Sustainable design responses for residential high-rises

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Abstract

Sustainable design responses for residential high-rises is a viable topic with multiple answers. There are many separate types of researches in the literature on building envelope and applicable green technologies, but the opinion of leading architects so far has not been sought. The study discusses the sustainable design responses through the experience of twelve architects, informing the various parties of four important aspects of the sustainable design of residential high-rises. The methodology is based on an interview protocol with these four questions. The interviews were carried out in January-June 2016. The architects provided comprehensive data on the topic, including how to design residential high-rises in order to foster more social interactions, how to make these buildings more energy efficient and their views on renewable energy solution available. The implications from this study are that design professionals and the general public can use this insight for improving the design of residential high-rises in the near future.

Key words*: compact city, design, high-rise, sustainability*

1. Introduction

Today's cities face rapid urbanization, related to increasing numbers of inhabitants and many environmental problems. World class metropolitan cities such as Tokyo, New York, Shanghai, London, Paris, Hong Kong and Seoul are relying on high-rises in accordance with the compact city plan to deal with problems generated in the city and in order to become the key growth engines for the city and nation (Shin, 2010). Even though there are important functional differences between high-rises with 10, 20 or more floors, as urban areas expand in population and number, urban designers and architects must approach and enhance the relationship between tall buildings and the built environment (Al-Kodmany and Ali, 2013).

In the private sector in cities, tall buildings (commercial and residential) are quoted as needed for urban competition, although it raises concerns that many developments may not include the good quality and iconic design that a few celebrated buildings can (Kearns, Whitley, Mason and Bond, 2012). Tall buildings represent the values of

competition, individualism, domination and immediate personal gain. On the contrary, the sustainability agenda stresses on the necessity to maximize scarce resources by sharing, collaboration and long-term thinking (Worthington, 2010). However, not every high-rise building is sustainable. Socially, there is a correlation between fear of crime, mental health issues and high-rise living, problems with accommodation of young couples with children, lack of social interaction and sense of community. (Kearns, 2012). Environmentally, high-rises consume a lot of resources during construction and during their lifespan. Their envelope and mechanical systems are crucial for achieving sustainability and in many cases, they are not appropriate for this goal. One can achieve buildings' sustainability in different ways: by thoughtful selection of building products and materials, by selection of the best building's design scheme from several alternatives, by utilization of the most suitable construction technology, etc (Saparauskas, 2003).

The main design factors that are crucial for achieving a high-performance tall building are site context, environment, structure and use of materials, energy consumption, use of water, ecological balance, community development, etc. (Ali, 2008). The ultimate goal of sustainable communities is to increase residential satisfaction. In the same time, the targets of housing satisfaction are contentment with family-friendly, neighbourhood-friendly, and environment-friendly design (Cho and Lee, 2011)

As a modern society, it is crucial to make a bigger effort in enhancing housing environments to provide everyone with higher conditions of living (Lee and Kim, 2014). Social sustainability is closely connected to the livability of the tall buildings which from the other hand is akin to the quality of life. Planning and design can achieve liveability. Sustainability features of the buildings influence to a great extent the residents' satisfaction with their living environment and this should be reflected in the policies and regulations guiding the development of the high-rise buildings. Resident dissatisfaction is a decisive indicator that some sides of the design are not efficient enough or are out of date. This may be caused by the design of the first floors, the parking condition, imposed overcrowding, the appearance of the buildings, the landscape qualities, etc.

The aim of the study is to investigate in detail the design practices and views that lead to a sustainable residential high-rise. The study achieves this goal through four research questions:

1. How to design residential high-rises in order to ensure more social interaction?
2. What are the efficient ways to reduce energy consumption in residential high-rise buildings?
3. What envelope should have the sustainable high-rise building?
4. Are geothermal energy and solar panels viable solution for residential high-rise buildings?

2. Methodology

The design philosophy of the leading architectural practices that undertake residential high-rise projects is in the basis of the built environment we have today. That is the reason why it is important for them to share their aspirations and experience, to influence the industry or to refine their views by dialogue with the public. This article is based on the interviews of twelve leading high-rise architects sharing their opinions on sustainable design responses for residential high-rise buildings.

Twelve leading high-rise architects shared their views in interviews carried out in January-June 2016. Different aspects of sustainability are studied, along with ways to increase social interaction, reduce energy consumption and implement modern sustainable technologies. The number of respondents is defined according to guidance from the literature. If the interview respondents form a homogenous group, for a particular group, saturation often occurs between 12 and 15 (Guest, Bunce, and Johnson, 2006).

The participants: 12 architects, designers of prominent high-rise buildings in England and the USA have been invited to take part in the interview. They have been chosen on the basis of their experience and knowledge about residential high-rises.

Table 7.1. Interviewed Architects Expertise
Architect 1 R.C. is a founding principal of Cunningham | Quill Architects, with over twenty years of experience in residential, infill, mixed-use, and commercial architecture. Some of the high-rise projects of his company include The Alta, Washington, seamlessly mixing modern architecture and city living with green building strategies, offering to residents ground-level retail, a second-floor lounge, and a parking garage.
Architect 2 A.A. from STUDIOS ARCHITECTURE is proud for more than ten years with them to solve complex challenges through simple and organised architecture. The architect is known to lead his clients and colleagues through rich, collaborative process to produce dynamic, unexpected solutions informed by the program, site and the culture of each client and project.

Architect 3, Sh. E. as a firm Principal of Torti Gallas, truly expresses the company philosophy when designing residential, mixed-use, and institutional building that are relevant to their environment, while being functionally and aesthetically innovative, economically sensible and delightful.
Architect 4 B.K. joined Pappageorge Haymes Partners in 1987 and since then provided leadership in the design and construction of projects ranging from planned communities, high-rise apartment and condominium towers to single-family homes.
Architect 5 B. N. worked for Pfeiffer for many years with a focus on projects for cultural and educational clients. The company employs 50 professionals—architects, planners and interior designers—with offices in New York City and Los Angeles.
Architect 6 D.C. leads SCB's research and work in the areas of sustainability and building performance, including consulting with project teams to set sustainability and performance goals and assess appropriate strategies.
Architect 7 F. G. is from Make, an international, award-winning architecture practice with one purpose: to design the best buildings, places and spaces in the world. Founded by Ken Shuttleworth in 2004, the practice has grown to over 150 people across studios in London, Sydney and Hong Kong.
Architect 8 L.L. joined Jestico + Whiles in 2002 where he has worked on a wide range of residential, mixed-use and masterplan designs in and around London and the South East. The architect is currently leading a team on phases one to five of the competition winning masterplan at Greenwich Millennium Village.
Architect 9 L.R. experience is in architectural design, interior design, project management, and implementation including multifamily residential, corporate offices and commercial interiors, urban mixed-use, institutional, municipal, commercial retail and LEED projects. He

coordinates R2L's work in commercial interiors and oversees the graphic design components of the firm.
Architect 10 S. E. is a principle in Erdy McHenry and his work has been recognized by the American Institute of Architects for excellence in design, earning more than 11 local, regional and national design awards. The practice uses a unique business model and Design Philosophy: Integrated Decision Making as a Design Tool, where Budget, Program and Schedule are reconciled each in terms of the other with each design decision.
Architect 11 C. S. from Sieger Suarez Architects has been a practising architect in many states since 1972. In addition, during his decades of construction management, he has overseen billions of dollars in new construction, including mixed-use high and mid-rise residential properties and single-family homes, commercial/retail and religious projects.
Architect 12 A.M. from Pickard Chilton has design leadership experience on prominent projects around the world. Some of his firm projects include 145 Broadway, Akamai's new headquarters in Cambridge, 2&U, a mixed-use office tower in down town Seattle, Rosslyn Plaza and many more.

The interviews: The interview consists of four questions, each addressing different sustainable design response in residential high-rise buildings. On some of the questions, some of the architects had no opinion.

Storage: The digital copies of the interviews are stored on personal computers.

3. Results

On the first question A.A. replies that "architecture by social engineering is a favourite thing for the architects to resolve, in his current practice, they really focus on design what they call inside out, that really focuses on the user experience and how that individual experiences the space, and then the building architecture and all that follows from it." The architect thinks that "a lot has to do with creating places that people want

to naturally go to, natural gathering places allowing relief and entice systems but also providing not so much space that it's unwelcoming or uncomfortable. What is interesting is in the 60's there was an urbanist named William Whyte, who did a lot of research in New York, his work stands from plazas, does anybody use them, are they good and had a couple of basic social observations. People tend to stand near objects, people tend to sit where are places to sit, a couple of some really straight-forward aphorisms that are somewhat intuitive, really how do you create a community, it is really about creating places where people can have chance encounters, where people can be comfortable exchanging ideas, people tend to go where people need to go. When it comes to residences those tend to become more and more important, as your typical apartments get smaller and smaller, you find that the places where people want to go, is kind of seeing and being seen, you know the coffee shops, the lounges, the bars, these types of kind of social interactive program take many forms and obviously there is a retail form of them on the street, but there is also a different form of these in high-rise building, and in a lot of these multi-family buildings the actual dwelling units get smaller, the focus is on the amenity spaces, which become really interesting really exciting, where the building has to have certain identity and they have to provide space where people can actually have a social life outside of their inner apartment. So in that sense, the pool is one of those spaces, but the real basic answer to the key for social interaction and social health is providing opportunities for people to have chance encounters around things they are going to do anyway."

B.K. also talks about "roof gardens and pools, all type of activities, this is what they do to ensure people have social interactions by gathering them in larger areas."

B.N. says they "try to create spaces for people to have a chance to meet each other and interact with each other, in a less structured way, where they just kind of hang out. In some cases, it is less of an amenity, more of a giving them a space to do that. Corridors, lobby, if instead of a corridor you have a lounge, a shared space where everybody passes through."

D.C. shares all their projects "have a fitness centre, they have a lounge, they have a lobby. In Chicago the lobby tends to be really formal, but in San Francisco some of the lobbies actually become more like a coffee shop space where people can sit and work, they are starting to see bike rooms becoming a bigger deal, in San Francisco where there is a like a bike maintenance area, right outside the lobby, even a bike mechanic comes on the weekend, to work on peoples bikes, so it is like a storage space, but they are starting to become a space just like amenity, where they could be some interactions, they are changing a little bit. Most of the clients are feeling that amenities are necessary to rent or sell the building. Mostly their company is doing rental buildings but in the past, they have done a lot of condos. It is going to be someone who over 2000 dollars for one bedroom, so the architect thinks that just to compete in that area you have to have these amenities." So in his practice, they definitely see that they "go for low-cost finishes, at amenity level as opposed to the lobby, so with the lobby you want to make

a big impact with expensive materials, but the amenity spaces the design has also become very important. When the architect first started the amenities was some space where you use the cheapest carpet and drywall, they really weren't designed at all, it was just space that you have, but now it is almost like designing a restaurant, hospitality, like a hotel."

F.G. thinks "it is again about mixing uses. Imagine someone leaving the office, having coffee in his apartment and then inviting someone for a breakfast. It is absolutely interesting because it feels like you are on a High Street instead of a traditional tall building. And then you might get invited from that person, go to their apartment, there is sort of connection there, and maybe you both go to the gym, or hotel, it is mixing the commercial world and the residential world, it makes it more like a community, because you are sharing an experience with someone that isn't just your colleague at work. The architect thinks for example in the Cube in Birmingham the retail levels incorporate the gym, and that is something the hotel uses, the residents use and the office uses and is a kind of shared facility that benefits everybody. And obviously, it ads viability to the building."

L.R. talks about "a mix of uses in their larger projects, the retail is usually at the base along the streetscape with restaurants, stores."

M.H. replies that "the types of different amenities that they include for interaction could be anything from interior green space that upgrades courtyards, plazas piazzas, depending on the context and depending on the site, and then within the building public lobbies, shared amenity spaces, and then sky gardens, exterior terraces, rooftop gardens."

R.C. thinks that "it starts with the deep understanding of urbanism, about the way that buildings meet the ground, about the way that there is some path through the building and a lot to do with spaces that allow spontaneous interaction between people. Amenities are a great idea. In his practice they have been doing a lot of live-work kind of buildings."

S.E. says they "encourage social interactions by providing public spaces dedicated to community life."

Sh. E. gives, for example, a building called CityVista. "The building has several areas for social interaction. It has a large courtyard on the second floor, called urban oasis in the middle of the city because the city in many cases doesn't have the large open space, the courtyard is a place where all the residents can meet and mingle. The second area is on the top level, on the roof, there is a swimming pool. The swimming pool and the roof terrace is again a second opportunity to all of the residents to come in and share the roof and socially interact. In each building, these are the common amenities, of all three buildings. The courtyard, the roof terrace with the pool, but each building has its own set of amenities, such as club room, again another opportunity for people to come in, interact, and what we like to do in the buildings nowadays is concentrate amenities in

one area, that used to be, ten years ago, amenities used to be in leftover spaces. It is no longer like this. Now the amenities are really in the heart of the building. You want everybody to go to these amenities, you want these amenities to be active so they tend to be near the lobby, they have a communal table so people can sit across to each other, not individual tables, it's in the centre where everybody, you enter the building and you see the lounge, you see the business centre, all these and the gym, all these are very close to the lobby or very accessible from the lobby, activating the lobby, so once you enter you feel the energy of the place, encourages you to be there. And the new lists of amenities adjust in time but just you find a lot of people have pets. So the idea of a pets spa and an area to walk your dog, in the building a place where you can wash your pet. Children of course. If you think you will have large families they have the tendency to put the larger units on the courtyard level. Or in a place where they will have a backyard or accessibility to the outside where children can play."

L.L. says "if you look historically, there are a lot of tall buildings that were just kind of sat in without a great deal of thought about design. In a big site of concrete or a big lawn of grass and none of that really helped the interaction, because people will just hurry in and out of the building, get out of there as quickly as possible, into unforgiving and threatening external area.

Fig. 1 The Red Road Flats, Glasgow

So the architect thinks allowing interaction people through landscaping, allowing places where people can meet and interact. Safety is a big issue, so allowing people to feel safe in buildings, so they have this security by design standards, plus they created roof terraces, creshe, gym, so allowing place for people to kind of mix safely."

On the second question A.A. replies that "it goes back to turning the energy into electricity to be able to kill two birds with one stone. If you think about how a tree heats and cools itself, it doesn't do it by creating a perfectly tight envelope. The way our technology is today is that we have to create a completely contain system. So, every bit that leaked from our building now, creates problems. So designers are very focused on creating a completely tight and sealed building envelope. Over time first of all anytime you say never as it is never going to be a leak in this building, there is always a leak. So, managing systems that plan for that kind of leaking and flow will actually help the sustainability story over time and they are starting to see that in a very basic way that rain screen building envelope systems which are essentially recognizing that there is a

certain porous. If you provide certain porosity in the outermost layers of the building skin you can change the wear and tear that that happens on the inner skin. So, you can really think about it as an example of you have your epidermis, your uppermost skin, your sweat pores and things that come of, and then underneath a very sensitive skin layer that does ultimately all your protection. The outer skin layer has oil on it so the water sheds off it, but the inner skin layer is really doing a lot of the work with the heat, and keeping your body heating, and the rain screen system in buildings has started to do that from a solid skin standpoint." They don't necessarily have an answer for that in glass yet, but the architect thinks that these are the types of things that are exciting potential developments in building technology future. The architect still believes in how we turn heat energy in both cooling and electricity one day.

B.K. says most of their projects "don't have a lot of component for renewable energy, they don't have photovoltaic panels or anything like that. For some of the projects they are able to do some hot water solar heating, but right now we are working on market-driven projects. They use a lot of glass, some of the projects are a combination of exposed concrete and glass, to try to reduce the amount of glass they have, and the concrete is basically insulated, they have tried to institute some of these plans quite often these important concrete buildings have balconies that extend out, they know from details that there are ways you can separate the balcony from the rest of the concrete frame for more energy savings. This is a very expensive detail to do and quite often it is not done."

L.R. says "there are a few ways to do it, one way that they focused on is the building envelope design, so better insulation in the walls, better insulation in the roof, low-e glass, thermo-broken windows as efficient as possible, it's not always possible on every project because not every project has the budget for it." And in his practice, they look "of different kinds of mechanical systems as well. They have seen the adoption of newer technologies that were more expensive and now because they are becoming more wide spread, the cost is coming down and people are willing to purchase them and install them in the building."

M.H. says "you have to be very thoughtful about the orientation of the building, the massing of the building, being thoughtful about the enclosure of the building and then in collaboration with our other teammates like mechanical engineers and sustainability consultants they are always looking for the best mechanical system, for the local environment. And looking for ways to use the top technology in terms of what will be the best HVAC system, so in many of their projects they are looking at chill beams, they are looking at heat recovery, design that tries to reduce the cooling load, and in northern climates for the enclosure as well as the mechanical system."

R.C. shares they "primarily reduce energy consumption through the building envelope which is how the windows, walls, etc. perform. You can achieve some very major

reductions by really being smart about the envelope but that also requires upfront money and upfront expense in order to use the best materials, the best insulator."

S.E. gives for an example a building called EVO in Philadelphia. "This building takes this entire site so all this green roof absorbs water and all the solid paved areas are actually a reservoir underneath, so there is five inches of basically a pond underneath those pavers, all that takes through the stormwater. And the building itself, in his practice they designed a curtain wall system which is three layers glass, which is designed to reflect solar heat but also thermally maintains the temperatures in the building. And this building is also, even though it is all glass, it's really only 40% vision glass."

Sh.E. says they are doing two things: "efficiency of the HVAC systems, second is the efficiency of the envelope." Typically they provide high insulation levels of the roof and the walls. For example, their walls are "minimum R19, code typically requires R11, but they provided R19. What is typically required for roof is R19, their is R30. So they do increase R, they provide efficient building through providing efficient HVAC systems, through insulating the roof, the walls, the windows, it is provided clear double glazing, but also energy efficient appliances, the refrigerator, any of appliances, provided within the units, in addition to efficient fixtures that reduce water consumption."

C.S. shares that in his practice they "have been reducing energy consumption on daily basis by LED lights, considerably less electric use previous incandescent, so all of their buildings are installing LED lighting, and there is recaptured heat loss with the air conditioning systems, solar panels, and in some of their buildings they actually have wind generating devices, on the top of the high rises. Geothermal energy is only usable in certain areas of the world where geothermal physical ground works can substantiate that, as an example they tried geothermal air condition where it uses water from the ground and then cools the compressors and the air conditioning system, but unfortunately in Florida they have high salt content of that water and it ruins that equipment very rapidly. So in certain areas, you can do it, say in northern climates, say Manhattan."

L.L. says that "overheating is a big problem, so passive ways of mitigating against this are worth investigating – solar shading, light shelves, louvres etc. Centralised systems are the other obvious solution to maximise economies of scale on M+E systems rather than many individual systems within dwellings."

On the third question, A.A. replies that "rain screens are the first step letting certain kinds of porosity within the building. It provides advantages. The rain screen today still has a very tight very waterproof layer behind it. That is very important for keeping the air and water separated from the outside and inside. The architect thinks what will be

the interesting next step is when they figure out the next technology that lets the building brief directly through the skin, but that doesn't lose the body heat or the cooling that is inside that lets the building kind of actually brief. Because the amount of energy and resources that we put into the mechanical what has been interesting is that sustainability movement over the last 15 years, what has happened is that the mechanical systems have become more and more elaborate, but they haven't necessarily revolutionized. You still are moving air through metal ductwork that is taking space within the building which makes the building taller which takes a lot of resources, or you are adding a lot of things that aren't necessarily fitting into the building purely for these mechanical systems. Ideally what we see in the next 20 to 50 years is new ways of thinking about ventilation. People are starting to see some of these too, like in the 19th century heating and ventilation were separate, because you have a fireplace, and you have a window that you could open. And then in the 40's and 50's those kind of got squeezed together when we invented air-conditioning which kind of started this whole thing, it allowed us to build tall buildings but it also made it so that we had to create these very particular isolated environments and now people are trying to deal with that, the sick building syndrome are the kind of the consequences of creating these very contained environments other than buildings that can breathe and absorb."

B.N. says "it is too expensive to implement a lot of the time energy efficient envelopes, you obviously have windows, you try to use low E on your window, you try to use window that performs well, if it is darker you get less light, there is a balance, low conductivity is pretty good, gives you pretty good energy savings, also not that bad looking. A building, for example, Colburn was terracotta rain screen, exterior envelope, but that was more of an aesthetic choice to match the brick on the existing buildings, then sort of an environmentally sustainable choice."

D.C. explains that "most of their buildings tend to be all glass, they are not all vision glass, so the biggest impact is the U-value of the window systems, our projects they are all high-rises, they are very sensitive to the cost of the external wall, so you don't see things like triple glazing in most of their projects, they try to use good, slightly better than the market frames, and they use very high-performance glass. One issue is when you don't have vision glass, it's hard to stick a lot of insulation behind it because it creates moisture problems, so they are working on a wall system that is inexpensive but will allow us to use more insulation, in the plain with the glass. It will make a big impact on performance. This is for colder climates, in warmer climates like typical Arizona, the problem is more about shading, and this is when they start to see shading elements on the outside." They used to do a lot of analyses to optimize the shading.

M.H. says that when in his practice they "can and when the budget and the local construction industry supports it, they like to use a unitized system, they like to have enclosures that are fabricated and assembled as units offsite, they find that gives us a better enclosure and better weatherproof, well-sealed enclosures, if they can they like to use a unitized system, also the prefabrication of the units makes the site construction

more efficient, less waste, when units are fabricated offsite, the waste can be recycled in a safer manner and it makes the system more airtight, they are trying stay up to date on the latest technologies on relative on coding and glass so many of their buildings are using the state of the art coding on the glass and then in addition to that, they are also always looking for a way to the enclosure to have elements that provide the appropriate shading based on its orientation. So, you will notice in many of their high-rise buildings they have a series of shading or elements that help cut the solar gain on appropriate façade."

R.C. shares that "the glass is in their projects is three layers of laminated glass, so that is the heavier glass you can get, that had to do with the thermal performance of the window, but also with the noise reduction performance of the window if you have very busy site, lots of noise is going up and they wanted to make sure the building was quiet."

S.E. says in the case of EVO "it is all glass but the glass is not a very good insulator, however, glass is only the finish of the outside of the material. So for instance, the darker area is a window, this part is actually solid behind it, so in terms of long-term sustainability relative to durability glass is an excellent choice, for the exterior of the building because it is very durable it is very cleanable, it has a very long lifespan. In addition, the skin between each of the panels is not a sealant joint but it is rather gasket joint so that waterproof joint is way back into the wall, which protects it from weather and is also doesn't wear out as a sealant does, so it is very sustainable skin system.

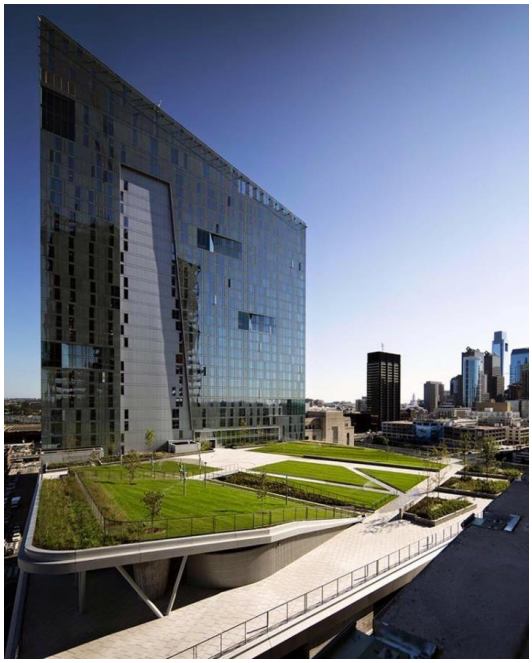

Fig. 2 EVO, Philadelphia, Erdy McHenry Architecture

So there are prefabricated panels, they happen to be completely solid, and there is the operable window this is how you get your fresh air so this panel opens up, so natural ventilation is also very important by a façade that wants to be very airtight but also needs to breath and allow fresh air in."

C.S. says "a lot of people are talking about wood, but you can't really do a high-rise in wood, so real sustainability has more to do with recyclability, if you do concrete and if you do reinforced concrete with steel, you have recycled all the structural part, and the envelopes where we work in South Florida are all concrete block, and glass which is also recyclable so the architect thinks sustainability has more to do with the life cycle, if all the parts that are produced are recyclable they would be much more sustainable.

These materials provide high-quality of life as well. The quality of life has to do with air and light, and in Florida, they use very large sliding glass doors that allow a beautiful transition between the outside and the inside, the balconies."

B.K. thinks "one aspect of living in a high rise building as opposed to other types of housing in an urban centre is the importance of views. People are drawn, in part, to a high rise building to have views. To take in the ever-changing landscape of a city. As a result of this highly efficient glass is an important aspect of the envelope. There have been experiments in developing Photovoltaic panels that are transparent that could clad a building as well as being a power source."

Sh.E. says that "while there are no specific regulations, the architect will recommend that the building meet the Requirements of the USA, LEED Silver Certification."

L.L. says "some things here are obvious: low maintenance, high thermal and airtight performance etc. Others perhaps not so obvious. The robustness of materials is important. Many cladding materials can rapidly deteriorate with weather and UV exposure, so the choice of materials that "wear in rather than wear out" is critical. Pre-fabrication is a potential area to be investigated to ease construction. Winter gardens are also worth mentioning as more useful outdoor space that is protected from wind and rain. Self-cleaning surface finishes can be useful."

On the fourth question, A.A. replies "that geothermal power and solar panels are absolutely suitable for high-rise residential buildings. If people get 99,9% of our energy on earth from the sun, it goes to the plants, the plants turn it into fossil fuels when they decompose or animals eat the plants and then turn it into fossil fuel, but everything is coming from the sun, so if we can skip all those middle sources and get it to the building directly, that is great. Solar panels today are not as efficient as they will be, but ultimately the architect thinks that is absolutely true. There is a risk of both of this sources that is coming from is there a point when you are depleting them enough to upset the balance of the planet and the architect doesn't know where that point is, the architect thinks from where we sit today it seems like unlimited resource but where they sat in the 18th century, fossil fuels seemed like unlimited resource or whale oil, so right now it seems like panacea, but obviously energy is in constant struggle in the universe."

B.K. replies that "in his practice, they have looked at solar panels and geothermal energy in certain projects but the expense is such that it makes no sense of using it in a high-rise building."

B.N. says they "didn't do any photovoltaic on the Colburn mainly because the roof had a helicopter platform on it so the roof wasn't open for photovoltaic, and nowadays you see products that people put on the façade." They also never did geothermal energy.

D.C. says their buildings "tend to be skinny so they don't have enough roof area and it is very expensive to integrate it into the façade, but they just finished a building in San Francisco that has solar power, two water collectors on top of it, but it is a fairly small percentage of the energy used. For geothermal, they haven't done it for high-rise residences, because of the first costs are high, but they did look at it in one project, the architect thought it is really interesting, they looked into integrating foundation and geothermal, these are very tall buildings, usually piling foundations, it means you already drilling down, to the ground which is what you do with geothermal, and that is actually the expensive part of geothermal, so they were looking at integrating the geothermal into the piling but it is complicated because all of a sudden you have to pour concrete and you have to put pipes, but it is an interesting idea because you are using something you already spending money on."

F.G. explains they "did not use anything in particular, the requirements from building regulations were high, but they did not invest in advanced systems for the Cube, Birmingham."

L.R. claims that in his practice they "would like to use geothermal energy and solar panels in their projects, they think they are suitable and interesting, they have not seen a lot of use for photovoltaic or things like wind turbines, just yet. They think that is going to change soon, they will start seeing the technology change and the actual windows themselves hopefully will start to have some of those technologies built into them. A lot of what they do in their high-rises when they are residential they try to really sort of maximize the roof area available to residents, because it is so important to be able to go on the roof and have that as an amenity space. Because the units, the apartment themselves are getting smaller and smaller, in their markets probably still bigger than in other countries so when the units get smaller, the common areas and things like roof decks and rooftop pools get more important to the people, so they cannot cover the entire roof in solar panels, and even if they did, it is such a small area it is not going to be that effective, but they look at them on the facades and probably integrating them into the cladding system will be part of the future."

M.H. says they "have several projects where they have incorporated solar panels in the roof scheme, not so far as a project where to incorporate PV on the façade, although they explore that, they have also looked at geothermal, less in high-rise towers, more in the low-rise building. Although they have one project with a type of geothermal, it happened to be a project that is located directly adjacent to the Chicago River. So the mechanical system directly uses river water and it is a precooler source for the chiller. So, rather than using a field of a well, it uses river water, directly adjacent to the site. That led to some pretty significant increases in the performance of the buildings' mechanical systems."

R.C. says they "have done geothermal wells and that can be a very effective strategy, also a house with geothermal including the pool heater, as well they have a solar farm

because they have a lot of lands so that house was designed to use no energy when the clients weren't there which is very difficult because there is still power in the house, there is still heating and cooling and all that, but they managed to achieve it."

S.E. thinks "geothermal is a very good system, and they have used it on a couple of projects, in the particular urban situation with EVO they did not use it because there was not enough ground area so the building footprint is very small, because it is a high-rise, but there is not enough underground or ground area space where they could actually have geothermal wells. Another project, the entire parking lot is geothermal, the building is only 50 thousand square feet, the high-rise is 10 times that size. The area is ten times that size. For 50 thousand square feet they needed a lot of area of wells, so this times ten in an urban condition, often you can't get enough surface area to drill the wells. They also had solar panels, on the roof. These are also cylindered panels, tubes, actually they are performing much higher it is the full effect of the sun regarding the location of the sun."

Sh. E. says "in his practice, they did consider solar panels, however, the cost of the solar panels of the time did not really justify the cost of the savings, they really looked at the efficiency of all systems, HVAC and envelope. The architect thinks that geothermal power is absolutely relevant to this kind of buildings, they do explore it, now with every new building they will explore it."

L.L. says "geothermal is a potentially useful idea for taller buildings due to the deep foundations that are required, even though the architect has no personal experience using it. Solar panels: PV or Solar thermal are more complex due to limited roof space – but they did look at a vertical PV façade mounted solution."

4. Discussion

Buildings, energy and the environment are the main topics engaging the building society worldwide. However, even though the architects design high-rises from Florida to London, it is appropriate to note that the climate conditions for their buildings are not extreme and the mind-set of the users is more Western. In order to ensure frequent social interactions, the architects tend to focus on creating attractive communal spaces. Amenities are a reoccurring theme. However, some other approaches such as attention to the creation of identity are related to the social interactions and their quality in the high-rises. The amenities might be swimming pools, roof gardens, fitness, lounge, the lobby is very important. Amenities are the way social engineering can be implemented in order to create a sense of community, fostering social interactions. Safety and social interactions are also related, people need to feel secure in order to use the communal spaces. The responses imply that it is possible to influence the users' behaviour by

design that considers the attitudes and dispositions of the residents. Furthermore, it implies that the architecture has a serious impact on shaping the lives of its users.

In many of today's buildings, the energy consumption can be significantly reduced by applying energy efficiency solutions. Because of environmental concerns and the high cost of energy in the last years, there has been a reborn concern in building energy efficiency (Sadineni, Madala and Boehm, 2011). The architects discuss turning the energy into electricity by future technological advances, using insulated concrete, efficient walls and windows, LED, efficient HVAC systems. The passive design also should be considered in terms of solar orientation. The fact that much of conventional, modern architecture is not sustainable in a long-term perspective is not new. Strategy to change this include using energy and materials more efficiently. Obviously reducing energy consumption is an area where more effort should be focused on the near future.

The building envelope is the interface connecting the interior of the building and the outdoor realm. A building's energy consumption to a great degree is defined by certain envelope design elements. Using the unitized system, architects like to have enclosures that are fabricated and assembled as units offsite, they find that gives them a better well-sealed enclosure and better weatherproofed building envelope. Some like to use laminated glass, the heavier glass there is, that had to do with the thermal performance of the window, but also with the noise reduction performance. These systems increase the environmental sustainability of the high-rises and reduce their footprint on the site. The numerous solutions available support a great diversity in the approaches and designs that are possible and yet environmentally sustainable and the architects share some really important practice experience.

The architects agree that geothermal energy and solar panels are absolutely appropriate for application in high-rise buildings, but sometimes there is not enough space to locate them. A better balance between amenities such as roof decks and the technology input must be sought.

5. Conclusion

The article discusses important design responses capable to enhance the social and environmental sustainability of residential high-rises, increasing the awareness of the professionals and the public on these questions. They describe the ways to reduce the energy consumption of residential high-rises, stimulate social interactions, efficient building envelopes and the application of geothermal energy and solar panels. The findings would help academics and the general public understand the rationale behind the operation of the building envelope materials and designs and remind them of the importance of energy saving characteristics of the envelope, the possibility for natural ventilation and the implementation of green technologies like geothermal energy and solar panels.

Even though the article is quite comprehensive, a further research on building envelope characteristic might be applicable.

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