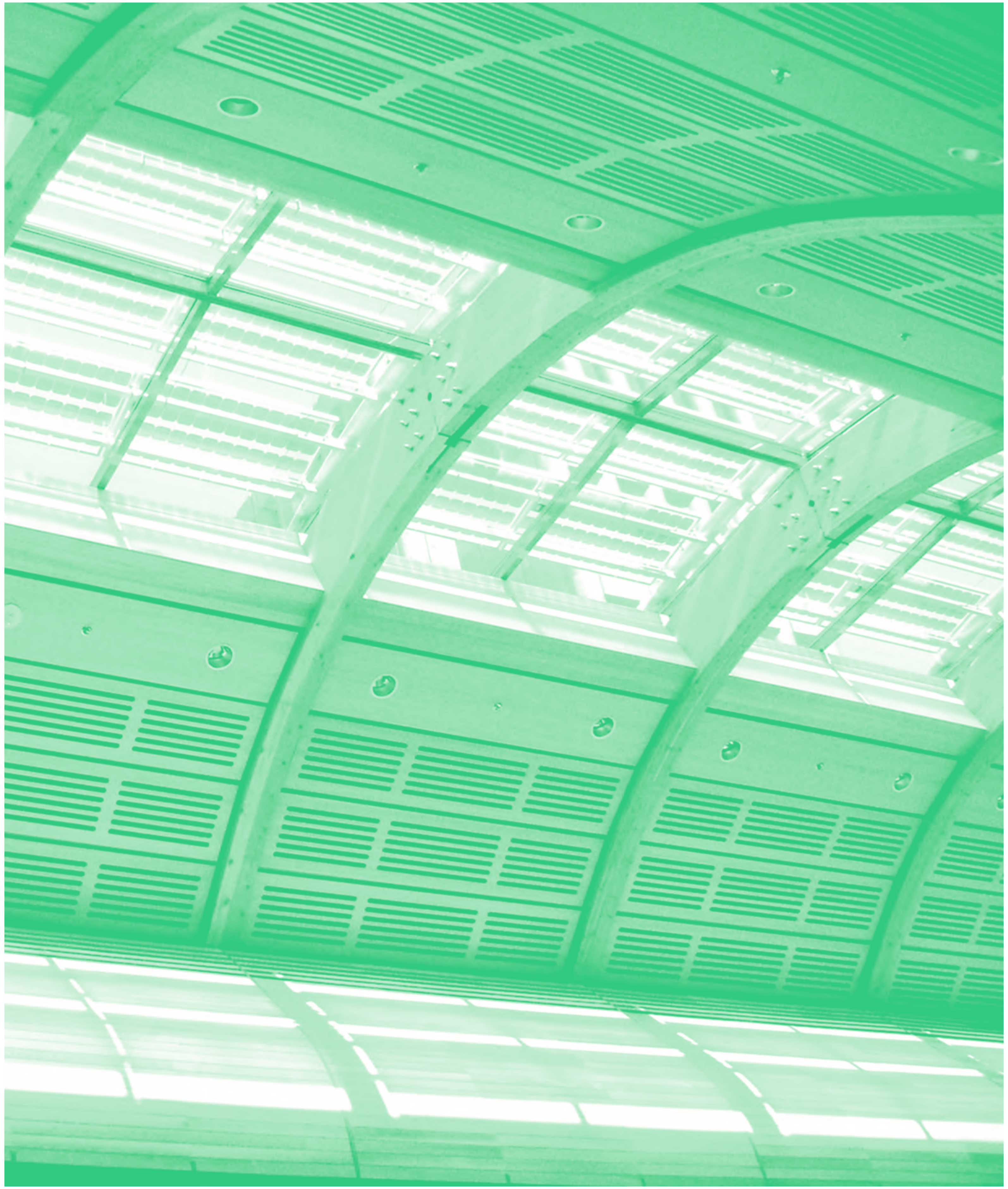

01

LOW CARBON

PAUL STOLLER
Sydney

Our aim 25 years ago was to bring a collaborative and bespoke engineering sensibility to the design of buildings and their services. Rather than hiding conventional systems behind conventional walls, we help architects to design climate-responsive buildings and we engineer specific services that respond to the challenges of site, programme and architecture. This objective remains just as true today as it was then.

In addition to careful engineering, we engage early in the design process with our architectural partners to shape a building's spatial experience in response to climate, light and other environmental resources. This practice of integrated design meant that our earliest projects – often with architects who, like Atelier Ten's founding partner Patrick Bellew, had studied at the University of Bath under Sir Ted Happold – were noted for their exceptional architectural quality as well as superior environmental performance. This design approach relies on using building elements and landscape to provide most of the daylight, fresh air and comfort conditioning. It regularly achieves step-change reductions in energy use and greenhouse gas (carbon) emissions.

01 A high-performance envelope and a rooftop PV array contribute more than 60 per cent of Kroon Hall's carbon emissions reductions.

The first decade: insulation, ventilation and thermal mass

Few projects from the practice's early years better exemplify low carbon operation and broader environmental sustainability than Notley Green Primary School (1999) in Essex, UK, completed with AHMM Architects. The building is full of daylight and naturally ventilated by earth ducts. Performance success relied on eschewing the 'passive schools' programme fetish for fully glazed (and inevitably overheated) south façades and opting instead for carefully designed fenestration and north lights along with extensive areas of highly insulated wall and roof. The building needs minimal heating, has excellent fresh air and operates with the lights switched off for most of the school day. Our simple holistic design accomplished exceptionally low carbon

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02 Great daylight, natural ventilation and careful solar control drove the design of Notley Green Primary School.

operation. It is worth noting that Notley Green was designed with no energy modelling, no natural ventilation simulations and no daylight analysis. Although we now have a wide range of sophisticated dynamic simulation tools at our disposal, we still begin each project the same way we approached Notley Green – with design decisions based on good environmental design logic.

As much of our early work was with structural engineers Atelier One, perhaps it should be expected that those projects reflected an interest in coupling building structure into passive and active building conditioning strategies. It has long been good design practice to expose thermally massive building elements, such as concrete structural ceilings, to help stabilise room temperatures and reduce heating and cooling energy use. (This is discussed in greater depth in the previous chapter.)

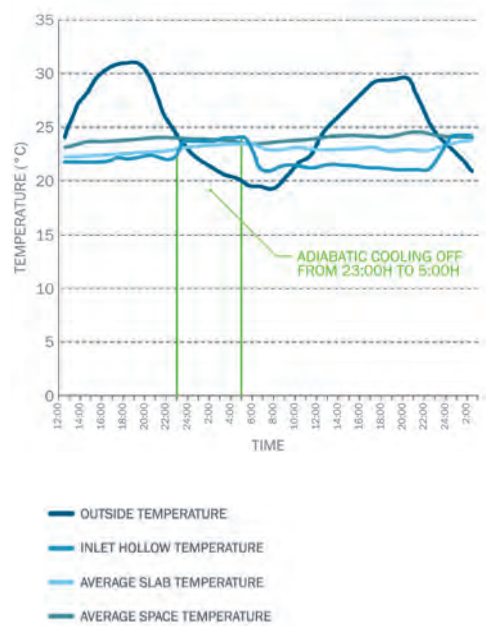
Pushing this thermal storage idea further, Atelier Ten was an early adopter in the UK of Swedish technology TermoDeck, which routes mechanically ventilated air through holes in precast structural floor planks, supercharging their thermal energy storage. For the Kimberlin Library extension (1997) at De Montfort University, designed with Eva Jiricna Architects, we challenged conventional wisdom by calculating that night-time building heating – the major thermal energy need for most Midlands university buildings – could be entirely eliminated by storing heat from the library's people, lights and computers. The building is fully conditioned without heating or refrigeration – and has proved highly popular with students owing to its exceptional comfort and air quality. The limited cooling that is needed in warm weather is provided by an adiabatic cooling system.

Our other approach to structurally integrated ventilation and thermal storage was the invention of the labyrinth for the Earth Centre (1999) with Feilden Clegg Bradley Studios (p.80). The design of the labyrinth also challenged us to develop new computational design modelling tools and adopt analysis software such as TRNSYS and TAS. These methods and the projects they enabled led to greater sophistication in our approach and set the stage for a new generation of ultra low carbon and carbon neutral buildings.

The second decade: comprehensive carbon

Atelier Ten's second decade coincided with the dramatic growth of the green building movement globally. Organisations such as the US Green Building Council came into being and benchmarking schemes like BREEAM and LEED were rapidly adopted by the property industry. Regulations emerged in the UK and in parts of the US that mandated significant reductions in carbon intensity. Thanks in part to this sea change, and based on a decade of lessons learned, we evolved from an energy-focused practice to one that tackled carbon emissions holistically in buildings and increasingly across communities or campuses.

Our holistic approach is best exemplified by Kroon Hall (2008), home to the Yale University School of Forestry and Environmental Studies. Working with Hopkins Architects, Centerbrook Architects and a top-tier design team, we shaped the design response to the school's ambition to build a fully carbon neutral building. The approach focused first on high-performance architecture – a fully daylit plan, a highly insulated envelope and a thermally massive exposed concrete structure. Next the focus was on efficient lighting and HVAC systems – in this case, displacement ventilation coupled with seasonal natural ventilation, with supplemental heating and cooling from ground source heat pumps. With the operational energy already greatly reduced, the further investment in rooftop solar PV renewably generates a larger portion of the building's annual energy needs. Collectively, these steps reduce Kroon Hall's energy and attendant carbon emissions by over half compared to a conventional building. The final step to carbon neutrality is the purchase of Renewable Energy Credits, which transfers carbon-free electricity from the commercial power grid to Kroon Hall.



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03 TermoDeck performance at Kimberlin Library at De Montfort University, highlighting the incredibly steady indoor temperature delivered with no heating or refrigeration.

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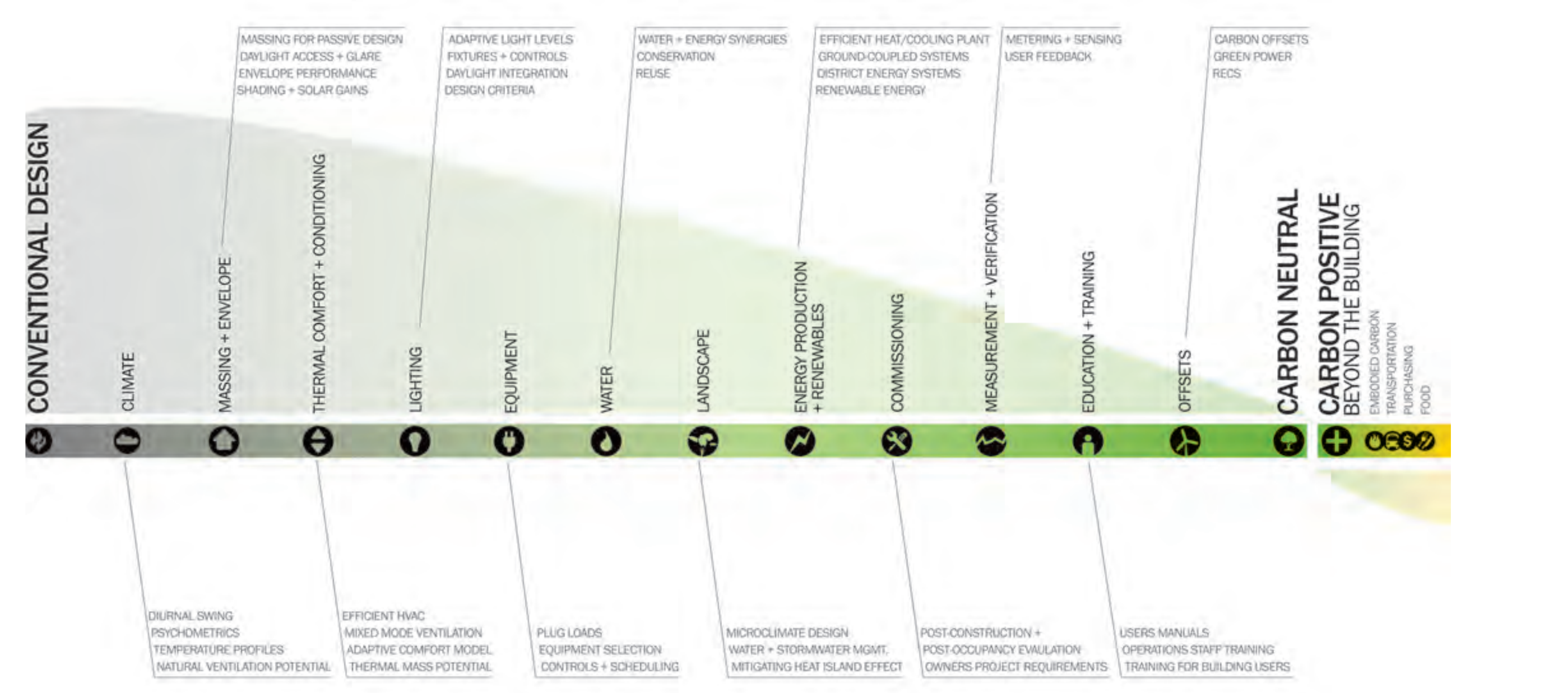
04 The extension to the Kimberlin Library at De Montfort University is entirely heated by computers, people and lighting.



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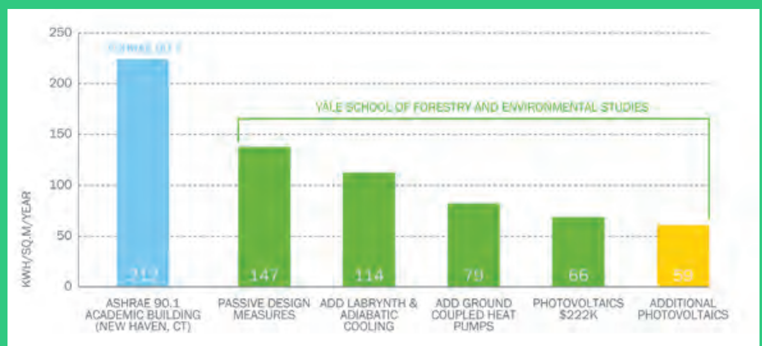

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05 The path to carbon neutral for Kroon Hall and other projects.

06 Preliminary design calculations for Kroon Hall, highlighting the importance of climate responsive architecture and advanced HVAC in achieving low carbon operations.

07 The Kohler Environmental Center generates more than its energy annually needs from a PV array in the adjacent meadow.

08 Photovoltaic panels on the roof of Kroon Hall, home of the Yale School of Forestry and Environmental Studies, provides up to 25 per cent of the building's electricity. The top floor shading structure doubles as a rainwater collection system, also expressed in the vertical leaders. Light coloured sandstone from a local quarry helps reflect solar gains and support regional business.

Also seen in this image is the front lawn, which doubles as a green roof for a utility space below.

Two of our buildings have gone further still, achieving 'net-zero' energy with on-site PV arrays that generate all of a building's daytime power plus a surplus of electricity that is sent into the grid; over a year the surplus offsets the electricity drawn from the grid at night. ZGF Architects' J. Craig Venter Institute (2014) in La Jolla, California, demonstrates that even research buildings with laboratories can achieve net-zero energy. Likewise, Robert A.M. Stern Architects' Kohler Environmental Center (2012) at Choate Rosemary Hall, which features the first earth ducts in the northeastern United States, is proof that net-zero performance is possible even in New England's harsher climate. While net-zero performance does not necessarily achieve carbon neutrality – grid power consumed at night usually has associated carbon emissions – this net-zero building reduces atmospheric emissions by an order of magnitude.

Most projects cannot afford sufficient renewable energy technology or do not have enough physical space for the equipment required to achieve net zero. So, for forward-looking clients like the US Federal Government, we have crafted future-proofed 'zero ready' buildings and infrastructure that allow for the easy addition of large PV arrays or other energy sources in the future. At the Benjamin P. Grogan and Jerry L. Dove Federal Building at Mirimar, Florida (2013), designed with Krueck + Sexton Architects, photovoltaic panel costs fell so much during construction that much of the anticipated array was bought and installed in time for the building's opening.

Moving beyond energy-related carbon reduction, the WWF-UK Living Planet Centre (2013), the World Wildlife Fund's headquarters in the UK, by Hopkins Architects, rigorously reduced embodied carbon, the emissions associated with the manufacture of building materials and their transport to the building site. Through careful material choices and construction planning, the team lowered the embodied carbon by over 40 per cent relative to the concept design. As we reduce the operational carbon intensity of buildings through good design, the relative importance of embodied carbon increases and becomes more important to lowering the lifetime greenhouse gas emissions of a project.

Beyond buildings – low carbon communities

When looking to minimise carbon intensity across the built environment, the best value can often be found at the scale of a precinct, campus or community. For Harvard University's masterplan of its Allston Campus Expansion (2007), we demonstrated that through reduced building energy intensity, increased central plant efficiency and renewable energy provision it would be possible to lower the new campus's carbon emissions by as much as 80 per cent. This analysis gave the university the confidence to enter the first legally enforceable carbon reduction agreement with the state of Massachusetts: in exchange for a more practically achievable 50 per cent carbon reduction for the first building projects, the state waived the requirement for a full environmental impact assessment, saving tens of millions of dollars.

In subsequent work within the Allston Masterplan for the Harvard Business School (HBS; discussed further in Masterplanning, p.208), we explored the difficult question of whether off-site renewable energy or offset purchase is better value than on-site investment in energy conservation. We conducted a meta-analysis of dozens of individual energy conservation proposals to determine which projects should

09 Atelier Ten showed Harvard University how it could cut the carbon intensity of its Allston expansion campus by well over half.

10 The Benjamin P. Grogan and Jerry L. Dove Federal Building in Mirimar, FL, exemplifies a new generation of 'net-zero ready' US government buildings.

11 The biomass fuelled cogeneration system at Gardens by the Bay, which is nearly carbon neutral in operation, supplies more energy than is required to run all of the Gardens' cooling systems.

be undertaken and their sequencing to reduce carbon while delivering a return on investment; beyond that, the school would purchase carbon offsets. We developed this market-savvy approach further into energy performance requirements for all new HBS buildings. Together, these studies charted a clear course for HBS to comfortably exceed their 30 per cent carbon intensity reduction target while at the same time allowing the campus to nearly double in future built area.

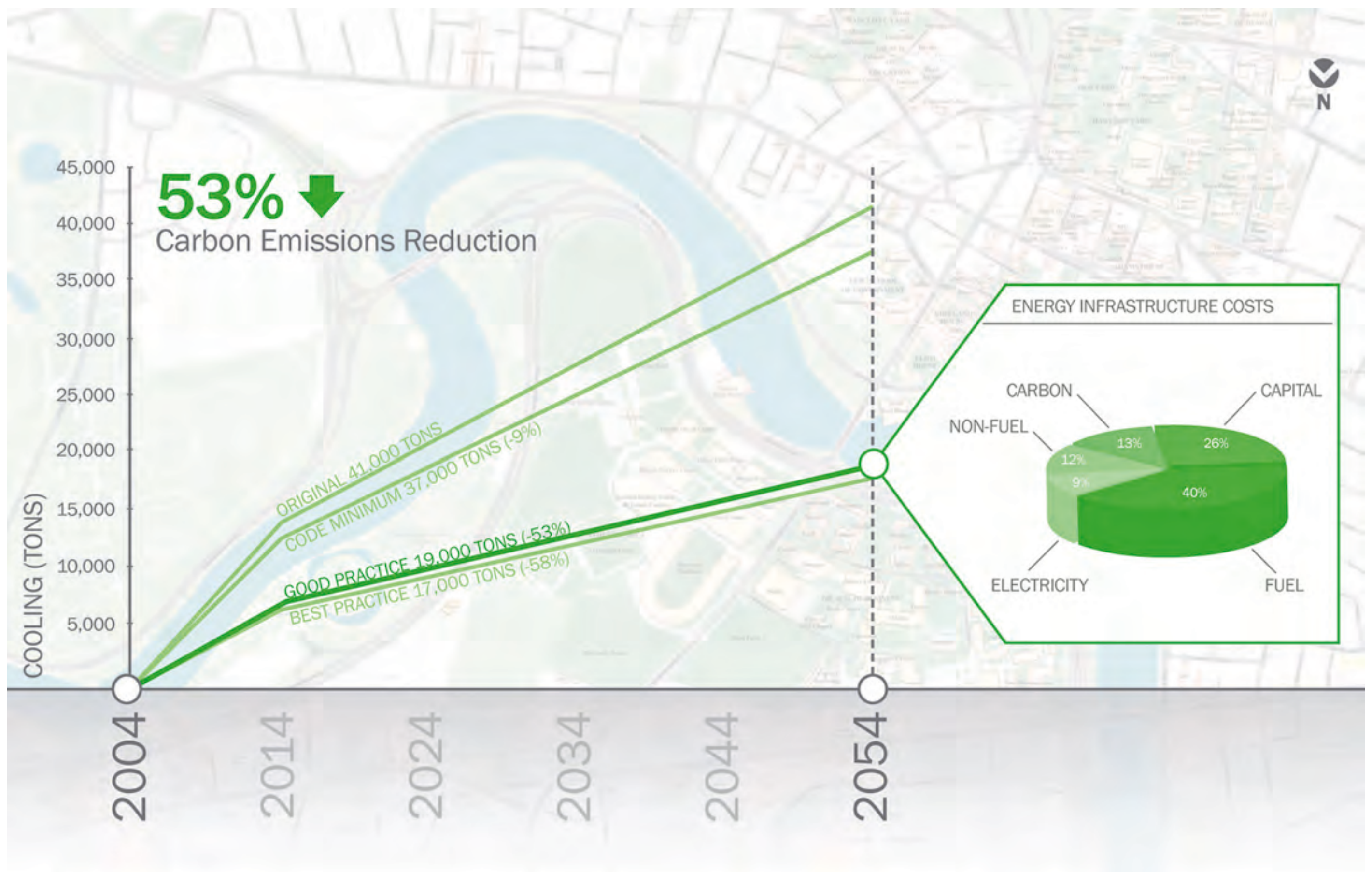
While most projects propose carbon reduction targets or aspire to carbon neutrality, Lend Lease's Barangaroo South precinct (completion 2022), in Sydney, Australia, is on track to achieve 'climate positive' operation and will set new benchmarks for sustainable community development. As defined for this project, climate-positive comprises carbon neutrality for all energy and waste-management emissions, and the generation on-site of recycled clean (but non-potable) water in excess of the potable water volume imported. Barangaroo's path to climate positive follows a familiar pattern: high-performance architecture, an advanced energy system (district cooling with harbour water) and then investment off-site in a very large PV array. A jump in scale – the array area will be many times larger than the precinct – makes carbon neutrality possible.

10

A similar jump in scale makes it possible for the conservatories at Singapore's Gardens by the Bay (2012) designed with Grant Associates and Wilkinson Eyre to achieve carbon neutral operation. The trimmings from all the street trees of Singapore plus all the waste wood pallets from the port of Singapore are added to the park's plant trimmings and converted to renewable energy for the site. The energy cycle is shown in the chapter on Modelling Gardens by the Bay, on p.126. Converting city-scale waste streams into energy generates environmental benefits that exemplify a climate-positive approach.

At the Taman Mini Museum in Jakarta, Indonesia (2013, with Grant Associates), we proposed waste oil recovery from food outlets as a primary energy source for a new waste-to-energy CHP plant. The streets of Jakarta are lined with food carts that produce huge amounts of waste oil that can be cleaned and converted to a bio-fuel with a simple esterification process. This reduces the waste nuisance in the sewers and at water treatment works and provides a useful fuel.

The clear lesson from our 25 years of experience is that carbon reductions at the order of magnitude required to mitigate climate change are achievable today. We already have the technical know-how and the broader view to dramatically reduce the built environment's climate impact. Looking forward, we should act on this expertise and continue to proactively challenge ourselves, our projects and our clients to become carbon-free.



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