

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

OK, great. Now we can start the opening questions. So I have opening questions, key questions, and then closing questions.

Interviewee 22

Yes.

Interviewer

So now I'll move to the opening questions. OK, opening questions, I have about 9 questions, then I'll move to the key questions. So let's focus on the opening questions. So in the opening questions, first of all, [Name of Interviewee 22], 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 22

I would say it's rather low.

Interviewer

OK. Now I'll move to the following question. So [Name of Interviewee 22], in your experience, what are the motivating factors for the application of multifunctional facade components integrating solar cooling technologies?

Interviewee 22

Well, the general drive....to decarbonize cooling needs....is there definitely, and people are looking for solutions. So that is a motivation. Another motivation is that it's cool, that it's something new and that it's innovative.....that's at least a reason to look at and....Yeah, that's I think these are the main motivators....and if in the best case now.....Let me add something. If you can actually show that you can in some save money with this, that would be the best, but I think that is a little bit harder to show because there's not so many, let's say, real evaluated products yet.

Interviewer

OK, got it. So decarbonizing, innovative ideas, and potential cost savings....probably

Interviewee 22

Yes.

Interviewer

OK, now I'll move to the following question. So what are your concerns regarding the application of multifunctional facade components integrating solar cooling technologies?

Interviewee 22

Well, there are definitely several. One is does it work? Do I still keep the main functionality of the façade which is being tight, being waterproof, being also fire resistant? That's a big issue. Then further concerns are who is responsible for which technology, because usually façade building companies are not the ones who care about heating and cooling in the first place, but they build façades. So where's the cutting point to other sectors? And also when installing, how does it need to be installed? Is it easy to install? Is it modular? How do I size it? Things in that respect.

Interviewer

OK. So these concerns....do you have something in mind that should be considered for such concerns? To address these concerns, for example, you mentioned the functionality.....

Interviewee 22

Yes, what I think is that the different sectors need to sit down in the first place and understand each other's concerns and necessities and boundary conditions. Then you need to first define specific solutions and then also define responsibilities, who builds it, who installs it, who's responsible if it doesn't work, who does the maintenance.....but in the first place I think is that you need to address them by combine projects where people sit together from different knowledges, from different backgrounds and do these things together. And that's my experience that is being done in applied research.

Interviewer

OK. Now I'll move to the following question. So how can we type of project, such as new building construction or renovation projects, influences the applicability of solar cooling integrated facades?

Interviewee 22

Well, in general, in new building construction, you have some more degrees of freedom, and thus it's easier if you already enter very early in the overall design process with such a technology that other obstacles can be removed early on. While if you go into renovation, you already have some fixed boundaries which are not easy to overcome and, where you have to fit in even better. You cannot think as broad as in new build.

Interviewer

Got it. Now I'll move to the following question. So now we talked about the type of projects. This question is about the type of building. So how can the building type...office, residential, healthcare, educational, etcetera, influences the applicability of such facade products?

Interviewee 22

Well from my experience in this context, is that it is the best if you can consider heating and cooling at the same time, and there you have very different needs. For example, in healthcare you usually also have quite a need for hot water, for example, while in an office building you have no significant share of hot water, in the cooling period I'm talking. So that can definitely change the applicability because you might have a use case where you at the same time together with the cooling, also have some heating need and hot water need, and that can change the economics dramatically. Especially for thermally-driven cooling because there you usually also have some heat and it's very useful when you can also make use of the heat at the time when it's there. So the load profiles is actually what changes the applicability. So you really need to look by different load profiles.

Interviewer

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

Interviewee 22

Well, in general, of course, when you're in a climate where you have more solar radiation, it is easier to install solar driven systems. That's a very general thing. And other climate conditions is if you have more cooling need, so more cooling hours in the year, that of course helps the economics because then the urge....In Germany, for example, you might have maybe 1000 hours within a year where you actually have active cooling need at the most and in other countries it might be 3000, and then the story looks different of course.

Interviewer

Got it. OK. In general, which locations and climate conditions would you suggest to apply such facade products?

Interviewee 22

So from our experience, it is, in general of course, the sunbelt, which is quite a broad thing, and then more in detail it gets harder when you have a very humid climate. Especially again for the thermally-driven technologies, because then heat rejection gets harder. That's one thing and then it also helps if in the nights you still cool down enough. So you can also shift some load to the night time.

Interviewer

OK, got it. So now I'll move to the last question in the opening questions, before moving to the key questions. So do you think 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 22

So the choice of either using electrically-driven or thermally-driven....Yes, of course, and that is very general, it is easier to integrate electrically-driven facades in the sense that you integrate PV because you can use it also easier for other things. That's the thing that I mentioned before. If you first, in the first place, collect heat, well, you cannot use heat to turn on your light in the first place. So it is easier with electrically-driven, I guess. Although if you have good use cases, you can collect more energy overall with the thermally-driven technologies and if you can make use of them they might be worth well considering.

Interviewer

OK, got it. So now I'm done with all opening questions. So now I'll move to the key questions. So as you can see, we have three groups of questions in the key questions. So I'll start with technical and product related, then I'll move to the financial, and finally I'll move to the process and stakeholders, before we move to the closing questions. So now I'll move to the technical and product related questions. So first of all, in your opinion, what makes solar cooling integrated façades complex products?

Interviewee 22

It's, as I said previously, the mix of different technologies and thus different requirements and responsibilities. You have a façade and you have all the requirements that you have on the façade, but you also have electricity or some thermal energy and you have to manage all this together, and still keep to the requirements.

Interviewer

So something you mentioned before....so how we can address this complexity in a way that.....how potentially we can address these complexities?

Interviewee 22

Well, again, by bringing together the different involved actors, stakeholders to find a solution that takes into account all these matters.

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?

Interviewee 22

Could you explain a little bit better what you mean?

Interviewer

The question is related to if there are challenges related to the space availability when we integrate these technologies, or interrupting other building services....how could we address these challenges?

Interviewee 22

I mean that if you look at the overall building, not all façades are accessible and are not ideally directed to collect solar energy. So you still have to fulfil cooling needs for the whole building, for example, and then it interrupts with the fact that you anyhow need another cooling system, maybe because it's not enough cooling energy that you solely by the façade can collect, and then you would maybe from a cost perspective, rather go for a centralized system that you size bigger and just put PV panels on the façade and use this electricity than centrally to produce cooling, which is not from my perspective, a facade integrated cooling solution, of course, but it's a facade integrated PV solution.....and same for solar thermal systems. So you need to consider the direct conveying of cooling energy also into the building and into the rooms. So it needs to fit that the size of the façade needs to fit to the cooling need.

Interviewer

OK, now I'll move to the following question. What are the key aspects to consider for the maintenance and the durability of solar cooling integrated facades?

Interviewee 22

I would say a certain modularity. So you can really disassemble it easily and take out parts that don't work and can replace them. That would be one. And well for the durability, it's both the durability of the facade element as well as of the internal technology, and that really differs from technology to

technology, which are specific issues, but they are probably not so different. If you integrate this technology into facade or if you put it elsewhere.

Interviewer

OK, now I'll move to the last question in the product related aspects. So [Name of Interviewee 22], how do you see the role of aesthetics in the widespread application of building facades integrating solar technologies?

Interviewee 22

So this is again about general solar technologies, yes it plays a big role and, for example, from our institute we have addressed this by designing and inventing colours that you can choose quite freely for PV modules to be installed and then to be manufactured with...mostly the same efficiencies, but you can pick which colour you want and which apparent to the outside you want. So this gives much more freedom to the designer, to the architect, to really choose this. It is definitely important and there are options, especially from the colours and then, of course, also from the shaping.....if you can allow different shapes, different sizes, it gives more freedom to the design of the facade.

Interviewer

I see. OK, so now I'll move to the second category of questions, which are related to the financial aspects. I have two questions. So first of all, in your experience, how can the industry develop affordable and financially feasible facade products integrating such technologies?

Interviewee 22

Same answer as before. Sit down with the experts from different fields and go into a specific product development and design process that takes into account all boundaries. Well I think, from externally, of course, the higher cost of primary energy helps that in the end such solar technologies in comparison to other technologies are more attractive, which can be seen obviously currently that if suddenly energy prices go up. People are very much more interested in solar technologies than before.

Interviewer

I see. OK. Now I'll move to the second question. What are the potential financial incentives that can support the widespread application of solar cooling integrated facades?

Interviewee 22

Well, I think in general a high CO2 cost would help all these technologies, and more specifically, well there are different incentives for PV or also for solar thermal collectors. It's basically the same and they are taken for solar thermal cooling and if you can show that your facade element integrated solar cooling works exactly like this, then you will probably also receive these subsidies, incentives as before.

Interviewer

I see. OK, now I'll move to the last category of key questions, before moving to the closing questions, which are related to the stakeholders and processes. As you can see, we have different stakeholders that are involved in the facade design and construction industry. In your experience, which of these stakeholders can support the application of solar cooling integrated facades?

Interviewee 22

Well, it's definitely the facade builder. They are the ones who need to be able to offer this technology, and then they need good suppliers...and they're all given here. You basically more or less need them all to work together to have a facade product, but the key is the facade builder collecting this, and then also probably taking the overall responsibility, which also means, and that was my practical experience in these projects that they really have to hire personnel, which they didn't need before. They need to have HVAC engineers, which they didn't need before, but in this case they become an HVAC supplier as well as a facade supplier, and that's a difficult thing because they first need to have the market and also all the legislation clear before they do that. So on the other hand, of course, it's the client and the architect asking for these solutions, and the more they want it and the more they're also willing to pay for this, the easier it is for the facade builder to say "hey that's my new business".

Interviewer

I see. OK, I'll move to the second question. So how can we increase the knowledge and experience of architects and engineers regarding technical aspects of integrating such technologies into facades?

Interviewee 22

That's a hard one because, well, it is really a case by case thing. I think, of course, you need to introduce this already at educational level. I think this is in general true for many types of energy related technologies that I have the impression that it should be more focused within the architects' education on the same level as design and aesthetics questions. That is one thing and the other thing is, of course, for already working companies, well it's a case to case thing. There could be from the...If a facade producer, manufacturer, has specific technologies there, they can teach the architects and they can pass over the necessary knowledge for this.

Interviewer

So now I'll move to the following question. Let's assume we'd like to have standards or guidelines for architects and engineers which are related to the integration of such technologies into building facades, so what are the core elements that should be in such standards or guidelines?

Interviewee 22

Well, it should be, in general, the knowledge that HVAC companies have, which means how to size correctly and design such a system, so it really supplies enough cooling or heating to the building. That's a key element, of course, and then the other one is more on specific technology related things. How to make sure that they work and that they are applied in a useful way, and not only as a, I don't know, green washing kind of thing which in the end doesn't work. I think it's, yeah, you need to transfer knowledge which is there from the HVAC business also into the facade business, if you really want to successfully supply this.

Interviewer

I see. OK, now I'll move to the following question. So how can the industry increase the variety of products that would attract customers to apply solar cooling integrated facades?

Interviewee 22

I'm smiling a little bit because increasing the variety of products actually suggests that there is already some variety and I wouldn't say there is a variety of products there already, but let's say to

come to the point that you have some products on the market....I am not sure which industry should increase this or who should be the driver for this. 'm really not sure it should....It's yeah.....

Interviewer

Yeah, I see. So now let me move to the following question. How can we increase the interest of designers, developers and the clients in solar cooling integrated façades?

Interviewee 22

I think by best case studies. You really have to do it and you have to implement it in buildings and in the beginning it will partly not work or cost quite a bit and still you have to make it work and you have to show the people that it works, and that's I think in the end, that's what really convinces.

Interviewer

OK. Now I'll move to the following question. How can changes in building regulations affect the widespread application of solar cooling integrated facades?

Interviewee 22

Well, I think that you have to give certain shares of the renewable energy integration for heating and for cooling, and that's the way that is also already being followed, and at the same time, you really have to cross check that the measures fulfil this, because for solar thermal...I mean there's many examples that show that people then just install the solar thermal collectors on the roof, but they're not even really connected and they don't run, and then you should rather not do it. So you really have to make sure that you do not only have the requirements, but that you also check that the requirements are fulfilled and that's not so easy actually. But I think that's the way, but it's probably rather even on the primary energy provision where as I said for example by high CO2 cost. You influence the primary energy prices and the electricity from the grid.

Interviewer

So CO2 cost is the way that....

Interviewee 22

Well, that's not a building regulation. It's more general, I think.

Interviewer

OK. So now I'll move to the following question. It's about energy policies. So how can changes in energy policies affect the widespread application of solar cooling integrated facades?

Interviewee 22

Yeah, well that's probably rather the point where you again put this high CO2 cost and, really looking at solutions that make electricity that is produced by fossil fuels more expensive. While if you locally produce it with the solar thermal or solar PV, it costs what it costs, but then comparing to what it is when you get it from the grid. It should be economically attractive by this, I guess. Yeah, that will do the biggest changes and I mean you can currently see this. If costs go up, people quickly think about how they can replace their commonly used technologies.

Interviewer

I see. So now I'll move to the questions about processes. You know we have different processes involved in the façade design and construction. So in your experience, which phase is key for boosting the integration of solar cooling technologies into building façades?

Interviewee 22

Well, it's probably the design phase still. It's because until now there's, from my knowledge, not so many good designs and then going from design to production...Maybe in between, it's the question...Of course you can have nicely working technologies, but still you don't know how to produce them in a good way, but I think these are the main issues. If you have that set up, and you will only get it set up if people know that they then also have a market for this. And market means that they can cover the other parts, but more importantly is to take really good care in the design and production phase.

Interviewer

I see. So now we'll move to the following question. What are the main aspects to consider during the design phase of a facade product that integrates solar cooling technologies?

Interviewee 22

Well, as I think it should be....how would you say....a stability towards various climatic and ambient conditions and requirements. It should stably work under various implementation cases. So it should be quite robust in that sense. That's, I think the one key aspect you....If you need for each situation a new design, you will never have a good product. If you need to build each facade separately and design it again and cannot take from stuck what is there, it will not fly.

Interviewer

Got it. Now I'll move to the following question. Actually, somehow you talked about it, but maybe you can elaborate more. So how can we achieve a closer collaboration between various stakeholders and disciplines during early design stages of solar cooling integrated facades?

Interviewee 22

Well, I think small but broad enough industry let consortia for development projects with support from applied research can quite quickly come up with solutions and throw out others. So my experience is that if you already plan a huge EU project and have already the demonstration companies and the manufacturers and everybody in there, it gets too big....but if you bring together a few key actors as a core, they will get the other competences from the outside, but bring together maybe one façade manufacturer and then some innovative technology provider for this specific solar cooling technology.....and then architect, engineering consultant, something who knows the requirements from different building sites.....and then maybe a Research Institute, applied research who does some performance checks and also gives the requirements for different locations etcetera, then I think.

Interviewer

Ok, so now I'll move to the following question. So I asked you about the design. Now what are the key aspects to be considered during the production phase of facade products integrating solar cooling technologies?

Interviewee 22

Well it would be good if in planning the production, some key aspects of sustainability are considered. So you mentioned end of life phase before, but that you already do this in the production process and production planning.....some green design and at the same time, well, a mass manufacturing compatible design.

Interviewer

What do you mean by mass manufacturing?

Interviewee 22

Well, that you have a modular design that you can implement in many different cases.

Interviewer

OK. Got it. What about the assembly phase? What are the key aspects to be considered for the assembly phase?

Interviewee 22

That you have people who actually know something about installing HVAC equipment, not only façade.

Interviewer

OK. What about the operation phase? What are the key aspects to be considered for the operation phase?

Interviewee 22

That depends a little bit on the technology, but I think in general people should be educated to make rational use of their energy. So, for example, in summer if you have a well ventilated room and it's cooled that you do not leave all the windows open when it's hot outside, and that you use shading and things like that. It's such things, but I think otherwise it shouldn't require from the end users too much. So and then rather maybe in terms of maintenance, some basic monitoring that it still works and that it works efficiently, should probably be included. I think that's for all energy technologies. It's direction where they are going that you have some basic monitoring in there, as to see if something runs wrong and then someone can come who is an expert.

Interviewer

We are at the end. so end of life. So what are the key aspects to be considered for the end of life of a façade product that integrates uh solar cooling technologies?

Interviewee 22

Well I think if you already in the production process thought about what to do in the end of life and considered this and have materials which can easily be disassembled and reused, maybe then that's it.

Interviewer

OK So we are almost done [Name of Interviewee 22]. So now I'll move to the closing questions. So do you have any final remarks about the widespread application of solar cooling integrated façades as building products?

Interviewee 22

No nothing more specifically which has not been mentioned yet. Maybe in general it should be part of, in general, looking at actively using façades. Beat for electricity or thermal energy production, and beat for heating or cooling. It should be one of the options that you can choose.

Interviewer

Got it. What do you think about the application of solar cooling integrated facades for enabling energy transition?

Interviewee 22

Well, I think for Europe it will not be the key question, let's say because the overall energy demand is not so much driven by cooling yet, and there are other solutions for cooling in many places which work as well. So it's one option for cooling. There are many different options for cooling and it's one of the options for cooling, and cooling in general is not the main, the biggest, driver and the biggest problem in the energy transition.

Interviewer

OK. So now I'll move to the last question. Do you mind to propose potential participants to be interviewed for this study?

Interviewee 22

No, I can propose more people to you. The question is who did you already talk to? So.....