

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 I'll move to the opening questions after the brief introduction. So [Name of interviewee 6], according to your experience, what is your opinion about the current level of knowledge in the building industry regarding the application of multifunctional facade components integrating solar cooling technologies?

Interviewee 6

I would say there are virtually non-existing. And that I think that's because they are not used that often. What we see is an maybe I'm a bit ahead of your questions, so please forgive me, we are seeing a trend within our company, but also in broader view that photovoltaics are moving into the facade area, moving from the roof to the facade. And that's because mainly mid to high-rise buildings lack space on the roof for the necessary PV panels, But the next step would be thermally driven installations in the facade itself. I think really next level.

Interviewer

I see. So maybe what you answer is somehow going to provide an answer.

So what are the motivations related to developing future building facade products integrating solar cooling technologies? Maybe I think you say in high rise buildings, the roof is limited compared to the façade. This could be a motivation.

Interviewee 6

Yeah, there could be a motivation, but also I think we need to move to decentralized climate installations instead of centralized. But I'm mentioned this for...[Name of a specific expert in the façade design and construction industry] knows for the last 15 years, we're trying to push that but MEP advisors, engineering firms are somehow not willing to propose these kind of installations because they are not used to it. It seems to be expensive and nobody calculates if it's expensive or not. Little alone that calculated on the total lifespan of the building and I think that's a good feeling that the decentralized installations which are fit from the façade, so to speak must be must be the solution and we're going to in the next 10 years. I would be surprised if it's not the best solution, but that's my personal opinion.

Interviewer

OK, so I can see that you the motivations is to develop decentralized installations, but on the other side, what are your concerns regarding the application of multifunctional facades integrating solar cooling technologies?

Interviewee 6

Concerns not, I think the technology is there, but since the building industry is very, very traditional, MEP advisors, façade builders, even clients are somewhat reluctant, I think, towards intelligent, more technological facade solutions.

Interviewer

I see. So these are your concerns.

Interviewee 6

Yeah, I think the technology is there. Well from an engineering perspective, it's simple.

Interviewer

OK, I get your point. So what are the potential issues needed to be considered for such concerns, do you think?

Interviewee 6

I'm not sure. I think once we show....Abroad in Germany and Switzerland, and more where they've built more high level and more technologically advanced facades, we have some good examples, even from the 90s and the early zeros I would say. But in the Netherlands there more or less no existence. So I think when we have a good example in the Netherlands, more will follow. There needs to be an urgency to put all this intelligent technology in the facade.

So I would say five years ago, nobody expected that it would be more or less normal that we have a facade design with PV integrated. Of course building integrated PV systems are 20, 30 years old, but not that much used.

Interviewer

I see. OK so now we talked about the current level of knowledge. We talked about the motivations, concerns, issues to be considered for concerns such as showing the good examples. I'll move to another question. Can you tell me how different types of projects such as new building construction or renovation projects can affect the application of solar cooling integrated facades?

Interviewee 6

I think both type of projects, newly built or renovation, are good candidates so to speak for.

But maybe renovation projects are more fit for...You have a more or less fixed building envelope. Levels of the building are fixed. Location orientation is all fixed. So you have not that much options for your installation principle. I think the facade is a good candidate to serve as a solution for these systems.

Interviewer

What about the new building construction?

Interviewee 6

Yeah, of course they can be, but there needs to be a more urgent.

Lack of space, of course, is one of the most, the best driver, I think for such systems, and the lack of space is there in renovation projects.

Lack of space for installations....for piping and cooling machines on the roof or whatever. So if you put all these installations on the façade, that should be easier than to try to...If you have a concrete structure, very rigid, small span or big span with big floors....but reduced floor height which cannot

be adapted that much, then it would be wonderful to put your whole, let's say, your whole climate installation in the facade integrated in the facade.

When you have a new construction, you can play with the floor height and think of the best space for a cooling equipment etcetera.

Interviewer

So it's easier in a new building construction than renovation projects?

Interviewee 6

Yeah. Well, I think the urgency is more present at renovation projects, but it's easier to adapt in a new building.

Interviewer

OK, the urgent is renovation?

Interviewee 6

Yeah, I will tell you that's my feeling.

Interviewer

You're feeling, but it's easier to because....but the issue with the renovation is that we, as you say that we have space limitation or....

Interviewee 6

Space limitation for a traditional installation with a cooler on the roof and a heat pump in the basement. That's true.

Interviewer

OK, I got your point.

OK, now I'll move to the following questions. We talked about the effect of renovation versus new building construction. So now, what about the effect of different types of buildings, office, residential healthcare, educational, etcetera on the application of multifunctional facades integrating solar cooling technologies?

Interviewee 6

I would say that let's say mainstream....Buildings where people live in, homes, apartments are a no go area.

And I think offices, laboratories, industrial buildings are the best candidates for these systems.

Interviewer

Why office are better candidate than for example residential?

Interviewee 6

I think because offices are used during daytime mainly and then you have solar energy. So there's always the point most people are not at home during daytime and that's where you can absorb or use the solar power at its best.

It's a dilemma. And to be honest, I think that's not exclusively a Dutch cultural problem. People like homes to be traditional. We still built in the Netherlands, we still built with bricks which is strange because bricks are environmentally unfriendly. They are heavy. Of course there are some benefits, but nowadays it's a very unlogical building material, but people like to have their homes being built traditional. Try to find a good example of a large scale residential project in wood in the Netherlands. You will not find it.

So I would like to say putting in advanced high tech looking façade system, which is energetically and technically perfect on a residential building, most people....I would like to live there and you also probably but we're engineers. So but I think most people want to live in a traditional looking building. So unless you can disguise your intelligent facade machine into a brick...

Residential buildings are no go I would say.

Interviewer

I see, OK, now we talked about the new building construction versus renovation Office versus other buildings.

Now let me talk about the location of the building and the climate condition. In your opinion how different locations of buildings and the climate conditions can affect the performance of solar cooling integrated facades?

Interviewee 6

Oh good question. I think the climate in Netherlands is small country, so the climate is more or less the same all over the country. We have a bit more sun and a bit more wind at the coast, of course, but that's marginal. I'm not sure if there is a big difference in that perspective between urban and rural areas. So I'm not sure. Urban areas, you have more shade of buildings in the neighbourhood, of course, and there is more heat but I'm not sure if that effects these façade systems that much. I'm not sure.

Interviewer

OK. But generally what are the recommended locations and the climate conditions for applying facade products integrating solar cooling technologies?

Interviewee 6

I would say South to southwest facade side, but that's true for the whole northern hemisphere, right?

Yeah most of the PV systems are faced towards South, but that brings us in the Netherlands into problems, because then we have our peak capacity at noon. So you see that these systems are shifting to east or even West or West or even east orientation, so. But yeah, well, my gut feeling says that at the hottest and sunniest moment of the day. Sun is facing, is shining from South, of course, so South and southwest orientations are the best. And it's gonna be urban or rural. I don't think there's a difference.

Interviewer

Ok so now I think you are somehow you may be interested at this point and you told me I think maybe you were behind. So I was going to ask: Can you tell me how different types of solar technologies electrically driven such as PV or thermally driven such as solar thermal collectors can

affect the application of solar cooling integrated facades? You mentioned this in the beginning, PV are moving to the facade nowadays.

Interviewee 6

Yeah. But not for not primarily or directly for climate systems.

Interviewer

OK.

Interviewee 6

That's purely and it's a bit of....Well it's because our building regulations ask us to generate our own energy at some level, depending on the building type and we see it especially mid and high-rise. The roof surface is simply too small to fit all the PV panels. Otherwise we would have put them all on the roof because putting PV in the facade is expensive. But it's happening. I think we have four or five projects where we have to put PV panels in the façade. Otherwise we have a problem. And it looks OK . We're getting better at it.

Interviewer

But what about solar thermal collectors?

Interviewee 6

We have never used them.

Interviewer

OK, got it.

Interviewee 6

And I think the point is, except from some systems you mentioned, like cooling with hot water which can be done I think. In the Netherlands mainly these systems are used to produce hot water and then residential projects are making more sense, and the use of hot water in offices is a very small part of the energy consumption. Hospitals might be different. Gamer. I'm not sure.

Interviewer

Ok so now let me move to the key questions. They have three main aspects. I have questions to ask about technical and product related, financial, and process and stakeholder. So now I have questions about technical and product related aspects. So [Name of Interviewee 5], what are the potential solutions that can address challenges related to the complexities of solar cooling integrated facades, such as the required space availability or interrupting building services?

Interviewee 6

Can you split it in the parts?

Interviewer

Yeah, we have different challenges related to the product complexities that that can be related to the required special availability or interrupting other building services. So what are the potential solutions that can be considered for such complexities?

Interviewee 6

I think interference with other building services is not really the case in our business and architecture, I would say. We always try to use let's say elements with a certain type of function. We try to put an extra function into it. So you can imagine that we use PV panels as a shading device fixed. Can be can be dynamical of course, but we've never done that. Or using PV panels as an architectural tool to be more expressive in our architecture. Space, especially in PV, is not really a problem. Visibility from inside to the back of a PV panel is a problem because they don't look that good from the inside. So especially when you have these white sheet PV panels which have the best performance. They don't look that nice. We have cabling and micro for...micro converters maybe, optimizers. So we aesthetical challenge there, but we manage.

Interviewer

OK, got your point. Now let me move to the other questions.

Can you tell me what are the important issues needed to be considered for the maintenance and the durability of solar cooling integrated facades?

Interviewee 6

As long as you're able to use your standard building maintenance unit or just a ladder to clean the whole system, that's not really a problem. We haven't faced any problems yet, but I can imagine when you have a building maintenance units or a guy or a girl washes the façade and they come across all these cables, that might look a bit strange, but there are on roofs and they are made to get a bit wet. So not sure if is there any problems there.

Interviewer

OK, I see. Now let me ask you about the aesthetics. So how do you see the role of aesthetics on the widespread application of building facades integrating solar cooling technologies?

Interviewee 6

I think it's an extra tool in the toolbox for the architect. It becomes a necessity, so you have to deal with it and it's better than to....well, get acquainted to it and make use of it. There are even white PV panels and nowadays that the performance is not that good, but I came across a building last week in Switzerland which was clad in this black panels, but it didn't look as PV So was great. And that's not true for all architects, I think. But we are more or less a technical firm, I would say, with a very clear handwriting and it fits our architecture. So that's we are lucky I think.

Interviewer

Ok, now let me ask questions about financial aspects. So in your opinion, what are the main issues needed to be considered to develop affordable and financially feasible facade products that integrate solar cooling technologies?

Interviewee 6

OK, it has to be clear that they can compete with traditional systems. That's the only thing. You have to prove it's as expensive or less expensive than traditional systems. So just that simple.

And it would be what it's needed to convince clients and MEP firms. Their performance should be very clear and I think I'm not sure that these systems are not yet incorporated in all the calculation

software that is needed to do all the energy calculations and I'm not sure how familiar you are with the Dutch regulations on the energy, but we have a lot of rules and regulations and specialized software that you need to use to do certain calculations. That's all certified. And it's very important that these systems are recognized, so to speak, by this by these software packages.

Interviewee

OK, I see.

So what are the potential financial incentives that can support the widespread application of solar cooling tolerated facades?

Interviewee 6

It has to be cheaper than the standard, and that will be a challenge, I think.

Interviewer

Ok other financial incentives you have in mind?

Interviewee 6

Yeah, I think the main....let me think about this....the big advantage of having a facade integrated installations is that they can act very local.

That's the big drawback of centralized installations. So as long as you can prove that on the long run, let's say ten 15, 20 years, this is much more good effective than a centralized installation. Then everyone will use these building facade integrated installation. I'm sure. And energy is getting as you might have noticed, a very expensive. So I think in the long run that the cost of the installation itself is less important than the energy consumption during the whole lifespan of the building. At least I hope so.

Interviewer

OK, now we'll move to the questions about the process and stakeholders. So, you know we have different stakeholders like as you can see from this chart in the facade design and construction industry. So new in your opinion, who could be the main potential supporters to the application of solar cooling to generated facades?

Interviewee 6

I think it's a combination of the architect and the consultant.

Interviewer

OK. Why?

Interviewee 6

Architects are designing facades and they must be supported by consultants to make these systems work, and with one of the two doubting about the capacity of these systems, it's not going to work.

General contractors, well, they make what we asked them to make, and of course, relevant input can be derived from the facade builder. We consult facade builders in a very early stage of each design. So when we want to enter to design these integrated systems, it would be very helpful if there is a facade builder who has this like the Wicono example you showed would be very helpful if

we get support from them with all the data and all the costs and details and stuff. It's not something that one of these four parties can invent for themselves. It's you need to cooperate very closely.

And let's face it the architect and the consultant have designed the system in their technical design package, which goes through the market then a general contractor is not able to find another alternative because it's....Yeah the word says it very integrated into the building. So it's very hard to find an alternative. So if it's in the package of the architect and consultant which goes to market, then I'm pretty sure that it will be built.

Interviewer

So taking into account your points, how a closer collaboration among various stakeholders and disciplines can be achieved during early design stages?

Interviewee 6

How to achieve yeah just do it. Well it starts with that you as a consultant or architect recognized that you need the other party. You cannot design a building as an architect without any input of a consultant that is real. So you need parties that understand that they need each other.

Interviewer

OK, so now we'll move to the following questions.

Can you tell me how to increase the technical knowledge and experience of architects or engineers about technical aspects related to the facade integration of solar technologies or solar cooling? How to increase their technical knowledge about technical aspects?

Interviewee 6

There must be some intrinsic interest. If it's not there, then....We are the type of architect that wants to know how our buildings are being built. So we are detailing at a very high level. There are also architects that are not interested in making details at all. So and that will be very hard then to integrate installations in the facade at all.

Interviewer

So there should be....you mean there should be an interest but generally how to improve the interest do you think? Or how can the future interest of designers, developers, clients can be improved?

Interviewee 6

If there is an urgent let's say from building regulations and laws, then it will come. So, if building regulations are asking from architects indirectly that we have to make, let's say, intelligent facades, then it will come by itself, I would say.

Interviewer

OK, so according to your point, how legal legislations affect their widespread application of solar cooling integrated facades?

Interviewee 6

How?

Interviewer

How would changes in legal legislations affect the widespread application?

Interviewee 6

Well, if we're heading towards a zero energy consumption built environment, so it will happen by itself. So it's not going fast enough I think. But I think that the government is...I'm not sure if they know by themselves. I had a very interesting conversation with a government official, let's say 2 weeks ago, and I said that the main driver for innovation is building regulations and he was very surprised.

Interviewer

I see.

Interviewee 6

That's my humble opinion.

Interviewer

OK. So OK what are the core elements needed to be considered in designing standards or guidelines related to the facade integration of solar cooling technologies? What are the core elements needed to be considered for developing standards or guidelines for people in the industry?

Interviewee 6

Could it's a different question. I'm not sure. We have all these norms in the Netherlands a bit too much, maybe. One thing we encounter at least that's true for PV panels integrated in the in the facades. There was a widespread discussion about fire safety of all these installations. We had this discussion in the Netherlands on concerning PV panels on the roof.

There were some accidents where these systems caught fire and burned down the whole building.

So we're encountering the this this discussion also when we put PV panels or PV systems in the facade that people are starting to ask questions if that's a safe thing to do and stuff like this. So I think regulations or rules or whatever concerning fire safety are important.

Interviewer

OK.

Now let me ask you another question. So in your opinion, in what way can the industry increase the variety of products that would attract customers to apply solar...?

Interviewee 6

I think it's always a good idea to design the systems in such a way that it doesn't look like a system. If you know what that mean. Should be just a few slides earlier, again, the WICONA system consists of these wonderful vacuum tubes. I think they're beautiful, but I think a lot of architects don't want to have lots vacuum tubes in the facade. So it would be very good that there's a lot to choose from an aesthetic point of view.

Interviewer

OK, I got it. So I have the final part before the closing questions.

I have questions about the processes. You know we have different design and construction processes. We have design phase, production phase, assembly, operation and then the end of life. So in your opinion, do you think there are particular phases that are considered to be the most important ones?

Interviewee 6

I would say the second to the third.

Pre design and development and architectural design. They should be I think.

Prediction, I think the industry is intelligent enough to produce these systems. Assembly is not a problem, I would say.

Maybe operation or yeah operation.

Interviewer

OK, let me move one.

So generally, what are the main issues needed to be considered during the design phase?

Interviewee 6

Well, I think we need off the shelf products, that is proven technology. That's would be the best. So then you skip system design. It's already there. There's a bit predesign and development and we go straight to architectural design. We can implement systems that are tested and certified and we know how they perform. We know how much they cost. That would be perfect.

Interviewer

OK. What about the main issues needed to be considered for the production phase? Do you have something in mind?

Interviewee 6

No. When the first is OK, when there's a system (system design), then production is not a problem.

Interviewer

OK. Assembly. Do you have something in mind?

Interviewee 6

No, it's the same as well. No, I think it's not really a problem.

Interviewer

Are there issues for the required workforce during the assembly or installation?

Interviewee 6

Yeah. Yeah, that's mainly.

Well facades are one of the most costly components of the building, apart from main load bearing structure and installations. And now you're mixing two and those are two very different disciplines, facade builders and installation contractors. So that that is interesting. You might encounter some

problems there, because there are literally in each other's way. I'm thinking of guarantees and things like this that could be a.....So it would be very comfortable to....

Well, let me go back. I think it would be a great that the facade supplier, façade builder give all the guarantees for the whole system instead of cutting all the whole system into pieces and that the guarantee for each pieces. I don't know the party if you know what I mean.

Interviewer

No, I didn't get your point.

Interviewee 6

The whole system has to be guaranteed to be working for a five, 10, 20 years by one party.

And I think that's the main challenge in. Let's say, well around assembly and operation.

Interviewer

OK. So one guarantee by one party for the whole system?

Interviewee 6

Exactly. Exactly. Yeah.

Interviewer

OK, now.

What about the operation phase? What are the main issues needed to consider for the operation phase for the facade product?

Interviewee 6

Well low or no maintenance.

Because maintenance and maintenance in the facade itself is, especially for high rise or urban situations, that's can be very costly of course.

You need to prevent that a guy needs to check the whole facade on the outside twice a year. That's costly.

Interviewer

Are there some aspects that can help in achieving low maintenance?

Interviewee 6

Yeah. No moving parts. I would say that's one thing, and or that you can reach all the high maintenance stuff from the inside. Yeah, well, electrical parts are low maintenance, right?

And now moving parts in the facade are always a problem, especially if they move from the outside.

So that's why we try to use solar shading in the building instead of outside, and we know it's performing better outside the building, but moving parts outside are....

Interviewer

I got your point so, but what about the end user knowledge?

Interviewee 6

End user knowledge. I'm not sure if that...

Yeah well depends who operates the building and maintains it.

We have a lot of buildings that are being built by developers so and they renting space to start-ups and other offices and companies and not sure who is maintaining and operating the building in. But there should be some kind of knowledge of course.

Interviewer

OK, now the last thing. What about the important issues needed to be considered for the end of life of a façade product that integrates solar cooling technologies?

Interviewee 6

Well as for every building component it is very important that you can take it apart in a small pieces as possible. So your carbon footprint at the end is low. The amount of waste is as low as possible, which is a problem with PV panels as we know. It can be a problem for these kind of systems. We have building regulations concerning end of life. So the more you can recycle or upcycle, maybe you're building product at the end of the life of a building, the better.

Interviewer

I see.

Interviewee 6

And it's being rated in certain software so.

Interviewer

So now I will move to the closing questions. So what are your final remarks about supporting the widespread application of solar cooling integrated facades as building a products in the construction market?

Interviewee 6

Well. I've mentioned them before. If we want to use these kinds of systems on a large scale, there need to be proven technology and the energy consumption or reduction compared with, traditional installations should be very, very clear. Because commercially it's a very difficult area because you're mixing facades and installations.

Interviewer

Yeah, I'm done, actually with all points in my interview. So yeah. So I'd like to thank you for your time and for your insights for all questions.

Interviewee 6

You're welcome.

Interviewer

For accepting the invitation, again thank you so much. I really I really appreciate all insights that you give me. I just have small point, do you mind to propose potential participants that can be interviewed for this study?

Interviewee 6

Have you already interviewed façade company or.....