

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. [Name of Interviewee 23], in your experience, what is the current level of knowledge in the building industry regarding the application of multifunctional façade components integrating solar cooling technologies?

Interviewee 23

I must point to the fact that you need to differentiate between the integration part and the system part. So integrating solar thermal or solar water tube systems is one thing, that doesn't matter if there is behind solar thermal or solar cooling, and then there's the system design. So in regards to the multifunctional facade, as you name it, such systems are implemented. There are several examples. You might also get out from Alejandro's PhD because he was also working on the solar cooling facades. So there are many products that try to implement solar thermal, or solar cooling, solar technology modules, driven by water. In regards to the system behind, the solar cooling in façades, I think that gets very thin. There are not very application because it's not so effective in the façade. So personally I only had one research project in that regard. I don't know any industrial implement it one, but I'm not in the implementation. So I'm not currently working in the solar thermal field anymore. So we skipped the whole solar thermal part when it comes to the integration into façades. So the last time I dig into that was six years ago, and then we stopped investigating on this filed.....But maybe try to add, solar cooling is not only driven by water-lead system, it's also driven by PV. So you can also, I don't know how far your scope goes, but when you talk about solar cooling out of the facade, it also includes PV systems linked to thermal heat systems that can cool or heat. So I would say that also as part of this discussion from my point of view.

Interviewer

Got it. Now I'll move to the following question. In your experience, what are the motivating factors for the application of multifunctional façade components integrating solar cooling technologies?

Interviewee 23

There are two motivations. In the beginning, for sure it was the energy efficiency or gaining energy from sun for cooling and heating.....and the facade is only one surface, one more surface besides roofs, to make that decentralized and to generate energy out of the facade, but it's for cooling or heating or ventilation, or whatever. So that was the original motivation. I don't see solar cooling booming really a lot. So it's in one hand, it's very closely linked to this water based systems which did turn out to be very smart to implement in the façade, from my point of view. There are many examples in the 90s, in the beginning of the Millennium, where they tested out tubes, you mentioned the tubes, you mentioned the flat systems. So they tested it, but it turned out not to be so productive for solar cooling, because solar cooling needs higher energy intensities and that's what you cannot gain out of the facade system. So from my reception in the field, in the market, PV is the more feasible system. Also because it's easier to install, and multifunctional facades go much more now to PV because it's easier. I mean, we talk about water in the facade. So I would say whatever.....if it turns out to be cooling then because the system behind is a thermal heat system or

whatsoever or desiccant that can be driven by PV, then I would say yeah, there are some options.....but would say motivation for sure is decentralization and use of solar energy, which is obvious.

Interviewer

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

Interviewee 23

I think I mentioned them already. The concerns mainly technical reasons....I would say two points. Technical problems. When we talk about water based systems, it is surely the difficulty of tightness and also heat and temperature differences you have in the facade system. So freezing problems and so on, and the second is the efficiency, the effectivity of solar systems for cooling, when they are water based again. So I think we have to differentiate between the water based which was the original solar cooling developments, and the PV combined systems.....And PV is more likely, I would say, that when you put the heat pump behind that's driven by PV, it's more likely than using a solar collector generating energy or heat for cooling systems.

Interviewer

Got it. So now I'll move to the following question. How can the type of project, such as a new building construction or renovation projects, influences the applicability of solar cooling integrated facades?

Interviewee 23

Well, I think it's obvious in new buildings that I can design the integration of such system from the scratch. So where to place the tubes, where to place the modules, where to place the storage and whatsoever is needed for the system. You can't do that so easily in refurbishments because you have set of former conditions by the building itself. So there's a lot of restrictions and limitations when it comes to refurbishment. So you can't already starting at the location and available surfaces....maybe not use it. So I think it's a determination. It's an early design stage in both where you need to define how flexible the conditions are to implement such a system. So this is a very general aspect. So yeah, refurbishment depends how much space do you have available, how much do you need to breakdown or redo to implement a system. Is it a minimal invasive refurbishment? Is it a full refurbishment? So I think this is rather obvious. I would more personally ask about the type of use. Building typology because this is a very general answer. I mean it depends on the project.

Interviewer

Yeah. The following question is about the type of building. So how can the building type....office, residential, healthcare, etcetera, influences the applicability of such façade products?

Interviewee 23

Because of the type of use, how much cooling do you need. So I think it's truly determined in regards of the cooling energy demand of the building, and then you can think about can you contribute with solar energy to this. So I mean it was a lot linked to hospitals or manufacturers, factories and those who have lot of cooling , or decided cooling need. It was less linked to residential area, because so far, and maybe we need to reframe this.....so far in Europe at least, it was not supported to implement active cooling in the residential sector. So I don't know if this has to happen in future,

then we have to rethink of this setting....what to use for cooling. I think we are now in the middle of reframing the usability of cooling technologies in all sectors, in all types of buildings.

Interviewer

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

Interviewee 23

It depends on the project. You need to do the location assessment. Check out the solar availability and check out the building typology and then do calculation. Is it useful or not? How much can you cover by solar energy? It depends on the solar availability on one hand and on the other hand on the usability in terms of building needs, and then you can decide.

Interviewer

Overall, do have something in mind about which locations that potentially could be considered?

Interviewee 23

I think this is dangerous because the usual what probably comes out then is the south in the warmer climate. That's wrong because the solar availability, the Watt per square meter is also high in the northern countries. It's just different time slots. It's more seasonal and it's more linked maybe to overheating days. So don't link it too much to locations. I think this is a totally wrong approach. You need to check the availability of the location and the use, and use includes does it need solar cooling....your use your type for cooling? Does it need any sort of mechanical cooling? And the other thing is the days.....how much of the year is this risk because we talk about overheating. So how much of the days and then you can come up that Scandinavian countries need solar cooling because in summer it's maybe only two months, but then they have overheating problems.....and at that time they have more solar availability than any other country in the South. So yeah, not focusing on location rather than on availabilities....and needs. So those two need to match, and then it can run anywhere.

Interviewer

OK, so now the following question.....maybe I can skip it because you already talked about it. I was going to ask you about the selection of different technologies, electrically or thermally driven, but you elaborated more than one time about the differences between electrically-driven or thermally-driven solar cooling. So it was actually the last question in the opening questions. So now I can move to the key questions. So in the key questions, I have three categories of questions. I have questions related to technical and product related aspects, financial aspects, then process and stakeholder related aspects. Actually, some of the aspects already mentioned. Maybe when I ask questions, maybe you can elaborate more. So the first question you already talked about but maybe you have something in mind to elaborate more. So what would make solar cooling integrated facades complex products?

Interviewee 23

It is because of everything what you mentioned here...technical, process, and financial aspects. It's a technical complex product because you have many parts and components to take care of to make it running, including the climatic situation in the façade.....And it's, for sure, also stakeholder aspect, because we have a solar thermal installer, we have to façade manufacturer, we have the operational facility manager. So they are part of a couple of people involved who needs to understand the

system.....and also talk about maintenance and warranties and all those aspects.....and for sure both are coming into the financial. So complex doesn't mean complicated, but it is combining constructive and technical aspects when we talk about solar active facades. So we always have a couple of stakeholders coming from those different domains to work together and to develop conditions not only for the implementation, but also for the operation. So who is responsible for maintenance? Who is responsible for delivering the energy that was actually promised to the owner?

Interviewer

OK. 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 building facades?

Interviewee 23

Well, that's controlled challenge in the first goal because other services, I don't know, I guess you mean ventilation and heating systems...classics. The link is for sure maybe common storage systems, thermal storage....they used together for various operations in the building. So you need to define the common infrastructure, all of the systems used.....and the second big thing is for surely the steering. So the control system that has to steer all the different components or services in the building. So it's on those two. On the steering is for sure a challenge for the facility manager, not only the implementation and planning phase, but also in operation phase. So controlling that everything runs smoothly and works when it should work without interfering the other, but that's controlled aspect basically.....and right dimensioning of the infrastructure for sure. So the right dimensioning that you don't over or under dimension the systems.

Interviewer

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

Interviewee 23

Well, that's what I said before. It's steering. This is the aspect you need to keep on thinking during the main control. So the control of the system....It's a dynamic system, and you usually need a period after implementation to make it run optimized. And you have to review this constantly or you have a monitoring process. So monitoring would be the best solution, but not everyone has a monitoring installed. So if there's no monitoring installed then the classic facility manager needs to do the job. And that's the main during operation.....and then the life expectancies of the components....and if you talk about solar thermal, so again, water-lead systems, then you need regular checks on the tightness of the system in a such...but it's classic solar installer tasks what we talk about. I would say the intersection between the complex part of it is surely the controls, optimization of the system between what I said before.....between the systems in the building. Everything else is classic, is traditional system, provisional system maintenance.

Interviewer

OK, got it. So now I'll move to the following question. How do you see the role of aesthetics in the widespread application of building facades integrating solar technologies?

Interviewee 23

Solar technology is also solar thermal. So water-lead.....because PV has made a big step towards aesthetic flexibility and solar thermal not. And solar thermal is also linked to this solar cooling quite often. So water-lead systems dropped out a little bit of further developments. They are not so much

developed, particularly when it comes into integration. And PV, I would say PV made a huge step forward by coloured modules in all ranges and we have patent modules. We have modules with all sorts of patterns hiding the PV basically to be so typically PV. So there's a lot that has been happened in the meantime in the PV sector.....Not so much in the solar thermal sector which is just linked to the solar cooling, which I don't understand because you can also drive heat pumps with PV and generate cooling.

Interviewer

OK. So now I'll move to the following question. I have two questions about financial aspects. So the first question is how can the industry develop affordable and financially feasible facade products integrating such technologies?

Interviewee 23

I'm the wrong person to ask this. You need to ask an economist. The incentives to make that more attractive is a matter of funding or certain programs done by national or local agencies or government. This is governmental related or maybe industrial or economy related, I would say. So technologically seen, the more you sell the cheap it gets. That's as easy as it is.....and surly you need experts who understand the system. So it is truly matter of teaching and training experts.

Interviewer

OK. So actually you answered two questions in one about financial aspects. So I was going to ask you about the incentives. You already described them. So now I'll move to the last part before the closing questions, which are questions about process and stakeholders. So, you know, we have different stakeholders involved in the façade design and construction. So the question is, which of these stakeholders can support the application of façade products that integrate solar cooling technologies?

Interviewee 23

All of them. It just depends if you want to name who are involved, I would say all of them, but not all of them in the same intensity. So the sun shade supplier maybe less relevant than the facade engineer and the architect and the facade builder. And it really depends. I mean you always need a solar expert, the solar installer. So this is the core you need to understand the system to implement. So the core team is surely solar expert, PV or solar thermal, and the facade construction, the facade builder because they need to understand the technical system and then it comes very quickly to the architect and the investor because we're talking about money. And all the others are adding to it.

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 how can we increase the knowledge and experience of architects or engineers regarding technical aspects associated with these technologies?

Interviewee 23

It's two very different words asked in one question because when we talk about the architect, we talk about the total different world than when we talk about the engineers. Yeah, you want to gain a lot out of it when you ask because the electrical engineer won't have a lot to do with solar thermal systems, and the plumber won't have to do a lot with PV. So it really depends on the type of engineer we talk about, and they are very well trained. I mean when they talk about those people who work with solar technologies, these other people who have a very high level of knowledge or

should at least have a high level of knowledge. When we talk about other engineers who are not dealing so much with it, it decreases....Like the same happens to the architect. If you if you have an architect to who had experiences with solar active buildings, their knowledge is surely higher than those who never had anything to do with it. So how to increase this, yeah, well more construction where you involve those who have the knowledge. And it comes with your former question. It comes with the funding programs, because now we are obliged in most European countries to integrate solar technology into buildings, and many countries made that to their main climate goal.

Interviewer

But what about unexperienced architects?

Interviewee 23

You have training. I mean It's obvious, isn't it? You need to train them so they need when they have to. In some countries, like in Switzerland, you have to have decentralized solar energy solutions on your building on every new building in some regions. So whenever they want to make a new building, they have to deliver that. So it's automatic that they either need to find an expert who can do that for them or they have to learn themselves, what are the most important intersections to architecture to make it working. So it's funding and it's governmental driven again. If you have to, you have to learn it. If you don't have to, it's up to the architect. You can't force them. You can only offer trainings and education, but you can't force it as long as it's not a law.

Interviewer

OK. So now I'll move to the following question. So if we would like to have standards or guidelines for architects that are related to the integration of such technologies. What are the core elements that should be in such standards or guidelines?

Interviewee 23

Maybe you look up in the IEA task because the they developed many years ago already guidelines for architects for solar technologies. One is IEA task 41 and that exactly gives you the answer. So 41 is not even a new. It was finalized three years ago, six years ago or so. But they had exactly the same question to answer there. So what sort of guidelines does it need?

Interviewer

OK. So let me move to the following question. Overall, how can we increase the interest of designers, developers, and the clients in solar cooling integrated facades?

Interviewee 23

It's the same. So look up 41 because that was a huge section in the beginning where they actually touched this problem and there are very good graphs in it telling what are the barriers of architects, designers, and engineers to use solar technology, and what could be the potentials. So I would say it's a very good framework to start with those and that I would like to point you to the IEA task 41 to get that view because unluckily not a lot has been changed since then. So I think perceptions didn't change a lot in the market since carrying all this information.

Interviewer

I see. So now I'll move to the following question. How can changes in building regulations affect the application of solar cooling integrated facades?

Interviewee 23

Well, I said before it changes attraction. Making information accessible is one thing, but we did that the last 10 years and nothing changed or it didn't boom as we thought it would boom, especially after collecting all this information for the planning and the implementation phase. So I think now it's only the governmental perspective that makes changes. So you need to force the building sector to implement it. Otherwise they won't do it because it's always coming to financial costs. You don't do it if it's voluntarily, unless somebody wants to pay for it. So if you make it a law, if you make it a duty and people have to deal with it and you can see this with the energy crisis now. Now, since we have problems with energy, people start to think about alternatives to coal and fossil energy because we're forced to. Before we were only talking about it, but we didn't implement. So from my point of view, it needs law. It needs the governmental involvement. Either on local or national or whatsoever, but yeah, it needs a governmental involvement to make it running to increase the implementation rate.

Interviewer

OK, got it. So now I'll move to the following part. So it is about the processes. So you know we have different processes involved in the façade design and construction. So which phase is key for boosting the integration of such technologies into building facades?

Interviewee 23

The key where the biggest problems could...surely in the design phase. When you do the system wrong, everything else that comes afterwards is going in the wrong direction. For sure the key...a good integrative design always starts with the very first scratch on an integrated version. Everything else is for sure is a result of this planning phase.

Interviewer

OK. So what are the main aspects to be considered during the design phase of such facade products?

Interviewee 23

You need an integral approach. You need to involve the system experts, the solar experts. You need to understand the building services' needs, so and that's related to the use of the building and the comfort situation and the location, as what we said in the beginning, the climate situation and then you need the architecture for sure to make a product solution and integrated solution that works fine with the architectural design. So what it needs definitely in this design phase what you show here, I would not even call them phases, I would say then it needs definitely an integrated design approach to make it well done. This is the optimistic version. The realistic version is at least the architect need to get in contact with the system engineers.

Interviewer

OK. So how can we achieve a closer collaboration among different stakeholders and disciplines?

Interviewee 23

Again, two things. If you make it obligation in the funding or in the building process, I would not even say funding, but even every new building has to have, then the traditional team which is usually the architects, the first contact with the client is the architect very often still, they are forced to get at least enough information to implement it....and maybe even then when you make the submission documents that they need already deliver first calculation, so they are forced to involve the system

designers, because when you need to deliver specific calculations they can't do it on their own. So they need to involve people knowing the solar system, and that might be the only chance to establish an integrated team because it's not paid otherwise and if it's not paid, you won't integrate. You don't integrate. You don't have time for it, time and money.

Interviewer

Got. So now what about the production phase? What are the key aspects to be considered for the production phase?

Interviewee 23

I'm not a solar manufacturer. I can't answer that. So you should ask the manufacturer. I can only talk about the integrative aspect.

Interviewer

OK. What about the assembly phase?

Interviewee 23

Yeah, the same as in the design phase. When you make a good job in the design phase, then you know how the assembly works in the best way. So it's a lot about time and integration tasks you have to deliver. So what is implemented at which phase and how to combine or join the components and that needs to be designed in the design phase. So it's not a big problem if there's an integrated design, because they know what to do at what point of the building site development.

Interviewer

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

Interviewee 23

Monitoring. It is a monitoring and control. So if it's installed, good. If not, well, it's a fate thing if the system runs well or not. And I would say quite often, particularly with solar cooling, it runs very bad because of the traditional design teams, many building service engineers implement the backup system just to be sure that in case the solar doesn't run that something classical runs and in the operation we found that quite often when we did monitoring of building, then in the end in the operation phase, the backup system runs continuously and the solar system not at all. And they didn't even realize that they were running on the backup system and not on the original system because there was no monitoring installed. So they didn't know that the solar technology is switched off basically. They thought that the solar system that provides them the cooling, and it was to back up. So I would say this is the most critical, also for governmental involvement and funding. They should target much more on this operation phase, much more. That should be a benchmark, not the planning, not delivering nice numbers when you submit planning documents, but you need to submit operation facts because then the whole thing turns around and the rest will develop around it. So if monitoring becomes obligatory and you have to show that the system runs well and I know that this is an obligatory benchmark, I have to reach as a design team, then I will involve people from the very first scratch to get this done well. So I would say operation is number one when you want to make a change. When you want to increase implementation, you need to target the operation phase, and you need to name it and nail it and install obligatory monitoring. This is the only chance because then we can see what's actually happening.

Interviewer

I see. So now I'll move to the last question before the closing part. So what about the end of life? What are the aspects to be considered for the end of life of the product?

Interviewee 23

Yeah. Again here it's better to talk to someone from LCA experts, because that's mainly about materials, and use, reuse of materials, or exchange of parts and so on. So this is very closely linked to life cycle assessments and life cycle solutions. Reuse, recycle.....I'm not an expert in that, although I know it's very important, but we have to deal with that with those people who know, have some answers.

Interviewer

OK got it. So now I'll move to the closing part. Do you have any final remarks about the widespread application of solar cooling integrated façades?

Interviewee 23

No not for me.

Interviewer

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

Interviewee 23

I think that's what I answered in the beginning. I feel solar cooling integrated facades need to be defined first, what systems are we talking about. At the moment I don't see much chances for water-lead systems in the facade. It's more centralized. These are the high level systems. These are the systems you need on rooftops where you can optimize the whole system towards the solar irradiation, and it's large scale systems. I don't see at the moment, with those technologies we have available, I don't see a big market for solar thermal, or solar modules, solar collectors in the façade. I see, and that's developing, for sure very wide and very high potential for PV integrated facade systems and that truly enables the energy transition because there's such a big range of PV possibilities. We have technology wise and aesthetic, in terms of aesthetics, that we can really now think on how to integrate those in the best way, and then the PV can always be linked to heat pump or any other cooling engine.

Interviewer

Got it. Do you mind to propose potential participants to be interviewed?

Interviewee 23

I think you know.....