SUSTAINING ARCHITECTURE DURING A REVOLUTION

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*The world will no longer be divided by the ideologies of 'left' and 'right,' but by those who accept ecological limits and those who don't.* Wolfgang Sachs, Wuppertal Institute

‘Limits’ and ‘revolution’ aren’t obvious bedfellows. Surely revolution is expansive, breaking the chains of an oppressive status quo? True, but it is nature that’s in revolt, not us, throwing off our chains, and as development continues at breakneck speed across the globe, throwing into question the whole of contemporary material culture: what we make, the way we make it and the way we dispose of it – or fail to. We are being swept up by the forces of nature rather than of history, though it’s difficult to distinguish between the two, given our contribution to nature’s current state. Historical inevitability is this time found in unavoidable ecological limits: the exploitation of the biosphere with little or no understanding of the environmental damage done by its pursuit has become unsustainable. Social and economic turmoil follow climatic turmoil as the biosphere struggles with its gathering disequilibrium, and we are tossed around in it.

Doomy, perhaps, but the sheer volume of empirical evidence on global warming pushes in on us daily. Just as climate change will reach a ‘tipping point’, and then accelerate dramatically, so a sizeable percentage of the world’s population seems finally to be approaching a cultural tipping point, after which, perhaps, the rate of acceptance of our new situation will also increase dramatically. Whether our willingness to act on it increases in tandem remains to be seen. Certainly but the built environment’s role both in contributing to, and mitigating, global warming needs to be more universally acknowledged by architects and urban designers, given their role in the creation of it. This means pursuing ‘sustainability’ much more consistently than most practices are presently prepared to: making root and branch assessments of the environmental impact of all the firm’s work at all scales, educating clients who want business-as-usual, and, in those countries with professional bodies like the American Institute of Architects, insisting those bodies voice their members’ environmental concerns to all levels of government. A tall order if you still believe things aren’t that bad, and that what is really important, as it always has been, is the economy, stupid. But in these revolutionary times, the economy is no longer separable from climate change, and adjusting to that now will spare us vastly more painful adjustments later on.

**a new bottom line**

To redirect practice in this way is to call into question long-held assumptions and sacred cows. Never a comfortable exercise, and the degree of discomfort it causes one group or another can be measured by the degree of resistance to it. Businesses have always been driven by ‘the bottom line’, architectural firms as much as any other. But ‘business as usual’, it is now becoming
clear, will soon cost more than any company can make, and those costs, environmental as well as economic, will be borne by all of us. This is part of a curious hybrid: an econo-ethical discourse in which, if you begin with money, you end up in morality, and if you begin with morality, you end up in money. Perhaps literally: The Stern Review, an independent study commissioned by the British government and published in 2007¹, provides a rigorous and detailed analysis of the ways in which acting sooner on climate change will save the larger amounts of money required if we are half-hearted about it. Under the title “The benefits of strong, early action on climate change outweigh the costs”, the report states unequivocally:

The evidence shows that ignoring climate change will eventually damage economic growth. Our actions over the coming few decades could create risks of major disruption to economic and social activity, later in this century and in the next, on a scale similar to those associated with the great wars and the economic depression of the first half of the 20th century. And it will be difficult or impossible to reverse these changes. Tackling climate change is the pro-growth strategy for the longer term, and it can be done in a way that does not cap the aspirations for growth of rich or poor countries. The earlier effective action is taken, the less costly it will be… The scientific evidence points to increasing risks of serious, irreversible impacts from climate change associated with business-as-usual (BAU) paths for emissions.²

It would take the report’s voluminous evidence to convince the sceptical of these bare-faced conclusions, but the message is easily grasped: change cultural attitudes and material practices now, or reap the whirlwind. A culture’s failure to perceive the intrinsic value of nature is no longer excusable, a value rarely factored into economic calculations about the ‘affordability’ of environmental technologies. Our attitudes to profit and nature must shift if we are not to be bankrupted by the effects of global warming.

Since the Industrial Revolution, it is the countries that industrialised first that have contributed the most greenhouse gasses globally (70% up until the present). New technologies, however, have the potential to uncouple the equation of ‘most developed’ with ‘biggest polluters’, but only if there is the will to do so. Perhaps it takes a scientist to fully appreciate the implications of the current revolution in energy technology. Angela Merkel, the German Chancellor, was a quantum chemistry researcher before she became a politician, and has committed the country to the most ambitious environmental targets in the world: a 40% reduction in CO₂ emissions, and an increase in renewable energy to 20% of total energy generation by 2020. The Renewable Energy Sources Act means any individual or enterprise generating energy from renewable sources is guaranteed a payment of up to four times the market rate for twenty years, which has given a

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² Ibid, 1,3
tremendous boost to the renewables industry and artificially reduced the pay-back time on these
technologies. If it sounds expensive, not doing it is more so:

The cost of reducing emissions should be seen as a sound investment. Unabated
climate change will slash prosperity by 5% to 25%. Rigorous climate protection will cost
only 1% of this prosperity and makes economic sense.\(^3\)

This top-down model of effecting technological change is vital to the eventual creation of an
economically level playing field, but an equally fertile ground for change is the worldwide bottom-
up activity generated by determined individuals, research groups and businesses. The private
sector is essential, not only in promoting new technologies but inventing them, and architects
have an urgent role to play in transferring environmental technologies from the computer to the
client, and from the developed world to the developing one. Those architectural firms committed
to deep change rather than green window-dressing or the ostrich position are the ones that will
be leading us through an uncertain future.

From an environmental point of view, it’s one of the two things architecture is good for, as new
projects, whether individual buildings or towns, can have no appreciable material effect on the
physical environment – there’s too little of it. The real work, after all, is to retrofit the billions of
existing buildings worldwide with insulation, double glazing, heat exchangers, solar hot water
panels, bore holes etc. so they cease to run like 1950’s Cadillacs Not the stuff of most architects’
dreams. However, the other thing architecture is good for environmentally IS the stuff of dreams:
making buildings and settlements that point forward to an altered state, to a condition that barely
exists, in this case, a built environment achieving the efficiencies and constructive
interdependencies of natural ecosystems. This pointing forward has a cultural, rather than
physical effect, but is as important, since the cultural climate must change before we can damp
down the actual climate. Any architectural firm with a tradition of interdisciplinary innovation has
the potential to effect that change, once its sights are set on sustainable innovation rather than
innovation for innovation’s sake. This requires change within the micro-culture of a firm, and then
of the profession, something that has evolved further in European architectural practice, mainly
because the European Union has been bombarding its members with environmental directives
for the past twenty years, as it has come to understand some new facts of life: “50% of material
resources taken from nature are building-related. Over 50% of national waste production comes
from the building sector. 40% of energy consumption in Europe is building-related”\(^4\).

This is the new, or really the re-newed element of the sustainability triad, the social and the
economic aspects having been part of architectural thought and practice for over a century now.

\(^3\) MERKEL, Angela interviewed in *The Guardian Weekend*, London, Jan 5, 2008:19
\(^4\) ANINK, Boonstra and Mak (1996), *Handbook of Sustainable Building*, London: James and James
(Science) Publishers. 8
It is the environmental sustainability of the built environment that demands architects acquire new knowledges and new skills. Environmental design in a contemporary context was never about a return to some pre-industrial arcadia. It is instead part of a radical reordering of material culture that will demand a constant stream of new ideas and technologies to cope with the scale of the challenge. Everything must become part of a culture that looks to nature for its operative models: “new building technologies closer to those found in and beyond nature need to be invented”. Once invented they could be of great benefit in realising a new and elegant economy of means: “this approach...is deeply connected with sustainability, as limited resources require us to maximise performance”.

With our forays into bio- and nanotechnology we’ve only glimpsed the edge of a vast terra incognita where the similes we currently use to describe an improved built environment become fact: buildings won’t be like plants, they will more likely be plants, at least in part, their remarkable structural and operational properties appropriated by us through biotechnology. Cities won’t be like ecosystems in their social and economic interdependencies, they will be artificial ecosystems in their metabolic processes, with biomachinic systems achieving closed circles of consumption rather than the present linear profligacy. At the moment resources and energy go in at one end, and wastes of various kinds come out at the other, most of which are dumped into the air, land and water. In ecosystems, the waste of one process is the raw material of another – the dung beetle springs to mind – in a waste-not-want-not model of consumption that used to be ours in the West, and still is in some developing countries. It seems not to be an aspirational model, but in fact requires, not self-denial, but creativity to make it work in a highly complex, increasingly urbanised world. Kalundborg in Denmark is one of the few working examples of a so-called ‘industrial ecology’:

In the early 1980’s, [the electric power plant] started supplying excess steam to the refinery and pharmaceutical plant. It also began supplying waste heat for a district heating system, allowing 3,500 furnaces to be shut off. In 1991, the refinery began removing sulphur for its gas, selling it to a sulphuric acid producer…[The power plant] is now selling its fly ash to the cement manufacturer and will…sell waste gypsum to the wallboard plant…

Hardly glamorous. The bowels of material culture rarely are. But operationally - and economically - sophisticated: in this model, waste is not only a source of raw materials, but of profit. Would that more building sites understood this.

Transition periods are always the most difficult to negotiate, and this transition, from a carbon to

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6 Ibid, 53
a zero carbon world, requires a sustained domino effect: a change in the cultural climate that leads to a change in the political climate that leads to carbon pricing (so we pay for our pollution rather than future generations), which leads to the financial viability of investing in new technologies, which leads to the proliferation of ‘clean’ technologies, which leads to a reduction in carbon emissions, which leads to the mitigation of the worst effects of climate change, which leads to greater social and economic stability. It’s not happening like that, and it won’t. We are proceeding by lurches forward and regressions. No matter. Out of this melee are emerging new models of being and doing, to which environmentally-informed, intellectually consistent architecture and urban design, perhaps particularly urban design, are essential. Both must be allowed to function as laboratories, to bring forward forms, techniques and technologies that may or may not work, and, vitally, to share information on the results. The architect-as-inventor, rather than social engineer, is the model we need to retrieve from the attic of the Modern Movement: the inventor of new relationships between building/city and environment, of new configurations to accommodate these relationships, of new systems to run them, of new conceptual and actual melds between nature and technology.

two-faced technology
Can technology cure the problems it has, at least in part, created? When we talk of environmentally sustainable design, are we talking about a different model of technology from the instrumentality with which we’re so familiar, that is, exploitation to the point of ruination? It could be argued that human development has always involved the exploitation of nature. Civilisations have risen by extracting what they wanted with increasing efficiency, and sometimes fallen from over-extraction. The only reason industrialisation, rather than human nature, stands accused is because technology since the 19th century has become so much more powerful than its earlier versions, and with an increase in power has come an increase in destructiveness. This is essentially a failure to think beyond the relationship between an intervention and its effect on us, to its effect on nature. Had we had the means earlier to transform the given as widely and swiftly as we can now, this ‘destructiveness’ would have made itself felt earlier. In other words, the drive to control the physical environment, to use it as a means to our ends, is as old and fundamental a cultural phenomenon – at least in the West - as the necessity, so far at least, of living within its limits.

These two positions, of domination and cooperation, informed the set of ideas we call modernism as they informed the cultures that preceded its emergence, but in inverse proportion. Within modernism, instrumentality – that is using nature or human beings as means to ends - grew and grew, a monstrous child that now threatens the existence of its parents. Earlier, however, instrumental technology was perceived as vital to that existence, and indeed was. The word technology is derived from the Greek techne. In classical Greece, techne was interpreted as a form of benign, rather than malign systematisation. Techne means literally craft, art or science –
‘technique’, since what you cannot conquer you have to find a way around. Ingenuity within the limited means at one’s disposal thus became associated with techne, but that is to reduce its complexity as a term. It is certainly associated with a grappling with limits, and in its widest interpretation, could be viewed as culture, the sum total of our efforts to protect ourselves from the hazards of nature. Techne encompasses everything from crafts such as house or boat building, to arts such as dance and music-playing, to sciences such as mathematics and astronomy.

In The Fragility of Goodness, Martha Nussbaum describes two versions of techne found in Plato’s Protagoras: that of Protagoras himself, and that of Socrates. Socrates’ definition favours the sciences, the more practical and effective kinds, those that can measure and be measured: “... [W]hat is measurable or commensurable is graspable, knowable, in order, good; what is without measure is boundless, elusive, chaotic, threatening, bad”\(^9\). Socrates was, in fact, pushing techne towards a fraction of itself: technology. Protagoras, on the other hand, defended techne’s original complexity. This is what Nussbaum refers to as a “bona fide techne”: “qualitative, plural in its ends, and in which the art activities themselves constitute the end”\(^10\). It is less effective than instrumental techne (technology). That is, it is not necessarily being used to overcome or replace what is there, but to understand and operate within it constraints. Socratic techne won out justifiably over Protagoras’ version in ancient Greece: life was unremittingly harsh and dangerous. It still is for too many of us, and there are aspects of nature we will always want to overcome - disease, for example. By the mid 20\(^{th}\) century, however, we began to see the environmental price we paid for attributing value only to ourselves, and not to the nature that sustains us.

Tectonics contains within it both versions of techne. In traditional vernacular architecture, highly differentiated architectures formed predominantly out of the regional, we were obliged to observe a Protagoran regard for things-in-themselves - materials, climate, topography – because we had no technological choice other than to build with climate and context rather than against them. Socratic techne liberated us from such traditional politesse. If we wanted to remove the top of a mountain to build there, we could and did. If we wanted to redirect a river, we could and did. Given this power to order as we see fit, some ask what possible rationality there is in imposing restraints. The answer lies in the price one is prepared to pay for misperceiving restraint as retreat. Designing with technologies as sophisticated as nature’s ways-of-doing demands the most from us, not a denial of it. Environmentally-designed architecture is an exemplar of a future in which technology is both Protagoran and Socratic, and the need for invention within ecological limits is understood and accepted. So that while we still need the power of Socratic technology, it

\(^10\) Ibid, 99
becomes curative, rather than exploitative, through its more knowledgeable (Protagoran) application. That, at least, is the intention.

two questions
Given the constraints of sustaining the economic viability of a practice, how is a radically reconfigured architecture to be achieved? Internal contradictions are present in all architectural firms successfully negotiating the mainstream, and yet being forced to think about changes to that mainstream. Although there is often a clear intention in many of them to improve the environmental performance of their buildings, at the same time there is a desire not to stray too far from their previous practice and its embeddedness in a profitable status quo. What is needed is a willingness to develop a consistency of position (no more ‘biggest’/ ‘tallest’ simply for its own or the client’s sake), and even more demanding, to choose the level of technology appropriate to the task. The first (too difficult) question is: ‘Does the client need a new building at all?’ A refurbishment or addition to an existing building may, in environmental terms, be the rational answer – less expenditure of energy, less extraction of natural resources, less to recycle at the end of a building’s life. But architecture is rarely about reason. Questions of architectural identity and client status, plus our incurable addiction to novelty, mean design is too often entirely irrational.

The second (slightly less difficult) question is: ‘What level of technology delivers the best balance between economics and environmental performance?’ In other words, how much money (and energy) do you have to spend to create an environmental system that will reliably deliver and significantly reduce environmental impact? One can be no more precise than this, as it’s a moving target, but would hope that an expensive piece of architecture would do better than the CO₂ emissions allowed for a LEEDS or BREAM ‘excellent’ rating. This may cost more, but at the high end of the market, this is what architecture can do: surpass norms, especially new, overly-tentative norms. So that for heating and cooling a private house in a moderate climate, there should be no need for anything more than a passive system. Even in a difficult urban environment with a demanding program and a big budget, the building envelope should do as much as passive mediation between inside and outside before one moves on to active systems. But what kind of envelope and which active systems? Is a double or triple skin of high performance glass really necessary? Economics aside, is the expenditure of energy and pollution to make such envelopes justified by their environmental performance? Is an energy-using digital building management system justified by its energy-savings? Could one have saved more by not having to make the sensors, wiring and computers that comprise it? ‘Smart’ buildings have something to teach us in terms of anticipation and flexibility, and they may be the only way of optimising energy consumption in public buildings subject to many and contradictory user demands. If digital energy management systems are still unreliable, then that is the role of architecture-as-lab: to keep developing them until they are reliable. Conceptually, digitl systems
are seductive, allowing the building to come much nearer the sophistication of a living organism, the new paradigm of all built culture. Almost twenty years ago, Walter Kroner of the Rensselaer Institute fantasised about a truly intelligent building that “may change its colour, envelope configuration, orientation and composition ... float in water, rise up and go down into the ground or rotate”\textsuperscript{11} as the need arises, carrying the organism analogy and the dynamic approach to environmental design to their logical, and one hopes beneficial, end. The important ideas here are responsiveness and performativity, whether achieved by low or high technology.

The shift of a firm’s priorities to maximising the reduction of environmental impact in all its output can be considerably helped by clients who demand this, rather than having to be persuaded. In the United States now, as in Europe in the recent past, many of the most environmentally ambitious buildings are commissioned by clients whose business requires them to be seen as environmentally ambitious: renewable energy research centres (SmithGroup, Science and Technology Facility, Colorado), earth centres (Kiss + Cathcart, Solar 2, New York City), and university science buildings (William McDonough + Partners, Adam Joseph Lewis Centre, Oberlin College, Ohio). A client can also impose a lack of environmental ambition, which is presumably why SOM’s home page is neatly divided between work that explicitly declares itself sustainable (Chongming and UNC), and work that does not (Burj Dubai and Infinity Tower). Faced with clients keen to build ‘against nature’ on a pharaonic scale, a firm has three choices: to reject them, to try to lead them onto a saner path, or to do what they want. Not all clients are convertible to the cause, and consistency of approach is easier for a firm that has begun its life by defining itself as ‘environmental’ than it is for one that has in the past led the field with a pre-environmental identity.

\textbf{identity and accountancy}

It is entirely possible for firms with already-established identities to evolve a more or less consistent environmental position, as the evolution of Richard Rogers + Partners into Rogers Stirk Harbour + Partners demonstrates. Theirs is an example of a high modernist practice that has redirected, rather than forswn, its modernist principles. There is the same commitment to experiment, the same faith in progress, the same reliance on new technologies to fix what earlier technologies broke, but the architecture has become less universal, more particular. There has been an embracing of a much wider palette of materials, natural as well as manufactured – for example the bamboo strips that make up the vast undulating ceiling of their new Madrid airport – and, where performance demands, of a much wider range of forms, as in their new Welsh National Assembly. Why? Because they perceived a potential for innovation within a modernist interpretation of the new environmental remit: ‘the built environment is clumsy, damaging and

inefficient, its performance always lagging behind other engineered artefacts, let's crank it up.\textsuperscript{12} Modernists said the same thing at the beginning of the 20\textsuperscript{th} century when faced with the machine. Now they say it faced with what the machine has done.

Consistency of vision and appropriate levels of technology demand an environmental accounting that forces tough choices on architectural firms. It means the environmental cost of a project is addressed first, and its economic cost second, with the understanding that rejecting environmental costs for some will increase environmental and economic costs for all. The more expensive a volatile climate becomes, the clearer this will be. What characterises sustainable technology, high or low, is the consideration of a building as one integrated system, not a collection of systems that may be at war with one another: "There is a breakdown of barriers between building fabric and services design. Both are part of the energy system design."\textsuperscript{13} Before mechanical heating, ventilation and air conditioning (HVAC) systems, the structure and configuration of the building - the fabric - had to do the mediating between external and internal climates, with heavy or light walls, large or small glazed openings, orientation toward or away from the sun, and various shading devices: shutters, verandahs, overhangs etc. As 19\textsuperscript{th} century inventions for heating and ventilating buildings were produced, the dream of complete control over the interior climate seemed within reach. In America, the goal was pragmatic: to make the skyscraper, the new temple of commerce, habitable. In Europe, it was more ideological – a new architecture for a new age.

Architectural histories tend to dwell on structural steel and the invention of the lift as the keys to this new building type, but new HVAC systems, electricity, the telephone and even the flush toilet were also vital, as Reyner Banham has shown.\textsuperscript{14} The vernacular model of differentiated structures for different climate zones was emphatically repudiated by the European Modern Movement:

Every nation builds houses for its own climate. At this time of interpenetration of scientific techniques, I propose: one single building for all nations and climates.\textsuperscript{15}

As if this universality of structure were not enough, the interior climate was to be universal as well:

The buildings of Russia, Paris, Suez or Buenos Aires, the steamer crossing the Equator, will be hermetically closed. In winter warmed, in summer cooled, which means that pure controlled air at 18C circulates within forever.\textsuperscript{16}

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\textsuperscript{12} See SLESSOR, Catherine ((1998), Eco-Tech, Thames and Hudson: London
\textsuperscript{13} EVANS, Barrie (1993), 'Windows as Climate Modifiers'. The Architects' Journal, 4 August, 39
\end{flushleft}
Mechanical systems became essential to mediate between human and climate and compensate for the building’s inadequacies of structure and orientation. The addition of computer controls from the 1970’s on merely reinforced the commitment to the sealed environment, which didn’t often deliver the always-reliable bland and seamless continuum of 18C throughout a building come what may: elegant glass blocks often overheated on their south sides, requiring a level of air-conditioning that drove those on the north side into jackets and gloves. Opening up the building to the elements again does not dictate one particular strategy. There are two main ones currently being pursued: 1) returning to a position where the building’s structure, configuration and orientation do all the mediating through passive environmental design, or 2) the most prevalent, opting for a hybrid strategy of “both/and” which uses both passive and active systems to control the internal environment.

This means that four sides of high performance glazing should probably give way to something more efficiently protective on a very cold or very hot orientation. For many firms and clients, however, this is a highly contentious strategy if architecture-as-response contradicts their architecture-as-identity, and their identity is one of transparency, abstraction, and high culture overcoming the constraints of nature, or an indigenous culture. Given the environmental necessity of responding to a context that is as much physical as cultural, architects will be led towards a repertoire of sustainable architectureS – plural. Responses can range from a contemporary take on traditional vernacular (e.g. Charles Correa’s social housing in India), to an existing architecture made more sustainable (most mainstream firms), to an environmental functionalism/determinism (ZED Factory, some work of Future Systems), to designs that are concerned not only with sustainable operation, but also with expressing a particular view of the relationship between nature and culture. The Dutch firm, MVRDV, is particularly good at witty and thought-provoking representations of the new partnership.

Though a firm could justifiably adopt all these approaches for different commissions, most maintain their identity by specialising. If energy efficiency comes after other considerations, social, aesthetic, or particular to the client, then it will not be allowed to dominate the design process, and form won’t respond to performance. If energy efficiency and reduced environmental impact are the most important considerations, and become the identity of the firm, then design will reflect that priority - in configuration, in choice of materials, in techniques and technologies employed. There is increasingly less choice between these positions. Climate change and its social and economic consequences (environmental refugees, storm damage) are here. Changing designers’ priorities from idea-driven ‘form giving’ to performance-driven ‘form finding’ in the

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16 Ibid, 159
17 See FRAMPTON, Kenneth (1999), Charles Correa, London: Thames and Hudson
18 See DUNSTER, Bill (2008), The ZED Book, Oxford: Taylor&Francis
20 See A+U Special Issue, Nov 2002, MVRDV Files Projects 002-209
interests of reduced environmental impact is now a matter of some urgency, and world class firms have a greater responsibility that goes with their greater reach and reputation.

Form-finding doesn’t just refer to open-ended avant-garde digital experiments, as in ABB Arkitekten’s BMW Pavilion (2001):

Arbitrary and fanciful factors create the total composition…Rather than design, we control, as the designer [sic], a process. The form is somewhere out there and is waiting for us to realise it. By means of a computer, we provide the form an opportunity to realise itself.²¹

Environmental design returns form-finding to its engineering origins, with the formal and the performative merging, and form, either wholly or in part, expressing a chosen environmental strategy (Nicholas Grimshaw’s Eden Project, T.R. Hamza and Yeang’s bioclimatic skyscrapers). If kept separate, with the expression of the environmental systems suppressed in favour of a building envelope of more conventional appearance (Ercilla + Campo’s Services Building, Catalonia Polytechnic, Spain), then performance will be less effective, but perhaps more acceptable to the client. (Something ’s better than nothing). Whichever way an architect jumps, however, there are performative criteria to be considered. In those countries that address environmental standards, the minimum is set by building regulations. The more-than-minimum is set by LEEDS or BREAM ratings or their equivalents, providing the client for whom it matters, usually for public relations reasons, with a good housekeeping seal of approval for the design, but not the finished building, which is much more to the point. The targets are conservative, and one would expect to see architects being more ambitious.

The tried and true rules of thumb for passive solar design at a domestic scale disappear in a swirl of behavioural complexity when technical envelope-pushing meets demanding program. There are simply too many variables to be able to digitally model with any certainty of the results. This is fascinating and nerve-wracking in equal measure. The hybrid building with air conditioning and openable windows seems such a good idea when modelled on the computer, and can be such a headache if not programmed properly: the air-conditioning at the centre of the building turning off when a user at the periphery opens a window, causing scores of clerical workers deep in the floor plan to wilt at their desks. Knowing how these systems interact, not only with each other, but with unwitting users, is essential to the correct functioning of an environmentally-designed building, and there is not yet enough post-occupancy analysis, not least because firms, for good commercial reasons, are unwilling to share their mistakes, thus continually flattening our learning curve. Only the most environmentally-committed firms will privately discuss what went wrong as well as what went right. For this reason, there is not yet a large enough body of measured precedents to help other designers and engineers. Experiment needs to be seen as part of the

role of architecture, and architectural experiment as part of a strategy to deal with climate-change. If this is important at building scale, it is crucial at urban scale, where the most damage is being done.

making artificial ecologies
Environmental design revolves around a particular idea of imitating nature in operation - its productivity: of energy, of clean(ed) water, of filtered air, of acoustic protection, of food, of (public) health. This is true at architectural and urban scales, but it is at urban scale that it may find its most radical expression, requiring design methods that bring about a reconfigured nature within intensely urban contexts: environmentally productive landscapes, in which buildings are part of the same productivity. This challenges conventional conceptions of the city as the site of built culture, of non-nature. The emerging practice of landscape urbanism has taken much of its meat from the ecological sciences, and is contributing to the linguistic and actual blurring of city and nature now so vital to the city’s survival, in particular cities already in environmental meltdown. Environmentally productive ‘urbscapes’ require the quantification of nature, something resisted by practices that are design- rather than engineering-led. The muddy-boots-practicalities of engineering, however, are the sine qua non of a new artificial nature that may one day appear on urban sites as a matter of course. At present, such models are experimental and the technologies emergent.

The London-based firm of Arup Associates and their design for the zero carbon new town of Dongtan is a case in point, as is SOM’s Chongming, an even more ambitious experiment with eight new high-density towns proposed to house a million people, and yet compact enough to preserve 85% of the island for organic agriculture and water management, and to protect it from the continuing sprawl of neighbouring Shanghai. If the client pursues the project past the construction of the new neighbourhood now being added to Chongming City, we will have two large-scale urban experiments in sustainable design, this and Dongtan, to learn from in operation. In Dongtan, a city intended to be for half a million people, Arup is using the concept of the ecological footprint to drive its spatial planning. Ideally, in any environmental design, whether building or city, nature’s supply and human demand are in equilibrium. This requires the analysis of a complex set of quantified relationships, and Arup is using a modelling tool called REAP (Resources and Energy Analysis Program), developed by the Stockholm Environment Institute (SEI) and the Center for Urban and Regional Ecology, University of Manchester. This helps calculate the quantity of natural resources on site to sustain life (energy, food, water), and the quantity of waste and pollution that can be absorbed there.

The comparative dispersal into the landscape of the first phase of Dongtan is one model of an eco-city, based on a careful assessment of the carrying capacity of the site, an ideal scenario,
but an unlikely template for a country with 1.3 billion people, and a planet that currently falls short of recovering from the rate at which we exploit it by over 20%. Dongtan’s average density will be about 240 people per hectare, or roughly 60 dwellings per hectare, extraordinarily modest by Chinese standards. Other firms are pursuing another, more fashionable model of compaction and densification, which is based, for the most part, on a very different parameter: transportation. The argument is that if distances between work, shopping, sleeping etc are reduced by designing more compact cities or parts of cities, or by densifying existing ones with mixed use developments, then fossil fuel consumption, especially by cars, will be reduced also. There is another reason for compaction, however, which has emerged from the studios of two other international practices, OMA and Foster and Partners, and that is climate. Both OMA in Ras al Khaimah with the design for a new city called RAK Gateway, and Fosters in Abu Dhabi with Masdar have used the traditional desert vernacular morphology of narrow self-shading streets and compacted city footprint to reduce the amount of surface exposed to intense solar radiation, and the consequent overheating and evaporation of what moisture is provided. The results are two surprisingly similar masterplans: perfect squares sitting in their respective deserts, RAK Gateway with a density of 400 people per hectare, or roughly 100 dwellings per hectare, almost twice as dense as Dongtan.

The updating of traditional settlement patterns that evolved to cope with the demands their particular context is daring, but contradicted by RAK Gateway’s reliance on a brand new fossil fuel power station that will produce electricity nationally. With the amount of solar energy available and the size of the budget, such an energy strategy, whether the client’s or the architect’s, is absurd. Only half the job of ‘pointing forward’ is done: if there is protection from solar radiation, why isn’t there also an exploitation of it? Realistically, what is of value in any zero carbon development is the reduction as far as possible of its environmental impact. This means using every technique, technology, idea and material available. ‘As far as possible’ allows for contextual constraints (the number of people requiring to be housed, the productivity level of the climate and land they’re to be housed on), economic constraints (some techniques and technologies may be beyond the means of a nation or a region), but not cultural constraints, not some project architect thinking environmental design is ‘a bit of a cliché’.

What is interesting in the new ‘eco-cities’ of the Middle East and China, nevertheless, is a new responsiveness to physical as well as cultural context. The new cities near Shanghai are in an area blessed with fertile soil and rain, and both Arup and SOM have responded accordingly. SOM’s Chongming is an interesting hybrid: eight dense and compact cities, but compacted, not for climate, but in order to preserve surrounding land doing valuable agricultural and ecological work. The cities will rely on this land to close the loop of their metabolic processes. If it is completed, and does what it says, Chongming’s new altered urban state will be incomparably more powerful an influence than a settlement that looks different and does the same old thing.
Arup’s Dongtan will be the first to become what its design leader, Alejandro Gutierrez, calls an ‘ecological demonstrator’, with one of its three constituent villages due for completion in 2010. Again, there is follow-through, an intellectual consistency to technological innovation that has sent them in every appropriate direction to avoid fossil fuels at urban scale: biomass, biogas, solar power, wind. Because the practice has the requisite new knowledge, it is able to understand and use what physical resources are available to the point of symbiosis, and not beyond.

Increasingly, the environmental case for urban densification is taken as given. It is even rolled out to defend the perfectly straightforward commercial exploitation of valuable inner city sites. Densification is presented as beneficial, not only financially, but environmentally, and the injection of thousands more people into an already overstretched infrastructure is left unexamined - at least by those standing to benefit from such development. Others, however, are questioning compaction as necessarily the *sine qua non* of urban sustainability. The concepts of ‘productive’ or ‘performatve’ landscape, whether for urban agriculture or renewable energy or psychological relief from densification, are indicative of such questioning, and can be part of a very different way of conceiving of city and non-city. Land empty of built development isn’t necessarily empty, merely full of something else. The unbuilt is potentially an event of equal intensity to the built, where the built is indicative of cultural activity, and the unbuilt of ecological activity. The uncompacted is capable of being, not a ‘waste of space’, but productive space, space that is ‘used’, but in different and equally valuable ways from building on it. Transport won’t always be fossil-fuelled, any more than buildings or cities will. Dispersal is here and its transportation impact must be reduced, but the sprawl of London or Sao Paulo or Los Angeles isn’t going to go away. The real job, as at building scale, is to reduce the environmental impact of what is already here. Dongtan and, if it’s built, Chongming, will be both laboratories and symbols of what might be to come, but they will have a cultural rather than a physical impact. Like NASA’s space program, these eco-cities’ value really lies in the new thinking of their clients and designers, and in the transfer of that thinking to the old cities.

**doing productive design**

Environmental design at all scales is about performance, which is why it’s small wonder the Architects-Formerly-Known-as-High-Tech find it seductive: it both justifies and focuses technology transfer from various forms of engineering into architecture, something that seemed in some past works to be more ideological than logical. Contemporary climate-responsive architecture is capable of far more than protection. Buildings can become water harvesters and micro-power stations, producing electricity from sun and/or wind. To maximise their productivity from these sources, however, their forms must be governed by the harvesting of these renewables. At architectural scale, solar collection has for the most part produced straightforward
orthogonal buildings with expanses of PV's, solar panels and/or glazing. Sometimes these elements are designed to track the sun, altering their angle of reception as the sun moves through the day and the year, but generally solar architecture remains conventional for economy's sake. When environmental productivity of one kind or another is used to **determine** a form, the results can be startlingly similar to some of the non-linear designs of the formalist avant-garde.

Reservations about this design method centre on one parameter, energy, dominating all others, and distorting the architectural object into a one- instead of a multi-dimensional response, but there is no reason why this has to be the case. Additional parameters can be added in subsequent iterations, and if environmentally performative architecture is to have any cultural value, this must, in fact, happen. Nevertheless, it's useful to look at an example of environmental form-finding that deliberately determines the design through the requirements of maximised energy productivity. Optimising wind collection is not easily done, and requires engineering the shape of the building. As a result, velocity-enhancing typologies are already beginning to emerge from two objectives: first, to accelerate a given wind speed to drive wind turbines located on the building faster, producing more electricity, and second, to maximise the number of wind directions the building can take advantage of. It is the acceleration of wind speed that is driving a change in wind-determined design - from tall buildings with turbines sitting on the roof, where the highest velocities are to be found, to horizontal or vertical axis wind turbines (HAWT or VAWT) incorporated within the form of the building itself.

The VAWT type requires the building to be hollowed in the middle to allow the mounting of a vertical turbine or turbines. The shape of the building can then accelerate the wind passing across the blades (the Venturi effect). **Project ZED**\(^2\), a European Commission-funded research project (1995-97) co-ordinated by the Martin Centre, University of Cambridge\(^2\), explicitly pursued environmental form-finding through three energy-producing designs by Future Systems in three European cities: Berlin, Toulouse and London. As Britain is rich in wind energy, Future Systems’ London case study opted for wind power in a 25 storey residential and commercial tower:

The design of the plan form has evolved from key environmental criteria along with architectural considerations... The overall form and principal layout of the typical floor plate dramatically changed during the design process. The most important strategic decision

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\(^2\) **Zero Energy Design**, also known as ‘zero carbon’ or ‘net zero’. Total renewable energy autonomy on site for electricity as well as heating/cooling is very difficult to achieve, and for complex programmes in cities, even more so.

\(^2\) **Project ZED: Towards Zero Emission Urban Development**, a research collaboration between The Martin Centre, University of Cambridge; Future Systems; GRECO, Ecole d’Architecture de Toulouse; RP+K Sozietat, Germany, and TUV Rheinland, Germany. The English version of the report is held in The Martin Centre library, University of Cambridge.
regarding the shape was the deflection of wind into the aperture of the building to increase wind speed in this zone and hence increase energy production.24

Every aspect of the building’s form and fabric was, to a large extent, determined by the requirements of energy productivity. Any doubts that this is so are laid to rest by the description of the evaluative process, in which both physical and digital modelling dictate changes to the building's form to optimise energy productivity:

The 'Mark I' scheme...had a lower [wind] capture ratio [than the 'Mark II' scheme] and was not aligned exactly to the statistically prevailing wind direction...The Mark II scheme was designed to correct these initial shortcomings.25

The floor plan on each side of the aperture was then changed from an egg-shape to more of a boomerang shape, to reduce turbulence and increase productivity. The Mark II scheme was estimated to be capable of increasing a given wind speed by 60%, thereby producing four times as much energy as a building carrying turbines without this modelling. Given that such performance is “critically dependent on building shape and orientation”26, it is hardly surprising that the form is generated from the wind modelling evaluations.

When there is a quantified target, the reasons for ending an iterative process are much clearer than they are in formalist experiments. With an energy-determined building, it is clear when one stops: when the building is judged to produce as much energy as it can under the given circumstances. Environmental determinism is itself determined by the laws of physics. The parameters for shape-generation are strictly governed by dynamic physical phenomena such as the behaviour of air at different temperatures and different velocities etc. In contrast, the parameters for much form-finding in avant-garde architecture are opaque, and the cut-off point for the iterative process arbitrary. Environmentally-determined design is often dismissed because of its lack of attention to the conventional concerns of architecture – people, context, aesthetics. Certainly the disjuncture in scales, and the disruption at street level of the ZED London case study would be as radical a departure from architectural norms as any from the formalists. Such rupture can either be the desired effect, or be mitigated by adding further parameters in further design phases. These would inevitably compromise the optimisation of the design for wind energy production, and was not the point of Project ZED, but outside a research project, this is exactly what one would have to do: wrestle with conflicting parameters - environmental,

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25 Ibid, 58.
26 Ibid, 57
structural, economic, cultural – and arrive at one of a range of possible solutions, depending on the priorities set by the designer.

**conclusion**

A design needn’t be environmentally-determined to be environmentally sustainable, but will inevitably be environmentally influenced if one is thinking in a ‘whole life’ or ‘cradle to cradle’ way about the building or the city. Effort spent on environmental performance is too often discounted if it isn’t presented through innovative form. Future Systems is one of a few exceptions in what is at present a surprisingly conventional-looking output, considering its potentially revolutionary effect on building design. The canyon that habitually divides the good from the cool is a curious thing, and one that may finally be bridged by young architects trained in goodness (environmental performance) and coolness (formal innovation) – both/and. The Modern Movement pioneers never had any difficulty deriving new forms from new technologies, though the case is interestingly different. Their forms anticipated building technologies it took another fifty years to develop into reliability. Today, it is more the case that our new technologies are ahead of the forms appropriate to them, and they are ahead because of the profession’s unwillingness or inability to embrace the fact of nature’s revolt. Finding those forms may entail looking back (as in Masdar and RAK Gateway) as well as ahead, but the Modern Movement’s youngest heirs have a similar ecumenism that allows them to slide from formal experiment to practical effect and back again, untroubled by distinctions between beauty and utility. They have, and will continue to have, just as much difficulty as the rest of us in precisely defining sustainability, but perhaps less difficulty in achieving it.