

Framework Validation Instrument (MS Forms)

Introduction

Integrating components of solar cooling technologies into facades can be defined as building envelope systems that include elements using and/or controlling solar radiation to deliver self-sufficient solar renewable electric and/or thermal energy needed to generate cooling effect in a particular indoor environment.

In this exercise, you will go through the process of designing and developing solar cooling integrated façades to understand how the aspects considered can support design decisions. The exercise will take approximately 5 to 10 minutes.

Kind regards,

Hamza Hamida

PhD Candidate

Architectural Façades & Products (AF&P) Research Group

Delft University of Technology (TU Delft)

Email: H.B.Hamida@tudelft.nl

Survey Informed Consent Form (Section A)

- I consent voluntarily to be a participant in this study and understand that I can refuse to answer questions and I can withdraw from the study at any time, without having to give a reason.
- I understand that taking part in the study involves filling an online survey.
- I understand that the study will end within 5 to 10 minutes.
- I understand that risks related maintaining the confidentiality and privacy will be mitigated by the following actions:
 1. Storing survey data on the TU Delft storage drive where it will have a restricted access only among the study team.
 2. Names of participants are not required.
 3. The use of Microsoft Forms platform provided by TU Delft is used as much as possible.
- I understand that survey does not collect personal information collected about participants that can identify them, such as names or emails.
- I understand that after the research study the de-identified information I provide will be used for publications and academic purposes.
- I agree that my responses, views or other input can be quoted anonymously in research outputs.
- I give permission for the de-identified anonymized transcripts that I provide to be archived in 4TU.Reserch Data repository so it can be used for future research and learning.
- I understand that access to this repository is unrestricted.
 - **I agree to all of the aforementioned points**

General Information of the Participants (Section B)

1. What is your main educational and technical background? (You can choose more than one option)

- | | |
|--------------------------------------------|-------------------------------------------------|
| <input type="checkbox"/> Architecture | <input type="checkbox"/> Mechanical Engineering |
| <input type="checkbox"/> Building Physics | <input type="checkbox"/> Electrical Engineering |
| <input type="checkbox"/> Civil Engineering | <input type="checkbox"/> Others: _____ |

2. What is your field of professional experiences in the building industry? (You may select more than one option.)

- ☐ Client Team: Owner, investor, and/or real estate/property developer.
- ☐ Design Team: Design coordinator, architectural designer, façade designer, and/or consultant (Mechanical, Electrical and Plumbing (MEP), building physics, or facade consulting).
- ☐ Construction Team: Contractor, subcontractor, supplier/manufacturer, and/or façade builder/assembler.
- ☐ Others: _____

3. Professional years of experience

- ☐ Less than 5 years
- ☐ 5 to 10 years
- ☐ 11 to 15 years
- ☐ 16 to 20 years
- ☐ More than 20 years

4. In which countries have most of the projects you have worked on been located? (You may select more than one option.)

- | | |
|-----------------------------------------------------|-------------------------------------------------|
| <input type="checkbox"/> Europe | <input type="checkbox"/> East Asia (E.g. China) |
| <input type="checkbox"/> North America (USA/Canada) | <input type="checkbox"/> Others: _____ |
| <input type="checkbox"/> Middle-East | |

5. Which of the following types of projects have you worked on? (You can choose more than one option)

- ☐ Design and/or construction of building facades (Design, production, installation, and/or maintenance/operation).
- ☐ Application of solar technologies in buildings (Photovoltaics (PV), Solar Thermal Collectors (STC), and/or Photovoltaic Thermal Collectors (PVT))
- ☐ Application of solar cooling technologies in buildings (Photovoltaic (PV)-assisted vapor-compression air-conditioning equipment, thermoelectric, absorption, adsorption, desiccant, or thermomechanical technologies).
- ☐ Façade integration of solar or solar cooling technologies
- ☐ Others: _____

4. Façade Design and Development Process (Section C)

In this section, you will go through the design and development process of solar cooling integrated façades.

Based on your background, you will assume the role of a design or construction team to explore how this process can support the application of the technology.

Please consider the following conceptual design for a new office building in Madrid. The project client is a private investor. The building has the following features:

- **Function:** Office building (5 story building)
- **Project:** New construction
- **Location:** Madrid, Spain
- **Window-to-Wall Ratio (WWR):** 55%
- **Opaque façade:** Ventilated Façade-Multi-layered opaque external walls (U-Value = 0.263 [W/m²K])
- **Glazing (Openings):** Double-glazing low-emissive (U-Value = 1.35 [W/m²K])
- **Roofs (Top slab):** Cast concrete slab (U-value = 0.21 [W/m²K])
- **Building annual energy use intensity:** 227.02 [kWh/m²/year]
- **Building annual cooling demand intensity:** 53.61 [kWh/m²/year]
- **Building average daily cooling demand in Summer Design Week:** 9805.58 [kWh/day]

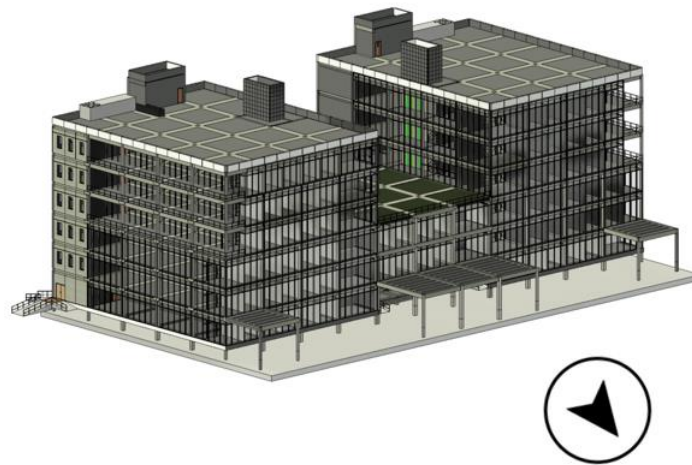


Figure 1: Reference Building

1. Consider the following five façade design and development stages. At which stage can the integration of solar cooling technologies (or other solar technologies) into the façade be considered?

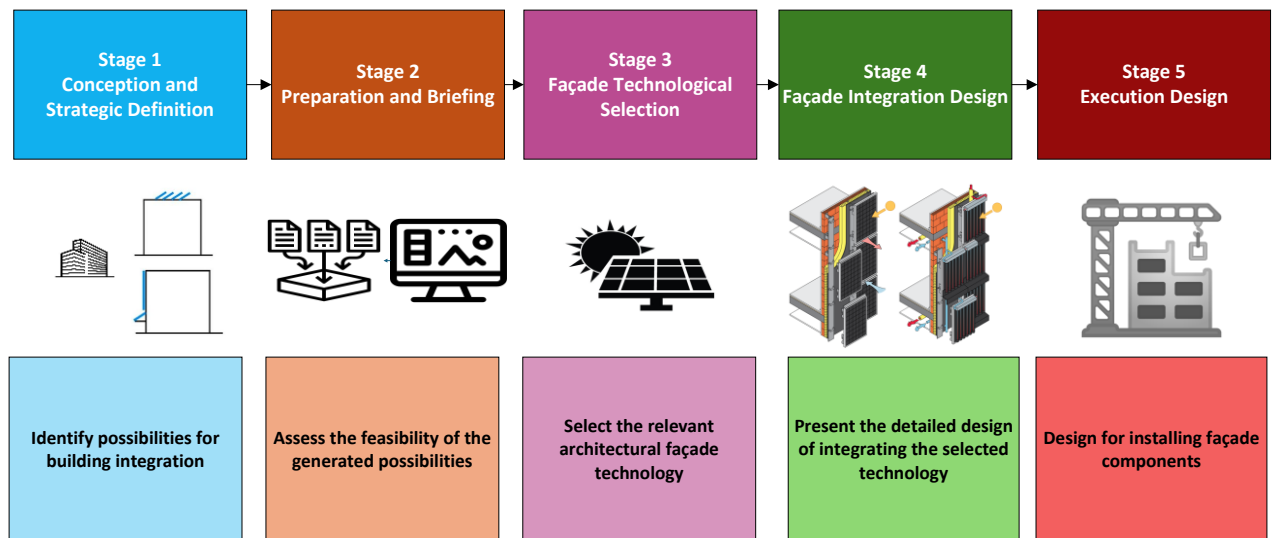


Figure I.2: Design and development stages

- () Stage 1: Conception and Strategic Definition
- () Stage 2: Preparation and Briefing
- () Stage 3: Façade Technological Selection
- () Stage 4: Façade Integration Design
- () Stage 5: Execution Design

2. To make the choice to integrate solar cooling technologies (or other solar technologies), which of the following key stakeholders should make this decision? (You can choose up to two options)

- | | |
|---------------------------------------------------------------------------------|------------------------------------------------------|
| <input type="checkbox"/> Owner, investor, and/or real estate/property developer | <input type="checkbox"/> Façade designer |
| <input type="checkbox"/> Architectural designer | <input type="checkbox"/> Building physics consultant |
| <input type="checkbox"/> Contractors | <input type="checkbox"/> Suppliers |
| <input type="checkbox"/> Others: _____ | |

3. If you would consider one of the following envelope integration possibilities, what key information is required to support or process these decisions? (You may select more than one option.)

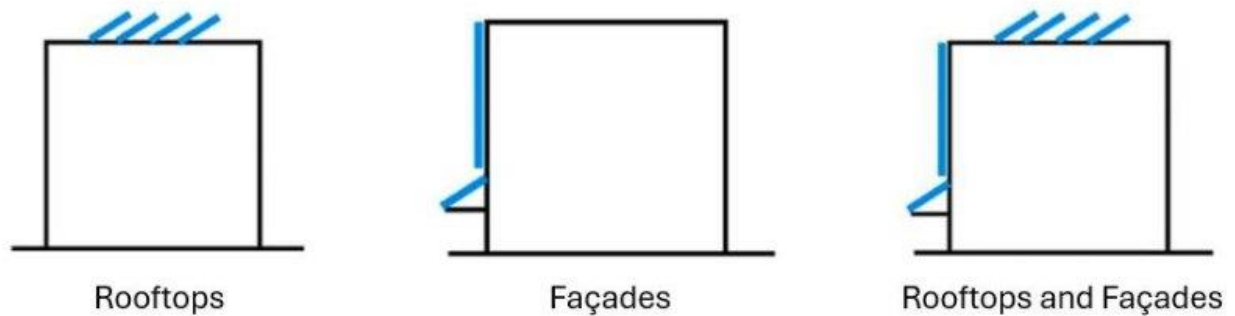


Figure 3: Envelope integration possibilities

- | | |
|------------------------------------------------------------|------------------------------------------------------------------------|
| <input type="checkbox"/> Construction activities | <input type="checkbox"/> Building drawings |
| <input type="checkbox"/> Working materials of technologies | <input type="checkbox"/> Performances and efficiencies of technologies |
| <input type="checkbox"/> Cooling Demand | <input type="checkbox"/> Costs |
| <input type="checkbox"/> Regulatory requirements | <input type="checkbox"/> Others: _____ |

4. Based on your expertise and the information provided about the office case, please rank the decisions in the order they should be made, from the first to the last. (Drag and drop the boxes vertically to arrange them accordingly.)

- Determine available envelope possibilities meeting cooling demand
- Determine installation techniques for the façade system and identify the required construction equipment
- Determine relevant measures to optimize building design

5. Based on your expertise, please rank the technical design criteria in the order they could be considered, from the first to the last. (Drag and drop the boxes vertically to arrange them accordingly.)

- **Assembly and connections** (connection of components, physical integration, and the nature of working principle of applied components)
- **Compactness and space usability** (amount of used area and space by solar cooling components, bulkiness of products, and structural support requirements)
- **Product performance and efficiency** (the ability to meet cooling requirement)
- **Maintenance requirements** (periodic maintenance, product cleaning, and product accessibility)

6. If you would determine a suitable solar cooling technology to develop design solutions, what key information is required to support or process these decisions? (You may select more than one option.)



Thermally-Driven Systems
(Absorption, Adsorption, Desiccant, or
Thermomechanical technologies)

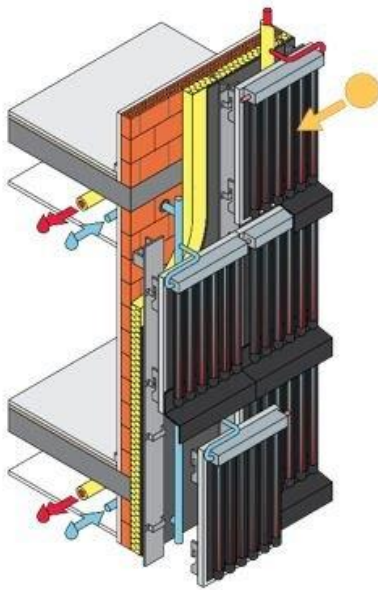


Electrically-Driven Systems
(Photovoltaic (PV)-assisted vapor-
compression air-conditioning equipment or
Thermoelectric technologies)

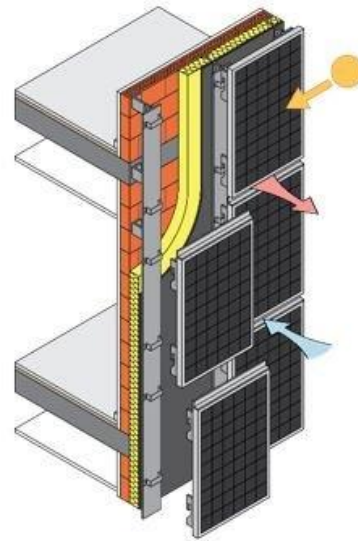
Figure 4: Types of solar cooling technologies

- | | |
|------------------------------------------------------------------------|-----------------------------------------------------------------------|
| <input type="checkbox"/> Building drawings | <input type="checkbox"/> Working materials of technologies |
| <input type="checkbox"/> Weather, geographic and urban data | <input type="checkbox"/> Construction characteristics of the envelope |
| <input type="checkbox"/> Performances and efficiencies of technologies | <input type="checkbox"/> Others: _____ |

7. Based on your expertise, what financial factors should be considered to evaluate the following design solutions?



Thermally-Driven Systems
(Absorption, Adsorption, Desiccant, or
Thermomechanical technologies)



Electrically-Driven Systems
(Photovoltaic (PV)-assisted vapor-
compression air-conditioning equipment
or Thermoelectric technologies)

Figure 5: Design solutions

☐ Initial Investment Cost

☐ Government Subsidies

☐ Energy Prices

☐ Return on Investment (Payback Period)

☐ Annual solar renewable energy produced by the
technology

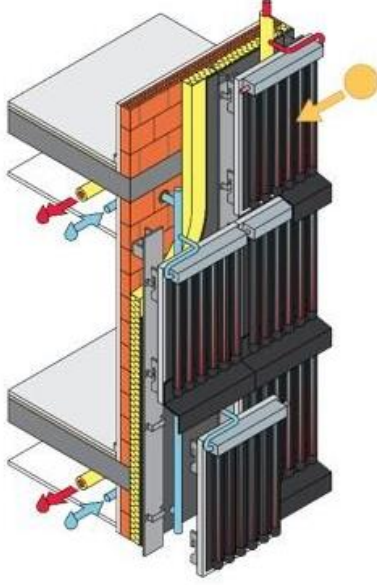
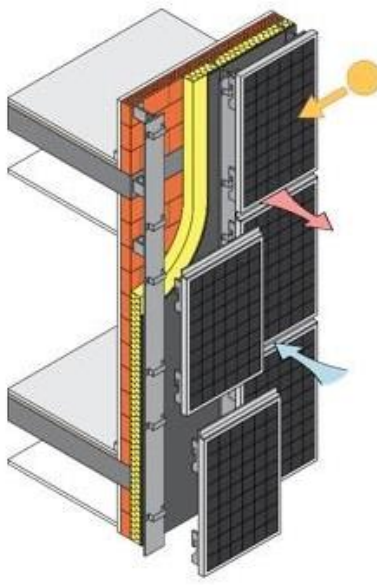
☐ Total life cycle cost

☐ Project Budget

☐ Others: _____

8. Which of the following design solutions might be relevant based on the provided information?

Table 1: Design solutions

		
Design Solution	Thermally-Driven Systems (Double-Effect Adsorption Chiller and Evacuated Tubes Collectors)	Electrically-Driven Systems (Water-Cooled Vapor Compression Chiller and PV Panels)
Efficiency of the solar collection system	65%	22%
Coefficient of performance (COP) of the cooling technology	1.2	2.6
Solar Fraction (Cooling effect delivered by the technology/cooling demand)	1.394	1.022
Life Cycle Cost in Annual Worth (20 years) [€/year]	111,800	52,800
Levelized Cost of Cooling [€/kWh/year]	0.095	0.059

- () Thermally-Driven Systems (Double-Effect Adsorption Chiller and Evacuated Tubes Collectors)
() Electrically-Driven Systems (Water-Cooled Vapor Compression Chiller and PV Panels)

9. What were the main factors that influenced your selection of this solution? (You can choose up to two options)

- ☐ Efficiency of the solar collection system
- ☐ Coefficient of performance (COP) of the cooling technology
- ☐ Solar Fraction (Cooling effect delivered by the technology /cooling demand)
- ☐ Life Cycle Cost in Annual Worth
- ☐ Levelized Cost of Cooling

Reflection (Section D)

1. Based on the provided information, would you integrate solar cooling technologies into the office building?

- ☐ Yes
- ☐ I am not sure
- ☐ No

2. How did the information presented during the process of designing and developing solar cooling integrated façades help you make decisions?

- ☐ To a great extent – they provide comprehensive guidance across all design stages
- ☐ To a moderate extent – they support certain key phases but not all
- ☐ To a limited extent – they offer only general direction
- ☐ Not at all – they are not applicable or relevant to the design process
- ☐ I am not sure / I need more information to assess

3. Based on the previous case, what were the key struggles you faced when making decisions?

4. Reflecting on the previous case, what information or support do you feel was lacking?