

Title:	<b>Green or Grey? The Aesthetics of Tall Building Sustainability</b>
Author:	Antony Wood, Executive Director, Council on Tall Buildings and Urban Habitat
Subject:	Sustainability/Green/Energy
Keywords:	Environment Sustainability Sustainability Certification
Publication Date:	2008
Original Publication:	CTBUH 2008 8th World Congress, Dubai
Paper Type:	<ol style="list-style-type: none"><li>1. Book chapter/Part chapter</li><li>2. Journal paper</li><li>3. <b>Conference proceeding</b></li><li>4. Unpublished conference paper</li><li>5. Magazine article</li><li>6. Unpublished</li></ol>

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## Green or Grey? The Aesthetics of Tall Building Sustainability

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### Biography

Antony Wood is Executive Director of the CTBUH, responsible for the day-to-day running of the Council and steering in conjunction with the Chairman and the executive committee. His field of specialism is the design, and in particular the sustainable design, of tall buildings.

Based at the Illinois Institute of Technology, Antony is also an Associate Professor in the College of Architecture at IIT. Prior to becoming an academic at the University of Nottingham, UK in 2001, and IIT in 2006, he worked in architectural practice in Hong Kong, Bangkok, Kuala Lumpur and Jakarta. Tall Buildings / large projects he has been involved in these countries include the £120 million, 11 No. mixed office / residential tower project of SV City, Bangkok (completed 1995), the £70 million 4 No. 44-storey condominium project of Kuningan Persada, Jakarta (1997) and the prestigious £200 million Kuala Lumpur Central International Railway Terminal, Malaysia (completed 2001).

He is editor of the CTBUH special annual edition of the John Wiley & Sons published Journal: 'The Structural design of Tall and Special Buildings' and co-chair of the CTBUH Tall Buildings and Sustainability working group. Antony is also founder of the Tall Buildings Teaching and Research Group, based between the University of Nottingham, UK and the Illinois Institute of Technology, Chicago. The educational and research output of this group can be found at [www.tallbuildingstarg.com](http://www.tallbuildingstarg.com)

He is working on research projects in conjunction with Arup, the University of Greenwich Fire Safety Engineering Group and the Hong Kong Polytechnic University Department of Building Services Engineering. He is also Supervisor for the 3-year PhD studentship Tall Building Technologies. He is currently writing two books, entitled 'Pavements in the Sky: The Use of the Skybridge in Tall Buildings' and 'The History of the Council on Tall Buildings and Urban Habitat'.

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## Abstract

This paper outlines the viability of the tall building as a sustainable element in our future urban centres and examines several tall building case studies that have embraced environmental approaches to a lesser or greater degree. In doing this, it suggests a number of design approaches which, collectively and broadly, could be interpreted as a new vernacular for the skyscraper based on sustainability. This vernacular is particularly relevant to developing cities, whose import of western models is contributing to a degradation of local culture and an homogenisation of urban centres globally. The paper concludes with a fledgling set of design principles to encourage this new sustainable vernacular in high rise design.

**Keywords:** Tall Buildings, Design, Environmentalism, Sustainability, Design Principles

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## Background

In terms of real recognition of the problem, if not yet global-wide radical change, it seems that the world has finally turned the corner on climate change and the need for more sustainable approaches to life generally. 2006 will most likely be marked as a watershed in the tipping of the balance in favour of the world finally taking sustainability seriously, especially in the US where the campaigning work of former Vice-President Al Gore and his book / film 'An Inconvenient Truth' (Gore, 2006) has galvanised opinion and action from the grass roots up.

This is not before time. Latest figures predict that the impact of climate change emissions will result in a likely increase in average global temperatures between 1.1 and 6.4 degrees Centigrade during this century and that the critical level of CO<sub>2</sub> concentration in the atmosphere (currently at approximately 400ppm) could reach 750 – 1000 ppm by the latter part of the century (IPCC, 2007). This is, without doubt, going to have a significant impact on the planet we inhabit. The governments of the world are finally waking up to the fact that the international community needs to achieve an 80% cut in anthropogenic CO<sub>2</sub> emissions globally to allow the atmosphere to be stabilised at a level below that needed to avoid catastrophic climate disruption. The increasing frequency of large-scale, climate-induced extreme events on a global scale (floods, droughts, hurricanes etc) are a constant reminder of that fact.

## Tall Buildings: Sustainability Credentials.

The built environment is recognised as being the largest single contributor to climate change, with the creation, running and maintenance of buildings estimated to account for 50% of all energy usage and more than

50% of all climate-change emissions globally (Smith, 2005).

Against this backdrop, the international community is still divided on the sustainability credentials of Tall Buildings as an appropriate typology in our existing and future urban centres. There are those that believe that the concentration of population through high-density (therefore reducing transport costs and urban / sub-urban spread) combined with the economies of scale of building tall, make the typology an inherently sustainable option, whilst others believe that the embodied energies involved in constructing at height, combined with the impact on the urban realm, make them inherently anti-environmental (see the summarised cases 'For' and 'Against' tall buildings, table, *Figure 1*).

Many owner-developers and professionals involved in the creation of Tall Buildings have not helped to convince the international community in this debate. Certainly most high-rise commercial towers internationally have followed the standard model – the rectilinear, air-conditioned 'box' – but, also, very few residential towers have strove to create anything other than the vertical extrapolation of an efficient floorplan. The 'transportability' of these non-site specific models allow export across the world, without regard for either the impact on environment or the relationship to the places in which they are located. This has served to create an alarming homogeneity and monotony across global urban centres – a creation of a 'one size fits all' skyscraper 'mush' – which matches in negativity the detrimental effect these buildings are having on the planet. In short, many tall buildings are helping to negate both the local and the global.

Case 'Against' Tall Buildings - according to Roaf (Roaf et al, 2005)	Case 'For' Tall Buildings - according to Author
Higher embodied energy in constructing at height – structure, materials etc.	Denser cities = reduced transportation (and consequential impact on environment).
High energy consumption in operation – elevators (up to 15% of bldg energy use), services etc.	Efficient land use in population concentration = reduced suburban spread / loss of countryside.
Higher energy consumption for both maintenance and cleaning (e.g. replacement of façade silicon joints).	Concentrated cities = reduced size of infrastructure networks (urban / suburban, power, services, waste etc).
Impact on urban scale; wind downdrafts, overshadowing (solar rights), wind rights, right to light, etc.	Proximity of residence and workplace = less travel time (less wasted time?).
Overpopulation in certain localities / greater demand on existing urban services and infrastructure.	Greater potential for mixed-use = less travel time, less duplication of building form / resources.
Anti-social internal environment – lack of open, recreational, communal space (especially in residential).	Standardisation of floor plates and use of materials = material (prefabrication?) efficiencies.
Greater wind loading at height (impact on size of primary structure, façade design etc).	Higher wind velocities at height = greater potential for harnessing wind energy.
'Sealed' environments at height; requirement for air conditioning, artificial lighting etc.	Higher atria / volume of space = potential for natural ventilation through increased 'stack effect' etc.
Less net usable area to gross area and restrictions on internal planning; vertical circulation core etc.	High 'thermal mass' = potential for use in natural ventilation / heating / cooling strategies.
Safety and Security fears (especially post 9/11) – including safety during construction.	Long, narrow floorplates = potential for good internal daylighting (and thus reduced energy).
Low ratio of external building surface area per floor area – impact on potential for solar arrays etc.	Space in the Sky = potential for 'secure' communal /recreational spaces, away from traffic, pollution etc.
Implications of power failure (impact on vertical circulation, safety etc).	Potential for more efficient energy production and distribution systems
Increased travel time (wasted time?).	Urban densification adds value and vitality to cities
People suffering from vertigo – building occupation / human rights legislation?	Urban signposting / way-finding
Recycling potential / urban impact of demolition / disposal of materials after demolition.	Increased access to view, light and air at height

Figure 1: Summarised cases 'For' and 'Against' Tall Buildings as an appropriate typology in urban centres

This is especially true of developing countries around the world, where the import of western high-rise models in recent times has created cities of disarming similarity – at least in aesthetic appearance – with their western equivalents. The search for an appropriate vernacular in these cities has been top of the local architectural agenda for some time. Of course determining such a vernacular is far from straight-forward. For a typology with its root in North America and a development history of only a little over 100 years – there is no historical 'local' precedent for such tall buildings in most non-western developing cities, and certainly no sense of an established high-rise vernacular.

The projects in these cities that have not shadowed the western model have either followed a design path of *literal cultural symbolism*, where vernacular elements such as pagodas are inflated to form super-tall towers, or a design path of *abstract cultural symbolism*, where more abstracted forms of inspiration are taken from local philosophies or religions (for more on these tall building design approaches, and 'isms' see Wood, 2005). In the vast majority of cases however, though the forms may be evocative of the locale, the aesthetic language of curtain wall and cladding is entirely western.

Thankfully, all is not lost. In the past couple of decades there has been a small but growing number of professionals and organisations who have looked to appropriate environmental responses as the main design generator for tall buildings – a design direction which is now gathering pace rapidly with the ongoing realisation regarding the effects of climate change and the urgent need for more sustainable building types and patterns of living. In looking to the environment for appropriate design responses these professionals have, perhaps unwittingly, created not only tall buildings which are rooted to the specifics of 'time' (responsibility) and 'place' (indigineity), they have created a new vernacular for the skyscraper; a vernacular based on sustainability.

### The rise of an environmental conscience in tall building design.....

Perhaps the first of these 'sustainable' skyscrapers, somewhat ironically given his clear anti-urban skyscraper beliefs, was Frank Lloyd Wright in the mid 1950's. Lloyd Wright stood apart from most of his contemporary profession in believing that the tall building did not belong in the city at all, but was most appropriate as a free-standing sculptural element in a predominantly low-rise (suburban or rural) landscape. Though this concept is almost the exact opposite of the dense, concentrated city model generally accepted as the sustainable way forward for cities in today's modern era, Lloyd Wright's motivating factors in proposing this arrangement are very relevant environmentally – borne of a desire to reduce suburban sprawl and loss of green land by concentrating higher numbers of people on smaller

plots of land within towers. His 1956 *Broadacre City* scheme (see Alofsin, 2005, pp. 40) stands as the suburban-rural pre-cursor of the dense, sustainable city.

Lloyd Wright's treatises on the skyscraper were perhaps too radical for their time and (discounting the 15-story, small-footprint 1950 *Johnson Wax Company Research Tower*), he only realised one tall building – the 1956 *Price Tower*, Oklahoma, USA (see Figure 2). This building established a number of themes which can be post-rationalised as 'sustainable'; (i) The building rejected the modernist ideal of the glass curtain wall which had revolutionised skyscraper design at the time (predominantly through Mies van der Rohe's 1951 Lake Shore Drive Apartments Chicago and SOM's 1952 Lever House New York) to create a largely opaque façade, punctuated with windows, which has more thermal mass to reduce solar gain and insulate against the extremes of climate, (ii) the building employed external louvers as devices for controlling solar gain and light, and (iii) the building programme fully embraced concepts of both mixed-use functions and what is now known as social sustainability, with a mixture of office and residential space within the one tower <sup>1</sup>.

In 1984 the firm of Skidmore Owings and Merrill built one of the first skyscrapers to truly follow an environmental approach <sup>2</sup>. Located in the hot solar extreme of the Saudi Arabian desert, their National Commercial Bank Jeddah (see Figure 3) introverted the glass curtain wall away from direct solar gain to occupy the 'internal' face of the skyscraper, shielded to the outside by strategically-positioned skygardens cut into



Figure 2: 1956, Price Tower, Oklahoma. Frank Lloyd Wright – the proto-type for the eco-tower? (source: courtesy of Emporis / Scott Murphy)

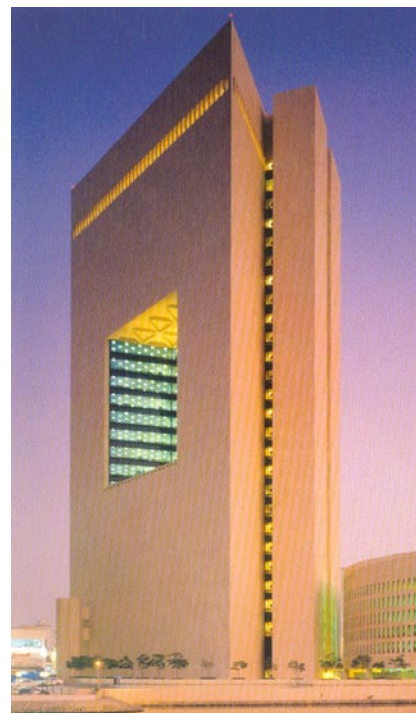


Figure 3: 1984, National Commercial Bank Jeddah. Skidmore Owings & Merrill – a radical environmental response in a hot desert climate. (source: courtesy of Emporis / Wolfgang Hoyt)

<sup>1</sup> Radically, this is still one of the only buildings in existence internationally which has achieved the office / residential mix on each floor rather than placing one function in a zone above the other vertically, which is the usual arrangement. It is perhaps obvious why this combination of office and residential function within a single confined floor plate of a typical tall building is difficult to achieve – it leads to small office spaces inhabitable only by a small number of employees and small organizations do not drive, finance and populate tall buildings – large corporations requiring many employees under one roof do. It is worth noting that Lloyd Wright's office space configurations have generally been economically disastrous, though the social sustainable themes driving them are perhaps to be lauded. For more on this seminal building, see Alofsin, 2005.

<sup>2</sup> This is, of course, a subjective statement. Some would claim that the early work of Geoffrey Bawa in Sri Lanka (e.g. the 1976 Mahaweli office tower, Colombo), Charles Correa in India (e.g. the 1983 Kanchanjunga Apartments, Bombay), or Harry Seidler in Australasia (e.g. the 1986 Riverside Centre, Brisbane) are more indicative of the first proto-types for eco-skyscrapers.



each face of the triangular plan (a strategy later employed to even greater effect by Norman Foster in his 1997 Commerzbank tower, Frankfurt). Although the aesthetic of the austere, monolithic stone block presented to the outside of the building is not to the liking of some, this introverted glass façade design strategy undoubtedly makes more sense environmentally than an external curtain glass wall in such a hot climate and, the author would argue, gives the building an aesthetic that firmly roots the building in both its desert locale and cultural context.

Perhaps not uncoincidentally, the Islamic culture in which the National Commercial Bank building is set has nurtured other excellent examples of ‘environmental’ skyscrapers internationally – a rich vein of work including Nikken Sekkei’s 1993 Islamic Development bank in the same city of Jeddah and other, unbuilt, examples such as SOM’s 2004 Bank of Kuwait proposal. Perhaps the best of these ‘Islamic’ skyscrapers, since it is clearly a tall building that relates to its location culturally as well as environmentally, is BEP Architect’s 1984 Dayabumi Complex in Kuala Lumpur (see Figure 4).



Figure 4: 1984. Dayabumi Complex, Kuala Lumpur. BEP Architects – environmental and cultural response blended to create a local high rise vernacular? (source: author)

This building is located just a few miles from Cesar Pelli’s seminal 1997 Petronas Towers and, coincidentally, both buildings are inspired in plan by the same multi-pointed Islamic star. However, whereas in Pelli’s case this two-dimensional cultural inspiration is the extent of the ‘vernacularising’ of the skyscraper with a typically western tower extruded vertically from this plan-form, in the Dayabumi tower the cultural inspiration is carried into three dimensions, with the stone façade forming an Islamic-pattern fretted outer skin to the curtain wall which sits behind. As such, not only is this one of the first uses of a ‘double-skin’ façade, with the outer, permeable layer shielding the glass from high solar gain environmentally, it firmly roots the building in its cultural context. This is quite clearly a building that responds to ‘place’ on numerous levels.

Also in Malaysia, but with a completely different approach to achieving a vernacular expression for the high rise, is the work of perhaps the most rigorous of the environmental high-rise architects – and originator of the term ‘the bio-climatic skyscraper’ – Dr. Ken Yeang of Hamzah & Yeang (and, more latterly, Llewelyn Davies Yeang). Unlike the Dayabumi Tower and others which look to incorporate architectural decoration inspired by the local culture (albeit serving a functional purpose also) to give the building its ‘localised’ root, Yeang transcends the cultural links and instead delves back farther in history, to the influences which informed the vernacular in the first place – predominantly practical and/or climatic – in a process which he terms ‘eco-mimicry’ (Yeang, 2006).

*“As the location’s most endemic factor, **climate** provides the designer with a legitimate starting point for architectural expression in the endeavour to design in relation to place, because climate is one of the dominant determinants of the local inhabitants’ lifestyle and the landscape’s ecology.”*

Ken Yeang, (Yeang, 1996)

Employing specific strategies for building form and orientation relative to sun and wind to reduce solar gain and encourage passive ventilation, as well as the incorporation of continual vertical landscaping, sky-gardens, systems for water and waste recycling etc, Yeang has created an aesthetic for his tall buildings which contains no historical references and yet is no less rooted to the specifics of place than buildings like Dayabumi. On the contrary, it seems that Yeang has created true tropical towers that seem to grow out of the location and embrace both the local and the cutting-edge modern in a way that perhaps Dayabumi and others do not.

Though Yeang has a proven track record of built tall buildings which employ these strategies and effects (see Powell, 1999) it is a project which was not actually built which perhaps best exemplifies the true potential of Yeang's ideas – the 1995 Tokyo-Nara Tower (see Figure 5). Here the dynamic combination of changing-form, continual landscaping and embedded technologies has created a vernacular expression which is at the extreme end of the potential aesthetic for the 'environmental skyscraper'.



Figure 5: 1995. Tokyo-Nara Tower, Tokyo. Hamzah & Yeang – demonstrates the extreme potential of a high rise vernacular based on sustainability (source: courtesy of Hamzah & Yeang)

Of equal stature to Yeang in terms of built environmental skyscrapers, though emanating from an entirely different design direction, is the work of Norman Foster. Exemplary in terms of quality of architecture, internal environment and technological integration, Foster's skyscrapers from Commerzbank Frankfurt (1997), Swiss Re London (2003), to the more recent Hearst Tower New York (2006 - see Figure 6) are amongst the best 'environmental' tall buildings ever built, but whereas Yeang has created a new aesthetic for the skyscraper, based on a material palette which encompasses verdant vegetation, Foster's aesthetic does not depart radically from the commonly accepted western palette of steel and glass. It is perhaps the work of these two architects more than any other – Yeang and Foster –

which encapsulates the debate of a possible future new high rise vernacular. This can be perhaps be summarised in the question; are the aesthetics of sustainable high rise architecture 'Green' or 'Grey'?



Figure 6: 2006. Hearst Tower, New York. Foster & Associates – an example of the 'grey' strain of environmental aesthetics (source: author)

### Models for the Future?

Several recent examples of 'environmental' tall buildings show that at least one part of the vernacular is taking a different path. Environmental technologies have become far more prominent in achieving 'sustainability' through harnessing energy at height or through providing alternative ventilation and other service systems. These technologies are becoming an increasingly significant part of the aesthetic itself where, in shades of the high-tech movement in architecture of the 1980's, the technologies are to be attenuated and proudly displayed. Perhaps the best example of this is Atkins' soon-to-be-completed Bahrain World Trade Centre towers with their huge wind turbines becoming the most dominant element in the aesthetic (see Figure 7).

Whilst many of these environmental technologies are still in the 'experimental' stage and projects such as the Bahrain World Trade Centre towers are to be lauded for both the depth of ambition and the commitment in realising it, not all 'environmental' towers exhibit the same integrity. Worryingly it seems that many of the environmental technologies in tall buildings exist at the 'applied' level – solar panels, water recycling, ground source heat pumps – which are applied to the standard, glass, air-conditioned box model with very few other



‘concessions’ to environmental considerations in the design. Worse, these technologies often only serve to overcome inadequacies in the design through the lack of holistic thinking in sustainability at the design concept stage – fundamental errors in building orientation, form etc.



Figure 7: 2008. Bahrain World Trade Centre, Bahrain.  
Atkins – environmental technologies are becoming an important element in tall building aesthetics (source: courtesy of Atkins)

Thus, despite the presence of these environmental technologies, the vernacular of these skyscrapers is not far removed from the international-style box. Even projects which do embrace sustainable principles and technologies on a number of design levels – such as the USA’s first LEED gold-rated tower; Fox and Fowle’s (later FX Fowle) 1999 Conde Nast building in New York (see Figure 8) – though the building undoubtedly out-performs its peers environmentally, it could be argued that the aesthetic is not too different to that of the standard, extruded-box, non-environmental skyscraper. Perhaps this is not such a bad thing, but the author would argue that the true embrace of sustainability offers the opportunity for a new aesthetic for the skyscraper, beyond the 50-year old language of slick glass which has dominated tall building design, and this would be more reflective of the age that we now inhabit, with its distinct challenges.



Figure 8: 1999. Conde Nast Building, New York. FX Fowle – has the imbedding of environmental technologies in tall buildings moved forward the aesthetic significantly from the days of the international style skyscraper? (source: author)

There have recently been a number of tall building design proposals that hint provocatively at this alternative environmental language for the skyscraper, beyond the all-glass, high-technology aesthetic. Other than the design approach of Yeang who brings vegetation into the material palette, others recognise the need for greater opacity in the skin of a tall building – away from the all-glass aesthetic. One of the greatest advocate for this is Ken Shuttleworth of Make Architects in the UK (formerly of Foster & Associates), who has proposed a number of innovative high-rise forms challenging the all-glass aesthetic.

*"The high-energy, gas-guzzling fully glazed office block is totally dead, a thing from a previous time when we all had a more naive, cavalier attitude towards the environment ..... It's the end of an era and we should all rethink what we are doing to the planet ..... facade design is on the frontline of a change"*

Ken Shuttleworth (Shuttleworth, 2005)

Shuttleworth’s proposals include the 2004 Kite Tower, the 2004 Vortex Tower and the 2005 Spiracle Tower, Leeds (see Figure 9). In this latter proposal, the solid bands wrapping around the building vary in height



fluidly around the building, creating varying window sizes and an aesthetic that is seemingly both biomorphic and anthropomorphic – two fields that have a not insignificant connection to sustainability.

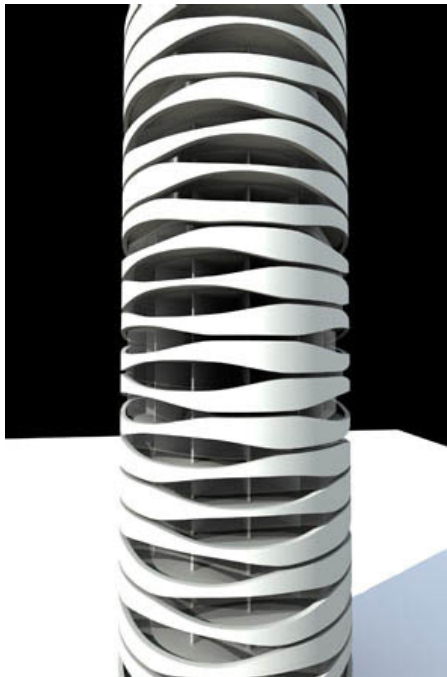


Figure 9: 2006. Spiracle Tower, Leeds. Ken Shuttleworth / Make – moves creatively away from the all-glass facade (source: courtesy of Make Architects)

Of course there is a trade-off to be considered environmentally with these reduced-transparency facades. Reduced transmission of daylight through the building skin could result in a need for higher levels of artificial lighting internally which has negative environmental influences in both energy-consumption and human occupant psychology. However excessive solar gain in a building (as well as glare) is not desirable either – there must be a balancing point somewhere between these poles. Can all-glass towers really claim to achieve this balancing point and thus be truly sustainable towers?

There are also many hybrid approaches in this development of a new environmental vernacular for tall buildings – proposals that use environmental technologies aesthetically in a more subtle way, or that are less pre-occupied with developing irregular form than articulating the possibilities of skin. One of the best examples of a proposal that embraces all of these concepts is Oppenheim Architect's 2007 COR Tower for Miami (see Figure 10). Here the transparent to opaque 'balancing-point' seems to be achieved in the building skin, whilst environmental technologies (in the form of wind turbines) are incorporated positively in the building aesthetic, but not on the dominant scale of the Bahrain World Trade Centre. It is this example by Oppenheim – departing not too-radically from the standard orthogonal

form and construction of the skyscraper – that perhaps hints at the acceptable way forward for a sustainable high-rise aesthetic; acceptable to those charged with the funding and constructing of such tall buildings, as well as the design appearance.

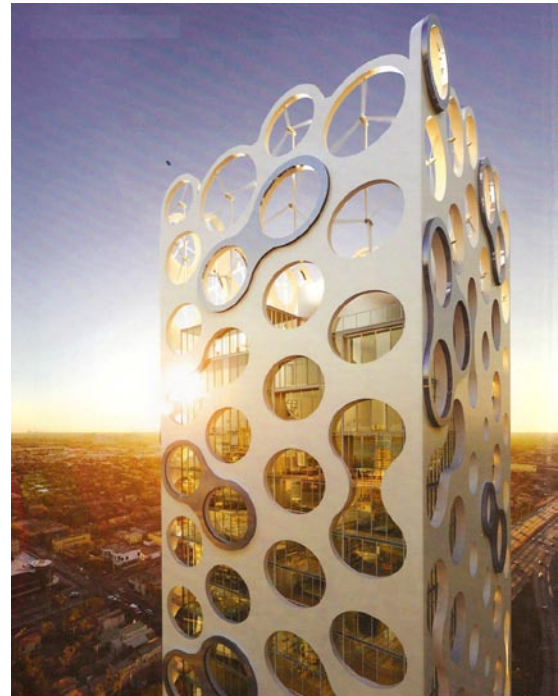


Figure 10: 2007. COR Tower, Miami. Oppenheim Architects – an example of the new breed of more subtle eco-skyscrapers? (source: courtesy of Oppenheim)

## Conclusion: Design principles for the new sustainable skyscraper?

In studying the environmental case studies outlined in this paper, a number of common themes have become apparent, which could become a set of design principles for the creation of future tall buildings looking to break away from the standard, international-style, air-conditioned box. These design principles are summarised below. The design principles could be the starting point for a new vernacular for the skyscraper; a vernacular concerned with creating; (a) interesting tall building form beyond the standard orthogonal box, (b) tall buildings that are rooted both physically and environmentally into the specifics of place, and (c) tall buildings that are responsive to the environmental challenges we face in today's world. This is a vernacular based on a response to climate; an aesthetic based on sustainability.

### Design Principles:

1. **Variation with Height.** Tall Buildings should not be monolithic vertical extrusions of an efficient floor plan, but should vary in form and / or surface texture with height. This variance in form and skin with height in the building can

- relate to either the building programme internally or the attributes of the location externally, both physically and environmentally. Since a tall building has a visual relationship with many places far and wide in the city, a visual dialogue with distinct places in the city can help inform a variance in form and skin to further connect the building to its locale. A tall building could be thought of (and designed accordingly) as a number of small buildings within an over-arching framework of structure, systems, aesthetics etc.
2. **New Programmes.** Traditional programmes for tall buildings should be challenged to increase the usefulness of the typology in sustainable cities of the future; This challenging of programme should occur on two levels (i) the type of functions that are traditionally accommodated within tall buildings and (ii) the number of functions that are accommodated in a single tall building. Tall Buildings have the versatility to accommodate uses other than the standard office, residential, hotel or small retail-leisure functions. We could see the radical incorporation of functions such as sports (external solar control skin as rock-climbing wall? mass tuned damper as swimming pool?) or agriculture (hydroponic greenhouse? façade farms?) etc. In addition, cross-programming / mixed-use within tall buildings should be encouraged, to give opportunities for more sustainable live-work patterns (dualities of car parking, support functions, servicing etc) as well as variance in tall building form and expression to diversify urban form. The term ‘mixed-use’ should no longer be attributable to buildings predominantly of a single function with perhaps a high and low-level retail or leisure function.
  3. **Communal Spaces.** More open, communal, recreational spaces (hard or landscaped, large and small) need to be introduced into tall buildings, rather than an insistence on the maximum financial return on every square metre of floor space. Such spaces have been proven to improve the quality of the internal environment which has an impact on the productivity of workers, satisfaction of residents etc (which will have indirect financial return). In addition, the inclusion of these spaces will make tall buildings more suitable for socio-economic groups often marginalised from tall buildings through the lack of such vital spaces where a sense of community can develop – families, the young, the old etc. Social Sustainability on an urban scale is a major challenge for our future cities.
  4. **Envelope Opacity.** Tall Buildings should be designed with more envelope opacity, not as all-glass transparent boxes. Although the impact on both view out and natural daylighting

internally needs to be considered, excessive solar gain (and glare) should be reduced. In addition, greater façade opacity gives an opportunity for greater thermal mass to allow the envelope to be more insulated from external temperature and climate variations.

5. **Vegetation.** Vegetation should become an important part of the material palette for tall buildings, both internally and externally. The presence of vegetation will improve environmental quality on both the local scale (i.e. part of the shading / air cooling system of the building itself) and the city scale (quality of air, reduce heat-island effect etc).

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