

### 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

So now I'll move to the opening questions. OK....So [Name of Interviewee 20], in your experience, what is the current level of knowledge in the building industry regarding the application of multifunctional façades components integrating solar cooling technologies?

#### Interviewee 20

I think it's quite low at the moment because it's not a common technology in façade design.....and by the way, facade design is really conventional most of the times in the Netherlands. So that's what I see and the application of this kind of technology is quite rare. Yeah, I didn't see it in projects yet.

#### Interviewer

So now I'll move to the following question. In your experience, what are the motivating factors for the application of multifunctional facades components integrating solar cooling technologies?

#### Interviewee 20

What we see is that the facade gets more and more important.....and very important aspects like climate control but also energy use of the building.....and in the near future, we will not be able to meet the requirements with the traditional technology. So we have to take next step in....for instance, solar cooling technology.....it adds to integrate of the use those technologies in the facade design. So yeah, I think that's.....yeah.

#### Interviewer

So these are the motivations. So now what are your concerns regarding the application of multifunctional facades components integrating solar cooling technologies?

#### Interviewee 20

Yeah, what we see is that developers are basically are a bit afraid of like a complex technology.....and a question that is often asked is "OK....is it a proven technology?". So they want to lower the risks to a minimum, or at least mitigate them to the max.....And with new technology, that's difficult. So it would really help if there is like some good references on projects, which preferably longer than 10 years. Otherwise they think well, it's still quite new and it's only for two or three years and OK, it functions now, but will it function also in 5, 10, 15 years? So, yeah, the proven technology is very important here.

#### Interviewer

So proven.....You mean by proven technology is....?

#### Interviewee 20

It's that it's applied and it functions with preferably.....without any defects or a complaint from users, etcetera.

### Interviewer

OK. Got it. So now I'll move to the following question. So this question is related to the type of project. You know we do have a new building construction. We have renovation projects. So the question is....how can the type of project, such as a new building construction or renovation projects, influences the applicability of solar cooling integrated facades?

### Interviewee 20

I think it depends a bit on which technology you want to use....When you design a new building, it's easier to apply new technology in it. When you have existing buildings, you have this baseline of specifications, of starting points. So, yeah, then it's more difficult to fit in these concepts, these technologies, but we've done it before.....I think we can do it also with this kind of technologies, but it's more difficult to detail it to.....for instance with cables and piping and stuff and that kind of things....yeah, your infrastructure of your installation. It can be difficult to go to the right spots in the building with your installation components. So in the facade I think it's not that difficult, but the installation behind is.....basically you don't have much piping and wiring towards facades, generally.....except maybe some electric wires for sunscreens and stuff, but when you want to transport, for instance, water or something, it requires bigger dimensions. So that can be an issue to get it in the right locations.

### Interviewer

I see. So now I'll move to the following question. So it's about the type of buildings. So how can the type of building, for example, office, residential, healthcare, educational, etcetera, influences the applicability of such facade products?

### Interviewee 20

I think it's easier to apply it in an office than residential, because.....for instance, when you build a high-rise and it's all apartments for sale, how you deal with ownership of the installation. It can be organised with what we have done in the Netherlands is VVE [Vereniging van Eigenaren – Owner's association]....It's like. Yeah, this vehicle that organizes the maintenance and stuff, and so everyone has to pay for it....and then the cost of maintenance or....So you can have installation which is not your private.....which are not a private owner. So for the cost and the benefits.....and so, for instance, what about....do you want to make a difference for housing with a South facades?....And with the north façade?.....because your system will have a different result in the end.....and how do you deal with that? So I think in residential, it's a challenge.....it's a bigger challenge than for an office, OK, because then you have one owner of the complete office. It maybe you have some multi-tenants or something, but that's possible....but then in the end, they pay for what they get or what they share or what they use....But residential it's more difficult, I think.

### Interviewer

I see. So now I'll move to the following question. So we talked about the type of buildings. We talked about the type of projects. So this question is about the locations and the climate conditions. So in your experience, how do the locations and the climate conditions of buildings affect the performance of solar cooling integrated facades?

### Interviewee 20

I don't have any experience with the solar cooling façade, so but I can imagine that location has an impact of the performance of the of the system. So and that not only for the location of the building

itself. It has to do with surroundings. So what's the urban structure around the building....but also it makes a difference on which facade you apply it.....So is it North or South, East, West. Is it in the upper part of a building, a lower part of a building? So it's all a really dynamic environment. So you have to deal with wind, inner-cities, does it affect? Does it help or does it not? So is there urban heat island? Yes or no? What about pollution? So inner-city pollution. Yeah, there's so many aspects which could influence the performance. So I think it's, yeah, really important to research on it before you choose to apply such things.

**Interviewer**

Generally, do you have something in mind about which locations would you suggest to apply such faster products?

**Interviewee 20**

Difficult question....Yeah....I don't know enough for which situation can such a system performs best. So first I had to do some research on performance, specification....what are the design aspects, which you have to take in account.....and then, after such study, then you think of the best position to place something like that, yeah.

**Interviewer**

Got it. So now I'll move to the last question in the opening questions, which is about different types of technologies. So do you think the choice of a solar cooling technology, namely electrically-driven or thermally-driven, would affect the application of such facade products in a particular building project?

**Interviewee 20**

Well difficult question....I cannot really say....I have to learn more about the two systems to say anything about this, I guess, yeah.

**Interviewer**

OK, got it. So now I'll move to the key questions. So in the key questions, I'll have questions about technical and product related aspects, then financial aspects, and finally process and stakeholder related aspects. So let me start with the questions related to technical product related aspects. So in your opinion, what would make solar cooling integrated facades complex products?

**Interviewee 20**

Yeah. First of all, the facade is a complex element in your building. So if you want add extra technology to it, you make it even more difficult to design.....and then solar cooling technologies are quite new technologies, I think, so that makes it extra complicated.

**Interviewer**

Do you have something in mind how could we minimize the complexities of such facade products?

**Interviewee 20**

What could help is that you think of it in a modular way. So what we do, we try to do in façade design in a lot of projects is that we think how we can prefabricate a modular facade system.....and if you prefabricate, you assemble the elements in controlled conditions....And I think that it's one of the important conditions to apply these things, yeah...So make sure that quality of installation is

100%. So that's I think.....And make it modular. So that you make one design, but you make like 200 facade elements with the same design.

**Interviewer**

OK. Now I'll move to the following question. How could we address challenges related to the space availability or interrupting other building services when we integrate such technologies into facades?

**Interviewee 20**

Yeah. What we often do is make like a setup for a risk matrix, and then identify risks. Think of mitigation measures and then try to elaborate these into design solutions as in detailing or calculations, or....yeah. So that we get grip on the complexity, and second thing is what we do is often if we have one big complex problem, try to tear the part into simple problems, and if you manage to solve the simple problems, most of the time you have solved also the complex problem. So that's what good engineering does....make complexity simple, but then you have to really think about to tear things apart and to the most simple questions.

**Interviewer**

I see. So now I'll move to the following question. So [Name of Interviewee 20], what are the key aspects to consider for the maintenance and the durability of facade products integrating solar cooling technologies?

**Interviewee 20**

First, one of the most important things in maintenance is that you can reach.....make sure that it's accessible, from the inside or from the outside.....doesn't matter, but make sure that in your first design stages to think of maintenance. So how do we go to maintain the building? Do we need installations? Do we need skyscraper? Do we need.....whatever. So but think of it in front. So that's important.

**Interviewer**

I see. So now I'll move to the following question. This is the last question in the product related aspects, before moving to the financial aspects. So how do you see the role of aesthetics in the widespread application of building facades integrating solar technologies?

**Interviewee 20**

I think it's one of the most important aspects because if it does not have aesthetical quality, architects won't agree with the application of technology. So the facade is like one of the.....When architect starts designing the façade....how it's going to look the building, the appearance, the look and feel....So anything that disturbs the architectural image, is going to reject. So the technology is OK, but we don't want to see it, except the technology which looks good. So yeah.

**Interviewer**

I see. OK. So [Name of Interviewee 20] I'll move to the second part, which is related to questions about financial aspects. There are only two questions. Then I'll move to the questions about stakeholders and processes. So now the financial aspects. So the first question is....[Name of Interviewee 20] in your experience, how can the industry develop affordable and financially feasible facade products integrating such technologies?

### Interviewee 20

I think when you're designing, you always have to think about two things, that's the feasibility and makeability. When we talk about the financial aspect, that's concerning the feasibility....and you always have to think, OK, is it affordable for the developer? Does it fit in the business case if we design facade with this and this and this? So when you designing these kind of special applications, yeah, so these extra features in it, and if it asks for extra investment, somehow he has to get return on investment...So does it give it an extra, a better look on the building, extra comfort, extra flexibility? Is it helping him with reaching sustainable goals or ambitions? Somehow he wants to make money out of it in the end. He has to because he's a developer. That's what he does. So when adding extra costs and he cannot raise like the rent or something, he is not going to do it. For instance, when he can get better tenants.....So that's all these kind of aspects are important for developer.....And we as technical designers, yeah, we have the task to give him the proper design so that he can fulfil his business case. Make it work, yeah.

### Interviewer

OK but....You mentioned something about the makeability. So could you elaborate more about the makeability?

### Interviewee 20

Yes....We can design things, but if there's no supplier or subcontractor who wants to make the design, then it's not going to be built.....Otherwise, for instance, if it takes like 50% more of installation time than regular, that can also be an argument not to do. We also always have to take into consideration the makeability in all aspects. So is it possible to produce? Is it possible to assemble? What's the extra time needed if we want to do these things? What are the risks when there's a failure or a defect in the system? Do we have a building without any energy supply? Can it be solved? So all of these questions.

### Interviewer

OK, got it. So now I'll move to the second question in the financial aspects. So [Name of Interviewee 20], what are the potential financial incentives that can support the widespread application of solar cooling integrated facades?

### Interviewee 20

I think high yields, for instance. So lower energy bills.....I think.....but maybe in the future....I think basically it's all about the total cost of ownership in the end. So how does it fit in his calculations for the total cost of ownership. So are there higher yields? Can he can get more tenants? What are the maintenance costs? So that are, I think, the main financial incentive.

### Interviewer

OK. So now I'm done with the questions about financial aspects. So now I'll move....

### Interviewee 20

Ohh well, maybe one more [Name of the Interviewer]....I know that's the correct English words.... Subsidy...so from the government...

So they get. Yeah.

**Interviewer**

OK. Subsidy from the government.

**Interviewee 20**

Yeah, that can also be a financial incentive. Of course, if there are any.

**Interviewer**

OK. So the financial incentives, you mentioned the aspects related to the total ownership costs or subsidies from the government.

**Interviewee 20**

Yes. Yeah.

**Interviewer**

OK. Do you have something in mind or should I move to the following...

**Interviewee 20**

That's OK. Yeah. Please. Move on....

**Interviewer**

OK. Thanks for illustrating that. So [Name of Interviewee 20], now I'll move to the questions about stakeholders and processes. So stakeholders first then processes. So as you can see from this chart, we have different stakeholders that are involved in the facade design and construction. So the question is....in your experience, which of these stakeholders can support the application of solar cooling integrated facades?

**Interviewee 20**

I think...They all have an important role in it, but I think it will start, most of the time, it will start with client, investor, architect and consultant. They, most of the time, come up with the first plan and then sometimes market consultation is done with, for instance, façade builder or sometimes a general contractor is involved in the early design stages, so then they have all influenced the decision making tree....Yeah., but I think basically all of them, but it depends on how the design is organized.

**Interviewer**

So what do you mean by how the design is organized?

**Interviewee 20**

Yeah, which parties are involved. Is it only the architect, consultants, for the investor, or is there already general contractor or maybe we think well, it's really specific we should ask this facade builder because he's the only one who can make it in the end. So that's depends on project.

**Interviewer**

OK so now I'll move to the following question. So the question is related to the knowledge and experience of architects or engineers. So the question is how can we increase the knowledge and

experience of architects or engineers regarding technical aspects of integrating such technologies into building facades?

**Interviewee 20**

I think to publish about it. I think to give exposure on knowledge that's already there. Yeah, that's. I think that's basically it is.

**Interviewer**

So what do you mean by to publish about it?

**Interviewee 20**

Write articles about the technology. What the benefits are? So what's in it, for instance, for investors to have such kind of installation in their buildings....So since it's not a really common known technology, I think, well, you first have to let the world know. So that's there and that's it's a good technology, preferable, already proven technology that it cost-beneficial, yeah etcetera.

**Interviewer**

I see. So now [Name of Interviewee 20], I'll moved to the following question. So it's related to standards and guidelines for architects or engineers. 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 20**

First of all, how it works. So you showed me some schemes and I saw in the internet also other schemes, which are a bit complicated sometimes maybe. So I think it's important that architects understand how the system works. That's one thing, but also what does it bring extra when you compare it with other technologies. So what are the benefits of this system? Why should they use it and what are the boundary conditions. So when can you use it. In what situation, and especially also when not? Yeah, maybe a list a bit dos and don'ts or something.

**Interviewer**

OK, now I'll move to the following question. How can the industry increase the variety of products that would attract customers to apply façade products integrating solar cooling technologies?

**Interviewee 20**

What do you mean with customers?

**Interviewer**

The clients that are going to adapt the technology or use it.

**Interviewee 20**

I think somehow they have to be sure that you can you have a return on investment. I think that's an important thing.....And how to increase the variety of products.....I think you have to be able to adapt your system to the project, somehow. If you only have one size fits all strategy, I think you're not going to succeed. So I think you must be able to ensure that you can modify things that it fits in projects.

**Interviewer**

OK. So adaptable to different projects?

**Interviewee 20**

Yeah, so dimensions, but also from an aesthetical point of view. From installation point of view, you want to really to have a plug and play. That's important. When it's too complex, I think risk will be too high to apply in your project. So the plug and play is, yeah, very important with installation, so keep it simple. We try to prefab as much as possible, that means that on-site...we only want to do plug and play with piping and wiring. It has to be like OK click, check, work. So that should be strategy, I think.

**Interviewer**

So now I'll move to the following question. So how can we increase the interest of designers, developers and the clients in solar cooling integrated facades?

**Interviewee 20**

First, make sure that it looks good. Second, make it affordable and be sure that it's....have really short period of time, that it's known that it's proven technology. So good....make the best guarantees.....and make sure that you upfront. Do a risk analysis. What problems could appear and that you think of solutions upfront.

**Interviewer**

Now I'll move to the following question. How can changes in building regulations affect the widespread application of façade products integrating solar cooling technologies?

**Interviewee 20**

Yeah, changes always have an impact on design. So and I think regulations will be stricter and more for all your installations or on your façade design. So that creates an opportunity for these kind of technologies, because we have to solve issues which we cannot solve with the conventional products and façade that we know.

**Interviewer**

OK, now the following question is about energy policies. So how can changes in energy policies affect the widespread application of façade products integrating solar cooling technologies?

**Interviewee 20**

Is that the same question as we....

**Interviewer**

The previous question was about building the regulations. This is about energy policies.

**Interviewee 20**

Ah sure. Yeah, I think they are connected at the moment. Building regulations...when they change, most of the time it's energy driven. So if we want to meet the goals in 2030 and 2050, it's all about energy. So yeah, I think it has an impact, of course.

**Interviewer**

OK, so now I'm done with the stakeholder part. Now I have questions about the processes. [Name of Interviewee 20] you know that the facade design and construction usually start from the design, then production, assembly, operation, and then the end of life. So in your experience, which phase is key for boosting the integration of facade products integrating solar cooling technologies?

**Interviewee 20**

Of course, they are all important, but I think what really could help.....I mentioned before proven technology. So in the operation phase, when you have your system is running, use them as references.....and that together with the business case....so your total cost of ownership.....That combination: proved technology and a good business case.....That's important when you want to speed up the process of application of the systems.

**Interviewer**

So now let move to the following question. So what are the main aspects to consider during the design phase of facade products integrating solar cooling technologies?

**Interviewee 20**

Does it meet the aesthetical quality? Can technology be guaranteed? And is the investment....is it affordable in the way that does the developer gets a good return on investment.

**Interviewer**

OK. Now I have another question about the design phase. So in your experience, how can we achieve a closer collaboration between various stakeholders and disciplines during early design stages of solar cooling integrated facades?

**Interviewee 20**

What helps is to start with defining ambitions for the project. So make sure that everyone is on the same page when you have.....they talk about the design, and you have an open structure and preferably with an integral design team. So yeah....I think that's important.....And then automatically you get a closer collaboration, I think.

**Interviewer**

OK, so now I'll move to the production phase. So what are the key aspects to consider for the production phase of facade products integrating solar cooling technologies?

**Interviewee 20**

First of all, you want to have certain standard, but they have to be adaptable, so that it will fit in the project.....but you don't want to invent every project to complete new system. So I can imagine you have fixed elements and you have adaptive elements. So I think that's important to also keep control in costs and risk of failure....the quality during your production phase.

**Interviewer**

OK. Now I'll move to the assembly phase. So what are the key aspects to consider for the assembly phase of facade products integrating solar cooling technologies?

**Interviewee 20**

Prefabrication and on-site plug and play.

**Interviewer**

Do you have something in mind about the required workforce?

**Interviewee 20**

You just need good assemblers on-site, but they assemble like complete facade module. So and when it's integrated in that, so then you don't....And on the inside of the installation, yeah, you need craftsmanship. So they know what they do, so but I think that should be obvious.

**Interviewer**

So operation phase....what are the key aspects to be considered for the operation phase of the facade that integrate solar cooling technology?

**Interviewee 20**

It's important that it's really a reliable system. So and if it has any defects that you have a high class service that they are within a few hours on-site to solve problems. So I think that's also important. Like your energy supply is one of the basic needs. So in the summer and winter it's important that it's functioning. So yeah.

**Interviewer**

OK. About the operation. Do you have something in mind about the end user knowledge?

**Interviewee 20**

I think these kind of systems, you don't want to have the user to do anything. It should be controlled by your building systems and not by the users. If they are going to play with parameters and stuff, then most of the time that's when the problems appear. So I think, preferably, not make it accessible for users. Maybe for one key user who knows how to reset or something with the system, but otherwise I would say just make it controllable on a distance and then when there's a problem, you give your supplier a call and they fix it from their own computer. I think that's best.

**Interviewer**

OK, I see. So now what are the key aspects to be considered for the end of life of solar cooling integrated facades?

**Interviewee 20**

Yeah, what we always try to do is to design a system which is a completely circular, but what we also see for installations is that you have this continuity in developing of technology. So most of the times when the system is like 10 year old or 15, when you want to replace it or something, then yeah, like your control boxes or something.....yeah, it's you have to take components out and maybe reuse, but you cannot reuse like the control boxes or something one-on-one again.....And also for the elements. Yeah it is depending.....You see it with PV panels. Like 10 years ago, you had to PV panels with 250 watts peak into insulation, and nowadays you have 400 Watt peak. So when you have to replace these old PV panels, what you're gonna do? So yeah that's what you see with recent technology that it really has an acceleration and developing the technology. So it's really outdated, maybe earlier

than what you want to. So that's a bit of complex, but if you succeed that you can design things that components or elements are reusable, so that that would be good.

**Interviewer**

OK, so [Name of Interviewee 20] I'm done with all key questions. So now I'll move to the closing part. So [Name of Interviewee 20], do you have any final remarks about the widespread application of solar cooling integrated facades as building products in the construction industry?

**Interviewee 20**

I'm not really....I think we discussed a lot already, but I think it's an interesting technology and we don't know a lot about it yet.....So, yeah, I saw some pictures of it in window systems, for instance....but I can imagine that you also have some systems, your close parts and if it helps to make facade a less strict boundary from inside to outside, it's an interesting technique, so yeah.

**Interviewer**

OK, I see. So generally, what do you think about the application of such technology for enabling energy transition?

**Interviewee 20**

Yeah, I'm quite curious if it's....I think it has potential for having an important role in the energy transition, but what I also feel a bit is that it's we have to have some trials, some project, maybe to see if it functions. So can we come to the status of proven technology, so and that's quite a big step. That's one of the most difficult steps for new products and new systems to take is, yeah, convince developers basically to go for such systems.

**Interviewer**

OK, so I'm done.....Just the last question. So [Name of Interviewee 20], do you mind to propose potential participants to be interviewed for this study?

**Interviewee 20**

Maybe I have to ask the first.....