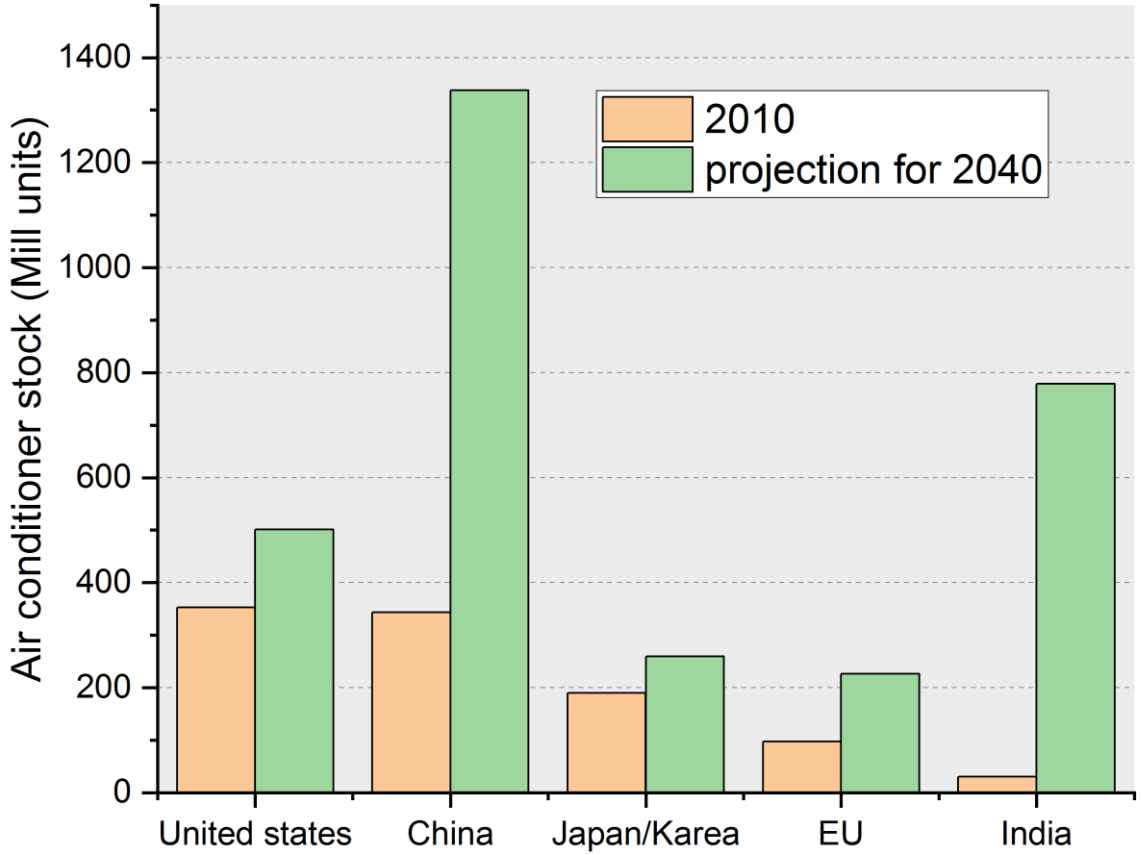
Cooling!

Today:

- Impact of cooling in residential buildings is negligible for the energy consumption in the European Union
- Impact of cooling in non-residential buildings is important for the energy consumption in the European Union, but not dominating

The future:

- Importance of cooling in residential and non-residential buildings will increase for the energy consumption in the European Union
- Cooling will globally dominate the energy consumption of buildings



https://www.iea.org/reports/the-future-of-cooling

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NETWORKING

Cooperation with other European consortia in the framework of SUSTAINABLE PLACES

PLURAL:

PLUG-AND-USE RENOVATION WITH ADAPTABLE LIGHTWEIGHT SYSTEMS

https://www.plural-renovation.eu/

PLURAL

POWERSKIN+

Highly advanced modular integration of insulation, energizing and storage systems for non-residential buildings

https://www.powerskinplus.eu/

POWER SKIN +

Fraunhofer FEP

Summary

Switch2Save:

- Provides window components for energy efficient renovations
- Demo sites are starting, effect can be measured in appr. 1 year

What is needed:

- Further funding for bringing up the TRL levels of the most efficient solutions
- Extending the view beyond Europe for achieving the highest possible effect of the developed technologies.

Switch2Save: Motivation

Reducing primary energy consumption in the building sector

The building sector accounts for 40% of total energy consumption in the European Union

https://www.irbnet.de/daten/iconda/CIB_DC26383.pdf

Windows are an essential component in the building envelope, regulating the flow of energy into and out of the building

M. Cassini ; Renewable Energy 119 (2018)

Improving the energy efficiency of existing buildings could reduce the EU's total energy consumption by 5-6%

https://ec.europa.eu/info/news/focus-energy-efficiency-buildings-2020-lut-17_en>

Fraunhofer FEP

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Thank you for your Attention