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Views & Comments

Tackling Global Grand Challenges in Our Cities[†]

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1. Introduction

In this Opening Session of the 2nd Global Grand Challenges Summit, the distinguished speakers before me have already done a great deal to set the scene and lay out some of the big issues and possible ways forward. No doubt we will hear more about the astounding developments we are seeing in information communications technology (ICT) and other technologies in many sectors and of the opportunities they bring to help tackle our grand challenges. And if I look through the prism of my own sector—design engineering in the built environment—I see exactly the same thing: Rapid advances in our thinking are taking place at dizzying speeds. Much of that is being driven by interdisciplinary collaborations ranging well beyond the orbit of traditional engineering and construction.

I would like to share with you some thoughts about the role of our cities in tackling these grand challenges.

2. Our cities—Our shared future

Rapid urbanization means we are of course to have close to three-quarters of humanity living in urban areas by 2050. From where we are today, we are adding 5.5 million people to our cities every month! And by that time, we are quite likely to have added another 2 billion people to the planet, most of them in the cities.

The number of "mega-cities" with a population of over 10 million people has gone from just one in 1950 to around 35 today and there are 560 cities in the world with more than 1 million population. The number is increasing, and the developing world is the host to most of these expanding cities. This is a massive challenge that will continue to grow.

Since we know that cities already account for 60% of global drinking water, 75% of energy consumption, and contributing up to 80% of greenhouse gas emissions, that is a big deal. Many cities are vulnerable to natural disasters and human errors. Not to mention the more pressing issues such as traffic congestion and air pollution.

And yet, it also represents the best opportunity we have to make real progress for the future—we design our new cities to be safer, far more efficient, sustainable, and resilient than our previous efforts. The best way to do that, of course, is through collaboration—collaboration between cities.

Even just in my own firm, for example, we have been working closely over the last few years with international initiatives such as the Rockefeller Foundation's 100 Resilient Cities programme, the United Nations Human Settlements Programme (UN-Habitat), and the World Economic Forum's "CEO Climate Leadership Group." The C40 Cities Climate Leadership Group consists initially of 40 cities, but has grown to 63, of the world's largest cities. These and similar initiatives taking place around the world point the way to what we need for the future. Efforts aimed at mapping actions; determining successful outcomes; and then transferring the knowledge and lessons about what works, and what does not, to city authorities across the globe.

And cities facing similar challenges can learn a great deal from their colleagues around the globe-without having to completely re-invent the wheel each and every time, e.g.,

- New Orleans and Manila are building their infrastructure for resilience against disaster;
- Los Angeles and Perth are learning the lessons of how to mitigate urban sprawl;
- Qatar and Mumbai are implementing new water management strategies;
- Hong Kong and Tokyo are illustrating the energy efficiency inherent in compact cities; and
- Berlin and London are retrofitting their infrastructure to become more liveable at higher densities.

In the last couple of years, major cities have doubled their climate change actions, particularly those involved in Smart Cities initiatives [1–3].

So while rapid urbanization may present its own challenges, global collaboration means we can raise the pace of innovation so that the next generation of cities is far better than the last. This need could not be more urgent.

3. Double the world's infrastructure

This is because, just to keep pace with projected global gross domestic product (GDP) growth will require an estimated $57 trillion USD in infrastructure investment between now and 2030 [4].

That $57 trillion USD represents more than the total estimated

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value of today's infrastructure. In other words, we may be about to double, or build the entire world's infrastructure all over again in the next 15 years.

So this is the time to make sure that we learn from past mistakes and build it better. Or we create a blight that will take decades to eradicate.

This is the time to ensure that we create the smarter, more sustainable and resilient future we all want to see. And this is the time to build a future where we recognize the co-dependence between our social, economic, and environmental needs, and design our infrastructure and our cities accordingly.

4. Looking forward—Buildings, transportation, and urban form

Compact City is the predominant model for developing cities, where energy efficiency is achieved through density, high-rise and mix-used buildings, together with an efficient public transport system. Let us now take a forward-looking view of just some components of such a city: buildings, transportation, and urban form.

4.1. Buildings

Buildings in a city account for a very significant part of our energy consumption and greenhouse gas (GHG) emission. In some cities, like Hong Kong and New York, buildings consume 90% or more of the city's total electricity supply.

So having high-performance high-rise buildings is of great importance. The aim being not just to have a resource-efficient building but that it helps to improve its neighbourhood's environment.

The designs of such new buildings are already sophisticated, involving many different professional disciplines and expertise, e.g., air ventilation, thermal comfort, building integrated photovoltaic (BIPV), human behaviour, solar heat and facade, and daylight and energy modelling (Fig. 1).

We are using new technologies to make old design concepts work far more efficiently, e.g., on the Middle East, this new building in Abu Dhabi features a dynamic shading system that opens and closes intelligently as the sun moves around the exterior of the building (Fig. 2).

4.1.1. Re-inventing the skyscrapers

For the future, we need to re-invent our tall buildings (Fig. 3) [5]. Imagining the future tall building:

- It is adaptable to different usages;
- It produces more resources than it consumes;
- It improves the environment;
- It is intelligent (to interact with human activities); and
- It is integrated with urban infrastructure systems.

4.1.2. Adaptable building

For example, a high-rise residential building that can adapt interchangeable units is being piloted in Shanghai (Fig. 4).

4.1.3. Bioreactive facade

Algae, fed with CO_2, is being used to provide light-responsive shading for a residential block in Hamburg, Germany, with the biomass by-product then used to provide power (Fig. 5).

We are on the verge of applying many new materials: self-healing concrete and CO_2-absorbing membranes, materials developed through bio-mimicry and bio-composite materials, to name but a few.

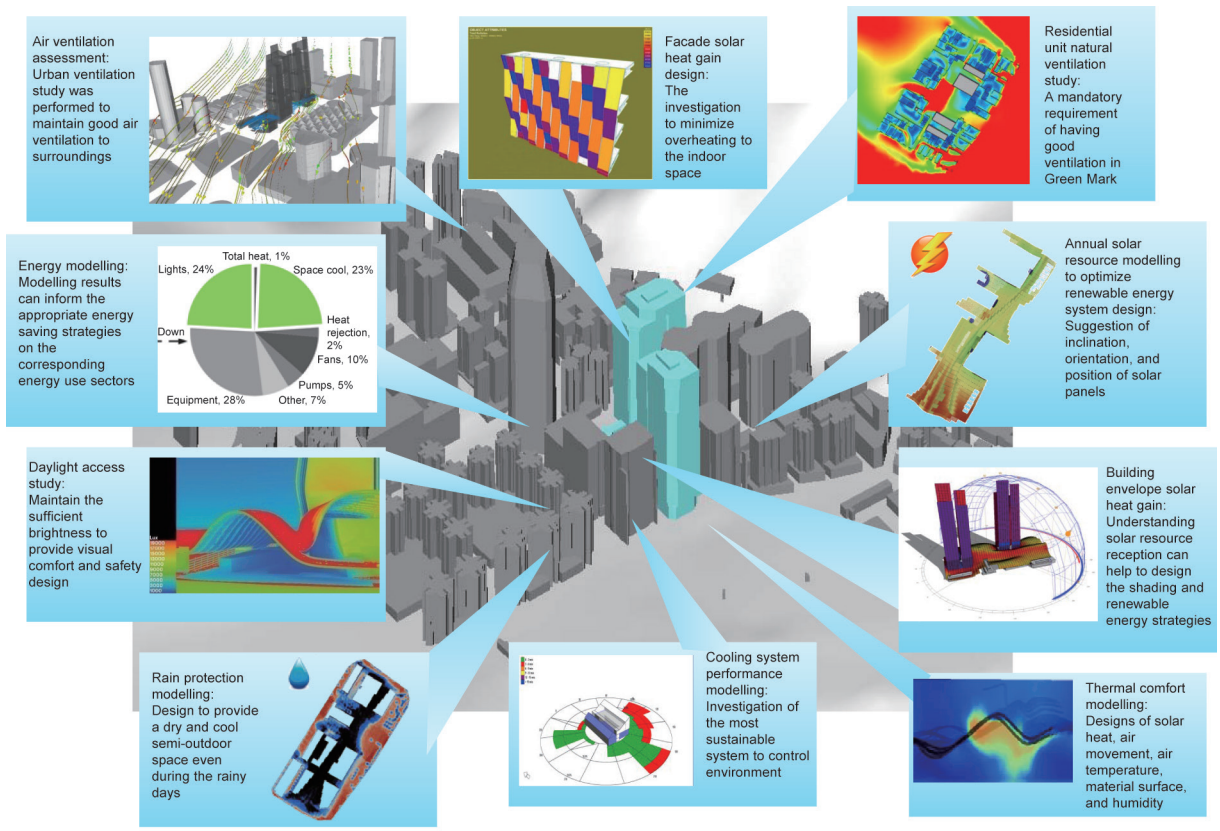

Fig. 1. Integrated solutions for high-performance building design.

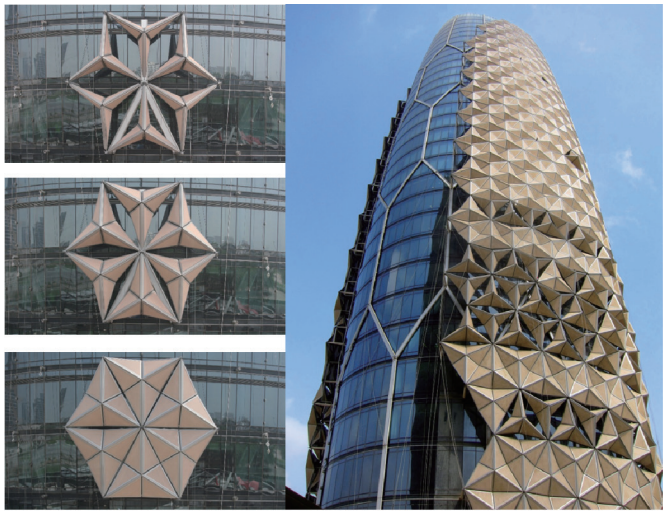

Fig. 2. Responsive building facades (Abu Dhubi).

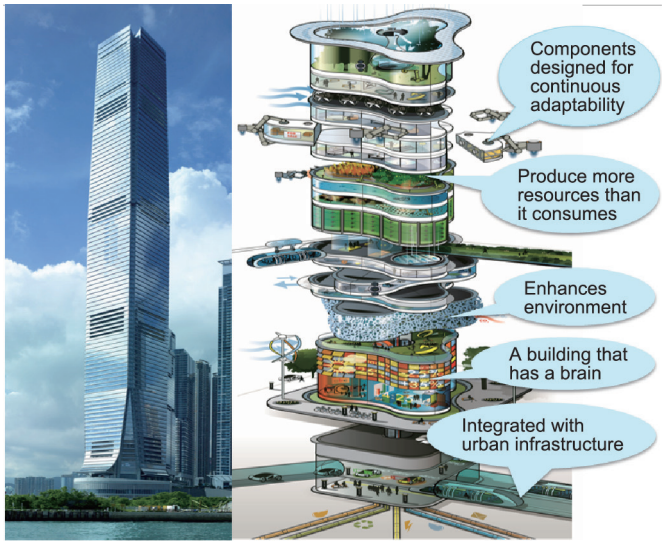

Fig. 3. Re-inventing skyscrapers—urban building of the future.

In fact, by looking at the entire eco-system, you suddenly find huge potential to create natural resilience in water management, urban heat islands, and even urban food systems.

4.1.4. Bio-composite facade panel

And with this wider view, we are creating strong foundations for a more human-centric future, where the concepts of the circular economy become second nature and we rediscover that there really is no such thing as waste (Fig. 6).

These are just developments on the way to making future buildings energy and carbon neutral.

4.1.5. Decarbonization process to urban development

We combine energy-saving technologies with smart microgrids and distributed energy systems, scaling up to achieve low-carbon district and so-called eco-cities (Fig. 7).

4.2. Transportation

4.2.1. Sustainable mobility

If we turn to sustainable mobility, we see a huge upsurge in shared cycling schemes springing up in cities across the world. Those cities learn from each other about how to curb congestion, air pollution, and health risks in a single swoop.

The rise of car sharing and other forms of shared ownership represent a clear recognition that we are shifting our attitudes in the way we own and use motor vehicles.

It is of course imperative to encourage the use of public transport, such as bus rapid transit (BRT).

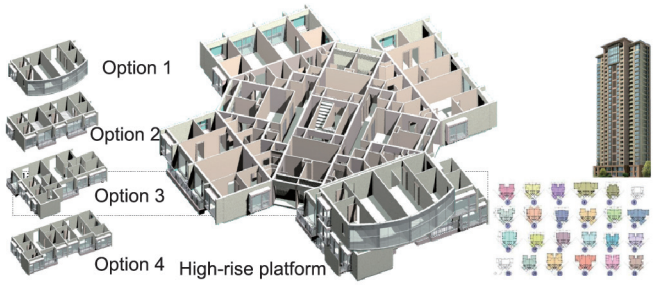

Fig. 4. Adaptable building—a customized apartment building.

Fig. 5. The bioreactive facade—algae (Bio Intelligent Quotient (BIQ) House, Hamburg, opened April 2013)

Fig. 6. Bio-composite facade panel—natural fibres plus resins (harvest wastes). Circular economy.

China is leading in scale on the switch to electric buses with thousands already running in many cities, while in places like Milton Keynes in the UK and in Korea, they are developing wireless induction charging technologies that mean the buses need never return to their depot other than for maintenance (Fig. 8).

Indeed, if the degree of interest in autonomous vehicles even begins to match the delivery, we will need a dramatic change in how we view mobility. And that is likely to have a massive knock-on effect on city infrastructure design.

4.2.2. Complex built environment

Today, we are already crowd-sourcing everything from planning to buildings and infrastructure design. In fact, for the design of one of the world's busiest and complex 7-level metro stations in Hong Kong involving a 4-line interchange and 1 million passengers per day, a digital 3D synthetic environment was created to time how long it took people to get from one part of the virtual station to another. Hundreds of passengers took part and the information was used to optimize the signage and security designs so that on Day One we will have a safe and most efficient flow of people (Figs. 9 and 10).

4.3. Urban form

Public transport will shape city development. One of the more sustainable forms of urban development is the transit-oriented-development (TOD) model, essentially creating a development hub at each mass transit station. And Hong Kong has been a successful example of this (Fig. 11).

The example of large scale TOD planning exercise for the city of Foshan in Southern China involves 2 metro lines and 52 stations, and a potential population of millions. Such urban development model, incorporating other smart infrastructure systems, I believe, will be a model for future city development.

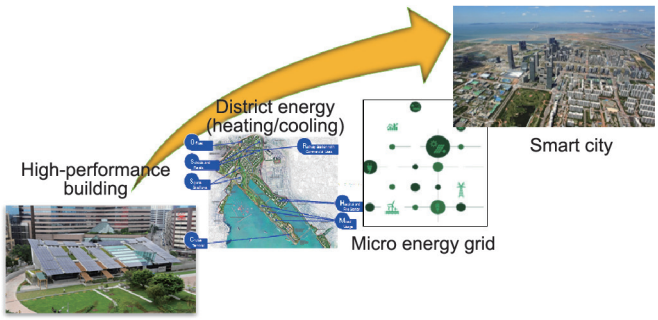

Fig. 7. Decarbonization process to urban development.

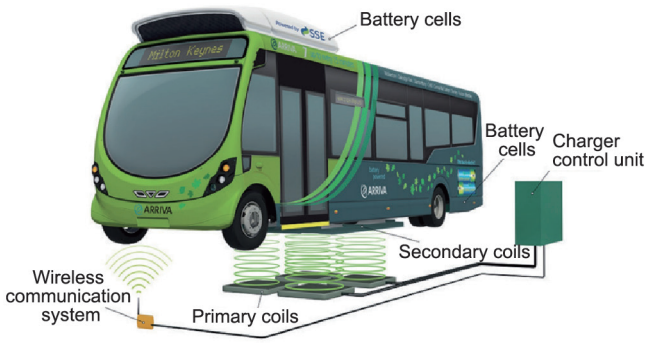

Fig. 8. Wireless induction charged electric buses (Milton Keynes, UK).

And in connection with this, again, a new digital tool is being developed where data on transport infrastructure, landscape, micro-climate, human behavior, and building physics are combined and 3D-visualised to enable citizen participation in an integrated urban design exercise (Fig. 12).

In this example, the aim is to design for maximum pedestrian retention in the commercial area by changing the design of landscape and micro-climatic environment (Fig. 13).

5. City as a complex system

Ultimately, to achieve resilience and sustainability, city is best treated as a system or a system of subsystems (Fig. 14). This is because the design and operation of each element of its infrastructure are inter-related, e.g., in energy consumption (Fig. 15). So solutions to grand challenges we face in cities must therefore be developed by a holistic and integrated approach, which also

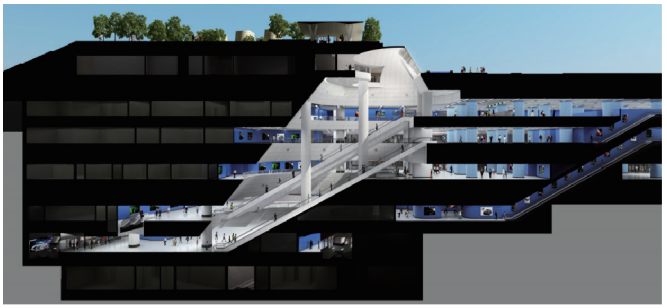

Fig. 9. Complex built environment (7-level metro station, 4-line interchange, 1 million passengers per day).

Fig. 10. Realtime synthetic environment logs users' wayfinding.

Fig. 11. Transit-oriented-development (TOD) in Hong Kong.

brings opportunities for new businesses and economic development.

6. Enriching life

And in the end, cities must not wallow at a "survival" or "basic" level. We must also seek to create a built-environment with amenities, spaces, and places that are enjoyable and inspiring to their users (Fig. 16).

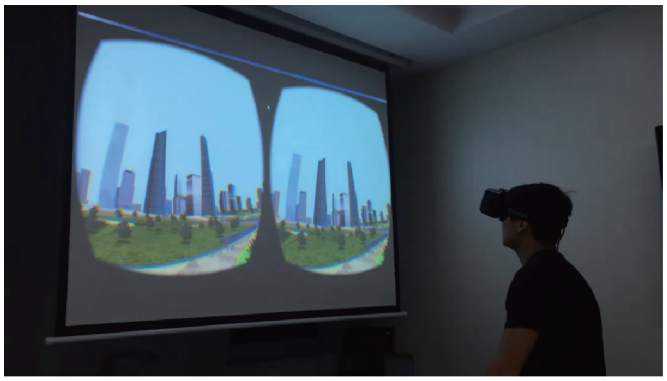

Fig. 12. Immersive virtual reality (VR).

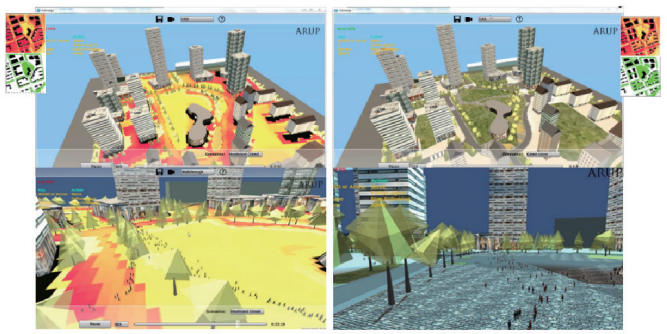

Fig. 13. Integrated urban design (human-centric). (a) Heat island overlay; (b) green cover overlay.

7. Broader knowledge base

Clearly, there are multiple ways in which we can create better, safer, more resilient, more efficient, and, crucially, more liveable cities. We will need to keep up the rate of innovation and development—and we will need to embed excellence in design across the globe—not just on a few specific cases. That is the only way to make sure that when we, in effect, build the world's existing infrastructure all over again, we do it in the right way. By smart I mean that the new approach must use a contemporary method that allies cutting-edge innovation cultures and new technologies with an understanding of the social and human elements that make a city productive, efficient, and human.

And that takes me back to the main point of this article:

- We will win or lose many of our global challenges in our cities, so we need interdisciplinary collaboration in global design.
- We will need new ways for our engineers and scientists to work together with social scientists, artists, and the local communities.

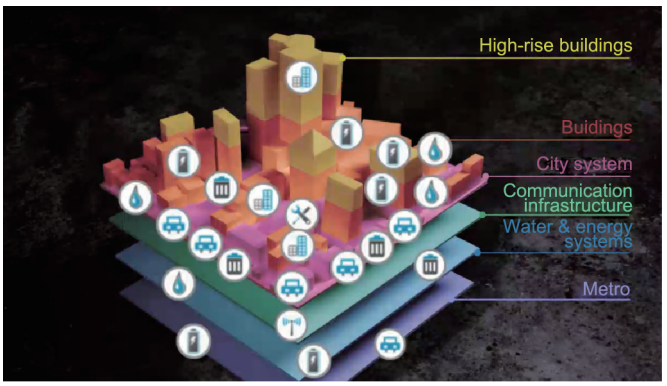

Fig. 14. City as a system.

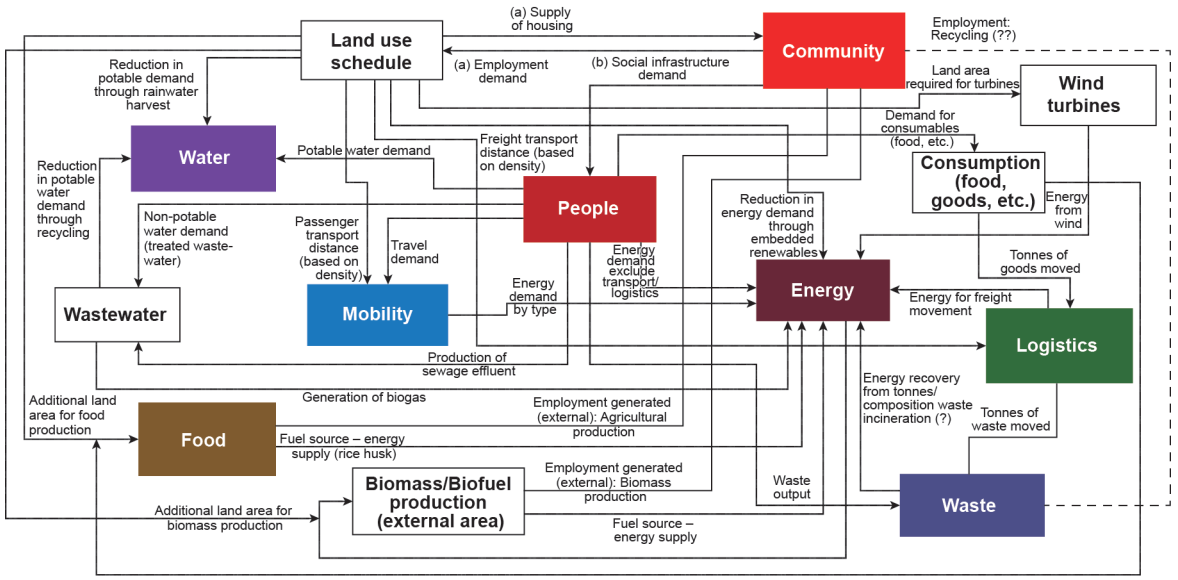

Fig. 15. City as a system—integrated resource management.

Fig. 16. Enriching life—enjoyment, education, civic pride, and inspiring.

- And we will certainly need the designers of our future to develop far broader skills.
- We need engineering education that incorporates challenge-based approaches where we set problems to allow people to acquire the necessary skills and solve real-world problems.
- We need to drive innovation in specific disciplines while sharing knowledge across people and cultures around the globe.
- This is how we move from global learning to local action, harnessing the best brains and skills not just of China, the UK or the USA, but of all countries.
- So we need new thinking—both incremental improvements as well as new and disruptive technologies.
- And we need to move from component-based to system-based innovation.

8. Conclusions

Looking around today, I am greatly reassured that we can do it—and we will do it.

I am optimistic. I hope that you are, too.

Acknowledgements

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