A2

NEW DIMENSIONS FROM ARUP | NO.11

Liquid gold

A water special

Inside this issue: exploring the risks and opportunities of water

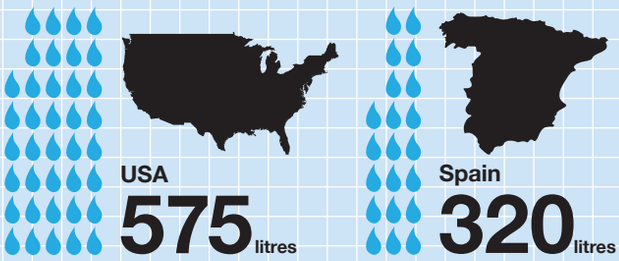
Wet island?

a picture of UK water use

Water use comparison 2002 per capita figures

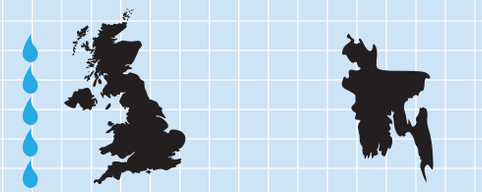
Source: UN (UNDP Human Development Report 2006)

= 15 litres



USA 575 litres

Spain 320 litres



United Kingdom 149 litres

Bangladesh 46 litres

Cambodia 15 litres

Mozambique 4 litres

Abstractions - England and Wales

Source: DEFRA 2010

Agriculture <1%

Fish farming 5%

Public water supply 30%

Electricity 56%

Industry 9%

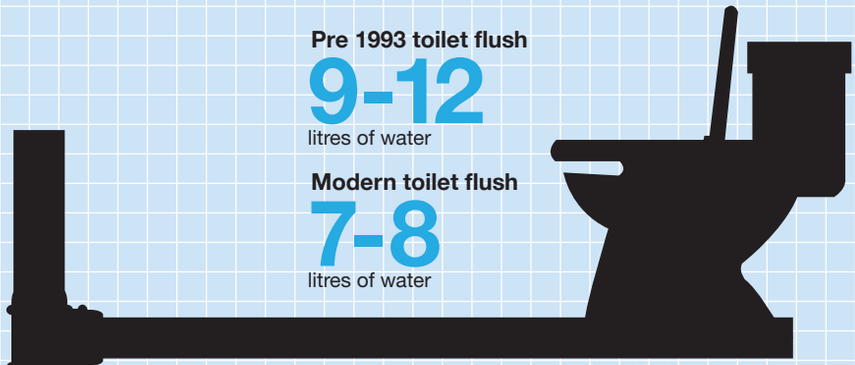
Source: World Bank 2009

Pre 1993 toilet flush

9-12 litres of water

Modern toilet flush

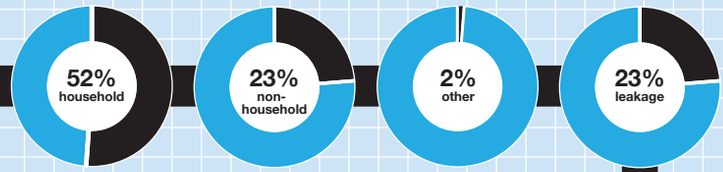
7-8 litres of water



Source: REUK.co.uk 2011

Public water supply

Source: Ofwat 2007

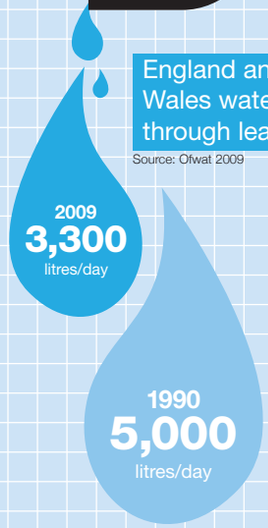


3.5kg of water = 1kg of steel

Source: World Steel 2010

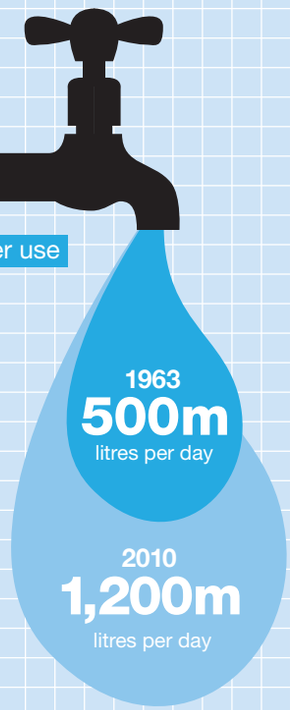
England and Wales water loss through leakage

Source: Ofwat 2009



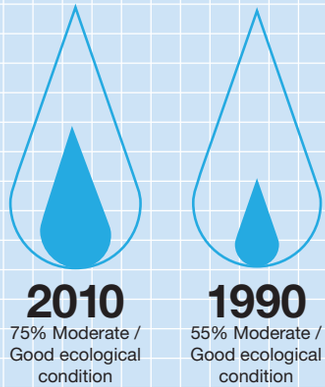
UK water use

Source: waterUK



State of British rivers

Source: Environment Agency 2011



2010 75% Moderate / Good ecological condition

1990 55% Moderate / Good ecological condition

Liquid gold

Alan Belfield, Director

Welcome to A², Arup's business magazine. In this edition, we focus on water – the risks and opportunities associated with this vital resource.

We examine how climate change, population growth and the increasing industrial use of water pose problems for us all. And we hear how organisations like P&G are tackling these issues, and why water is such a priority for the World Bank's investment programme.

Overcoming these challenges creates opportunities and the prospect of a future where cities are resilient to the risks they face. The stories in this edition of A² show that to achieve such a future, we must plan for the long term and create the infrastructure our grandchildren and great-grandchildren will need.

In the course of putting together this edition of A², we've enjoyed extremely valuable insight from contributors. I hope you find it equally valuable.

For more information on any of the topics featured in this magazine, please visit arup.com or email a2@arup.com

Heathrow pod opens

The Heathrow pod, a world-first personal rapid transit (PRT) system that promises passengers travelling between the T5 Business Car Park and T5 a faster and easier journey, opened on 13 September.

Arup designed the infrastructure for the 3.8km system, which uses a fleet of 21 driverless vehicles, each capable of carrying four passengers and their luggage, travelling along a dedicated guideway. The vehicles make the journey non-stop, reaching speeds of up to 25mph.

For airport operator BAA the on-demand vehicles have both operational and environmental benefits. "The Heathrow pod will deliver a fast, efficient service for passengers and will save more than half of the fuel used by the public and private transport it replaces," says Max Vialou Clark, BAA Heathrow Commercial Director.

1 Heathrow pod

2 The future for urban living

1

2

'What next for Urban Living?' asks debate

On 4 November, 100 influential figures attended a provocative and challenging debate at the invitation of The Ove Arup Foundation and the Guardian.

Chaired by Larry Elliot, economics editor of the Guardian, What Future? New ideas for Urban Living challenged conventional thinking about city living. During the evening, speakers including Design Council trustee Pam Alexander and designer and broadcaster Kevin McCloud shared their insight on political, economic, social and technological issues.

For more information, visit: guardian.co.uk/what-future-urban-living

Gautrain wins award for technical excellence

The Gautrain Rapid Rail Link in South Africa has been awarded a certificate of merit for technical excellence in the Johannesburg Branch Project Awards 2010/2011 by the South African Institute for Civil Engineering (SAICE).

Arup was the independent certifier of the rail link, which provides a safe and efficient service for commuters from Johannesburg Central Business District (CBD) to Pretoria CBD and from Sandton to OR Tambo International Airport.

Project director Ric Snowden said: "We are delighted with the success of this project. The award recognises our involvement in delivering South Africa's first high-speed rail network, linking the country's commercial and legislative capitals of Pretoria and Johannesburg."

The project will now be entered into the SAICE National Awards in the technical excellence category.

3

London gets energy efficiency fund

On 2 September, the Mayor of London announced the creation of a new £100m fund to help make public sector buildings in the capital more energy-efficient. Established with investment from the London Green Fund, the London Energy Efficiency Fund (LEEF) provides affordable, flexible loans for public sector organisations wishing to reduce the energy consumption of their assets by at least 20%.

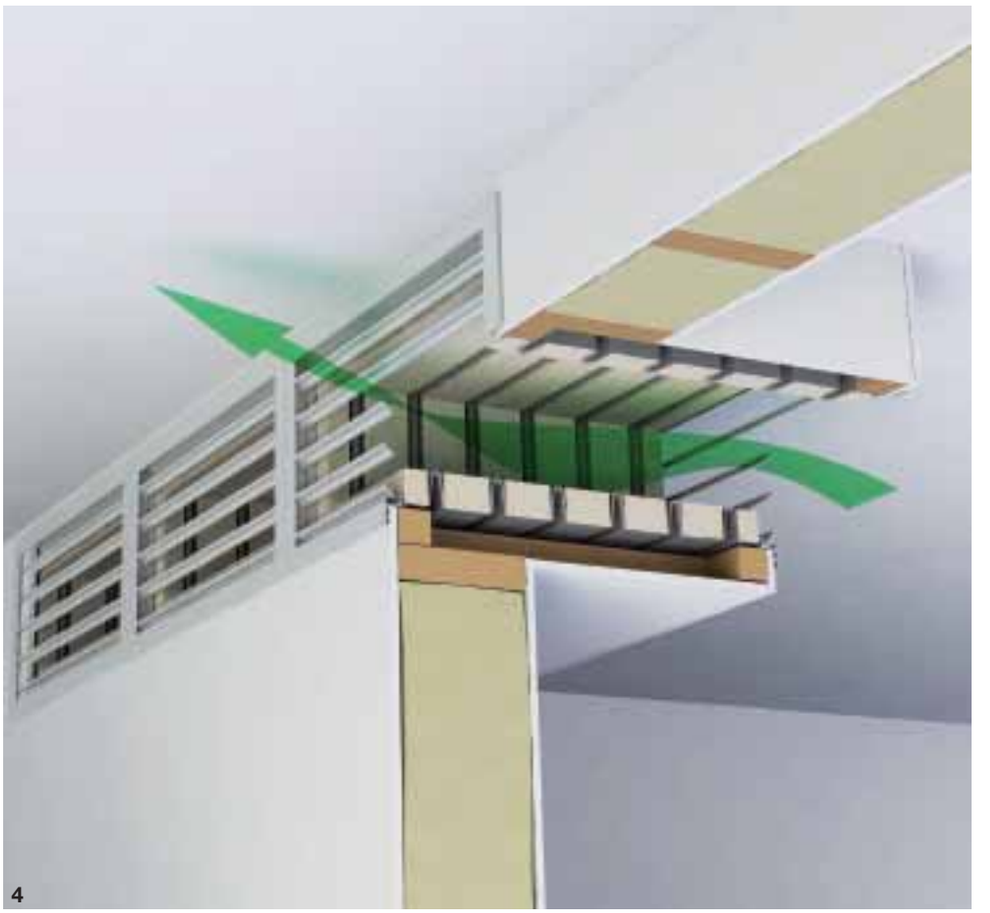
Arup is acting as technical advisor to The Amber Green Consortium managing LEEF on behalf of the Mayor's London Green Fund. If your organisation is interested in applying to LEEF, please contact Malcolm Ball, Thomas Briault or Charles Abel Smith on 0207 6361531 or visit the website www.LEEF.co.uk.

Milestone for the Crystal

A groundbreaking green building in the heart of London's Docklands marked a construction milestone when it topped out in October. The Crystal, A Sustainable Cities Initiative by Siemens, aims to be one of the most sustainable buildings yet – with the Arup project team hoping to achieve some of the most stringent international design and construction standards including BREEAM and LEED.

"We are working extremely closely with Siemens to ensure that the whole building is designed to work effectively with their management and control systems," explains David Richards, who leads Arup's buildings team. "Integrating the different systems seamlessly gives occupants the ability to tune the building to an unusually fine degree."

The Crystal is due to open in 2012.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SoundScoop: for a quiet, sustainable internal environment

A revolutionary yet simple acoustic air vent, designed by Arup's acoustics team and manufactured by Passivent. SoundScoop tackles noise transfer between rooms as well as in the façade of naturally ventilated buildings. Its unique design is patented and beats its competitors on sound reduction, air flow and cost.

3 The London Energy Efficiency Fund (LEEF)

4 SoundScoop

Specialist cancer centre to open in 2012

5 Visualisation of UCH Macmillan Cancer Centre

6 The shortlisted design from Amanda Levete Architects and Arup

7 Arup Penguin Pool

A £100m specialist cancer centre designed by Arup and Hopkins Architects will provide patients, their families and carers with a range of specialist services.

The new University College Hospital Macmillan Cancer Centre in London will offer outpatient consultation, treatment facilities, respite support areas and daytime accommodation for patients. It also contains the UK's first PETMR scanner, which will produce higher quality images and is one of only a few worldwide.

The centre is specially adapted for rapid diagnosis and designed to make maximum use of natural light. "One of our key priorities was to provide a cost effective facility that could also easily achieve an excellent BREEAM rating," explains Arup associate director, Mike Booth.

Construction of the centre, which will open to patients from April 2012, began in 2009.

AssetMAP tool

Helps Queen Mary achieve its energy targets

Using a new tool developed by Arup, Queen Mary is on track to achieve its carbon reduction target of 34% by 2020. AssetMAP identifies how to improve the energy performance of new and existing buildings, providing companies with long-term value and cost savings.

"For us, AssetMAP has been an extremely useful tool, providing the university with the capacity to develop an effective carbon management plan for several buildings," says Rebecca Maiden, head of energy and environment at Queen Mary, which is part of the University of London.

Arup helped to assess the university's estate, identify and evaluate carbon reduction options, and integrate them into a carbon reduction strategy for the Mile End, Whitechapel and Charterhouse Square campuses. As well as satisfying the requirements of the Higher Education Funding Council for England (HEFCE), the AssetMAP report enabled the estates department to secure the estimated £7m of capital funding needed to deliver the first phase of the implementation to 2015.

Originally developed for commercial office buildings, AssetMAP is now helping Arup's public sector clients improve on post-construction assessments and reduce the energy consumption of their buildings.

New carbon reporting and measurement service

Beacon, Arup's new global carbon measurement and reduction tool, enables organisations to view the impact of emissions from their global supply chain for the first time. Based on exclusive access to the global supply-chain greenhouse gas emissions intensity dataset compiled by the Centre for Sustainability Accounting (CenSA), the tool provides a full carbon footprint across Scope 1, Scope 2 and Scope 3 carbon emissions.

For further information on the service, contact carbonmanagement@arup.com

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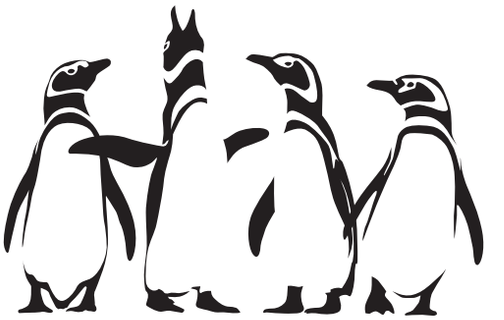
Pylon for the Future: ‘visually dynamic’ design shortlisted

A design by Amanda Levete Architects and Arup was one of only six to be shortlisted for the Pylon for the Future competition run by the Royal Institute of British Architects for National Grid and the UK Department of Energy and Climate Change.

The competition challenged entrants to design an electricity pylon that can deliver power for future generations while balancing the needs of local communities and preserving the beauty of the countryside.

The judges said of the design, called Plexus: “The design is very much of its time and the panel admired the grace of this visually dynamic proposal.”

The winning design was the T-Pylon by Danish architecture, design and engineering firm Bystrup.



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Design events inspire, inform and entertain

Inspired by an idea from Sir John Sorrell, founder of London Design Festival, and instigated by Arup, the Penguin Pool is a series of sociable events bringing together the creative design community to form connections and spark collaborative ideas.

During August and September, thinkers, designers and innovators from different fields gathered at Penguin Pool events in Sydney, London and Beijing. During evenings full of speakers, performers and displays they had the chance to meet others from diverse creative fields and exchange ideas.

Arup offices across the world, including Hong Kong, Los Angeles, Manchester, Milan, New York, San Francisco and Singapore, are now planning Penguin Pool events of their own. To get connected, follow @ThePenguinPool on Twitter.

Post-tsunami masterplan wins Holcim Award

Arup’s work with architects Elemental on a post-tsunami masterplan for Constitución in Chile has won Silver in the Latin American category of the Holcim Awards for sustainable construction.

The city of Constitución was severely affected by the earthquake and tsunami on 27 February 2010. Arup’s hazard assessment helped to develop a more resilient community as part of the post-disaster masterplanning for the city.

To improve resilience to similar events, Arup is currently engaged in a joint research project with University College London (UCL) and HR Wallingford. The research aims to better understand tsunami loading on coastal structures.

“This is still very much a developing area and after each event there’s a lot to learn,” says Ziggy Lubkowski, a seismic skills leader at Arup. “By looking at it in the research lab, you can focus on understanding specific issues such as the loading on different structural types, the limit of penetration of waves into an urban environment, and uplift on foundations.”

Manufacturing savings

As manufacturers tackle water efficiency, Procter & Gamble is leading the way

The United Nations estimates that industry is responsible for 22% of water use, so the sector has a vital role to play in alleviating water shortages. "Globally, industry uses a lot of water," says Arup director Duncan White. "So there's a big opportunity for it to help save water."

"There are water shortage issues right across the globe and industry needs to find ways to make sure it doesn't contribute to them unnecessarily," agrees Don Flanagan, a global water engineer at P&G. "From the design and siting of manufacturing facilities to the water used by consumers using their products, companies need to start reducing their water footprint."

With Arup's help P&G has already started doing this – P&G worked with Arup to create sustainability design guidelines for their worldwide manufacturing and office facilities. "We've introduced new measures, such as using less water in processing and making sure our equipment runs efficiently," says Flanagan. "We're also developing products that don't use as much water – like cleaning aids that need less water and lower temperatures. We want to help consumers reduce their water footprint, as well as minimising ours."

The company has taken its efforts to reduce water usage even further at its Milenio facility in Mexico. The Planta Milenio (MAPS) uses advanced technology to recycle and reuse water and wastewater, to harvest rainwater, and to achieve zero liquid discharge from site. The effect has been a 38% reduction in source water usage.

"The MAPS project is our first Gillette manufacturing facility to be designed around our sustainable water management strategy, and it's been a big success," says Gordon Wrin, who managed the design and construction of the Milenio facilities in Irapuato, Mexico for P&G. "It embodies our commitment to sustainability, and has led the way for how we design and build plants. "In February 2011 we increased our commitment to sustainable design by pursuing LEED certification for all new sites we design and construct."

"It embodies our commitment to sustainability, and has led the way for how we design and build plants." Wrin explains that the MAPS plant generates around 220m³ of wastewater each day from a combination of the manufacturing process and other water use. But by treating this at an on-site treatment plant, 90% of the wastewater can be recovered and reused in cooling towers. When available, rainwater is harvested for use for cooling in manufacturing processes.

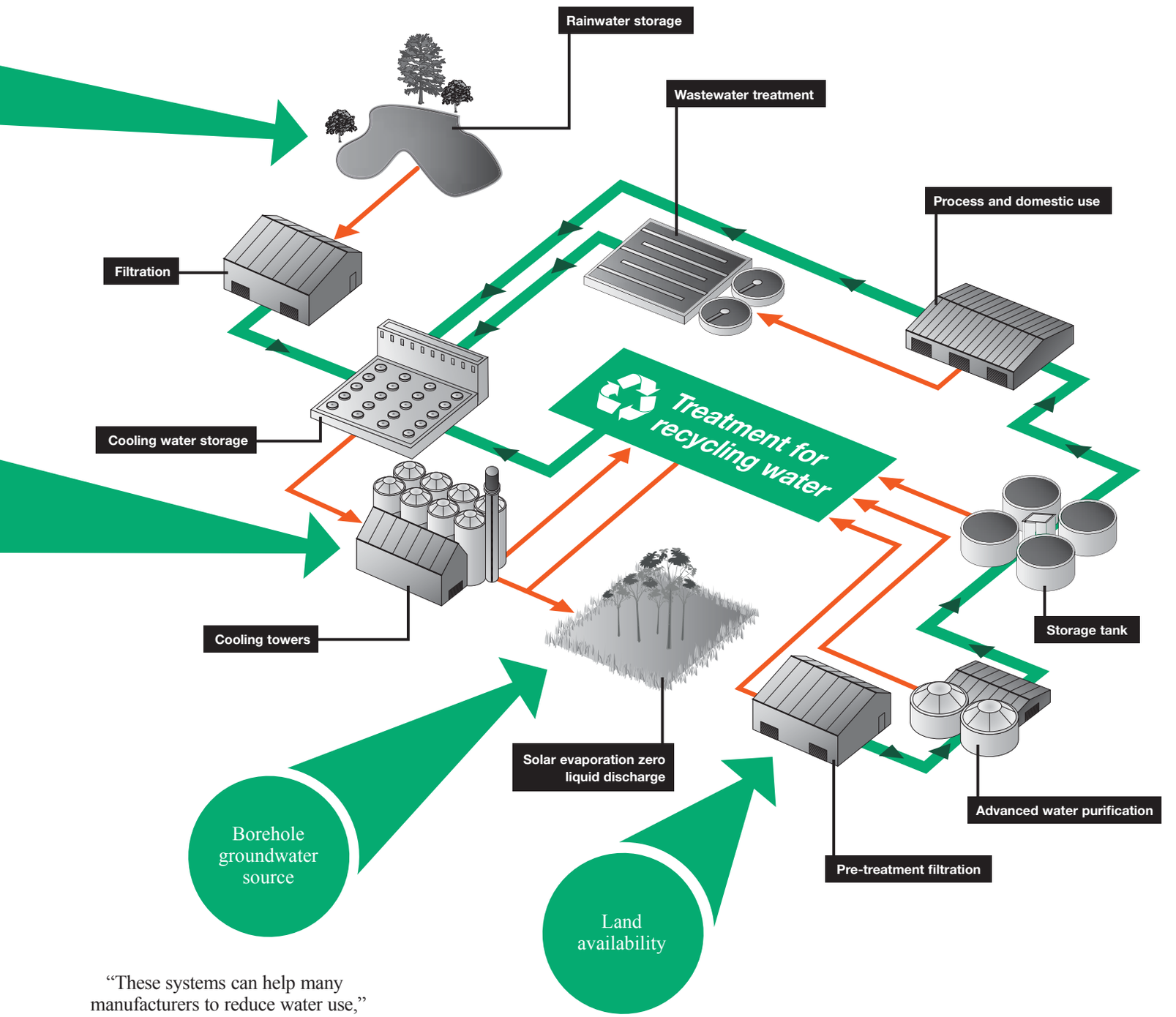
The facility uses low-flow plumbing fixtures to further reduce water usage. These use around 50% less than conventional fixtures. Incorporating low-flow plumbing has, Wrin says, reduced on-site water use by over 18,000m³ a year. This has reduced carbon emissions by around 63 tonnes – equivalent to roughly 300,000 air miles.

However, the biggest challenge of the MAPS project was achieving zero liquid discharge – a big step towards P&G's commitment to zero waste. The Milenio site is not connected to a municipal sewage system but instead has its own wastewater treatment plant and a 2 stage reverse osmosis recovery system to filter the recycled water for use in the site's cooling towers. The water that is eventually rejected by the reverse osmosis membranes (after several cycles) is sent to a site evaporation system.

"Developing the strategy and the technology to ensure no wastewater is discharged from the MAPS site was incredibly difficult," says Flanagan. "That's where Arup really helped us. Their team designed alternative technologies that ensure every drop of wastewater – from the borehole to the manufacturing process and final treatment – is captured."

Drawing on reverse osmosis systems, rainwater harvesting, wastewater treatment and innovative evaporation technologies the MAPS plant exemplifies sustainable design. But is this an approach other businesses could follow?

The Planta Milenio, Mexico (MAPS)



"These systems can help many manufacturers to reduce water use," says White. "Fitting low-flow fixtures in bathrooms and showers should be a first step. After that, simple monitoring of the industrial waste stream can help to decide if liquid waste can be re-used efficiently using a similar approach to that employed at MAPS."

Measures to reduce water consumption are likely to be particularly beneficial, White points out, for businesses involved in water-intensive processes such as paper production, drinks manufacturing or steel making. Saving water is also a key consideration in areas where water is scarce or expensive.

Indeed, water may become an increasingly important factor in choosing where to site facilities. "Location is very important," says Flanagan. "At Procter & Gamble we actively avoid water-scarce regions when we plan new plants."

Flanagan believes that by placing water at the heart of their strategy, industry can make a significant difference. "Industry as a whole could do more to reduce its water footprint," he says. "Companies need to have a long-term plan for reducing their water consumption – short-term measures are not enough."

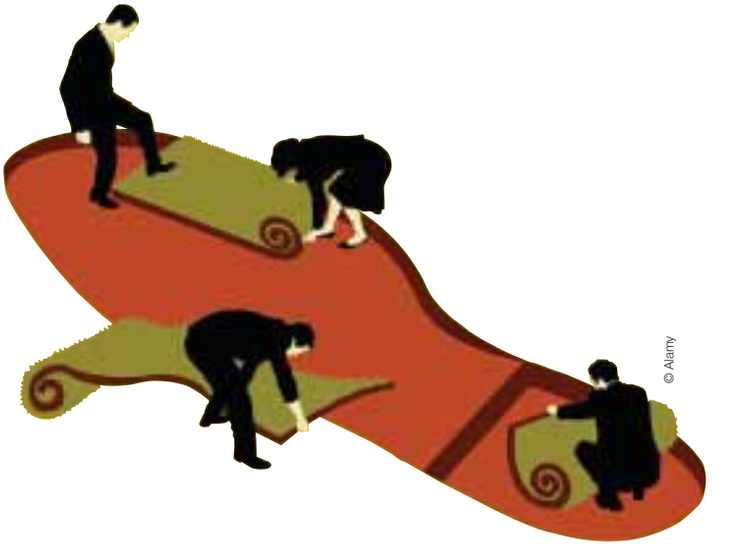
- The MAPS plant is designed for 3,000 staff and workers
- The facility generates around 220m^3 of wastewater each day
- Using an on-site treatment plant, 50% of wastewater is recovered and reused in cooling towers
- Low-flow plumbing has reduced water usage by factory employees by more than 50% – giving a carbon saving equivalent to 300,000 air miles

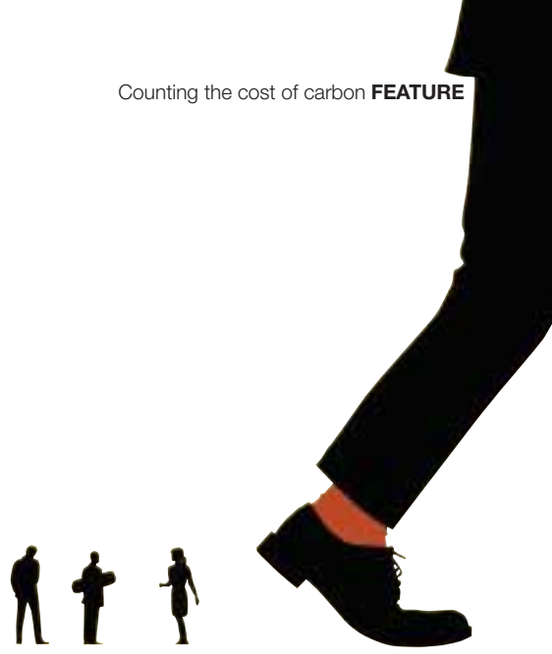
Riding the carbon escalator

What will higher carbon prices mean for your business?

It's widely recognised that the current carbon trading price has only a limited impact on investment decisions. But changes in the market landscape look set to make organisations pay the true cost of carbon. James Rooke, who leads the resource and carbon management stream in Arup's sustainability consulting team, explains.

"Organisations have come to understand carbon as a tangible and tradable commodity through mechanisms such as the EU Emissions Trading Scheme," says Rooke. "However, they focus on the retail price. At about £12 per tonne, this reflects the cost of disposing of the carbon emissions liability. But that doesn't include the energy used in generating it. Including this in the price would make the cost more like £160 per tonne. Conversely, it also fails to capture the potential revenue opportunity from trading – it's all part of the carbon equation."





"As well as offering businesses a better understanding of the risks associated with higher carbon prices, this [the GHG Protocol] could also give them the opportunity to reduce their carbon footprint – effectively by getting their supply chain to do it for them"

Carbon – risk and opportunity

Rooke points out that organisations tend to think of carbon as an operating cost when reporting, reputation and brand actually represent the greater risks and opportunities. "As these factors can directly influence revenue, organisations need to assess them as well as the more immediate, tangible cost liabilities," he says.

The UK's Carbon Reduction Commitment (CRC), which is now mandatory for most large organisations outside existing schemes, is an example of what Rooke calls this 'double whammy' of issues. "Schemes like CRC present what is now effectively a flat tax on carbon," he says. "But it also affects reputational performance. In October, a league table will be published detailing the performance of all companies in that scheme. For brand-sensitive companies this is more of a risk than the cost exposure of CRC."

New Greenhouse Gas Protocol standards – a wider perspective

Most large organisations, says Rooke, understand their direct carbon emissions. And many have begun managing and reducing the associated costs. But the new GHG Corporate Value Chain accounting and reporting standard released on 4 October looks at their wider business activities.

This is significant, Rooke points out, because it encourages more visibility of emissions in the supply chain. "Until recently, there has been no globally-agreed methodology for measuring emissions like this," he says. "The new GHG Protocol standards will change that."

The new standards establish the first internationally-agreed approaches for measuring and reporting greenhouse gas emissions throughout product lifecycles and supply chains. "As well as offering businesses a better understanding of the risks associated with higher carbon prices, this could also give them the opportunity to reduce their carbon footprint – effectively by getting their supply chain to do it for them," says Rooke.

Carbon tax escalator

But UK businesses do face significant cost exposures from the carbon tax escalator. The proposed UK carbon floor price would see costs rising from £16 per tonne in 2013 to £30 in 2020. Rooke believes the long-term rise in energy prices of 3-4% above inflation provides a powerful incentive to mitigate the costs of the carbon escalator early on.

It's a complex picture of incentives, standards and taxes but Rooke emphasises that it's one businesses must navigate. "If you run a business, you need to ask yourself: 'Can I quantify the risks and opportunities associated with carbon, now and tomorrow?'"

The CRC scheme will apply to organisations like hotel chains, supermarkets, or central government that consume more than 6,000 MWh of electricity per year. Most of these organisations fall below the threshold for the EU Emissions Trading Scheme, but make up roughly 10% of UK carbon emissions. The scheme will cover their emissions from direct energy use as well as those from purchased power.

The Greenhouse Gas Protocol is the most widely-used international accounting tool for government and business leaders to understand, quantify, and manage greenhouse gas emissions. www.ghgprotocol.org

How the cost of carbon unlocked a green energy opportunity

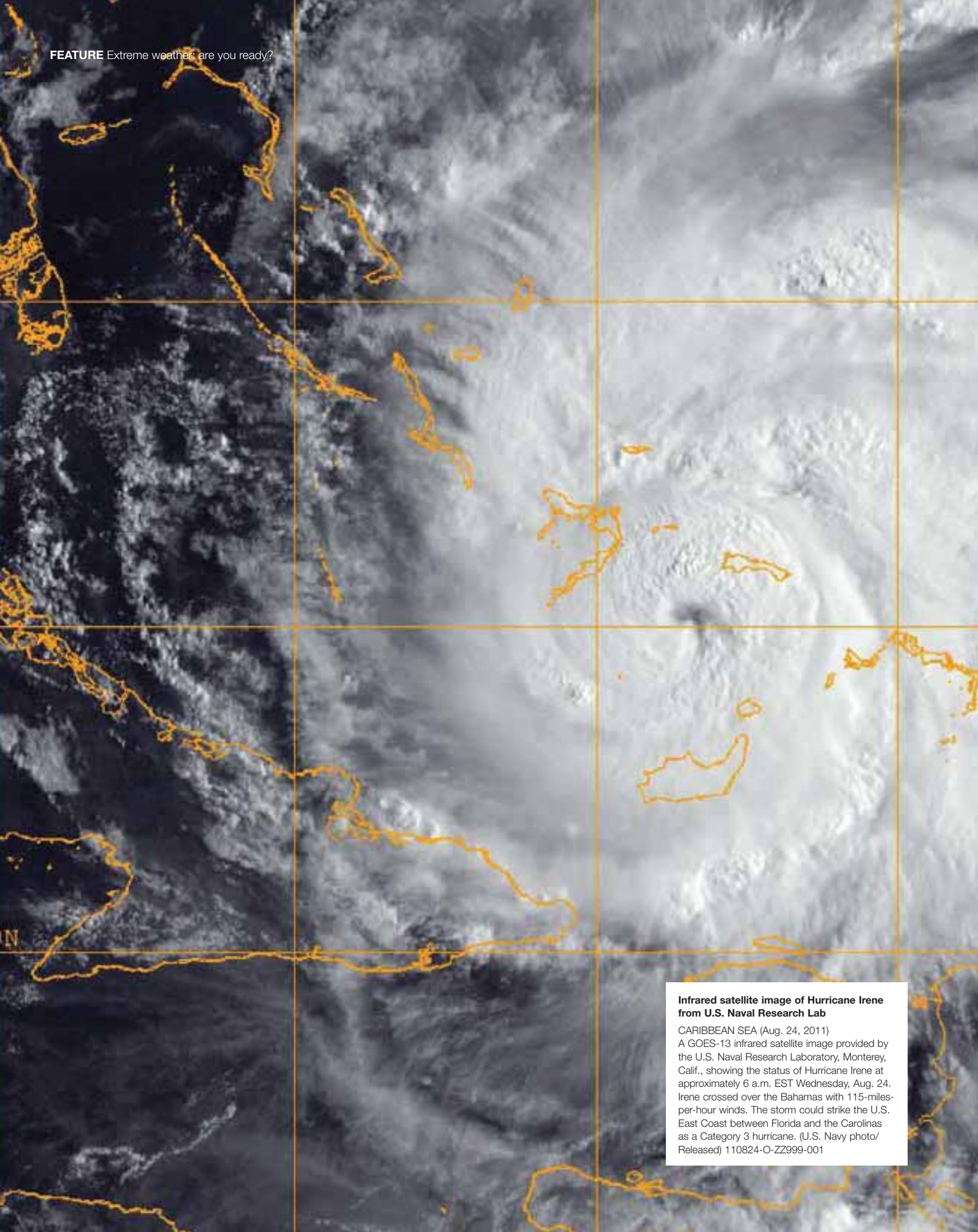
When Welsh Water wanted to install anaerobic digesters to generate energy from waste, the company was able to claim one Renewables Obligation Certificate (ROC) for each MW generated.

By installing digesters at Afan and Cardiff waste water treatment works and linking them to combined heat and power (CHP) plants, Welsh Water gained a total of 4.6 MW generating capacity – reducing CO_2 emissions by 34,000 tonnes per year.

Excess energy is sold back to the grid, generating a new income stream for the water company, and the ROCs help Welsh Water meet its targets to reduce CO_2 emissions by 50% by 2035.

How saving water cut carbon emissions

On page 8, we feature Procter & Gamble's Milenio facility in Mexico. The Planta Milenio (MAPS) uses advanced technology to recycle and reuse water, to harvest rainwater, and to ensure zero liquid discharge. Reducing on-site water usage by over 18,000m^3 a year has also reduced carbon emissions by around 63 tonnes – equivalent to roughly 300,000 air miles. Read more about MAPS on page 8.



Infrared satellite image of Hurricane Irene from U.S. Naval Research Lab

CARIBBEAN SEA (Aug. 24, 2011)
A GOES-13 infrared satellite image provided by the U.S. Naval Research Laboratory, Monterey, Calif., showing the status of Hurricane Irene at approximately 6 a.m. EST Wednesday, Aug. 24. Irene crossed over the Bahamas with 115-miles-per-hour winds. The storm could strike the U.S. East Coast between Florida and the Carolinas as a Category 3 hurricane. (U.S. Navy photo/ Released) 110824-O-ZZ999-001

Extreme weather: are you ready?

When it comes to insuring against extreme events, it pays to be prepared

"We monitor locations of clients and talk to them to figure out a plan before loss happens – what they need to do and what resources are available. So with Hurricane Irene, we were constantly talking to clients who were in the path of the storm."

A hurricane or earthquake can lead to massive insurance claims for property damage and business interruption. "If Hurricane Irene had hit Manhattan as a Category 2 storm, the total economic damages would have been around $58bn dollars – nearly as much as Katrina," says Frank Russo, who is managing director of insurance broker Aon's global risk consulting business. "It would have been a massive event."

Russo argues that, in the race to get businesses up and running after an event like this, the winners will be those who are best prepared. "Hurricane Katrina proved that the services you need to get back in business – everything from accountants to structural engineers – will be in great demand in the aftermath of something like a hurricane or an earthquake. If you can reserve them beforehand, you'll be ahead of the game."

To help businesses do exactly this, Aon has teamed up with Arup to offer clients the Aon Rapid Response service. "Rapid Response gives you suppliers on call," explains Russo. "So when a loss happens, these experts will be at your site within 24 hours to help you mitigate any loss. From day one, you're moving as quickly as possible to get back in business."

With the help of Arup's engineers, organisations are able to find out quickly the extent and nature of their damage, and act accordingly. "The most important thing is that organisations stay out of facilities they shouldn't be in, and that they are able to use facilities they can be in safely," explains Andy Thompson, leader of Arup's risk consulting practice in the Americas.

With some extreme weather events, the Rapid Response team starts working even before disaster strikes. "We monitor locations of clients and talk to them to figure out a plan before loss happens – what they need to do and what resources are available. So with Hurricane Irene, we were constantly talking to clients who were in the path of the storm."

Being prepared for the worst could pay off in other ways too. "Insurance companies look on well prepared clients as a more favourable risk in an insurance contract," says Russo. "We're also working towards a premium credit for Aon Rapid Response clients – so being better prepared would also mean that a company could also benefit from lower premiums."

Hope for the best, prepare for the worst

So how can you make sure you and your insurance are prepared for an extreme weather event? Russo offers this advice:

- Practise and prepare but stay flexible. You can't predict every event and when a loss happens there's always something you didn't think of.
- Work with your broker to understand the coverage that's available and find the right insurer for your business.
- Do as much risk control as possible – including understanding your values for both assets and potential business interruption.
- Use a service like Rapid Response to get to know the vendors you'll need after an event.
- Communication is key – talk to your insurance company before a loss happens and understand what you'll need to do in the event of a claim.
- And most importantly, if the worst happens, make prudent decisions to get back to business as quickly as possible. When you act in this regard, your insurance company will support your decisions most of the time.

Rapid responses

Arup has worked with Aon to help organisations recover quickly from extreme events, including:

- Virginia earthquake 2011
- Japan earthquake 2011
- Chile earthquake 2010
- Hurricane Ike 2008
- Hurricane Gustav 2008
- Covina, California, earthquake 2008

After Hurricane Ike in 2008, one Rapid Response client got fuel delivered for their backup generator four days earlier than the best estimate from local vendors, and before their competitors – getting $1m in sales over those four days through increased market share.

After the magnitude 8.8 Chile earthquake in February 2010, Arup helped a Rapid Response client assess the damage to 14 of its facilities. In one facility, the firm's recommendations ensured that a damaged tank of toxic ammonia remained intact during a 7.0 magnitude aftershock, preventing significant environmental and financial losses.

Reviving the Beam Parklands

How water is helping to regenerate a deprived area of East London

- A new wetland urban nature park on the River Beam, near Dagenham, exemplifies the type of project that will increasingly be required to comply with important new European Union water policy.
- The EU Water Framework Directive aims to trigger a renaissance in the quality of the water environment by requiring member states to apply a range of measures to improve the ecology of all waterbodies.
- Arup worked with the Environment Agency and the Land Trust to design a scheme that has restored a section of the River Beam and created twelve hectares of new wetland habitat. This was part of a wider strategy to manage flood risk on the Thames Estuary whilst safeguarding biodiversity.
- The project will deliver a critical element of the East London Green Grid. It provides a wildlife-rich green corridor, connecting the River Beam to surrounding green spaces and the River Thames. It reduces flood risk to communities in Dagenham and is a significant educational resource for the local community.
- The project is part of the wider regeneration of the area, which includes redevelopment of a deprived housing estate and the opening up of a former landfill site area to public access.

May 2009
Public engagement at Leys Playing Fields

June 2009
Public engagement at Mardyke Community Centre

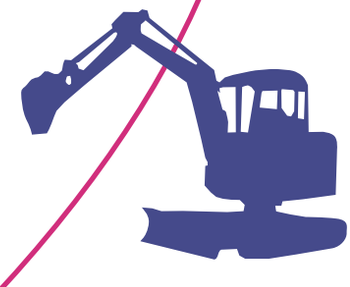
July 2009
Dagenham Town Show

February 2010
Advance vegetation clearance

June 2010
Advance achaeological investigation

July 2010
Planned start date on site

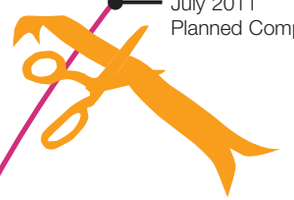
July 2010
Dagenham Town Show



December 2010
Planned start of planting on site

The Beam Parklands scheme won the Chartered Institution of Water and Environmental Management's 2011 Living Wetlands Award.

July 2011
Planned Completion Date



January 2013

January 2012


Ponds for local wildlife, providing opportunities for pond dipping
Natural Playground with mounds and fallen logs
Viewing mound beside the playing fields
New entrance to the park with paths leading to ponds for interaction
Ponds to encourage Great Crested Newts
Open woodland area next to the Wants stream
Most of the site kept open and unaffected during the works
Resurfaced path
Viewing mound at the old hospital site
Playing field kept open for public use
Community orchard planted by local residents
More natural looking stream
New park entrance adjacent to the community orchard
Viewing platform over the Wantz stream
Community Orchard, planted by local residents
Bridge over River Beam
Ponds and reeds for local wildlife, providing opportunities for pond dipping
More natural river edge with access to the water
July 2013
End of all initial maintenance phase and full handover to the new managing body
Ponds and reeds for local wildlife
New pedestrian and cycle path, with views over the wetland park
Wetland park, encouraging local wildlife
Feature tree planting, providing year round interest
New entrance to the park with signage and information

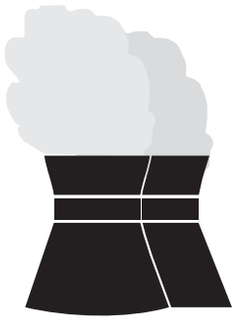
The food, energy and water nexus

Research from Arup's Foresight + Innovation team reveals the systemic link between food, energy and water – and how tackling them together can address some of the world's most pressing problems

As the global population grows and emerges from poverty, the fastest-growing countries are also where the most development must occur. As a result, demand for food, energy and water is increasing rapidly at a time when supply is becoming less certain. Total global demand for water is predicted to increase by 30% by 2030, with energy demand projected to rise by 40%, and food demand by 50%, during the same period [1].

Energy and food

Our current system of food production relies upon astonishingly cheap energy. This makes our food supply highly susceptible to the effects of Peak Oil. As energy prices rise, pressure to reduce the embodied energy in food will require the entire supply chain to be re-engineered.



7.3

units of fossil energy are consumed for every unit of food energy produced (U.S.A.) [4]

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3 The Pacific Institute, 2009, Water Scarcity & climate change: Growing Risks for Businesses & Investors. http://www.thesapientsolution.com/research/20090525_Water_Scarcity_and_Climate_Change_thesapientsolution.pdf p.9

4 Center for Sustainable Systems, University of Michigan. 2010. "U.S. Food System Factsheet." Pub. No. CSS01-06, http://css.snre.umich.edu/css_doc/CSS01-06.pdf

5 United Nations Secretariat 2010, Department of Economic and Social Affairs, Population Division. World Population Prospects: The 2010 Revision, http://esa.un.org/unpd/wpp/index.htm (The current population is approx. 6.9 Billion; UN forecasts for 2030 range from 7.9 Bn to 8.7 Bn.)

Food and water

Food and water are intimately related, and both are being affected by climate change. There is scope for design and engineering to tackle this issue. For example, effective irrigation can conserve water and ensure that food production does not pollute water supplies. As climate change affects rainfall and water stored in snow and glaciers, the water cycle will need more management.

2000 to 5000

litres of water to produce a person's daily food [2]

Daily drinking water requirements per person are **2-4 litres** [2]

Water

+30%

Demand by 2030

Global population

8 billion

by 2030 [5]

Water and energy

You need water to deliver energy and you need energy to deliver water. Making buildings and infrastructure more self-contained would help conserve both energy and water. Solutions such as sourcing water locally (such as rainwater harvesting) and reusing water will become increasingly important.

Energy

+40%

Demand by 2030

178m³

of water is consumed by biofuels (1st Generation) per megawatt hour [3]

Compared to:
solar **0.0001**, wind **0.001**, gas **1**
coal **2**, nuclear **2.5** and hydropower **68**

Banking on water

World Bank expert Julia Bucknall talks to A² about the organisation's wide ranging investment in water projects

The vital role that water plays in driving development and growth is reflected in the World Bank's investments. "Simply put, we invest in everything wet," says Julia Bucknall, who manages the bank's central unit for water, known as the Water Anchor. "Our investments cover water resources, irrigation, hydropower, water supply and sanitation."

Written in stone at the World Bank headquarters building are the words 'our dream is a world free of poverty' and investing in water plays an important part in that dream. The bank lends to water projects that otherwise wouldn't get funding. And by investing in these projects, it can tackle wider problems such as health, food security and climate change.

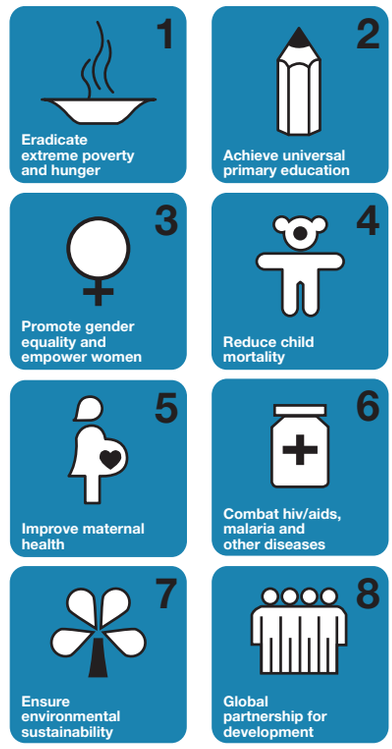
"More children die of diarrhoea than of AIDS, malaria and tuberculosis combined," says Bucknall. "So basic sanitation, combined with hand-washing, is one of the most cost-effective interventions available to improve health. It also has an impact on education, because children with diarrhoea can't attend school."

Bucknall points out that investing in water can tackle one of the biggest constraints to development in poorer countries: power generation. "With an increasing focus on clean energy, hydropower makes wind and solar renewables more attractive because it provides a flexible source of power that can be switched on quickly if the sun goes in or the wind stops blowing."

All this needs a joined-up approach, Bucknall stresses. "Managing water resources ties everything together," she says. "Because if you've allocated more water than you've got available, those investments won't work. If the quality of the water is too poor to use, they won't work. And if you've developed irrigation based on groundwater that's going to run out, they won't work either."

How does the World Bank realise the

8 Millennium Development Goals



development benefits to be gained from investing in water? Bucknall points out that although many of the world's problems don't have easy answers, we do know what to do about issues like basic sanitation and water provision – we just need to get on and do it. For this reason, much of the World Bank's efforts focus on moving water issues up the political agenda.

Bucknall highlights one example of how the bank approaches this challenge. "A year ago, the donors who finance 80% of aid investment in water and sanitation met with the finance ministers from the 17 countries who are not meeting their Millennium Development goals in these areas. Together, we worked out ways they could accelerate their progress."

For individual projects, the bank often carries out political economy analysis. "We look at who will benefit and who will lose out," explains Bucknall. "Often issues are polarised and the voice of some minority groups representing legitimate concerns can be lost in the polarisation. We believe that sustainable solutions consider all views and seek to enhance the environment, society and the economy, and where negative issues are an inevitable consequence, mitigate against them."

The water issues the bank tackles differ around the world – and Bucknall points to irrigation as an example. "In Africa, irrigation is often under-exploited and new systems are needed. But in other areas, existing irrigation needs rehabilitation and modernisation. For example, irrigation systems in many former Soviet countries have suffered from years of under-investment."

Ensuring these investments deliver results is no easy task – Bucknall points out that, by definition, the World Bank invests in the things that nobody else wants to invest in. But the organisation is enjoying strong results, with water projects outperforming its other investments.

Promoting sanitation in rural Benin

In Benin, in West Africa, the World Bank invested in an innovative rural sanitation promotion programme championed by the country's Ministry of Health. Launched in 2005, the programme shows people how to:

- build a sanitary latrine;
- transport, store and use improved drinking water safely;
- maintain good domestic hygiene; and
- wash their hands with soap at key times.

Within the first one-and-a-half years, the programme has seen sanitation coverage improve by 10 percentage points (from a baseline of 6.2%) across 80,000 monitored households. One in ten households in enrolled communities have built improved latrines. And a further 2 to 3 out of every ten households are either planning improved latrines or in the process of building them.

On the waterfront

Why waterside sites are key opportunities for urban regeneration

From bywords for inner city dereliction to beacons of urban regeneration – waterways have undergone a startling transformation in recent years. British Waterways estimates that waterside property now commands a premium of 20% and waterside regeneration projects have brought millions of pounds into revitalised areas of towns and cities.

So what's special about waterside sites? "Water has a remarkable effect on people," says Paul Johnson, who leads Arup's environmental consulting team. "It brings energy to an environment – from its light, movement and sound. But it also brings calm and reflection."

"These qualities mean that water creates a feeling of wellbeing; it lifts people's spirits," he continues. "So waterside developments are environments that are full of energy and vitality. They're enjoyable to spend time in and this is reflected in their value."

As the organisation that cares for 2,200 miles of the UK's canals and rivers, British Waterways has been keen to unlock the value of underused waterside sites. Historically, the only way to do this has been to sell the land. But in more recent years the organisation has become much more active in regeneration, through joint ventures with developers, and is now involved in £3bn of projects in London alone.

In Liverpool, Arup helped British Waterways re-establish the historic connection between the city's underused South Docks and the Leeds & Liverpool Canal. Before the new link was completed, canal boats rarely entered the South Docks as the journey involved passing through large commercial shipping locks and tackling the 10 metre tidal range of the River Mersey. Now boats bring colour and life to the South Docks all year round.

Liverpool Canal Link

This has opened up the city's waterfront to leisure and tourism and proved a catalyst for further development – including the new Museum of Liverpool, the largest newly-built national museum in Britain for more than a century. Each year, the new one-and-a-half-mile canal link is expected to attract 200,000 extra visitors to the waterfront, who will spend an additional £1.9m. In total, British Waterways estimates the link will add £3.3m to the local economy.

"The canal link has encouraged further development, transforming the waterfront into a world-class destination," says Richard Longton, project manager for British Waterways. "We've got cruise liners calling there, a new 1.65 million sq ft retail and leisure development – the whole city centre seems to have moved towards the waterfront."

"The whole city centre seems to have moved towards the waterfront"

Longton also points out that the canal link is a major selling point for residential and commercial property in the area. And traditional boat-building business further along the canal are benefitting from the increase in traffic too – British Waterways expects over 4,500 boat movements every year.

Crucially, Longton and his team engaged the local community in the project. "We hired office space in the centre of Liverpool which was open to the public to show people what we were doing," he explains. "We had four potential routes for the new canal link and we asked people to select their preferred option. We said: 'it's your city, you choose'. And the final route across the famous Pier Head was the one that 87% of people preferred."

British Waterways estimates the link will add

£3.3m

to the local economy.

Visualisation of Songdo International Business District

Such is the power of people's emotional connection to water that simply revitalising a watercourse and its surroundings can improve a whole area – as Arup helped to do along the River Beam in Dagenham, London. "The Environment Agency and the Land Trust wanted to create a new wetland park for local residents, so they engaged us to design an appealing, naturalistic setting for the river that would provide an amenity for local people," Johnson explains.

Arup's work along the River Beam, featured in more detail on page 16, has created a biodiverse landscape. "The parkland setting with the sinuous river and ecological planting creates a much more pleasant environment for both people and wildlife," says Johnson.

Can this personal connection people feel with water ensure the success of a large-scale development project? It certainly seems to help. When United States developer Gale International was engaged by Incheon Metropolitan City to build a new city on reclaimed land near Seoul, South Korea, it incorporated at its centre a massive 41-hectare park with a seawater canal.

"Developing around water provides emotional benefits in terms of quality of life, environmental benefits from the green space and the economic benefits of increased real estate value," explains Tom Murcott, of Gale International.

Murcott believes Central Park, for which Arup worked on the master plan created by Kohn Pedersen Fox, will help Songdo International Business District become a vibrant home for 65,000 residents and 300,000 workers. "People can enjoy the park – they can play, jog, take picnics or go to concerts," he says. "And they can use it as a pleasant way to get where they're going, walking alongside the canal or taking a water taxi."

For Murcott, the emotional connection people make with water is the key to unlocking the potential of waterside sites. "You've got to put people first," he says. "The greatest architecture or engineering in the world will be wasted if you don't deliver a living environment that people want to call home."

A vibrant home for 65,000 residents and 300,000 workers.

Shaping flood-resilient cities

Can an integrated approach help cities to withstand the effects of flooding?

"If a city can't withstand flooding it stops working properly," explains Arup associate director David Wilkes, who is the current president of the Chartered Institution of Water and Environmental Management (CIWEM). "Flooding directly affects some of the population in their homes, workplaces or schools; other people can't get the services they normally expect; trade is lost and business goes elsewhere. Part of making a city resilient to shocks is making sure it can function during a flood – or, if that's not possible, how normality can be restored quickly when the floodwater recedes."

Image showing predicted extreme flood event of London – Environment Agency

UK legislation – what's changing?

(FWMA) FLOOD AND WATER MANAGEMENT ACT 2010
This act has introduced a significant new flood risk role for local authorities. The act was the result of the Pitt Review, set up to recommend improvements to flood risk management after the floods of 2007. It's being implemented in stages.

(FRR) FLOOD RISK REGULATIONS 2009
Under these regulations, which implement the EU Flood Directive, each Lead Local Flood Authority has undertaken Preliminary Flood Risk Assessments (PFRAs) to identify the areas within their district that are at risk of flooding.

(WWP) WATER WHITE PAPER

"...we need to use our green spaces and green cover to slow the rate of water flowing into our drains and use these solutions to work alongside our existing drainage system."

In the UK, changes in legislation have placed more responsibility on local authorities to ensure their cities are resilient. And a new funding allocation system is designed to encourage communities to take more responsibility for the flood risks they face. It all means the organisations involved in managing flood risk will have to work together more closely to find ways to tackle the issue, something CIWEM supports.

Tackling surface water flooding

London is not only at risk from the Thames – the city is also vulnerable to surface water flooding. Heavy rainfall can swiftly overwhelm the drainage network, leading to flooding in low-lying areas. In 2007 more than 1,000 homes, over 80 schools and parts of several hospitals were flooded.

The situation could get worse. Climate change is projected to increase the frequency and intensity of heavy rainfall events, and London's growth will mean that more people and assets will be at risk. Experts predict that a one in 50 year rainfall (or 2% annual chance) event today would flood one in seven buildings in London, with insured damages running to tens of billions of pounds.

Climate change adaptation

In response, the Mayor of London will shortly be publishing the London Climate Change Adaptation strategy. "This identifies the key climate risks to London and recommends a series of actions to improve our resilience to extreme weather today, and to longer-term climate change over the next century," explains Kulveer Ranger, the Mayor of London's environment director. "These include retrofitting our buildings and infrastructure to be more resilient and energy efficient, and increasing the amount of green space in London to cool the city and reduce flood risk."

"Our RE:NEW homes programme has successfully improved the water and energy efficiency of 10,000 homes to date and will reach another 45,000 by the end of 2012," Ranger continues. "We've initiated two rainwater harvesting retrofit pilots to schools in London and we're working with the boroughs to develop surface water flood risk management solutions, such as green roofs, rainwater gardens and permeable paving."

Dec 2011

FWMA - Consultation on sustainable drainage systems (SuDs) will begin. Implementation of SuDs measures has been delayed while final questions are considered and resolved by the government.

FRR - The Environment Agency will report the national flood risk assessment for England and Wales to the EU.

WWP - The paper will move forward Defra's commitment to reform the water industry to enhance competition, improve conservation and protect poorer households.

Apr 2012

FWMA - SuDs implementation expected.

Extereme flood: visualisation of Tower Bridge in London swamped by a storm.

A joined-up approach to drainage

Another initiative already underway is Drain London, established in 2007 to provide a London wide forum for improvement. With no single agency responsible for managing all the drainage and surface water flood risk in London, this forum creates a partnership for all the key organisations involved in the city's drainage.

"The forum will enable us to take a more creative approach to managing rainwater," explains Ranger. "Heavy engineering solutions have served us well, but we need to use our green spaces and green cover to slow the rate of water flowing into our drains and use these solutions to work alongside our existing drainage system."

"Drain London will bring everyone together to share information," Ranger continues. "They'll map where surface water flooding could occur, identify areas where there is a risk to people and property, and develop projects and partnerships to tackle high risk areas."

Through Drain London, each London Borough has mapped its surface water flood risk, has identified where flooding poses a potential risk to people and property and is developing surface water management plans to manage the risk in these areas. These borough risk maps will provide a London-wide picture to help identify regional priorities.

Raising awareness is another key aspect of the forum's work. "Most Londoners are oblivious to flood risk – on the most part because they're well-protected, and the effects of heavy rainfall have been very localised," says Ranger. "So we need to ensure that we raise awareness. Drain London has funded the development of borough flood plans, it will fund borough training and it is working with communities to develop community flood plans.

For Drain London and similar forums to succeed, working closely will be vital, says Wilkes. "Initiatives like this depend on people co-operating and developing responses in a joined-up, integrated way."

Drain London forum members

- Greater London Authority
- All London Boroughs
- Transport for London
- Environment Agency
- Thames Water
- London Councils
- DEFRA

Protecting our power networks

UK Power Networks provides power to a quarter of the UK's population through its electricity distribution networks. The company provides the power supply to more than eight million homes and businesses across London, the South East and East of England.

"UK Power Networks' infrastructure faces three main flooding risks – from surface water, river flooding and coastal flooding," explains Patrick Clarke, the company's director of operations. "Clearly, one of the main risks we could face in London is from surface water flooding. This would normally only have a very local impact, but we have experienced more serious difficulties from burst water mains."

"Modern drainage systems help keep problems to a minimum. But the floods in July 2007 are a good example of how abnormally heavy rainfall can cause serious problems for electricity networks. They also demonstrated the impact flooding can have on communities when vital services, like power and water, are affected.

In response, the electricity industry is setting new standards for flood protection and has agreed a timescale for upgrading at-risk sites. UK Power Networks has also taken measures to ensure key sites are protected in the meantime.

"Whilst we upgrade sites we've invested in 1km of flood barriers," explains Clarke. "Because we chose the same type of barrier used by the Environment Agency, we can work effectively together. We've also conducted exercises in joint working with them and the emergency services."

Making reliable water a reality

Vision

Values

Triple-S: working with local and national partners to ensure rural people get water services that last

One in three rural water supply systems in developing countries doesn't function at all or performs far below its expected level. As a result, about 25% of the developing world's rural population who supposedly have an improved supply actually do not. The six-year Sustainable Services at Scale (Triple-S) initiative is addressing this acute need for sustainable rural water services.

Led by the IRC International Water and Sanitation Centre and funded by the Bill & Melinda Gates Foundation, Triple-S is mapping out the key components that support sustainable service delivery. Arup's international development team is providing strategy and programme management expertise to the initiative.

"Until now, the approach has been to focus on technology and projects," explains Samantha Stratton-Short, an associate at Arup who works with Triple-S. "Between 1990 and 2008 a collective investment of billions of dollars has created new infrastructure for some 720 million rural people. But this infrastructure hasn't always done its job, with failure and breakdown rates somewhere between 30% and 40%. As a result, there's a growing recognition that new approaches are needed to provide sustainable services at scale, rather than stand-alone projects at community level. And that's where Triple-S comes in."

To learn about what worked, and to identify constraints, research was conducted into existing rural water

services. Drawing on expertise in water infrastructure and complex programme management, Triple-S was able to develop the concept of a service delivery approach for supplying safe water to millions of people.

"The foundation of reliable supply is a defined level of service and an agreed way of reaching that level of service," explains Harold Lockwood of Aguaconsult, who was instrumental in getting the Bill & Melinda Gates Foundation involved in the initiative. "In the UK, there's a clear structure to the way private sector water companies serve houses. In developing countries there are elements of that system in place, but it's often not clearly defined. National level policy must be clear and everyone must know what it is."

"For example, if the community is to run the water service, they will need a legal structure that enables them to do it," Lockwood continues. "And before creating the infrastructure, you need to think through and support the institutions that will help keep the water service going. It's also important to think through the full lifecycle of service delivery – including upgrading infrastructure and covering the costs of people to support and monitor communities. It means investing in the entire framework that supports these systems."

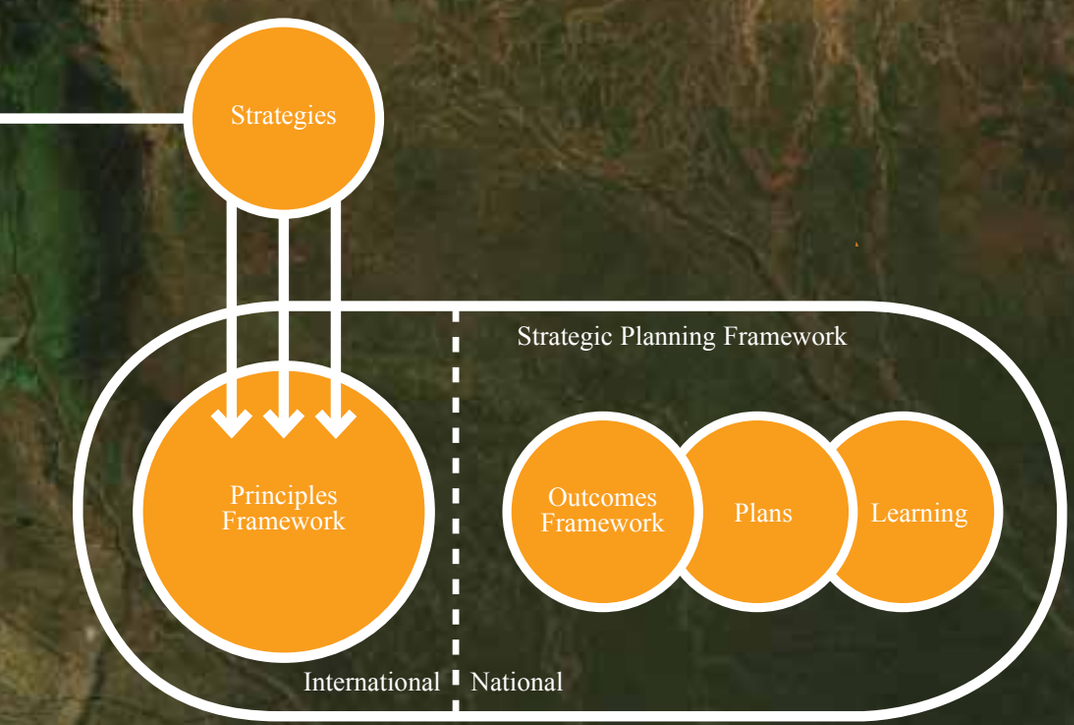
To help countries focus on establishing a service delivery approach, Arup led a collaborative process to create a strategic planning framework. "There are already principles for sustainable water services, but when you look at them as a list of good ideas it can be hard to know how they relate," Stratton-Short explains. "The first layer of the framework acknowledges all the interdependent principles you need to address to get a service delivery approach, as well as how they are rolled out and tested so that there is a continuous learning feedback loop. And it takes into account different strategies at different levels of implementation – right up to national level."

The Principles Framework developed by Triple-S enables countries in different situations to focus on creating a service delivery approach. The first two countries to try the approach are Ghana and Uganda, who are now one year in to their work with Triple S. And the initiative will start in Burkina Faso in late 2011. If the approach is successful, it will encourage adoption in other developing countries that are in dire need of large-scale approaches to delivering sustainable water supplies.

The framework recognises that each context is different but facilitates learning lessons from others' experiences. "Ghana and Uganda are very different," explains Lockwood. "Ghana has strong economic growth but its water sector suffered from fragmented or piecemeal donor investment and is weak. Uganda has a history of being well organised — it was one of first Sub-Saharan countries to adopt a sector-wide approach into which donors can channel support, along side government funding. But maintenance challenges remain a critical concern and mean that the true rural water access rate has remained at around 50% for the last four years or so, with a stagnant coverage rate of 64% and a functionality rate of 81%."

Triple-S hopes to change this by fostering the service delivery approach. And on 31 January 2012, Arup's London office will host a one-day event focussing on how to shift to this approach. Organised by Aguaconsult, IRC and Water for People, the day will see NGOs, charities, consultants, donors, foundations and research agencies gather to share ideas.

Image courtesy Jacques Descloitres, MODIS Land Rapid Response Team at NASA GSFC



The principles framework is at the heart of the strategic planning framework for Triple-S. It provides a series of layered matrices, with pathways defining the specific outcomes, planning, and learning that will create the desired change.

What is Triple-S doing?

Triple-S is promoting a shift to sustainable water supply at scale by working with governments and other partners on the ground in Ghana and Uganda and at an international level.

At the country level, Triple-S is working with local partners to:

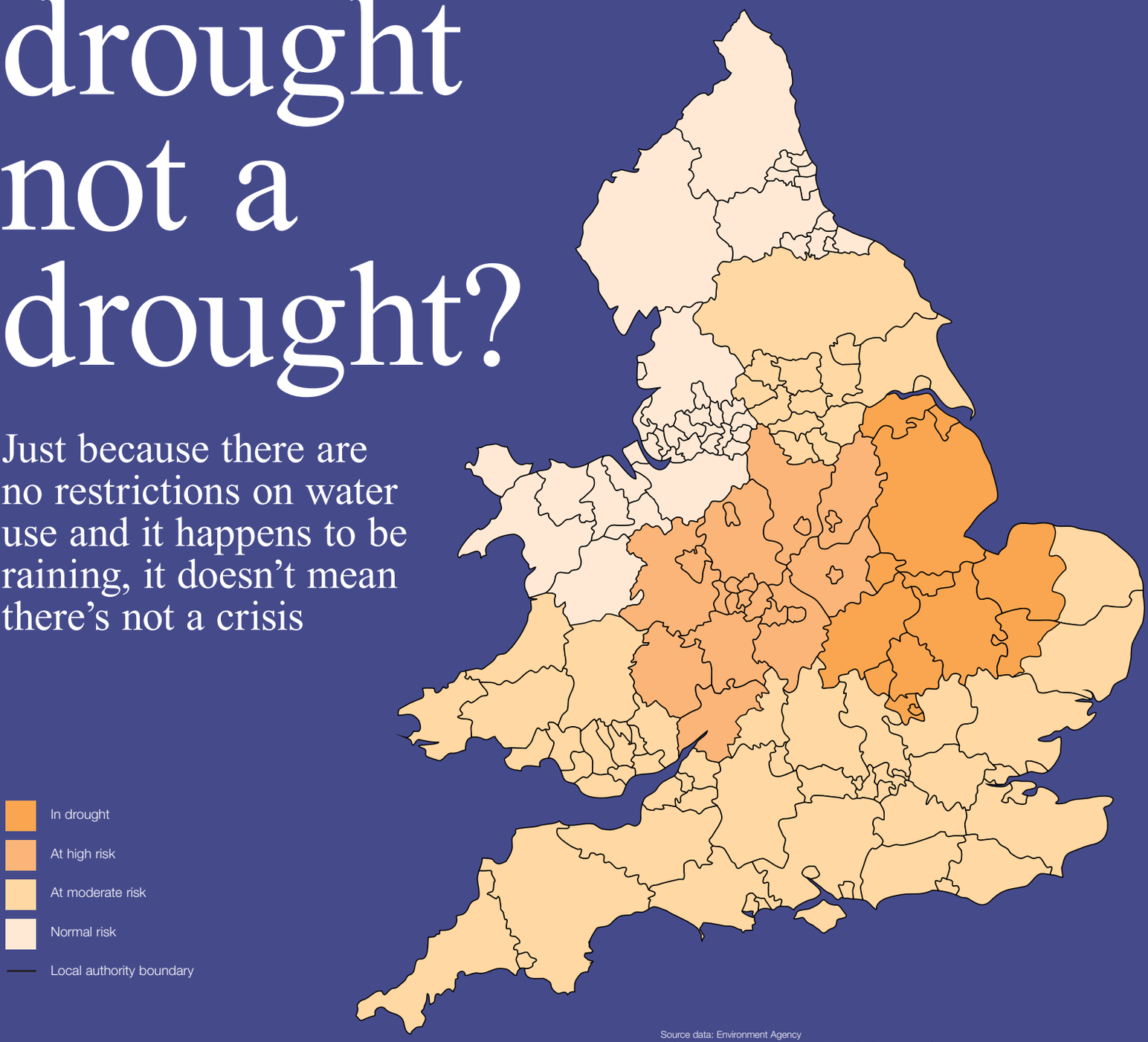
- diagnose problems with policies and practices;
- develop, test and implement new solutions at the district level;
- scale up successful models; and
- strengthen learning and knowledge management.

At the international level, its activities include:

- recording and sharing positive examples;
- learning with organisations that are moving successfully to more sustainable approaches;
- developing and promoting tools for sustainable service delivery; and
- working with donors, international financial institutions, NGOs and other development partners to change the way support to rural water services is provided to make it more sustainable.

When's a drought not a drought?

Just because there are no restrictions on water use and it happens to be raining, it doesn't mean there's not a crisis



Source data: Environment Agency

Drought in Africa has hit the headlines recently – and on page 26 we hear how the Triple S project is fostering sustainable rural water supplies in Ghana and Uganda. But if you're reading this in the UK, you might be surprised to hear that some of the country is suffering drought conditions. At the time of writing, parts of five counties in South East England are still officially in drought.

It's the result of the driest spring in East Anglia and South East England since records began a hundred years ago. But it's a fact that's passed many of us by because there have been few hosepipe bans or other restrictions on using water. In these areas, it seems, a drought is not a drought.

Martin Shouler, who leads Arup's environmental services engineering team, explains: "This situation comes about because there are a number of ways of looking at drought," he says. "You can define it in terms of the water that's in the environment – a hydrological drought. And you can define it in terms of the water that's available for us to use – a water resources drought, or 'social' drought."

Are we drinking our rivers dry?

Some experts are worried that by continuing to take a lot of water from the environment during hydrological drought, we're causing damage. The issue hit the headlines in September when the BBC current affairs programme Panorama asked whether the water industry and its regulators in some parts of the UK are doing enough to protect the nation's rivers and ecosystems.

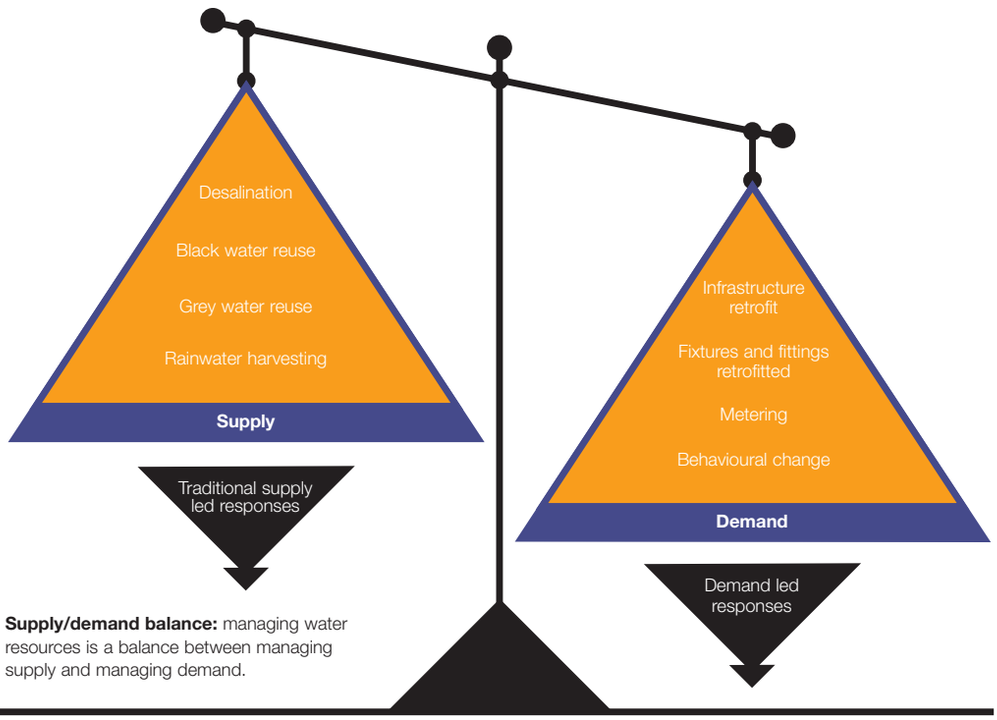
"Even though there are no drought measures placed upon the public at the moment, the aquatic environment is in stress," says Shouler. "This could be a growing problem because the science tells us to expect more frequent droughts as a result of climate change. So we are certainly going to face some stark choices in the years ahead."

The water hierarchy

How can we make those choices? With water demand management set to become increasingly important, Shouler believes the water hierarchy can help designers and engineers consider the implications of different options. Based on the reduce-reuse-recycle principle, the hierarchy suggests considering water demand management options before alternative and increasingly expensive water supply options like harvesting rainwater, using greywater and advanced techniques such as desalination.

"Because droughts occur naturally due to a lack of rainfall, they can't be prevented. But we can strive to use the water resources available more efficiently to reduce the demand for water placed on the environment and minimise the effects of drought."

Environment Agency



Supply/demand balance: managing water resources is a balance between managing supply and managing demand.

So what constitutes a drought?

Drought is defined as a period of time where precipitation (rainfall or snow) is significantly lower than normal. This reduces river flows, lake and reservoir storage, groundwater levels and the level of moisture in the soil – a condition known as hydrological drought.

On the other hand, a water resources drought is defined by the availability of water for our consumption and use. So as long as there's enough water for us to use, there can be a hydrological drought without a water resources drought.

"As pressure on our water resources increases, the water hierarchy is going to become an increasingly important tool," says Shouler. "It works with residential and commercial buildings – for both new build and refurbishment projects – and it has commercial and agricultural applications too."

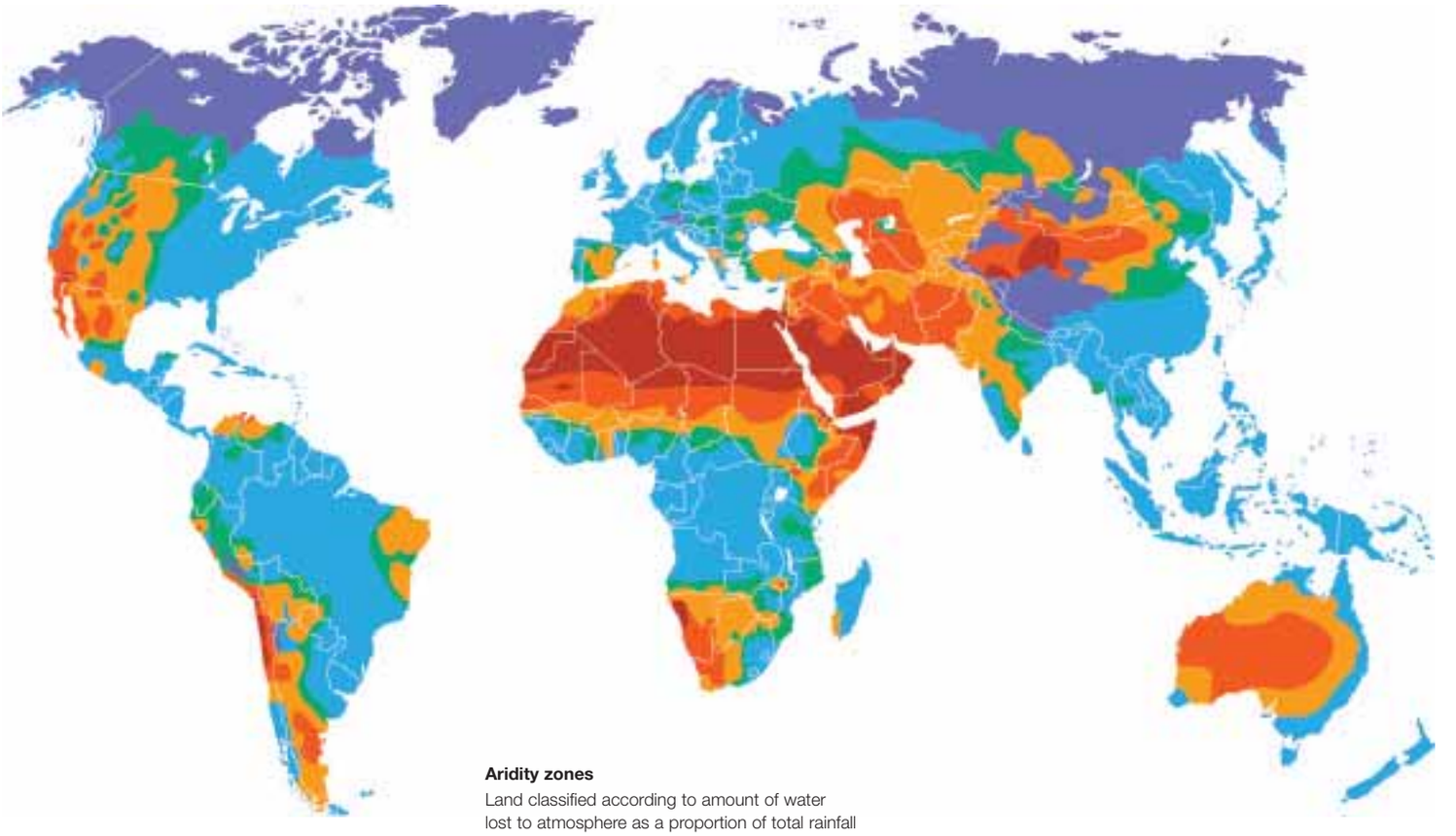
Sustainable water services for Africa

On a global scale water scarcity is not always associated with absolute physical shortages of water. "Other factors are important and it is the inter-relationship between these factors that determines the impact on water users," Shouler explains.

He points out that countries in East Africa are facing a very different drought problem to the UK – one of supply, rather than demand. "Although hydrological droughts on the continent can be severe, they are often relatively localised," says Shouler. "But in many countries the infrastructure is not capable of moving the water to where it's needed – and people suffer the consequences of a severe water resources drought. This is made worse by the fact that there are no regulatory controls available to reduce water use during times of drought."

On page 26, you can read more about how the innovative Triple S project is helping to change this and get people the water they need.

Mode of Scarcity	Description
Physical	Caused by naturally low water availability, for example in desert areas.
Economic	Limited access to water caused by the inability to pay for supply or the inability to provide labour and or time to collect water. If a lack of finance and therefore water infrastructure is the primary cause of urban water scarcity, this shapes how a city can respond to water shortages, particularly in the developing world.
Managerial	Scarcity caused by the poor management and maintenance of water infrastructure and supplies. Examples include over exploitation of aquifers and poorly functioning (leaky) water supply networks. This has implications for investment in future development in urban business.
Institutional	Institutional scarcity refers to the failure to manage imbalances between supply and demand through either failing to anticipate changing supply and demand patterns and or failure to provide adequate interventions.
Political	This form of scarcity occurs when people are barred from accessing water resources for political reasons. This is relevant for some transboundary rivers or rivers shared between states in federal countries (for example USA and Australia).

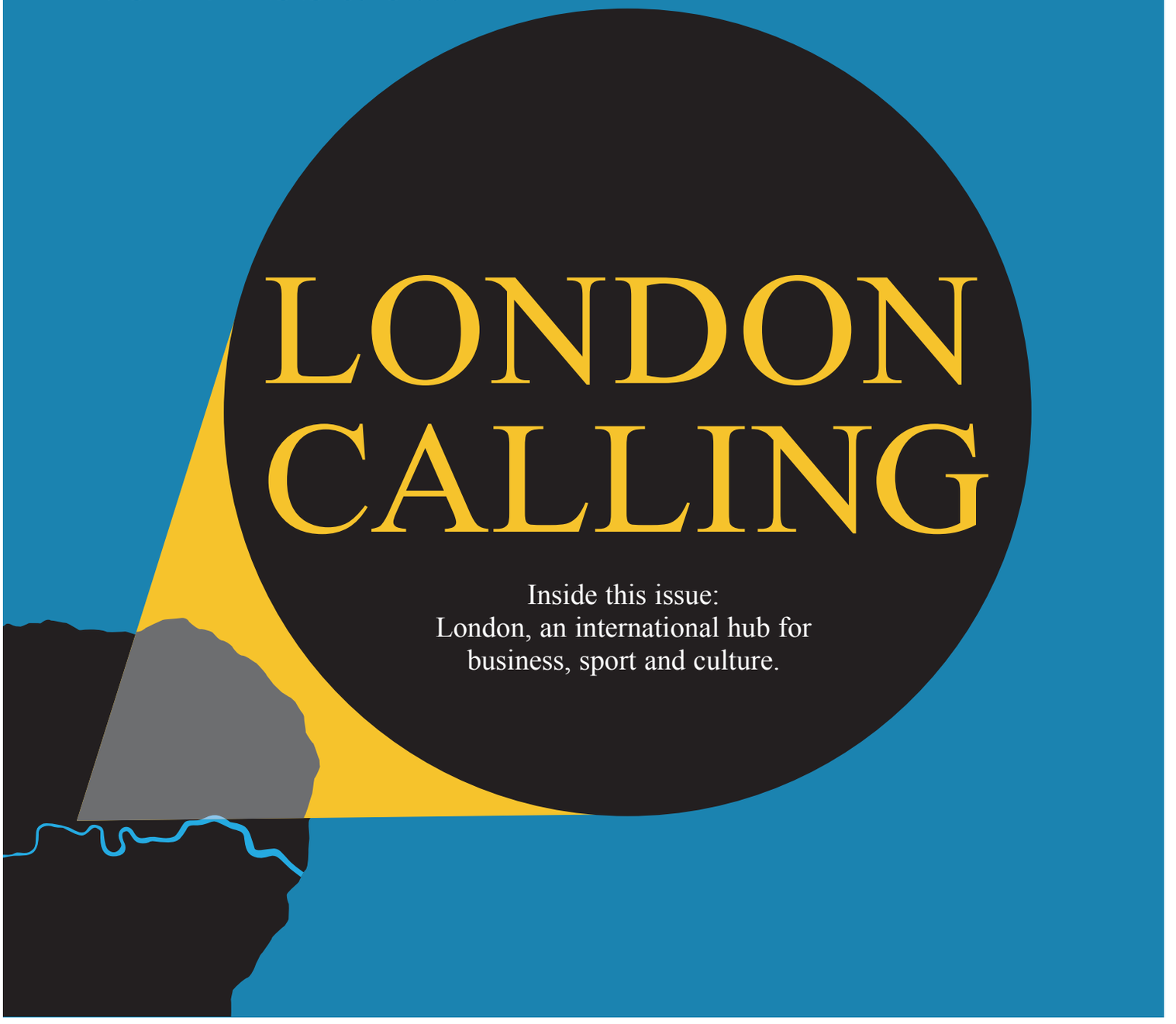


Aridity zones

Land classified according to amount of water lost to atmosphere as a proportion of total rainfall

hyper-arid | arid | Semi-arid | dry sub-humid | moist, sub-humid and humid | cold

Next issue...



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We are keen to ensure that this publication is enjoyed by our readers and provides interesting, relevant and informative articles. All feedback is welcome, so please send your comments and suggestions to our editorial team at a2@arup.com.

For more information on any of the topics featured in this magazine, please visit www.arup.com or email a2@arup.com

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