

### 5 to 8 Minutes Introduction

- Collection of information about the interviewee (educational and technical background, field of professional experiences, professional years of experience, involvement in different types of projects).
- Brief introduction about the interview.

#### Interviewer

Now let me start with the opening questions. So this was only a brief introduction. So [Name of Interviewee 10] let me start with the first question. In your experience, what is the current level of knowledge in the building industry regarding the application of multifunctional facade components integrating solar cooling technologies?

#### Interviewee 10

I think the current level in the building industry is very low, I think. Yeah, a lot of people even think that it is not possible to use PV in the facade, although we have done that for more than 25 years.

#### Interviewer

OK

#### Interviewee 10

And other people think it's very dangerous. And solar cooling.....Well I have rarely met any people who think about that.

#### Interviewer

OK, I got your point. Now let me move to the following question. So in your experience, what are the motivating factors for the application of multifunctional facade components integrating solar cooling technologies?

#### Interviewee 10

Well we have to make zero energy buildings to prevent the climate change, first of all. And I think the solar is beautiful source of free energy that that we can use for that. And we have a high cooling demand in our buildings, of course.

#### Interviewer

I asked you about the motivating factors....Now what are your concerns regarding the application of multifunctional facade components integrating solar cooling technologies?

#### Interviewee 10

Well, the biggest problem for PV is fire safety. By far I think. And the biggest issue for solar thermal is to prevent freezing in the systems. This is quite complicated to make a good working system in the facade with all those tubes and water.

#### Interviewer

So for these concerns. are there some ways to address such concerns?

#### Interviewee 10

Ohh yes yeah.

**Interviewer**

So for example?

**Interviewee 10**

About fire, yeah, you have to use a certain quality of the PV panels. So no standard PV panels with glassed glass. You can use insulation materials that are non-combustible.

And further you can separate the different PV parts from other parts so you don't get a.....You reduce the fire spread along the façade. So that there are a few things that you could do to prevent a fire in the facade. About solar thermal collectors, well there are ways for anti-freezing systems...And the take technology is there but it is not known in the building industry. It is the field of the mechanical engineer, usually. And that are two different worlds that you have to combine, if you bring those together. Yeah.

**Interviewer**

OK, now let me move to the following question. So I'll move to more to the built environment. So I have few questions about the built environment. So how can the type of project such as renovation project or new building construction influence the applicability of solar cooling integrated facades?

**Interviewee 10**

Well, it starts with the initiative to do so. You need a principle that wants to make a zero energy building and with not afraid for a few complications, for not proven technology. And those principles are very rare. That's the first thing and the second thing is that innovation is expensive and it needs more time. It needs more money. And I think it would help if we get some funding from the government to do so.

**Interviewer**

OK, but how do you see the application of façade products integrating solar cooling technologies in different types of projects? So we have like the application in the new building construction or renovation projects. So how do you how do you see this variation of the projects...how can it affect the applicability of such facade concepts?

**Interviewee 10**

I don't think I understand the question, sorry.

**Interviewer**

So let me ask...so how can the type of project such as new building construction or renovation projects influence the applicability of solar cooling integrated facades?

**Interviewee 10**

Yeah for new buildings you have more options of course, or design freedom. Make it easier to define a certain layout of your facade. New builds usually easier than renovation.

In renovation project projects, we also have to improve the thermal performance of the facade, of course. Usually the fire safety, the noise .... we have so many other issues to solve.

**Interviewer**

OK. This is what I meant by the question to have your opinion about different types of projects. So now I have the same question but instead of the type of project, it is about the building type. So how can the building type such as office, residential, healthcare, education or others influence the applicability of such facade products?

**Interviewee 10**

Well, I think there is a...we have to question about the....how do you say that the amount of solar energy that you generate and the amount of cooling that you need? And that there must be a kind of balance in it. And what we have seen in our study is that the that balance is different for different types of building. For example in a living you need a daylight, enough daylight or in an office or school you need a lot of daylight. So there is little opaque panel left for PV or solar thermal systems. But on the other hand, there was also a different need for cooling or hot water maybe. That's also an opportunity, of course.

**Interviewer**

I see.

**Interviewee 10**

Like, for a hospital you need a lot of hot water and so you don't even need a conversion from the solar thermal panels to the hot water. That's even easier.

**Interviewer**

OK, I see.

OK, now I'll move to the following question. In your experience, how do the locations and the climate conditions of buildings affect the performance of solar cooling integrated facades?

**Interviewee 10**

Yeah, the main issue is adjacent buildings. Have some shadow on the facades. And we built a lot in our cities, of course. And also the new buildings are usually placed on small spots in cities. So they're partially shaded.

**Interviewer**

OK. So generally what are the locations and the climate conditions would you suggest for applying facade products integrating solar cooling technologies?

**Interviewee 10**

Well with no shading or little shading.

Usually Southside.

**Interviewer**

South sides, OK.

So now, I'll ask about the technology. So do you think that the choice of solar cooling technology namely electrically driven or thermally driven would affect the application of such facade products in a particular building project?

**Interviewee 10**

Yes, I think so.

**Interviewer**

So in which way it will affect?

**Interviewee 10**

If we want to introduce this in an economic feasible way, we need to have products that are easy to install and also match what the other requirements that we need for a facade. But yeah, what I said, the most difficult thing is that how do you combine the electrical installation or the mechanical installation with the building installation? That are two different worlds, two different engineers, different companies. So you need to solve that in a very simple way, a plug and play system, for example, to make such an idea feasible, I think.

**Interviewer**

OK. So now I covered the opening questions. I'll move to the to the key questions.

So in the key questions, I'll have questions about technical and product related aspects, then questions about financial aspects, and then I have some questions about process and stakeholders. So let me start with the technical and product related aspects. So in your opinion, what makes solar cooling integrated facades complex products?

**Interviewee 10**

The tubes that have to be connected. And the risk of freezing. So you must always empty the system in case of cold weather, at least in our climate, of course.....and that makes it....yeah...vulnerable because such system can fail maybe.

**Interviewer**

So one way to address such complexities like we make them empty during cold weathers or something like that...?

**Interviewee 10**

Yeah and I know we do that in the roof applications as well. So it's possible but it has to be designed.

**Interviewer**

OK, so now let me move to the following questions.

How could we address challenges related to this space availability or interrupting other building services?

**Interviewee 10**

What do you mean with space....? Boiler...vessel or?

**Interviewer**

The special availability required for the for the equipment.

**Interviewee 10**

Yeah. It should do...you have to design it in the basement or on the rooftop or...In offices there is a lot of room in the in the ceiling.

But yeah, in the cities the thickness of the façade is even important because they want to make the building as big as possible on the spot that they have. So a more bulky facades, not desirable for the project developers.

**Interviewer**

OK. Now let's move to the following questions. So I have just two questions about product related aspects. Then I'll move to the financial aspects. So what are the key aspects to consider for the maintenance and the durability of solar cooling integrated facades?

**Interviewee 10**

Yeah, it always deals with total cost of ownership, of course. Some maintenance should be easy.

Yeah, what is important....yeah, maybe connections. I think that they could be risky in terms of maintenance.

**Interviewer**

The connection between...?

**Interviewee 10**

Yeah, cables or tubes.

**Interviewer**

OK, let's move to the following question. So how do you see the role of aesthetics in the widespread application of solar cooling integrated facades?

**Interviewee 10**

I think it's a key aspect, because if an architect is not enthusiastic, it will not be applied in the building. So it must be nice to have...Yeah.

**Interviewer**

So now I'll have some questions about financial aspects. So in your experience, how can the industry develop affordable and financially feasible facade products integrating such technologies?

**Interviewee 10**

Yeah. What we saw 20 years ago, it was at that time it was almost feasible for office buildings where the heat pump system.....So, yeah, I think....I don't know if the heat pumps are more expensive than 20 years ago, but I expect that they are less expensive. So like maybe you can confirm that....So that make me think that maybe we are not so far ahead and that there are other things that stands in our way to broad application.

**Interviewer**

OK, now let's move to the following questions. So what are the potential financial incentives that can support the widespread application of solar cooling integrated facades?

**Interviewee 10**

Subsidies, usually.

But maybe also, yeah, it's not financial, but legislations...That way have to make zero energy buildings.

And if not, yeah, you should be fined...we say that.

**Interviewer**

So what type of subsidies do you have in mind that could help?

**Interviewee 10**

Yeah, I think especially in the in the installation.

Design and installation phase because once it is there, yeah, there's always someone responsible for the following costs, so.

**Interviewer**

OK, so now I'll cover questions about processes and stakeholders. So let me start with the stakeholders. So you can see from this chart we have different stakeholders that are involved in the facade design and construction.

So this chart summarizes the relationship between different stakeholders in the facade design and construction industry. So my question is, in your experience, which of these stakeholders can support the application of solar cooling integrated facades?

**Interviewee 10**

Yeah, it's first of all, the investor. He or she plays a key role, I think, because in Netherlands we have many project developers who want to build for the lowest price, and like a building as simple as possible to sell it for the highest price as possible and those investors are not so interesting for application of new technologies. But when we have an investor who wants to use the building for himself and have a low total cost of ownership that could be the potential clients, especially in the in the beginning phase.

So there where it starts and what I said, the architects must like it. The general contractor must....I don't know if you notice theory of Professor Lichtenberg, but he says if there is any stakeholder in the building chain who doesn't want the new invention, It won't come. You need them all. You need them all, yeah. Otherwise it is going to fail.

**Interviewer**

OK. So my let's move to the following question. We are still in the stakeholders. So now in your opinion how can we increase the knowledge and experience of architects or engineers regarding technical aspects of integrating such technologies into building facades?

**Interviewee 10**

I think the best way to do so is to realize pilot projects. They can be small. I would recommend to keep them small in the beginning. But you must demonstrate that it works. And then you can make other people enthusiastic. So no complicated reports or whatever. Just do.

**Interviewer**

I see. OK, now let me move to the following question, but it is still related to this subject, but it's related to standards and guidelines. So what are the key elements that should be in standards or guidelines for architects and engineers that are related to the integration of solar cooling technologies into building facades?

**Interviewee 10**

For PV, we need more instructions or standards for making the system fire safe.

So what to do with cables? What to do with connectors? That kind of thing.

But they are all related to the temporary or to today's building guidelines.

So for solar thermal.....I don't know. No, I don't know.

**Interviewer**

OK. So now let me move to the following question. Generally how can the industry increase the variety of products that would attract customers to apply solar cooling integrated facades?

**Interviewee 10**

Maybe they can create a wanna-have product. Many buildings... .Many building designers want to make a unique building, with a unique appearance, so maybe they can think about an element that could have a print or the colour or whatever to customize it to your building. That would make it attractive and nice to have.

**Interviewer**

OK, I see now. Let me move to the following question. So overall, how can we increase the interest of designers, developers and the clients and solar cooling integrated facades?

**Interviewee 10**

Yeah, the same as what I said just before, it just do demonstrate how it works and let people look at your pilot project. Invite them. Let do measurements and demonstrate the revenues.

**Interviewer**

OK. Now let me move to the following questions. I have two questions about somehow stakeholders before moving to the processes. So how can changes in building regulations affect the widespread application of solar cooling integrated facades?

**Interviewee 10**

Well we must think about buildings that generate electricity instead of using electricity, and I think there is room for improvement in...Solar cooling is one of those means that we have.....but, yeah, I think most designers don't either think about this technology. So we have to promote it. That could work.

And before it could work, yeah...and I'm sure that if you build a pilot projects, it is not economically feasible at the moment, but yeah, you need to do it many times before you get an industry.

And make it, yeah, make it feasible....economically and yeah...that process should be supported.

**Interviewer**

OK, so now I have a question about.....So what about the changes in energy policies? How it would affect the application of solar cooling integrated facades?

**Interviewee 10**

Can you repeat the question?

**Interviewer**

How can changes in energy policies affect the widespread application of solar cooling integrated facades?

**Interviewee 10**

Yeah, they should even reduce the permissible energy amount that....the energy amount that you might use for a building.

And especially....how do you say it.....the generation of sustainable energy.

That should be....the level should be higher.

**Interviewer**

OK, now we'll move to the last part before the closing questions. I will move to the process aspects.

**Interviewee 10**

Yes.

**Interviewer**

So you can see that we have different processes. Starting from the design till the end of life.

So we have the design phase that have different like maybe considered sub-phases and we have the production phase, then the assembly phase, operation phase and for sure the end of life.

So my question is which phase is key for boosting the integration of solar cooling technologies into building facades?

**Interviewee 10**

Yeah. It starts with design phase, but if there are no products that could be integrated, the designers won't use for it. So I think that you have to use both.

And after all, the production phase will not come if there is no view on the assembly and the operation.

**Interviewer**

OK. So let me take each phase. So first of all, what are the key aspects or what are the main aspects to consider during the design phase of solar cooling integrated facades?

**Interviewee 10**

The energy balance of the building and the space that has to be used for this technology.

And the look and feel.

**Interviewer**

OK. Now let me move to the second question. So in your opinion how can we achieve a closer collaboration between various stakeholders and disciplines during early design stages of a facade integration of solar cooling technologies?

**Interviewee 10**

I think you need people from the solar cooling industry in the design phase of a building. Yeah, usually the design process is very traditional. We have an architect and fire consultant and the building physics consultant...but for this technology, especially in the pioneer phase, you need the experts from the industry to think with you to design a product and application. So there is a lot of way of t working than we are used to.

**Interviewer**

OK.

So now let move to the second one.

What are the key aspects to consider during the production phase of solar cooling integrated facades?

**Interviewee 10**

Yeah, the production phase....The main thing that counts is efficiency, and the efficiency is needed for a good process and a good price and a reliable product. So scaling up.

**Interviewer**

OK, scaling up.

**Interviewee 10**

Yeah.

**Interviewer**

So yeah, what do you mean by scaling up?

**Interviewee 10**

In the beginning you have one project than 10, but we will end with 100,000....before, yeah, the technology is grown up.

**Interviewer**

OK, So what about the assembly phase? What are the key aspects we need to consider for the assembly phase?

**Interviewee 10**

It should be simple without mistakes.

Plug and play, fast, without mistakes.

**Interviewer**

So are there specific aspects related to the required workforce? Do you have something in mind about the required workforce?

**Interviewee 10**

Well you see that the workforce is not always educated in the building industry. People come from all over the world, have several backgrounds. Both just want to do a job and then it's important that you need little specific knowledge to install such product. That is possibly, yeah, what I said, plug and play. It should be makeable with IKEA instructions, for example. Everybody could do it. Yeah.

**Interviewer**

So now let me move to the....I'm moving one by one. So now let me move to the operation phase. So what are the key aspects we need to consider for the operation phase of a façade product that integrates solar cooling technology?

**Interviewee 10**

Reliable. That is the key aspect and the second one is maintenance cost and reduction of maintenance cost.

**Interviewer**

OK, so but let me have a.....So are there some ways that we can reduce the cost of maintenance? Something in mind that could help?

**Interviewee 10**

Well, it should be good if there is little maintenance needed.

**Interviewer**

OK, OK. But what about....Do you have something in mind about the end user knowledge?

**Interviewee 10**

The end usual knowledge.....An then do you mean the building owner or the...?

**Interviewer**

The user like....the building user knowledge. So it's during the operation, we have the user.

**Interviewee 10**

The building user, yeah. I think the user isn't interested in the technology. It should work. When it's cold, you need some heat and when it's warm, you need cooling and that's it. A button to turn on. Nothing more.

**Interviewer**

OK, now let me move to the last question before moving to the closing questions. For sure it's about the end of life. And you are at the end of this part. So what about the end of life? What are the key aspects that we need to consider for the end of life?

**Interviewee 10**

Yeah, my personal opinion is that it should be circular. So that at the end of life it is dismantlable and we can reuse the components or the materials into new products.

**Interviewer**

OK. Can now let me move to the last part, which is the closing questions. So, first of all, what are your final or do you have any final remarks about the widespread application of solar cooling integrated facades as building products?

**Interviewee 10**

Well, as I see an opportunity for flat plate collectors that you could integrate in standard façade system and just by plugging it in, for example. And that a flat plate has an appearance that you could customize to your own colours and then, yeah.....and I know it will make it less, how do you say that, the yield will drop, maybe, if you use the wrong colour. But it will improve the application.

**Interviewer**

OK. So what do you think about the application of solar cooling integrated facades for enabling energy transition?

**Interviewee 10**

I believe in it. Yep. I think it is possible. It is feasible, but still unknown. But we have to find new ways, additional ways to meet the Paris [...] goals.

**Interviewer**

Now the last question, do you mind to propose potential participants that can be interviewed for this study?

**Interviewee 10**

Maybe it could be interesting to do interviews with the people.....