

### 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 we'll move to the opening questions. So now the first question is....[Name of interviewee 3] can you please tell me 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 3

Yeah, so I think it depends a bit on if you're talking about, let's say product compact product, which are actually not really available on the market for facade.

So I mean just the PV direct example to a small size heat pump, or a cooling system.

I mean it's not so...again on the market. So in general if you just say that if I put the heat pump and I just let's say put a lot of PV in façade, and this a solar cooling technologies.....Then of course the level of knowledge I think is increasing and just because the photovoltaic technologies well known and it's integration in building is also very much discussed since many years and both in the research field. But I would say now many lighthouse projects and also on the market, products are available to really design and implement a nice great PV façade.

So the level of knowledge and the level of complexity is much higher when we talk about products integrated products, let's say first answer, and is much more complex and so the knowledge is much more rare in case of solar thermal driven solar cooling more than....yeah photovoltaic driven. This will be my second answer.

#### Interviewer

OK, OK.

#### Interviewee 3

So generally I think it is still a niche topic in terms of knowledge in the building industry in general, but then of course, if we consider just having a photovoltaic integrated in a facade and the centralized heat pump, then probably the level of knowledge is much higher.

#### Interviewer

OK, I see.

OK, now, but in your opinion, what are the motivations regarding the application of multifunctional facade components?...and on the other side what are your concerns regarding the application of multifunctional façade components?

Yeah sorry it's....what are the motivations and concerns regarding the application of multifunctional façade components integrating solar cooling technologies?

### Interviewee 3

So motivation and drivers to yeah, to integrate is I think is to go to what decentralized technologies, which means in a way better let's say control of the system, but on the other side about here is to increase the number of components and let's say so diffuse technology, against the centralized and so this, I would say is the first challenge which is on one side a driver on the other side is a barrier.

Of course for example specifically for thermal driven solar cooling that is the topic of a much more complexity of the of the system, so difficult to get the very compact, yeah, product easily to be integrated, and probably the main barrier in general is that centralized system still is the....

Especially electrically driven is much more simple and is much more a state of the art, so it's very difficult to compete with the integrated product. Conversely, of course now following also the trend of prefabrication, probably the installation time and let's say fully decentralized might offer also cost decrease if the product is really well designed, let's say.

### Interviewer

So can I say like prefabrication can be one of the issues that should be considered for barriers related to the complexities?

### Interviewee 3

Yeah, maybe more driver, I would say so if I really manage to design a good integrated product and to prefabricate that like I'm thinking into a curtain wall, you know, then it becomes really like a solar active curtain wall able to provide heating, cooling, whatever you save a lot of let's say investment cost on the building technical systems side.

### Interviewer

But what are the core issues, so the core issues that mainly we should consider for the complexities available, the current complexities? Is it like we should consider prefabrication and decentralization?

### Interviewee 3

Yes, I would say yes.

### Interviewer

OK, decentralization and prefabrication are one of the....

### Interviewee 3

In general yes

And for the thermally driven I think is the kind of physics, so you know like a selection of the fluid and technologies for absorption, adsorption and so on. It's a bit of...still a topic for the decentralization.

### Interviewer

Ok let us move to...OK, we talked about technology, you talked more about the differences about the thermally driven electrically driven. But let me move to the real building sector. So can you tell me how different types of projects such as the new building construction or renovation projects can affect the application of solar cooling integrated facades?

**Interviewee 3**

So I see a lot of let's say potential in both new building and renovation projects. But of course the topic of integration of such a product, complex products, is much easier in the new building because you can conceive the new building and the new let's say a facade with this kind of integrated component since the very beginning.

But I mean potential market could be the renovation because if you manage to integrate it very in a compact way, you really could save a lot....you could offer to the renovated building a nice added value having cooling when having a new cooling system might be not so easy. Let's say for renovation.

**Interviewer**

OK, got it. What about the effect of different types of buildings, office, residential, healthcare, education on....?

How the different types of buildings can affect the application of solar cooling integrates facades?

**Interviewee 3**

Yeah, I think the demand side change quite a lot because residential user might not be so...so might consider having a cooling technology not so crucial of course, is an added value for the comfort. Conversely, office healthcare and so on, really need the cooling by default, so this might be a nice market driver.

**Interviewer**

OK, but how different locations of buildings and climate conditions? How they do affect the performance of solar cooling tolerated facades?

**Interviewee 3**

Yes. Yep.

My PhD was on that one, and of course the more the colder, let's say, the climate is, the less interesting is the technologies, because you have let's say passive strategies that are much more interesting. So I think of course location and climate influence a lot...and then, of course, we know that also the façade exposure is crucial in this sense.

**Interviewer**

OK. So can you tell me what about...what do you think about the what are the recommended locations and the climate conditions for applying facades of products integrating solar cooling technologies?

**Interviewee 3**

Yes, I would call the Mediterranean climates. Probably if we go to office building where let's say, internal loads for an office building are still high, then you could maybe cover also part of mild, let's say climate, so I would say South France, Germany (some part of Germany)and central Europe, let's say climate where summer might be still quite warm.

**Interviewer**

Yeah, I see.

OK, now I think you already talked about it. I was going to ask about how different types of technologies electrically or thermally driven affect the application, but we already discussed this.

**Interviewee 3**

Yeah, yep.

**Interviewer**

So I'll move to the second....key questions.

So the key questions....I'll cover three main aspects, technical and product related aspects, financial aspects and then process and stakeholder aspects.

So the technical and product related aspects, I have a question about....I think we already talked about it. So maybe you elaborate more...I was going to ask about what are the potential solutions that can address challenges related to the product complexities of solar cooling integrated façades, such as the required space availability or interrupting other building services?

I remember you mentioned the decentralization and prefabrication.

**Interviewee 3**

Yeah.

**Interviewer**

So because we have complexities like the required space availability or interrupting other building services. So do you think that this decentralization again and prefabrication should be considered for such complexities?

**Interviewee 3**

Yeah, yeah of course. Of course. I think yeah, space and...yeah, reduction of let's say building technical services, of course can be the driver for which the solution of having decentralized and prefabricated solar cooling technologies. Yeah are well-fitting I'd say.

**Interviewer**

OK.

So now what are the important issues do you think that we should consider for the maintenance and durability of solar cooling integrated facades?

**Interviewee 3**

Yeah, this ,is a bit critical in general for the centralized components. So I think the key would be to rely on a really the simplest technology as possible, reduce it as much as possible, the number of components, the number of moving components and probably a kind of compromise should be found from maybe the best performing integrated solar cooling technology and again the simplification you know. So I could expect maybe also climate dependent situation where we can say, OK, I still accept a simpler technology, maybe working not so efficiently, but you know then on the on the life cycle side we are safe side because if you really go to the centralized then you really cover the building of things that might be broken.

**Interviewer**

So, but what do you mean by a simple technology? Do you have something in mind to describe such simple technology?

**Interviewee 3**

No....I might let's say my knowledge of solar cooling technologies now is not so much up to date in terms of research, because yes is I think 4 years I'm not so much in that sector, so my ideas my might be already a bit old.

**Interviewer**

Yeah but example like a simple technology, what do you think it would be?

**Interviewee 3**

Yeah. For example on the market, heat pump coupled to PV. So well sizing this kind of two components might be already a good solution because you're working with, yeah again, commercial product. You have a maintenance systems and if the system is well designed probably it is today sufficiently known in the building industry, which allows, you know, easier life cycle management. That would...could be let's say not so innovative, but still life cycle efficient product.

**Interviewer**

OK. How do you see the role of aesthetics on the widespread application of solar cooling integrated façades?

**Interviewee 3**

Yeah is crucial and I think is well known because it's related to BIPV and solar thermal aesthetical challenges. So yeah, solar thermal and BIPV...and of course now if we should rate, the PV technology is much more aesthetically acceptable and accepted. So

**Interviewer**

OK, great, so now I have few questions about financial aspects. So in your opinion what are the main issues need to needed to be considered to develop affordable and financially visible for certain products integrating solar cooling technologies?

**Interviewee 3**

So one topic could be like energy self-consumption, so related to the...let's say currently risky context of energy sources availability. Then this could really influence a lot the financial, let's say plan for solar cooling facade and could be an added value. And I think this is still the main driver from the economical point of view, and then of course this might be also supported by incentives in case of local or European ones.

**Interviewer**

OK, So what type of incentives there could be like your European incentives, governmental or...?

**Interviewee 3**

Now I see a lot of, yeah, efforts also from European level to, yeah, to set the this kind of independency of energy. So why not? Even if I mean, we know that it is much more ...much harder

to be achieved, this kind of incentives. National and local I think are the most important related to work with. Quite well.

**Interviewer**

So national and local?

**Interviewee 3**

Yeah.

**Interviewer**

OK. And then you have the European level?

**Interviewee 3**

European eyes but I don't know if it's politically acceptable.

**Interviewer**

OK.

Great. So now I'll move to the last part before the closing questions. I have a couple of questions about stakeholders and processes.

**Interviewee 3**

Yeah.

**Interviewer**

So now I'll move to this chart. You know we have different stakeholders in the build industry.

So you can see that this chart summarizes the relationship between different stakeholders in the facade design and construction. So in your opinion, who could be the main potential supporters to the widespread application of solar cooling integrated façades?

**Interviewee 3**

I think so the facade builder could offer really you know like all in one product, which might could be really, yeah, a plus as a marketing strategy.

So I think still they could really offer that and this could move really the market towards an acceptance of this. But of course we know that the then the architect and the clients are the one that has the power to decide this. So I think probably coupling between architects and products developer. So façade designer, so for façade manufacturer could be those really pushing for this and having the major role to, yeah, to..

**Interviewer**

Can they so they attract the clients?

**Interviewee 3**

Yeah, yeah, that's it. Yes,

I see especially the application in tertiary buildings. So I'm thinking more to curtain wall at the moment as a first step, you know, for like a market interaction. And then at this point, architects and for façade builders might be, yeah, maybe the one.

**Interviewer**

What type of what type buildings?

**Interviewee 3**

Tertiary so office building, or I don't know...shopping malls or...

**Interviewer**

Got it. OK. To.

So do you have something in mind about how to increase the technical knowledge and experience of architects or engineers about technical aspects related to the facade integration of solar coding technologies?

**Interviewee 3**

Sorry can you repeat?

**Interviewer**

OK, so the question...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 such technologies?

**Interviewee 3**

Yeah. So I think on the one side you should be there a role of course for courses let's say from the university to specialized association...and giving this kind of courses....but also in closer relation to facade manufacturer in the moment they might have the product.

So this works quite well when the course is based on experience on products not because of selling the products, but because of a yeah, you can really touch then the system, the components and you understand much more better the how the situation is.

**Interviewer**

OK, so now if we would like to have some standards or guidelines, so what are the core elements needed to be included in designing standards or guidelines related to the facade integration of solar technologies?

**Interviewee 3**

Yes, this is a relevant topic so I think....first the complexity which belongs also to the whole set of multifunctional façade is that is not really defined. There is not a common definition and so all the construction product data active, you know, it's just very general. Then every kind of products as it's own specific regulation and but the concept of multifunctional façades still is it totally missing.

So as part of multifunctional it will be nice to have this kind of let's say issue taken into consideration and thanks to this eventual solar cooling integrated technology might have all the topics of let's say the product construction regulation with the special indication for solar cooling integrated

technologies you know, and I think the BPAV is an example. So they have done a work which is able to match both the electrical, let's say topics but also all what is the building product requirements so.

**Interviewer**

BPAV is it a standard or guidelines for architects?

**Interviewee 3**

Now there is a standard for a guideline. I don't remember the number, but I think since five years they have done the first big step to realize the dedicated standard, you know. And so I mean, this will be nice and again this would be nice for in general from it's functional façade.

**Interviewer**

So OK, but keep in mind. So what, for example, it we would like to have guidelines for people in the market or guidelines, so guidelines for them, what are the core elements that should be there?

**Interviewee 3**

For example, the calculation and measurements. So how to calculate or measure the goodness basically of the integration from building physics point of view.

Keeping safe, of course the performances of the machine. Then we kind of a verification to be done to prevent the risk of fire, for example, given this kind of let's say highly technological component into the façade. So I would seek basically the directive of construction product, and I would try to follow that kind of pillars, but taking, yeah, let's say declined for the solar cooling integrated technology.

Giving recommendation on methodology again for testing calculation and in the different topics, so acoustics, thermally, environmetrics, fire, structural, and the durability you know.

**Interviewer**

I see. So I have let me move to the other question...now in what way can the industry increase the variety of products that would attract customers to apply solar cooling integrated facades?

**Interviewee 3**

Yeah, I think the challenge is to either to...I see a lot of potential application you know, but that's been studied. So different kind of absorption, adsorption and so on. These of course doesn't not help to let's say have a clarity on the goodness of products. So basically it would be nice to focus on the most promising one and make some step forward. Probably again to have really compact product, the maturity, but the technologies is not so high,...so for the market, still too many technical shortcomings, but a way would be to yeah, to realize this kind of study, you know of, simplification, yeah.

Because finally for the....I'm thinking to the photovoltaics, so the photovoltaics managed to intend to the market because finally then it was the technology. Of course there was a variety, but the principles, the main system....is the same and this helped a lot to develop a vast variety of different photovoltaics products, but still very similar one to the other. The solar cooling it seems like every system is a story, every system has his own complexity and this does not help to....yeah demonstrated widely, yeah.



**Interviewer**

OK, but generally, how to improve the future interests of designers, developers and clients about solar cooling integrated facades?

**Interviewee 3**

Yeah, I think the idea to have really self-standing product and we do it its own and autonomous operation, you know. It's really attractive also in this changing complex, changing context and also with all the topic of heat waves and so on. So that should be definitely a pro on that should drive the interest to this kind of products.

**Interviewer**

OK, now how would legal legislations affect the widespread application of solar cooling integrated facades?

**Interviewee 3**

Yes, I think there might be again drivers more related to sustainability....to energy autonomous....buildings and....that's may help to get several this kind of technologies.

On the other side, all the all the lacking norms for product is a barrier...so you know this...the regulation should go on both ways. On the one side, to better identify the technology in order to get the right specific technical norms. On the other side to get the incentives, direct or indirect for this kind of integrated concepts.

**Interviewer**

OK.

Now I have questions about processes, so we have the design, production, assembly, operation and then end of life. Now taking it into account, do you think there are particular phases that are considered to be more important than the others?

**Interviewee 3**

I think the design...It's crucial because you have both to make a good integration and then a good sizing...That is really crucial.

Then probably....yeah, I'm thinking to highly prefabricated product to have a relevant assembly, but then I would say the operational phase is, yeah, it's crucial because you need to have a system that act the way it is the solar cooling technology is working, and let it properly work.

So I would, if I have to put priority, in the first phase whether the technology might go to the market, I think design and operation, then of course in a more mature phase...of course the end of life jump in as we are now seeing for the construction products on the market.

But of course they are all very mature so.

**Interviewer**

OK, so the core issues to be considered during the design, I heard that you mentioned it is crucial because we need the proper integration and sizing. So those are the core issues we should be considered.

**Interviewee 3**

Because today still are lacking in this sense. Of course that the best would be to have that related to end of life. So you know with all the principle of design for disassembling which could really also help to solve some problem in terms of maintenance, and the possible substitution and so on, so I know.

**Interviewer**

So design for disassembly is important for both, during the operation and maintenance, as well as for the end of life?

**Interviewee 3**

Yeah.

End of life.

**Interviewer**

I got your point and what about...do you have something in mind that how we can have a closer collaboration between different disciplines and stakeholder during early design stages?

**Interviewee 3**

Well I mean the first one is that solar cooling technology relies on mechanical, let's say, design more than building architectural design and so on. So this should be the first one, the easiest one and then all the topic of social acceptance and the way and the final user use it is also a key for the success. Yeah, I would put this basically as a core interdisciplinary working group.

**Interviewer**

OK, so I heard that you again repeated about during the assembly....You mentioned the important that we also consider the prefabrication for the assembly or installation...OK what about the production phase...are there important issues that should be considered during the production phase?

**Interviewee 3**

yes, I mean it's the critical part to get an integrated product working properly. So the interface between the, let's say bear...the bear facade and the components that you have to ease ...the façades is crucial is critical, you know, and this interface might be not so regular let's say in shape or just in in the way connecting. You might be needing to connect electrically but also air ducts or water pipes and these are not, let's say, standard building products, let's say is more related to the technical equipment word. And so probably a manufacture, a building facade manufacturer doesn't know at all to how to handle this kind of technical services, basically.

**Interviewer**

So what are the potential issues....?

**Interviewee 3**

So he had the potential is that if this is really an integrated product, then you have to plan production with the new skills. So basically you should hire as a producer not only let's say people used to deal with the glass or with metal or with timber, but you have to hire people that are plumbers or electricians and just the team, you know that is fully dedicated to this kind of interface.

**Interviewer**

So we talked about the design, we talked about the production, assembly, operation, but do you have something about for example during the operation?

Do you have something in mind about some aspects you need to be considered for the end user knowledge?

**Interviewee 3**

Yeah, that is the result, the topic of let's say rising the awareness of how to use the system, let's say.

So how to avoid I would call it blackout situation, meaning people that's just switch it off because they don't like it or they think it does not work properly, but maybe because it was not the right moment and I don't know. So I mean it's important to have a kind of systemic view to drive the user into the operation of which the solar cooling technology is one part, let's say.

**Interviewer**

OK, I see.

I think I covered all questions. Now I have covered questions about processes. I covered the questions related to the stakeholders. I have covered questions about financial, product, technical and the opening. So now I'll just end up with two points in the closing question. So I have first of all, what are your final remarks about supporting the widespread application of solar cooling integrated facades as building products in the construction market?

**Interviewee 3**

OK, so it's reduce the complexity, and this is more on the developer side, technical developers, and let's say drive with the proper let's say guidelines...and incentives...tries the market uptakes from, let's say the policymaker point of view. Yeah, and I think keep a systemic view, so it's not anymore questions just to add the new technology in the facade, but it's really to add the new technology because of a system, because of the benefit for the whole system. So and then I think the key would be really to yeah think this in terms of decentralized prefabricated components.

**Interviewer**

Decentralized and prefabricated?

**Interviewee 3**

Yeah, yeah.

**Interviewer**

OK, I got your point. OK.

So thank you for your time.

**Interviewee 3**

Thank you.

**Interviewer**

I have just final question, so do you mind to propose potential participants that can be interviewed for this study?

**Interviewee 3**

Ohh yes, I can think about.....