TECHNICAL TRANSACTIONS | CZASOPISMO TECHNICZNE
ARCHITECTURE | ARCHITEKTURA
2-A/2014

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FUTURE CITIES: DESIGN OPPORTUNITIES FOR THE IMPROVEMENT OF AIR QUALITY

MIASTA PRZYSZŁOŚCI: IDEE PROJEKTOWE NA RZECZ REDUKCJI ZANIECZYSZCZENIA POWIETRZA

Abstract

This paper proposes a series of questions on how recent cities' eco-programs and design ideas could (or not) contribute towards reducing air pollution in future cities while creating vibrant and livable environments. Design Strategies related to a series of European, American and Asian cities affected by poor air quality condition, are critically discussed. Because effective policies to reduce carbon emissions take a long time to initiate, urban planners and architects have the unique opportunity to creatively re-examine city streets, landscape and buildings as active solutions to inspire sustainable living and combat poor air quality.

Keywords: *urban design*, *mobility*, *softscape*, *air quality*, *green washing*

Streszczenie

W artykule przeanalizowano współczesne programy ekologiczne i idee projektowe ukierunkowane na redukcję zanieczyszczenia powietrza w miastach. Autorzy komentują wybrane strategie/koncepcje architektoniczne i urbanistyczne miast charakteryzujących się wysoką emisją dwutlenku węgla. Przywołane przykłady pochodzą z Europy, Azji i Ameryki. W związku z tym, iż skuteczna polityka na rzecz redukcji zanieczyszczenia powietrza jest procesem złożonym i długotrwałym, architekci i urbaniści mają szczególną okazję do ponownego twórczego przebadania struktury miasta pod kątem adekwatnych rozwiązań inspirowanych ideą zrównoważonego rozwoju, z akcentem na aspekt jakości powietrza.

Słowa kluczowe: *projektowanie urbanistyczne*, *ekoprogramy*, *mobilność, transport*, *jakość powietrza*

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1. Introduction

We are bombarded with statistics about the future of cities these days, at the same pace as the cities themselves are growing. It is a relentless rate of expansion that will see over 70% of the global population living in urban areas by 2050, requiring the equivalent of a new city of 1 million built every five days between now and then. These figures make impressive headlines for breathtaking reports on urbanization, which are being discussed at conferences globally, but such statistics are meaningless without asking how these cities are being designed, who they are for, and mostly, will the future cities be inspiring-healthy environments with clean air, sustainable transportation and have any connection with nature?

This paper proposes a series of design questions of how urban design and architectural ideas could contribute towards reducing air pollution in future cities. Design Strategies related to a series of European, American and Asian cities affected by poor air quality condition, are critically discussed.

2. Background

As the map illustrates (Ill. 1), pollution "hot spots" are centered on the world's largest urban conglomerations. Cities worldwide consume more than 75% of the world's energy and emit 80% of global greenhouse gas emissions and pollution. The burning fossil fuels provides power to the infrastructures that define urban areas. According to the recent assessment of *Air quality in Europe — 2013 report*[1], 90% of the urban population is exposed to harmful air pollution, which is considered hazardous to health by the World Health Organization (WHO). Pollution affects not only the urban fabric, but also the ecosystems, impairing vegetation growth and harms biodiversity.

The main issue is related to developing economies in the world. For example, in Europe, a country such as Poland has a political strategy that may work against clean air[2]. Facilitating economic growth entails clearing more land for development, thereby clashing the environment quality. Unsatisfactory regional and urban planning has generated polluted cities such as Krakow[3]. The city exceeds the permissible level of 50g/m^3 for over 200 days/year. Pollution here is primarily generated from the heating of coal and the wood-burning furnaces in private homes (40%) and vehicular traffic (30%) and the rest is related to local industries (30%).

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[1] European Environment Agency, 2013. *Air quality in Europe – 2013 report. EEA Report No 9/2013*. Copenhagen: European Environment Agency. This report presents an overview and analysis of air quality in Europe from 2002 (or later, pending data availability) to 2011. The analysis covers up to 38 European countries (1), including EU Member States and other EEA member countries as of 2011.

[2] According to the adopted by the EU in 2007 Protocol on Climate Change, Poland has to reduce carbon dioxide emissions by 20 percent, improve energy efficiency and 15 percent must be obtain the energy from the renewable sources.

[3] European Environment Agency, 2013. *Air pollution fact sheet 2013 – Poland.* Copenhagen: European Environment Agency.

In cities such as Krakow, urban regulations have historically contributed to misallocation of land use and growth of urban forms that are not necessarily conducive to the improvement of air quality. The high cost of the technological integration necessary for making Krakow, and other cities, an eco-city is a major challenge. However, as shown in the article simple design solutions can be successful, and have positive impact towards air pollution at low costs. The paper proposes a series of strategies such as designing an efficient distribution of spaces for living and working in order to reduce the need of cars. Influencing the life style of people with thoughtful design, can be more effective than the use of sophisticate technology aimed to "eat" pollution. Finally, designing the city, its hardscape and softscape, its streets, spaces and buildings can contribute to controlling air quality in various ways.

3. Cleaning Air in Historic Cities

Challenges associated with planning and managing sustainable programs are always extensive. Cities that want to become more sustainable are, at first glance, faced with retrofitting existing structures and having to continuously deal with concurrent management of sustainable urban expansion and development. The costs and infrastructure needed to manage these large-scale projects seems to be enormous, and beyond the affordability of most cities, so this is increasingly becoming the main obstacle to changes. However a closer look shows how, solutions proposed by politician are sometime expensive and involve complex transformation and the extensive use of complex technologies. The article focus on a series of design ideas that connect to the city's horizontal and vertical hierarchies, some of which are not expensive to implement, and that are supported by both the political arena and with the successful engagement of architecture.

One example is Vienna. In order to reduce emissions, the city introduced a Climate Protection Program, named KliP. Successful results were achieved in 2006, during the first phase of the program (1999–2009). The second phase of the plan (2010–2020) looks at a total reduction of another 4.5 million tons per year in greenhouse gas emission. The plan both stimulates technical and design solutions. The first is related to district heating and power generation. The second is about housing envelopes, eco-mobility (a combination of public transport, cycle and pedestrian traffic)[4], and vegetation.

In addition, new innovative strategies subsidize green initiatives, especially in areas where street trees cannot be planted (Ill. 2). A green ecosystem with trees, shrubs, grasses, and other vegetated surfaces becomes predominant in the cityscape. Fifty-one percent of the cityscape is greened. This percentage includes roofs and living walls, which today contribute to the overall image of the city. The facades of Vienna today include 17,000 plants contributing to air pollution reduction.

Another interesting example is the transformation of Stockholm, which is becoming a non-polluted city through the program Vision 2030[5], launched in 2006. The initiative

[4] Vienna City Administration. *KLiP – The City of Vienna's Climate Protection Programme*, http://www.wien.gv.at/english/environment/klip [accessed 5 February 2014].

[5] Stockholms Stadt. 12 January 2012. *Vision 2030-Vision and reality*, http://international.stockholm.se/Future-Stockholm/Vision-2030 [accessed 5 February 2014].

takes a holistic approach to urban growth, focusing not only on expanding physical capacity but also on the nurturing of vibrancy, diversity and the overall quality of a dynamic urban lifestyle. Beyond Vision 2030, Stockholm is planning to be fossil fuel free by 2050. In terms of urban planning, Stockholm currently requires mandatory reuse of empty surfaces before urban sprawl can be contemplated. This policy has led to complete revitalization of run-down and abandoned industrial areas that have been transformed into mix-uses areas and car free areas. Here the use of vegetation is part of creating an inspiring environment. The Hammarby Sjostad district (Ill. 3) of Stockholm is the primary example of this practice.

These gains are measured by the environmental load profile of the area, a life--cycle assessment tool, which allows for environmental performance analyses in terms of environmental costs, such as the amount of emissions, and benefits. These efforts were recognized in 2010 by the European Union, which deemed Stockholm – The European Green Capital for *leading the way towards environmentally friendly urban living.*

4. Are new city models responding to air pollution issues?

With the sudden urban growth happening in developing countries, how far are the new city visions in line with the tangible needs of healthy environments by most of its citizens? Driven by local politicians and global investors keen to capitalize on the next frontiers, satellite cities are popping up across Africa and Asia, Russia and the Middle East. But to accomplish these specialized communities of science and technology, leisure and luxury - they bear the risk of becoming ghost towns; hence diverting funds away from meeting the essential needs of the countries' healthy environment?

Masdar City[6] is one of the most expensive new city developments with a large acreage of buildings and public spaces characterized by new technological developments aimed to achieve zero carbon and zero waste. It is the latest of a number of highly planned, specialized, research and technology-intense municipalities that incorporate a living environment, similar to KAUST, Saudi Arabia or Tsukuba Science City, Japan. At huge costs, it has a new underground transit system and other advanced efficiently-driven solutions. Whether this type of development can be successfully applied to less cost-effective environments is highly questionable.

Masdar, as well as other cities and neighborhoods seem to be only symbolic, and that it may become just a luxury development for the wealthy. Masdar is the culmination of a gated-community concept: *the crystallization of another global phenomenon: the growing division of the world into refined, high-end enclaves and vast formless ghettos where issues like sustainability have little immediate relevance.*[7] The project is supported among many others, by Greenpeace which however stresses that there should be more focus on retrofitting existing cities to make them more sustainable rather than

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[6] Masdar City. *The Global Centre of Future Energy*, http://masdarcity.ae/en [accessed 4 February 2014].

[7] Ouroussoff N., In Arabian Desert, a Sustainable City Rises. *The New York Times*, 26 September 2010, Retrieved 12 September 2013.

constructing new zero-carbon cities from scratch. As one looks back today at polluted cities, it may appears more interesting to look at the requalification of existing structures rather than building new flashy neighborhoods.

5. Smart (or not) cities

Masdar boasts a series of innovative technology and intelligent controls potentially becoming precedents for other future smart cities. Smart cities are today presented as the next step forward: the use of networked systems for collecting, processing and implementing urban data. No longer narrowed to programming traffic flows, the smart city's sensors can detect citizens' routines, air pollution, building emissions, etc. The citywide computer knows where it's best to locate a shop, where people should live, how much amenity space they should have, in relation to topics such as air pollution. The smart city can fix and interface with irregularities, bringing order to urban chaos. But is outsourcing our collective civic intelligence to a computer algorithm, the ultimate answer for providing good livable cities? Can modeling people and energy flows become a strategy that drives new intervention in the city?

In Masdar, simulation showed how automobiles could be banned within the city and travel is accomplished via public mass transit and personal rapid transit (PRT) systems (Ill. 4)[8]. After the experiment and the user feedback, public transport within the city relied on methods other than the PRTs[9]. Masdar will instead use a mix of electric vehicles and other clean-energy private vehicles inside the city. This experiment shows how smart cities and systems need to be coordinated with lifestyle and human-sensitive factors. A mathematical algorithm itself, could not answer to the challenges of mass-transportation. As simulation begins to determine the character or quality of a city, the human behavior (largely connected to cultural factors) may be marginalized. The design sensibility of urban planners and architects coupled with their unique ability to relate design to social and cultural factors needs to temper the power of performance related to computing.

6. Reducing traffic congestion

In a city where land is extremely scarce approximately 720 square kilometres and with a population of 5.3 million, Singapore has been a long and tested proponent for the restricted entry of private vehicles into the CBD (Central Business District) zone (Ill. 8). In 1990, the population density of this small island was about 5000 people per square kilometre. The density of vehicles was the highest in the world at 300 vehicles per 1.6 kilometre of road. Since the implementation of the ALS (Area Licensing Scheme) along with the VQS (Vehicle Quota System) the city has successfully kept the CBD relatively free from traffic

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[8] Dilworth D., Zero Carbon; Zero Waste in Abu Dhabi. *BusinessWeek*, 1 August 2007, Archived from the original on 28 July 2012

[9] Masdarcity. *Sustainability and the City: Transportation*, http://masdarcity.ae/en/62/sustainability-and-the-city/transportation/ [accessed 2 February 2014].

congestion[10]. These schemes were originally very unpopular when they were introduced. They were viewed as infringing on people's rights to vehicle ownership and use.

The Singapore government took on great risks with regard to political popularity when introducing these controversial schemes since no other city in the world had established such an aggressive but functioning road pricing system before. In order, to implement these schemes effectively and with minimal impact on commuter's lives and maximum gains to environmental sustainability, it was imperative that a comprehensive and efficient system of public transportation be made a priority. The success in reducing the urge to travel excessively was brought about by the decentralization of commercial centres to sub-regional centres outside of the main CBD frame. The deregulation of land use and housing markets brought a closer proximity between the workplace and residence, which contributed positively toward this effective transport policy. The model of Singapore has inspired and still is a source of inspiration for other cities looking at reducing transportation related emissions.

7. New Mobility in Dense Cities

As cities expand both upwards and outwards, whether hyper-dense or dispersed or sprawling, how will transport solutions adapt to changing patterns of movement and towards reduction of air pollution? Are the elevated cycleways the answer to commuting, or will they delay fixing problems on the ground and distract from the bigger picture of creating integrated streets for everyone?

Foster + Partners have designed SkyCycle[11] (Ill. 5), which proposes a 135-mile network of elevated bike paths suspended above existing railway lines, allowing users to easily reach locations in the city without meeting cars. The project, would see over 220 km of car-free routes installed above London's suburban rail network, suspended on pylons above the tracks and accessed at over 200 entrance points. Measuring up to 15 metres in width, each of the ten routes would accommodate 12,000 cyclists per hour and improve journey times by up to 29 minutes.

The rail network has long been seen as a key to opening up cycle networks in various cities, given the amount of available land alongside rail lines, but no proposal has yet implemented. An attempt was made with the California Cycleway (Ill. 6). In its vision, in the 1890s, it was planned to connect Pasadena and Los Angeles with 14 km of raised timber decking, but only 2 km of the track was built. More than a century later, will this SkyCycle team have better results? Is the model replicable to other cities? The design of new types of infrastructure to allow cycling, is an interesting challenge for the community of designers and an effective measure against air pollution.

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[10] Ministry of Transport. *Electronic Road Pricing*, http://goo.gl/7U6Hux\ [accessed 3 February 2014].

[11] Foster + Partners 2014. 29 December 2013. *SkyCycle, proposals to create safe new cycle routes throughout London*, http://goo.gl/BhbRzz [accessed 5 February 2014].

8. Turning old freight viaducts into parks

For the majority of people in the 20th century, the futuristic city was simply living in a park-like setting as described in the "Garden City" or "Radiant City", once so cherished by architects and planners. Yet since then, real cities were modelled and fashioned with asphalt, brick and concrete. Now some cities seem to have returned to these 'cities-overgrown--by-greenery' scenarios but with a post-industrial spin. The abandonment of industry in most inner cities left large areas available for village greens, parks, urban farms and all other sorts of venues with a more exotic horticultural theme attached to it. In recent years, those spaces have been reclaimed or built over. Both the London Olympic Park and the New York High Line[12] (Ill. 7) are well known examples. Is the transformation and decontamination of these industrial wastelands, and turning them into verdant parks – a viable sustainable move?

In the New York High Line, the revitalization of the elevated railway into an urban park has created a very vibrant environment, promoting density and a spirit of renaissance into the adjacent neighborhoods. Due to the popularity of the High Line, there have been several proposals for museums and other cultural venues, i.e. the expansion of the 20,000 sq m Whitney Museum of American Art. By 2009, more than 30 projects will be planned or be under construction in the neighborhoods of West Village and Chelsea. The success of the High Line in New York City has encouraged other cities, which see it as "a symbol and catalyst" for gentrifying neighborhoods. In the US, other cities also have plans to renovate their abandoned railroad infrastructure into parkland, including Philadelphia and St. Louis.

In Sydney and Chicago, there are proposals for turning old freight viaducts into parks; in Cape Town, architects have issued plans for the remodeling of an unfinished flyover into a combined park, a rejuvenated power station and a museum. Fletcher Priest Architects recently won a competition for a London High Line, which would take the form of a '*funghi farm*' in a disused mail tunnel[13]. It can be argued that it costs substantially less to redevelop an abandoned urban rail line into a linear park than to demolish it. Could these projects inspire urban planning authorities elsewhere? Are they likely to be major sightings in cities of the future?

9. Building integrated vegetation to combat urban pollution

The rapid urbanization around the globe during the last five decades has come with a heavy price to the environment with rising air pollution, urban heat-island effect, and the loss of biodiversity and green spaces. With increasing awareness about these issues, cities are looking at building-integrated vegetation (BIV) – green roofs and green walls – as a tool to mitigate the environmental degradation and improve livability.

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[12] High Line Information Line. 3 February 2014. *Stay Updated on High Line Conditions during Winter Storms*, //www.thehighline.org [accessed 5 February 2014].

[13] Fletcher Priest Architects. *High Line for London*, http://www.fletcherpriest.com/High-Line-for-London/competitions/ [accessed 2 February 2014].

Unlike other "green" sectors such as solar photovoltaic or biofuels, BIV adoption is not driven by national-level policy measures, but entirely by city-level priorities. Value proposition against competing technologies is a major barrier for adoption of green surfaces. Green roofs and walls offer a multitude of benefits such as reducing solar heat gain during summer, removing pollutants from ambient air, reducing storm-water volume, and increasing acoustic insulation. However, for every such benefit, a competing technology exists with arguably a better cost-to-performance tradeoff. Installation costs for green roofs and green walls are excessively higher than technologies such as coatings that offer the thermal insulation benefits, photo-catalytic coatings that remove pollutants from ambient air, and rainwater harvesting tanks that reduce the storm-water volume. Therefore, cities or building owners evaluating technologies to address a single environmental issue will be likely not to adopt green roofs or walls. Only cities that are looking at all possible environmental benefits of green roofs and wall designs have supportive policies in place. This is the case of, among others, Vienna, Copenhagen, Beijing, Shanghai, Tokyo, and Sydney, New York and Toronto.

One building may not do much by itself in order to clean air but it could set an exceptional precedent, a manifest when integrated into the total urbanity that also includes extensive green spaces. The façades of the Bosco Verticale[14] (Vertical Forest), a residential tower complex designed by Stefano Boeri Architetti currently under construction in Milan, is covered by greenery that is equivalent to 2.5 acres of forest (Ill. 9). The foliage sits on cantilevered terraces off each unit, cooling the interiors by shielding them from direct sunlight. These towers according to the claim of the architect will dramatically reduce the city's CO_2 emissions. While it is a compelling approach, its impact to the air of Milan is probably negligible unless other typologies follow suit to this similar claim and perhaps 10 acres of forest would begin making a significant change to the quality of air in Milan.

A more radical approach is the one of Vincent Callebaut Architects. In their project, Farmscrapers[15], they believe to remove air pollutants while providing greenery in the city of Shenzhen. Six towers "function as a completely self-sustaining ecosystem with individual orbs containing highly sophisticated cleansing apparatus. They claim: incorporating vertical organic gardens, the towers tackle a breadth of issues that are crucial to creating a cleaner, less polluted environment while reducing the city's overall carbon footprint. City residents are re-connected to agriculture and production, rather than just consumption, by bringing the concept of a farm into the city center". By looking at the towers, two questions are obvious: how much energy and emission is needed to build it? A second concern is whether eating zucchini and tomatoes grown on top of one of the most polluted cities in the world is rather a dubious thought.

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[14] Stefano Boeri Architetti. *Vertical Forest*. http://www.stefanoboeriarchitetti.net/portfolios/bosco-verticale [accessed 1 February 2014].

[15] Vincent Callebaut Architectures. *Asian cairns, sustainable megaliths for rural urbanity Shenzhen 2013 China*, http://vincent.callebaut.org/page1-img-asiancairns.html [accessed 5 February 2014].

10. Buildings Eat Pollution: dream or reality?

Some architects seem to believe that there is some truth in the idea that a building can have the capability of cleaning the air in a city. Such imaginative proposals, often described in architectural magazines use complex engineering systems, sophisticated technology and complex mechanical systems leading to high environmental impacts for the building production, use and dismission. Another concerning question is: how the sequestrated pollution is disposed of?

To help reduce CO2 emissions from the 77,000 cars that use Chicago's Congress Parkway Interchange each day, Danny Mui & Benjamin Sahagun have proposed the pollution--eating Congress Gateway Towers[16]. The residential buildings bridge over the highway by a connecting public restaurant with a complex air filtration system. The architects claim "CO_2 is first absorbed at the crown of the tower by carbon scrubbers and then filtered through the algae growing inside the building. The algae are then processed into biofuels to provide energy for the building residents' clean vehicles". One could wonder why a restaurant and residential towers be situated in such a polluted location, making it even more of a difficult urban site.

There are few examples of buildings that claim to be able to clean the air of the city. The Berlin-based firm Elegant Embellishments has developed the Prosolv 370e[17], a decorative architectural tile that reduces air pollution and can easily be installed on any existing building (Ill. 10). "Coated with a nano-thickness of titanium dioxide (TiO_2), this pollution-fighting mineral is activated by ambient daylight. The tiles neutralize air contaminants when situated near traffic or other polluting sources". Do we believe this? It is intuitive and probably there is no need for complex analysis to understand that the quantity of air that a single building surface can filter is not relevant, especially in cities that are not exposed to significant winds. It is also improbable to cover a whole city with such technology.

But the most bizarre and outrageous concept to help combat air pollution woes in highly industrialized cities definitely comes from Hao Tian, Huang Haiyang, and Shi Jianwei. Their PH Conditioners[18] resemble "enormous floating jellyfish but actually help clean the acidic fog commonly found in many of China's cities. The conditioners are kept afloat by hydrogen gas and utilize a system that filters Sulfur Dioxide and Nitrous Oxides, two chemicals that lead to destructive acid rains in China's forests". Obviously this outlandish design will probably never be realized.

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[16] Jessica Escobedo, 2012. CO2ngress Towers Reduce Air Pollution in Chicago. *eVolo*, 22 September, http://www.evolo.us/architecture/co2ngress-towers-reduce-air-pollution-in-chicago [accessed 5 February 2014].

[17] Elegant Embellishements, http://elegantembellishments.net/prosolve.htm [accessed 5 February 2014].

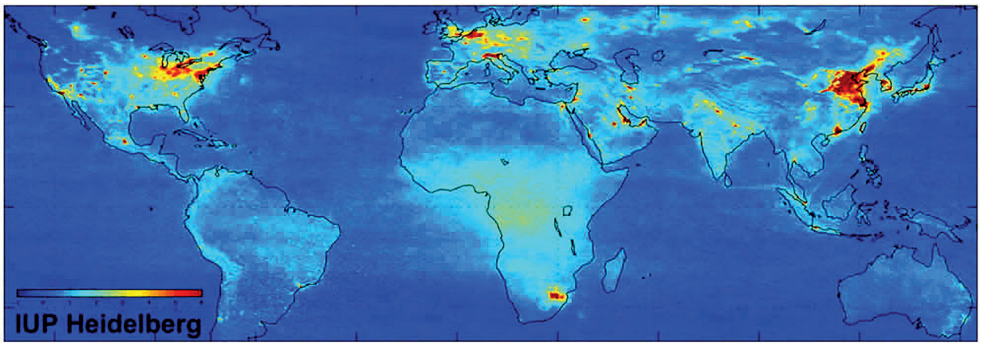
[18] Carlos Arzate, 2013. PH Conditioner Skyscraper. *eVolo*, 12 March, http://www.evolo.us/competition/ph-conditioner-skyscraper [accessed 2 February 2014].

11. Conclusion

While the architectural renderings of such projects are no doubt impressive, one could wonder if these visions are merely other instances of paper architecture or an idealistic piece of design with almost zero possibility of being realized. The potential role of tall buildings as *cleaning agents* for the air in large metropolises is something to be further investigated. While keeping these visionary proposals in perspective, a wide variety of other strategies will be needed to address the entrenchment of acclimatizing buildings and all of its negative externalities.

Architects have thoughtfully articulated possibilities, but it is helpful to remain realistic about the possible impact their proposals will have. Clean air will not be achieved through the construction of one singular building. What is the true value of visionary design projects like these? Is it worth probing the limits of our imagination, or are we better served focusing on what is feasible?

While conducting these comparative studies in order to distinguish effective solutions from "Green Washing", the paper also attempts to present case studies of design endeavours with a holistic approach towards mobility and the "greening" of city-scapes. Their integration can be considered as a decisive measure to contribute towards the cleansing of air in cities, while stimulating urban life and preserving the cultural-values of discarded industrial sites and streets.



Ill. 1. The image reveals pollution hotspots above cities and even shipping lanes (Image: University of Heidelberg)

Ill. 2. Nouvel-Tower, Praterstasse 1, Vienne (Image: Roland Halbe)

Ill. 3. The new district of Hammarby Waterfront, Stockholm, Sweden (Image: Pepesec)

Ill. 4. Masdar personal rapid transit podcar, Masdar City, Abu Dhabi, United Arab Emirates (Image: Jan Seifert)

Ill. 5. Due to the high congestion in London, the architects have thought of elevated pathways instead of constructing new roads and tunnels (Image: Foster + Partners)

Ill. 6. A tolled elevated cycleway connecting Pasadena and South Pasadena in 1900 (Dobbins Collection, Pasadena Museum of History)

Ill. 7. The High Line at 20th Street, looking downtown, an aerial greenway. The vegetation was chosen to pay homage to the wild plants that had colonized the abandoned railway before it was repurposed (Image: Beyond My Ken)

Ill. 8. The entry into the CBD (Central Business District) zone, Singapore (Source: www.transportpolicy2013.blogspot.ca)

Ill. 9. Bosco Verticale, Vertical Forest. The steel-reinforced concrete balconies were designed to be 28 cm thick, with 1.30 metre parapets (Image: Boeri)

Ill. 10. A Prosolv de-polluting facade is installed at Hospital Manuel Gea Gonzales in Tlalpan (Image: Prosolv)

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