A2

NEW DIMENSIONS FROM ARUP | NO.9

Powering the planet: an energy special

Inside this issue: the policies, infrastructure and opportunities that are changing the way we think about energy

ARUP

Powering the planet

Welcome to the latest edition of A^2 – our business magazine which, this time, has a special focus on energy. "Powering the Planet" is an ambitious title, but it neatly describes the scale of the challenges which face us all. How will we provide power for all those people who will need access to heat, light, running water, electricity, mobility, communications and entertainment as the world population rises towards 9bn, and global standards of living begin to equalize? And, even if we can keep up with this level of demand, how will we achieve this whilst simultaneously reducing the release of greenhouse gases to the atmosphere?

Fortunately, there is no shortage of natural, clean sources of power in the world; solar, wind, tidal and geothermal sources exist in abundance. Our challenge is to harness them economically, and to do that successfully may require a different way of thinking. So, here in this edition of A^2, you will find a collection of articles which, we hope, will begin to provoke your own thoughts as to how we might face these challenges and then begin to overcome them for the benefit of future generations.

I hope you will enjoy reading these articles as much as we have enjoyed writing them.

John Miles
Global chairman: energy, resources and industry businesses

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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Arup chairman to advise UK Prime Minister

UK Prime Minister David Cameron has convened a small group of business leaders from strategically important sectors to provide regular, high-level advice on critical business and economic issues facing the country. This Business Advisory Group includes Arup's chairman Philip Dilley, as well as business leaders from HSBC, WPP, John Lewis, Sainsbury's, Google, Centrica, BAE Systems and EasyJet.

"Through both contractors and consultants Britain remains a world leader in providing first-class know-how to the built environment," says Dilley.

"I am very much looking forward to helping see that the priorities of our industry are recognised at the highest levels, and of course I welcome the Prime Minister's personal interest and direct support."


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World's first wireless charging technology for electric vehicle

In November, HaloIPT – a company jointly owned by Arup and Uniservices – launched its revolutionary wireless charging system for electric vehicles.

Halo uses inductive power transfer (IPT) to enable cars fitted with receiver pads to charge automatically when parked over transmitter pads buried into the ground, at a comparable rate to cable charging. HaloIPT is the first company in the world to bring the technology to market.

"We're making it easier, simpler and safer to own and charge an electric vehicle, while also ensuring that we keep costs down," explains Dr Anthony Thomson, CEO of HaloIPT. "Our technology will not cost any more than the plug-in equivalent."

HaloIPT aims to build a commercial-scale demonstration of its technology by 2012.

Gulf of Mexico oil spill 'threatens UK economy'

A group of leading UK businesses has warned that knock-on effects from the Gulf of Mexico oil spill threaten to damage the UK economy and heighten the risk to energy security over the next five years. The warning came in a briefing note published on 17 November by the UK Industry Taskforce on Peak Oil and Energy Security (ITPOES) – of which Arup is a member – into the impact of the oil spill.

"The serious issues highlighted by the Gulf of Mexico spill serve to underline the vulnerable state of future oil supplies," says John Miles, chair of Arup's energy business. "The UK needs to prepare for an era of expensive oil, and this means we must step up our commitment to reducing dependence on oil."

Download a copy of the report at http://peakoiltaskforce.net

1 Philip Dilley, Arup chairman
2 HaloIPT enabled car and charging pad
3 The Shard, London

The Shard reaches a new peak

London's skyline is soon to reach a new high as the Shard becomes the capital's tallest building. The structure will reach 236m metres in December this year.

When complete, the 72-storey structure will stand 310m tall. This makes it higher than the Rockefeller Center in New York and One Canada Square (the Canary Wharf Tower), which is currently London's tallest building.

Arup is providing mechanical, electrical, plumbing and fire engineering for the Shard, which was designed by architect Renzo Piano and under development by Sellar.

"Arup is and has been involved in many of the world's most iconic and tallest buildings. On a project of this scale and unique design, there are some really novel challenges to overcome," says Nick Offer, Arup's project director. "The fire engineering is incredibly complex, as is preparing the building for its tenants – the mixed-use design adds a level of complexity as all of the future tenants' expectations must be predicted and built-in during construction."

Designed as a 'vertical city', the development will house offices, restaurants, an 18-floor hotel, residential apartments and viewing galleries offering unprecedented 360° panoramic views across the capital.

New foundations for UK offshore wind turbines

Working in partnership with Costain and Hochtief, Arup has devised a new approach to offshore wind turbine foundations.

Self-buoyant concrete gravity base foundations can be towed out to deep-water wind farms by standard tugs. Installing the foundations – by filling them with water to sink them – requires no specialist marine equipment and minimum seabed preparation.

"The latest round of UK offshore wind farm development will be in deeper water, where traditional steel monopiles are unsuitable," explains Gordon Jackson, who is leading Arup's work on the project. "84% of these sites are in water over 30m deep, where concrete foundations may prove the best solution."

Concrete gravity base foundations can support the next generation of wind turbines, which have a capacity of up to 10MW.

C40CITIES

Arup to publish C40 reports

In December, Arup will publish the first in a series of reports setting out strategic actions to help major cities tackle climate change.

The reports are part of the firm's UrbanLife workshops with the C40, a group of 40 of the world's largest cities. The first report will draw on the Ho Chi Minh City workshop to address flooding and water resilience.

The reports will be made available via arup.com, but register for an advance copy at urbanlife@arup.com

Drivers of Change: Oceans

Arup is updating its popular Drivers of Change publication with a new set of cards focussing on 25 of the most significant drivers affecting the world's oceans today.

"Drivers of Change: Oceans is an opportunity to engage with these issues and create a connection between the built environment and the world's oceans," explains Elizabeth Jackson from Arup's Foresight and Innovation team.

"Around 40% of the world's population lives near the coast, and the impacts of actions upstream are felt by the environment downstream. This is an important issue for Arup clients because without a healthy ocean we won't have a healthy planet."

Oceans...

...are the largest global carbon sink

...cover over 70% of the Earth's surface

...carry 90% of global trade

Drivers of Change: Oceans will be available in early 2011.
To register your interest, contact elizabeth.jackson@arup.com
www.driversofchange.com

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China's tallest tower opens

Canton Tower in Guangzhou, China, opened on 29 September after Arup's engineering expertise helped realise its highly unusual structure.

The country's tallest tower houses TV and radio transmission facilities, observatory decks and revolving restaurants – as well as exhibition space, conference rooms, shops and 4D cinemas.

"Canton Tower embodies the excitement of Guangzhou's urban development and marks an engineering triumph which firmly puts the city on the international map," says LM Lui, Arup's East Asia chairman.

Capable of withstanding typhoons, the 600m tall structure is made up of a concrete core wrapped in a triangular lattice of structural steel, concrete-filled columns, rings and diagonal tubes. Lit from within by LEDs, Canton Tower forms a luminous beacon on Guangzhou's skyline.

High Speed Two heads north

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In parallel with Arup's work on the London-Birmingham section of the proposed new high-speed rail line for the UK, the firm is now helping to identify a route north from Birmingham to Leeds.

Appointed by High Speed Two Ltd (HS2) – the company established by the UK Government to advise on developing high-speed rail services between London and Scotland – Arup will identify the best engineering options for the 400kph route.

The firm's global rail leader, Colin Stewart, comments: "This is an exceptional opportunity to drive forward ideas for the new rail network – a project with the potential to have a vast impact on travel around the UK, and the economic landscape."

Arup is also working on other major high-speed rail projects – including California High Speed Rail, a high-speed rail station for Florence, the Guangzhou-Shenzhen-Hong Kong Express Rail Link, and Portugal's high-speed rail system.

4 Gravity base foundation with wind turbine
5 Canton Tower, China
6 High speed Eurostar train

Transforming energy infrastructure

Demand for greener energy has sparked unprecedented investment in infrastructure. National Grid chief executive Steve Holliday looks ahead to a bright, efficient future.

"The most significant energy challenge the world faces today is change," says Holliday, whose company delivers gas and electricity to millions of people across the UK and the north-eastern US.

"We all need to use energy more efficiently, aided by new technology like smart metering. And infrastructure needs to be modernised to cope with rising demand and new sources of energy."

"At the moment, electricity systems in countries like the UK are designed so that supply responds to demand," he continues. "In the future, as we rely more on renewable energy with varying output, supply will become less predictable and demand will have to become more flexible."

Holliday explains what this could mean for energy consumers: "I expect that in ten years' time customers will be offered contracts that allow energy companies to switch off power to fridges and freezers in homes for short periods of time – for example when the wind isn't blowing – in return for a discount on their bill."

This growth of renewable energy and the changes it brings are driven by carbon reduction targets. (The UK's goal is to cut CO_2 emissions by 80% by 2050.) Measures such as putting more electric cars on the roads are expected to have a dramatic effect on demand for electricity.

"Today, the UK's electricity consumption is 330 terawatt hours (TWh) per year," says Holliday. "With more electricity used for things like transport, we think it will be close to 500TWh in 2050. And that's a conservative estimate; the government thinks it could be over 600TWh."

The picture is similar in other countries too, Holliday points out – Denmark is predicting that its electricity demand will double by 2050. "The increase in energy demand is one of the great unknowns," he says. "At National Grid, we've run scenarios up to 2050 to inform our investment decisions and to understand the mix of energy we will need."

Although there is a strong desire to green the grid, Holliday is keen to point out that it's not the only driver for investment; much of the energy infrastructure in countries like the UK is reaching the end of its life and needs to be replaced. "We're dedicated to creating a low-carbon, efficient energy system in the UK," he says. "So both de-carbonisation and modernisation are driving our investment."

"Through our investment programme we're making big technical changes, such as evaluating the use of sub-sea technology to take cable systems offshore, or developing new electricity storage projects," Holliday continues. "And we're still making sure we give new generation access to our grid building the connections needed for new offshore wind farms and nuclear power stations."

The UK government's green agenda is driving this infrastructure renewal much faster than elsewhere. "We've invested £14bn in the last five years, and we'll be investing another £22bn in the next five years," says Holliday. "Only £6bn of that is in the US, the remainder is in the UK."

"Over the last five years we've built the capability to deliver this huge investment programme," Holliday continues. "We've broadened our supply chain and are working with major contractors to ensure they understand our investment plans and are ready to help us deliver. And we're working with schools and universities to encourage people into science and engineering so we have the qualified technicians and engineers we need for tomorrow."

What kind of industry will these engineers of the future find themselves working in? "One of the questions I always get asked is: 'What's the right mix of energy?'," says Holliday. "'Is it wind, is it solar, is it nuclear?' The answer is: all of these. To get a secure, lower carbon and affordable energy supply, you need to pursue all the available solutions, including carbon capture and storage."

"It's inconceivable that a natural resource like the world's remaining coal will remain unexploited, particularly in the Far East," he continues. "So we have to find a way of capturing the carbon that burning it produces. The UK can lead the field, as it already has a number of depleted gas fields where carbon could be stored, as well as the infrastructure needed to pump it there. At National Grid, we're currently working with universities and generator companies on pilot work in this area and we certainly see it as part of the energy future."

Holliday believes that nuclear power also has a vital role to play. "We cannot de-carbonise electricity and continue to deliver reliable energy supplies without nuclear energy," he says. "In the future, a significant proportion of our energy will come from nuclear power. It will help to keep energy costs down, which makes it an essential part of the energy picture."

Although Holliday believes in pursuing all promising technologies, he also believes carbon reduction is vital and is keen that National Grid should lead the way. "Before government targets came into force we had already set ourselves a target of reducing our CO_2 emissions by 45% by 2020," he explains. "We're on track to meet that target. For each of our investment projects we monitor our carbon footprint, and look at options for reducing that footprint wherever we can. We also have climate change champions across the business. And our largest centre in the US, just outside Boston, has been awarded an LEED Platinum rating."

"If I had a magic wand, I would use it to put energy efficiency much higher on everyone's agenda."

Not only does energy-efficiency make environmental sense, it will also – increasingly – make financial sense, says Holliday. "Investment in green power systems costs money, and energy businesses will need to recoup the costs," he explains. "This means charging customers more for their energy. So as a consumer, reducing your consumption will be an important way to keep down the cost of the energy you use."

"If I had a magic wand, I would use it to put energy efficiency much higher on everyone's agenda," Holliday concludes. "One of my biggest concerns is how to get people to use less energy – our ability to meet carbon reduction targets relies on reducing our energy consumption."

Do the green thing

Changing behaviour to save energy

Meeting targets for saving energy, reducing waste or increasing recycling can be tougher than many organisations expect. By the end of 2009, nearly a third of UK government departments were missing their CO_2 emission reduction targets.[1] Could the psychology of behavioural change help?

"Rather than relying solely on technology, organisations are recognising that you need to work with employees rather than impose things on them," says Jonathan Taylor, an occupational psychologist and member of Arup's people and organisational change team.

"You can build a great piece of sustainable technology but people might not use it effectively unless you encourage this behaviour," adds fellow Arup occupational psychologist Laura Bache. "With energy-saving technology like automatic lights or temperature gauges, people can still manipulate it to suit their own purpose."

Positive reinforcement

So how can companies incentivise green behaviour? "People are influenced by the here-and-now," says Bache. "You need to use positive reinforcement to link their green behaviour to an immediate positive outcome."

"Traditionally, green initiatives have relied on making people feel guilty if they don't act," she continues. "But guilt only encourages people to do the minimum needed. It's much more powerful to incentivise green behaviour, to make it a habit."

"Positive reinforcement works best when it's immediate and framed in an accessible way, such as referring to savings using monetary value rather than carbon emissions," adds Taylor. "So you could display a message at the end of a video conference telling people how much money they've saved by not travelling to the meeting."

Creating a sense of urgency

It's important for these messages to make green issues feel urgent, argues Taylor. "Most people recognise the need to be more sustainable," he says. "But they feel the need to save energy as a future necessity rather than an immediate need. As a result, people will often put their current needs first."

"Companies need to make energy-saving feel urgent by pairing it with an immediate issue people care about. This could mean reinvesting money saved into causes employees are passionate about, such as the Pakistani Flood Appeal. But it could simply mean providing more reasons to save energy – such as enhancing the company's reputation or the need to reduce spending in difficult times."

Webs of behaviours

Understanding the way we behave is the key to changing how we act, says Taylor. "We often assume that humans are logical and rational," he explains. "But psychological research suggests we can be irrational in predictable ways, driven more by habit than conscious thought. For example, your recycling behaviour will be affected by the way you're used to dealing with waste."

"This means behaviour change initiatives need to recognise that behaviours form in webs, they are inter-connected," he continues. "The most effective way to change behaviours is to look at key decision points within a behavioural cycle which can be targeted to make long-lasting changes."

"For example, people may get into the habit of leaving their monitor on when shutting their PC down. Rather than a communication campaign that they will read and forget, why not target the point at which the employee can act? You could include a pop-up message when they log off, which makes them question their normal routine."

Leading from the top

Crucially, say Bache and Taylor, green behaviour must be everyone's business. "One mistake companies often make is to have a green team," says Bache. "But for employees this makes it seem that being green is someone else's job. It has to be clear that it's everyone's responsibility to do things like saving energy or recycling."

This responsibility has to extend to board level, says Taylor. "Champions in an organisation are important, but if they don't have the authority to make the change happen – and it's not embedded into the company's metrics – it won't have the same impact," he says. "It won't be seen as commercially important."

Designing for green behaviour

Sarah Daly, managing director of Cheltenham-based Heath Avery Architects, has focussed on engaging clients with green behaviour in this holistic way. "We're trying to get organisations to think about behaviour change as a whole – beyond energy to really understanding the multiple gains in health and wellbeing, productivity and other factors," she explains.

"To illustrate this with clients, we've devised a return-on-sustainable-investment calculator. This shows that designing high performance, energy-efficient buildings delivers huge pay-backs. We recently showed a large insurance company how the sustainable design of its new headquarters could save the company £21m each year by halving staff turnover and increasing productivity by 5%. We know that for every one degree of overheating, for example, people's productivity falls by an average of 1.8%. Not only is this costly in energy and carbon terms but the real cost is millions to industry. The performance numbers eclipse the energy figures yet are never used in specification appraisals."

"My work is all about showing organisations the direct benefits they can

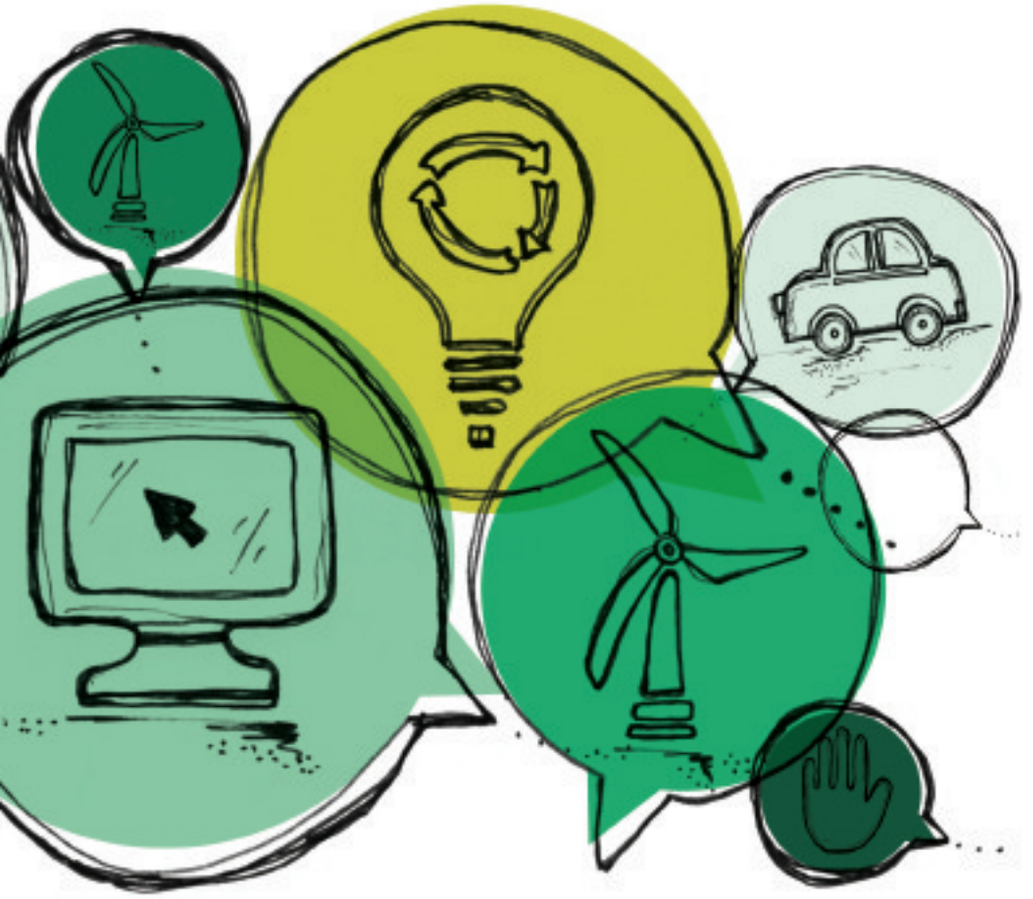


Illustration © Dawn Gardner

get from green behaviour changes coupled with investment in refurbishment or new build, rather than talking about the impact of energy and carbon reductions alone," says Sarah. "If you get the other areas right, these reductions will naturally follow. We need to talk less about the features and benefits of technical solutions and more about the overall benefits to organisational performance, because this is what will keep the company competitive and safeguard jobs."

"This holistic approach to green behavioural change is the method that's most likely to get results," agrees Bache. "And with deadlines for CO_2 reductions looming, there's an increasingly urgent need for those results."

Easy Green
Switching people on to green power

A pilot project in South Australia is making it easy for people to choose green energy – by automatically opting them in to receive it. The Easy Green scheme hopes to overcome people's natural inertia over changing their energy supply.

"A lot of people want to switch to green energy but most never get around to actually doing it," says Tim Jarvis, Arup consultant and creator of Easy Green. "This scheme overcomes that inertia by automatically supplying them with green energy and offering them the chance to opt out."

With the backing of Australia's two principal energy companies, and involving thousands of households, Easy Green will run for ten months from the end of 2010. Those taking part will be opted in to a green energy supply, with different groups offered different levels of information and energy pricing to determine the reasons why people choose to opt out. The results will be assessed to see how opting people in increases the number of households receiving green energy.

"By connecting more consumers to green energy in this way, we can encourage suppliers to build the infrastructure needed to generate more of it," says Jarvis. "As things stand, we haven't got a chance of reducing CO_2 emissions by 80% by 2050. That's why we need a scheme like this. I think Easy Green could get an extra 20% of people opted in to receive green energy."

Footnote
1 The State of the Estates in 2009, OGC (2010, p.5)

Green behaviour checklist

Make it normal

- Create champions to influence others
- Use a pilot scheme to find role models and create success stories
- Publicise what others are doing and create competition
- Make people feel part of a community

Create awareness

- Educate people to dispel any myths
- Create a sense of urgency
- Reinvest in causes chosen by employees
- Publicise positive actions

Give recognition

- Offer incentives to encourage sustainable behaviour
- Provide positive reinforcement to make effort worthwhile (don't rely on guilt)
- Give immediate feedback where possible

Set goals

- Work with your team to set clear, achievable goals
- Make goals public to create pressure to meet them

Overcome barriers

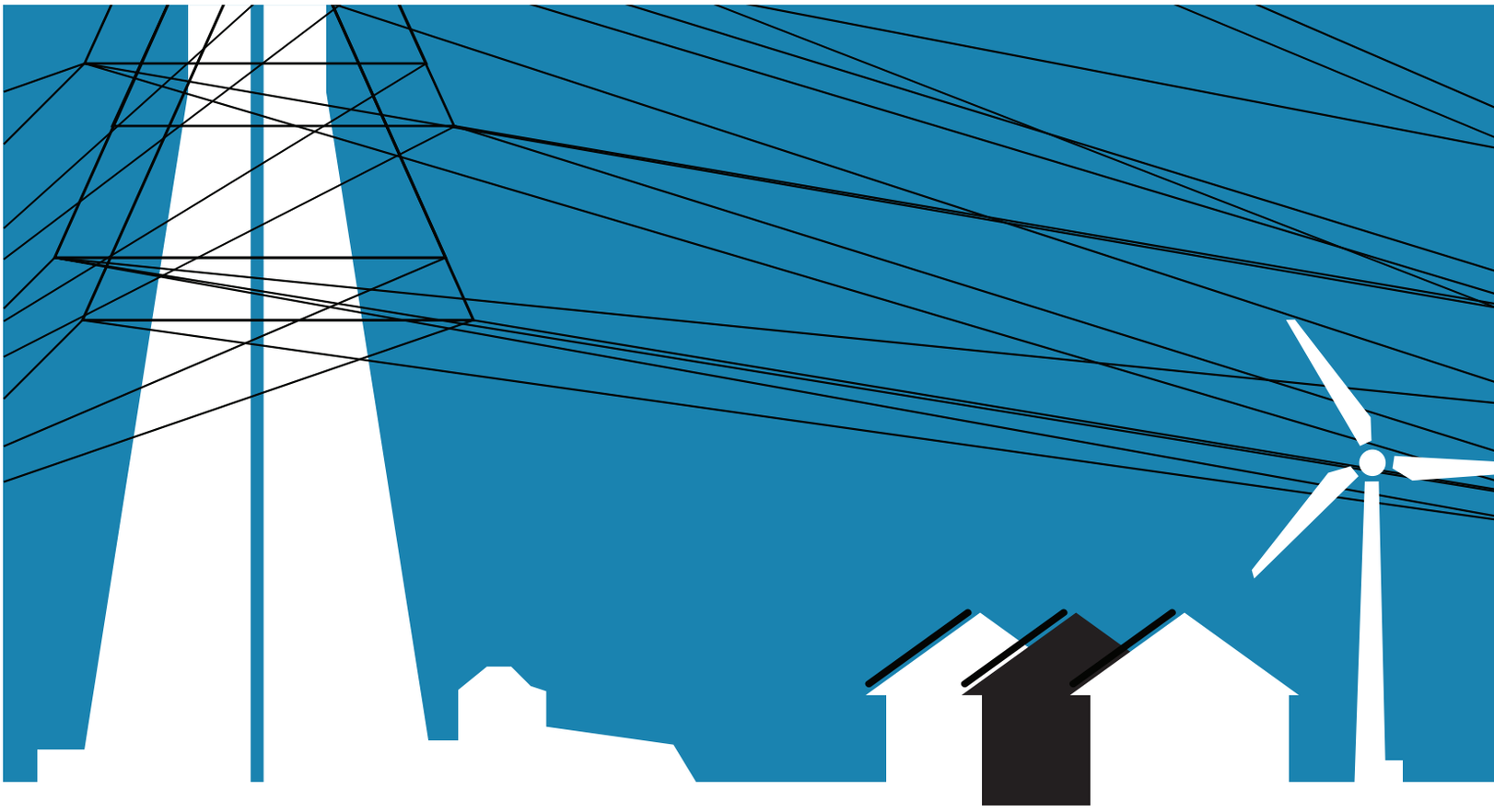
- Make sure people know exactly what to do
- Design facilities around the needs of the team
- Make being green more convenient than not being green
- Engage people from the beginning to make them part of the solution

Change habits

- Provide information only when it's needed so people take it in
- Identify key points that can be targeted for change
- Make green behaviour automatic

Generate your own energy

Fit for the Future – making small-scale renewable energy pay



A new report from Arup and Friends of the Earth is helping people to make the most of the UK's Feed-in Tariffs. Launched in September 2010, Fit for the Future is the first ever analysis of the financial performance of local renewable electricity projects using the UK's new Feed-in Tariffs (FITs) and the proposed Renewable Heat Incentive (RHI).

"Arup's analysis shows how the Feed-in Tariff makes small-scale renewable energy commercially viable for local authorities, schools, housing associations and other organisations – as well as individuals," explains Quentin Given, major campaign coordinator for Friends of the Earth. "Before this report, it was difficult for them to get useful data."

Introduced across the UK in April 2010, the Feed-in Tariff sees the government pay a guaranteed, above-market price for renewable electricity generated on a small scale (less than 5MW). And the RHI – a similar scheme for renewable heat generation – is due to start in 2011. The schemes cover things like solar power, wind turbines and biomass boilers.

The schemes follow success in other countries. In Germany, feed-in tariffs have helped the country to get 16% of its electricity from wind, solar and other renewable sources – three times more than 15 years ago.

"The introduction of the Feed-in Tariff is a pivotal moment in the UK renewables market," says Mark Watts, a director of Arup's energy consulting team. "It has the potential to unlock investment in a vast number of small-scale renewable energy systems across the country, which are necessary to the UK achieving its target of producing 20% of its energy from renewable sources by 2020."

"Before the Feed-in Tariff was introduced in the UK, mostly just big energy companies would invest in renewables," explains Arup engineer Tom Bailey, who also worked on the report. "Groups such as local authorities, home owners and community organisations were put off by the investment risk and the complexity. The Feed-in Tariff is designed to help them."

But to take full advantage of the tariff, organisations need to know how to develop viable small-scale renewable energy

"The introduction of the Feed-in Tariff is a pivotal moment in the UK renewables market."

Mark Watts, Director
Arup energy consulting team

schemes – vital information that this report gives them. "This is the first piece of work that attempts to communicate the Feed-in Tariff in terms that are important to local authorities and similar organisations," says Bailey. "It focuses on issues such as rates of return and payback, as well as explaining the factors that influence whether a renewable energy scheme is viable."

The report shows, for example, that a community co-operative could buy a 1.5MW wind turbine (enough to power 1,000 homes) and potentially get up to a 15.9% return on investment annually for 20 years. The scheme would pay for itself in just seven years.

Fitting 8kW solar panels to a community centre could generate up to 11.5% annual return for 25 years, with the scheme paying for itself in around eight years.

And a school could earn almost £8,000 a year by putting up a 15m tall wind turbine on its playing fields, while a housing association could earn more than £7,500 a year by installing 20kW solar panels on a small block of flats.

With the report revealing how to unlock such potential, it's not surprising that Fit for the Future has attracted a lot of attention. "We've had a tremendous amount of interest in the report from local authorities across the UK," says Bailey.

Working with the Energy Saving Trust and Friends of the Earth, Arup presented the report to over 600 representatives from housing associations, local authorities and other organisations in a series of four free seminars. Following the general election, Arup's analysis also helped Friends of the Earth campaign to save the Feed-in Tariff.

"The research for the report helped us protect the Feed-in Tariff and Renewable Heat Incentive," says Given. We arranged a meeting with Chris Huhne, the Secretary of State for Energy and Climate Change, where Mark Watts and Tom Bailey from Arup presented a summary of the research. By that time the new government had lifted the restrictions on local authorities selling electricity they generate. Thanks to the report we were able to demonstrate how this – together with the Feed-in Tariff – could unlock massive potential."

The recent government spending review announced that Feed-in Tariffs will be refocused on the most cost-effective technologies, and that the Renewable Heat Incentive would be funded out of the public purse. "While we would have liked more, we were still delighted with the result," says Given. "We knew that the Treasury wanted to cut back the scale of scheme and we think the report and the work done around it was decisive in preserving them."

To download a copy of Fit for the Future, visit: http://www.foe.co.uk/resource/reports/fit_for_future.pdf

In the pipeline

A new study models the CO_2 transportation infrastructure needed for Europe's carbon capture and storage plans

The emerging technology of carbon capture and storage takes CO_2 emissions from sources like coal-fired power stations and stores them underground or beneath the sea floor in sinks. Getting emissions from their source to suitable storage sites will require a network of pipes.

A joint study for the European Commission (EC) by Arup and Scottish Carbon Capture and Storage shows, for the first time on a Europe-wide scale, the network that will be required to transport CO_2 across the continent and make carbon capture and storage a reality. The study reveals that unless objections to onshore storage are overcome, a much more extensive – and expensive – pipe network will be needed to transport CO_2 offshore.

Dom Ainger is the hydraulic modelling and pipeline engineer who led Arup's work on the study. "The shape and extent of the network needed for CO_2 transportation depends on whether onshore storage is available and accepted," he says. "And the total network costs are highly variable – depending on the quantities of CO_2 captured. But the study indicates that using onshore storage could save up to €7bn."

Proposals for onshore storage in the Netherlands and Germany have encountered public objections, mainly due to concerns about leakage and worries that it could affect property values. Onshore CO_2 is already used in Algeria and Canada, but these are relatively unpopulated areas.

Because Europe has a lot of potential onshore storage, pipe networks could be much less extensive than even the researchers expected. "Before running the model we anticipated that pipelines might need to grow into a large, interconnected network by 2050," explains Ainger. "But in most onshore scenarios the results showed relatively little interconnection and cross-border transportation."

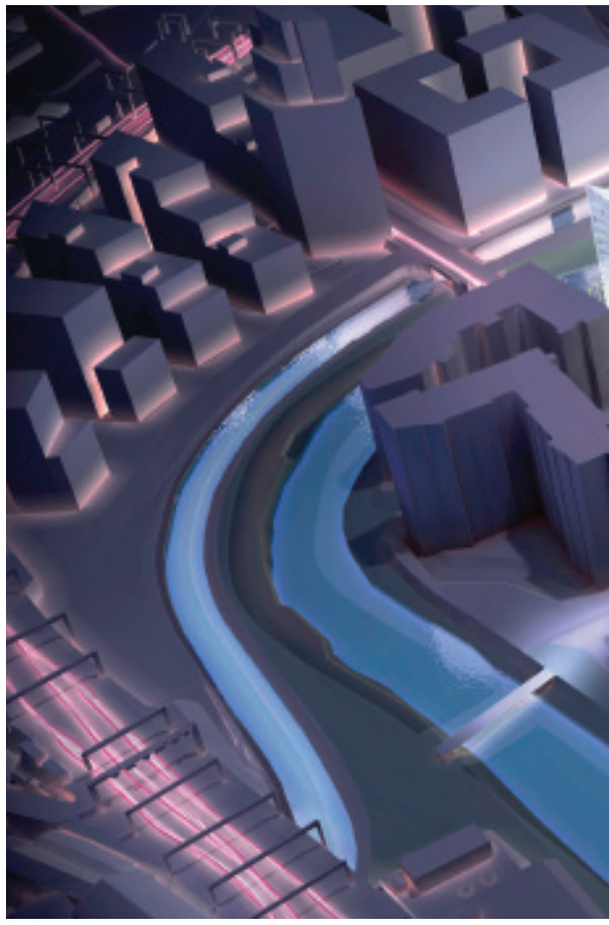
To establish these scenarios, the team began by looking at the amount of storage available – using data from the GeoCapacity project that was set up to assess European capacity for geological storage of CO_2. This showed that the continent has around 120 gigatonnes of storage capacity; enough to last for many decades if utilised efficiently.

Next, they used existing economic information to come up with three scenarios for CO_2 capture in 2030 and 2050: low, medium and high. After plotting sources and sinks on a map to show their location and scale, the team began to identify a blueprint for the transportation infrastructure that each scenario would need. They used an optimisation algorithm to find the most cost-effective network to link sources with sinks.

Aside from the question of onshore storage, the model raises other important issues planners will need to consider as they look into CO_2 transportation. "By testing different network layouts, the model showed there is a cost premium for security of supply," says Ainger. "Building duplicate routes would be very expensive. It also shows that by 2050 much more capacity will be needed than at 2030, so much so that it could be cheaper to build a lower-cost network and replace or upgrade it before then."

"It shows that hydraulic models with optimisation algorithms can be used to study key strategic planning issues," Ainger concludes.

The team presented their report to the European Commission's Fossil Fuels Forum (the Berlin Forum) in October 2010. Here it was confirmed that CO_2 transportation would be included in a new European instrument for energy infrastructure, due in 2011.



Power to the people

Making distributed energy viable: the public sector's role

"With sustainability targets and legislation driving increased interest in distributed energy, the public sector has a vital part to play in developing low-carbon energy infrastructure," says Malcolm Ball, head of Arup's energy strategy team.

In many countries, the deregulation of the energy sector – ending the top-down approach to power generation – has fostered the growth of distributed energy. By 2003, the US was already generating an estimated 250,000GWh of electricity in this way, roughly one tenth of its total generating capacity.[1]

In the UK, government policy is focusing more attention on distributed energy. "Planning policy increasingly requires that new developments are connected to district heating schemes," explains Paula Kirk, an associate in Arup's energy strategy team. "This puts the onus on private sector developers to consider combined heat and power and ensure there is some connection to district heating."

But relying on the private sector alone can only get you so far, experts warn. "The commercial model for distributed energy lends itself to both the public and private sector," says Ball. "Selling the energy to homes and businesses can be done easily by the private sector. But the bit in the middle – the pipe that distributes the energy – is trickier. It's the asset that takes the longest to pay back, and its continued expansion is vital for schemes to grow. So it needs to be managed by someone who can take a long-term view."

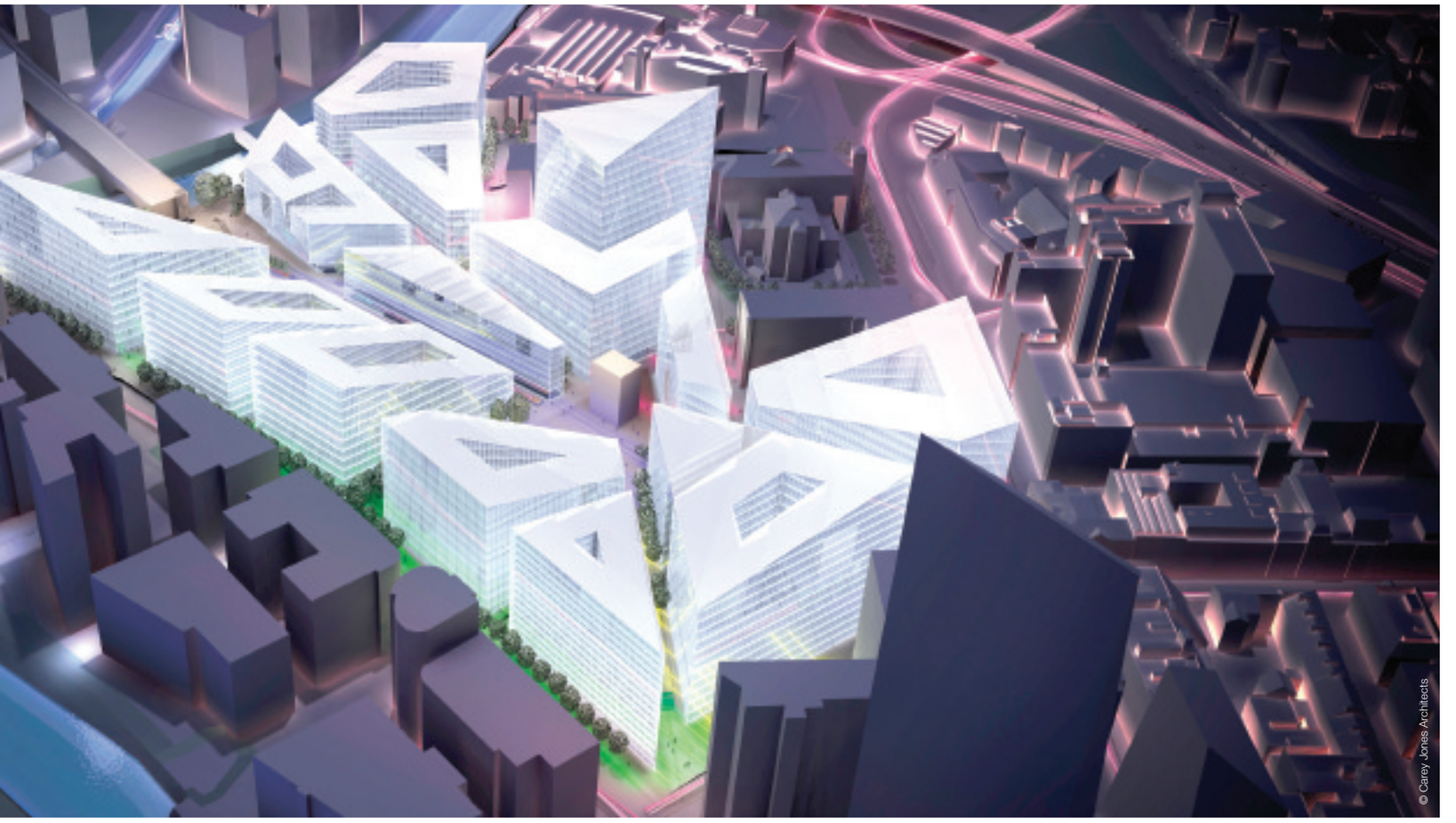
"Distributed energy projects often have a web of commercial histories that prevent them expanding in a logical way," he explains. "Birmingham is the only scheme I know of in the UK that is expanding rapidly. There is an arrangement between a private company and the city council that gives the council a say in what the company does with its pipe network."

In the US, Arup is working with developer Ekistics on a sustainable masterplan for a new urban community in the City of Baltimore – the State Center Project. As well as creating green building designed for the development's early phases, the firm is exploring sustainable, low-carbon infrastructure strategies which include distributed energy. The developer is particularly interested in learning how to use an existing district energy system to provide a cost-effective energy source for the mixed-use development.

"Communal energy systems have a number of benefits versus the business-as-usual approach," explains Brian Renehan, Arup's project manager for the State Center. "They save space in individual buildings. And they reduce the life-cycle costs of energy infrastructure, as well as lowering maintenance costs and improving reliability. They also allow you to use renewable energy sources such as solar thermal, solar electric (photovoltaics) and biogas. Using these with a district energy system further reduces the energy-related carbon footprint of a development."

If the results of Arup's initial feasibility studies show that there is potential to implement a combined district and renewable energy scheme in the State Center Project, more detailed technical and financial analysis will be required. This will look at the impact of available tax incentives, the availability of low-cost financing schemes, potential public-private ownership models and delivery methods.

"The detailed financial analysis will allow us to explore potential partnerships between the State of Maryland, a major stakeholder in this deal, and the private developer client," explains Renehan. "The



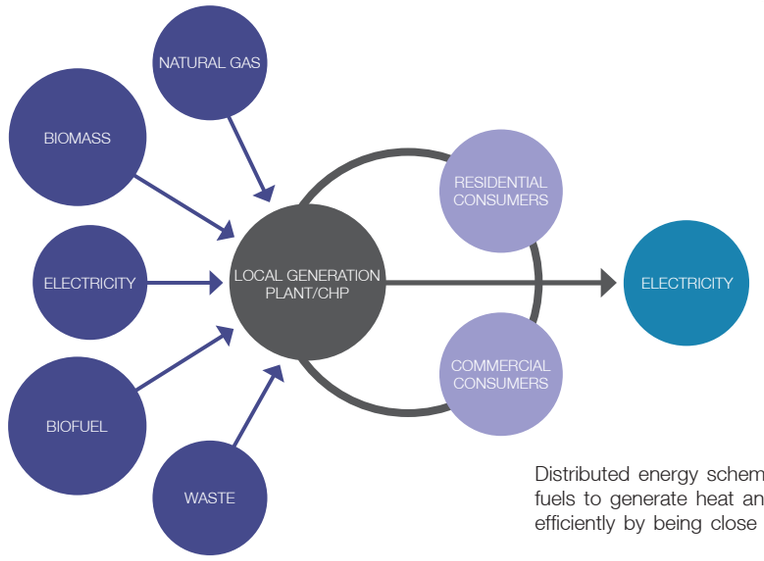
Wellington Place, Leeds

public sector has access to low-cost debt and cheap fuel, as well as the potential ability to clear regulatory issues that govern localised electricity distribution. The private sector has the ability to design, build and operate a high-quality facility more cost-effectively in the long term. We're trying to help our client put together a delivery structure that brings together the best of both worlds."

Ekistics hopes that making use of existing assets for the distributed energy system will reduce life-cycle costs and enable the project to meet its aggressive sustainability goals. "We hope the analysis will prove that this project is a win-win in terms of sustainability and economic benefits," says Chip Veise, the owner's representative for Ekistics and State Center LLC.

Should more public sector bodies be switched on to the potential of distributed energy? "The State Center Project could provide a vital demonstration of how public and private can work successfully together," concludes Ball.

Footnotes
1 The Future of Distributed Power Generation, Paul Breeze, Business Insight (2007, p.17)



Distributed energy schemes use a range of fuels to generate heat and electricity more efficiently by being close to the point of use.

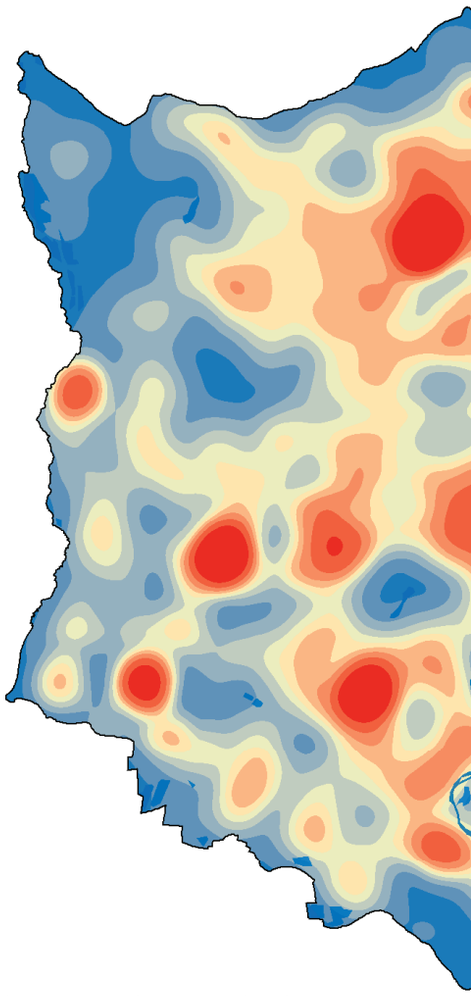
What is distributed energy?

Distributed energy schemes use a range of fuels – including waste and biomass – to generate heat and electricity more efficiently by being close to the point of use. The heat is used for district heating networks, to generate chilled water for cooling and for industrial processes. The electricity is sold locally or exported to the grid.

For example, a new hospital might use a combined heat and power (CHP) plant to generate its own heat and electricity. Using the excess heat produced by engines or microturbines in this way is more efficient, and has lower carbon emissions, than sourcing electricity from a large regional power plant and heat from on-site boilers. The hospital might also feed excess heat to a local housing development, or electricity to the grid, in order to improve the project's economics.

Hot topic: heat mapping

Why plotting the potential for low-carbon heat demands a joined-up approach



Heating homes, businesses and public buildings accounts for 17% of end-use CO_2 emissions in the UK. So meeting the government's targets to reduce emissions by 80% by 2050 will depend on developing commercially viable district heating networks.

"Generating low-carbon heat isn't difficult, but distributing it is," explains Malcolm Ball, head of Arup's energy strategy team. "You need to develop district heating networks, but first you need to identify where it's commercially viable to install them."

The solution? Heat maps. By plotting supply and demand, heat maps show where combined heat and power (CHP) and district heating schemes are viable. Once the heat map has identified opportunities, more detailed technical and financial feasibility studies can be carried out.

As part of its work on the city's Decentralised Energy Master Planning (DEMaP) programme, Arup manage the London Heat Map, which is currently being updated with real-world data collected by the different boroughs. "In London, having a common map helped join everything together across boundaries," says Ball. "So a large heat demand in one borough could be linked easily to a source in a neighbouring area."

The map has already helped to develop smaller projects in the Royal Docks area, as well as the wider London Thames Gateway Heat Network (LTGHN). This flagship scheme will connect up to 120,000 homes, business and public buildings through 67km of pipework. It will reduce annual CO_2 emissions by 100,000 tonnes.

With several schemes now close to completion, and suppliers, funders and customers negotiating contracts, London will soon have more community energy projects. Together, they will help the Mayor of London meet his targets to reduce carbon emissions by 60% and decarbonising 25% of the city's energy supply by 2025.

The Mayor of London's Environment Advisor, Martin Powell said: 'I am really pleased with the work we are doing with Arup on the London Heat Map. This is providing boroughs, private sector developers and heat suppliers with a reliable source of information about where distributed energy networks and opportunities exist. This is an essential part of a suite of interventions we are making to encourage and enable the delivery of district heating networks in the capital'.

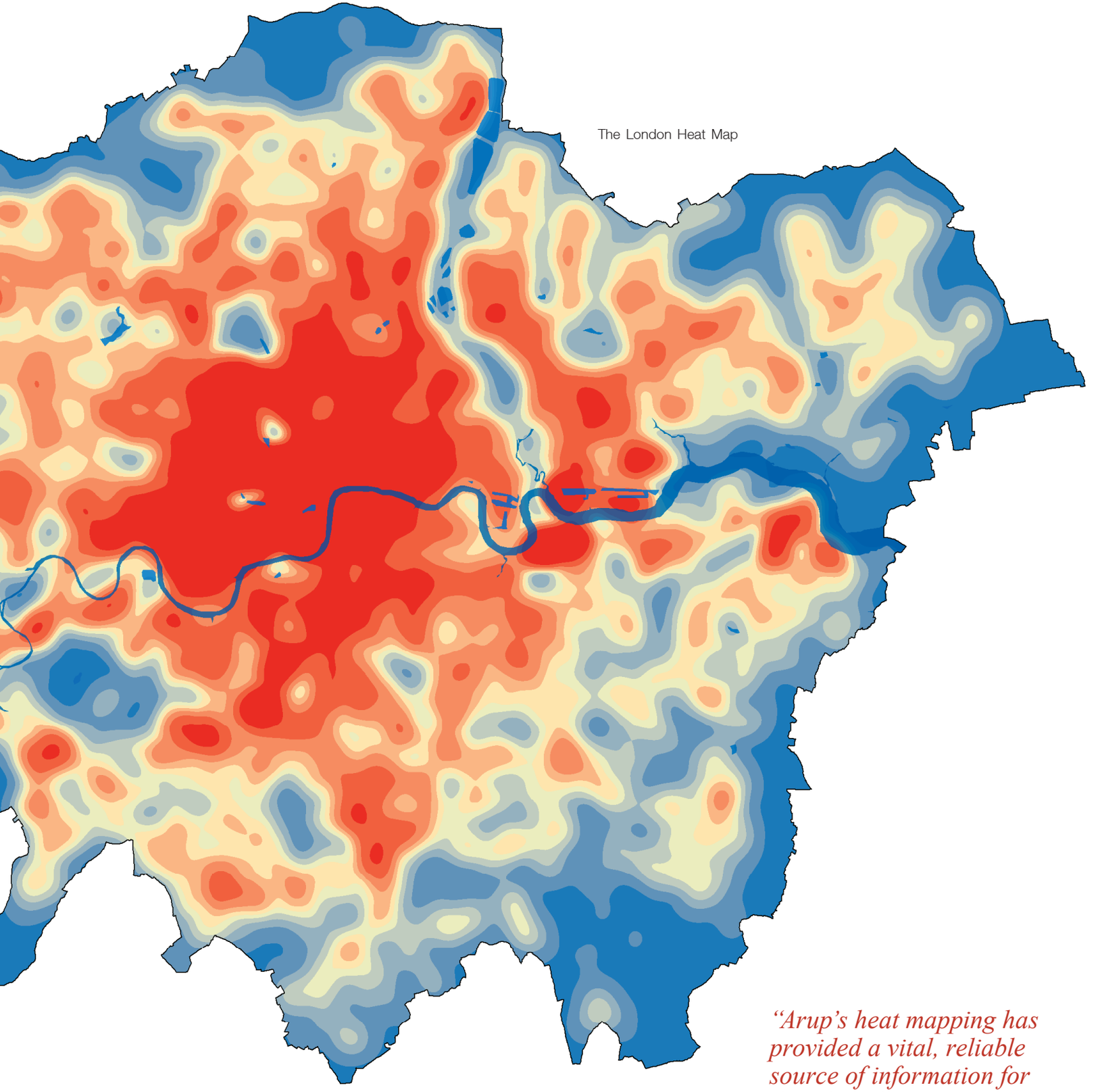
One key to the London Heat Map's success is its use of building specific real-world data – many other heat maps, including the national maps developed so far, use benchmarked data rather than actual readings.

The team behind the map also took the kind of pragmatic approach that building a national heat map would demand. "We focused on places that had obvious opportunities and carried out detailed mapping there," explains Paula Kirk, an associate in Arup's energy strategy team. "So we haven't mapped areas like Bromley, Havering or Richmond – the outer boroughs where we know there are fewer opportunities for district heating."

It's an approach she recommends on a national level. "There's no point in heat mapping the Outer Hebrides because they can't support a heat network," says Kirk. "A national map would need to look at which sources of low-carbon energy are right for each area. So, for example, the south west of the UK has more biomass available and also has the potential for tidal or wave energy. In urban areas, district heating is the obvious solution."

Kirk and Ball argue that UK policy should follow London's lead. "The London Plan – the spatial plan for the capital – says new developments must use the London Heat Map to see if they can connect to a heat network," explains Ball. "The previous government's Household Energy Management Strategy recommended London's approach should be replicated nationally."

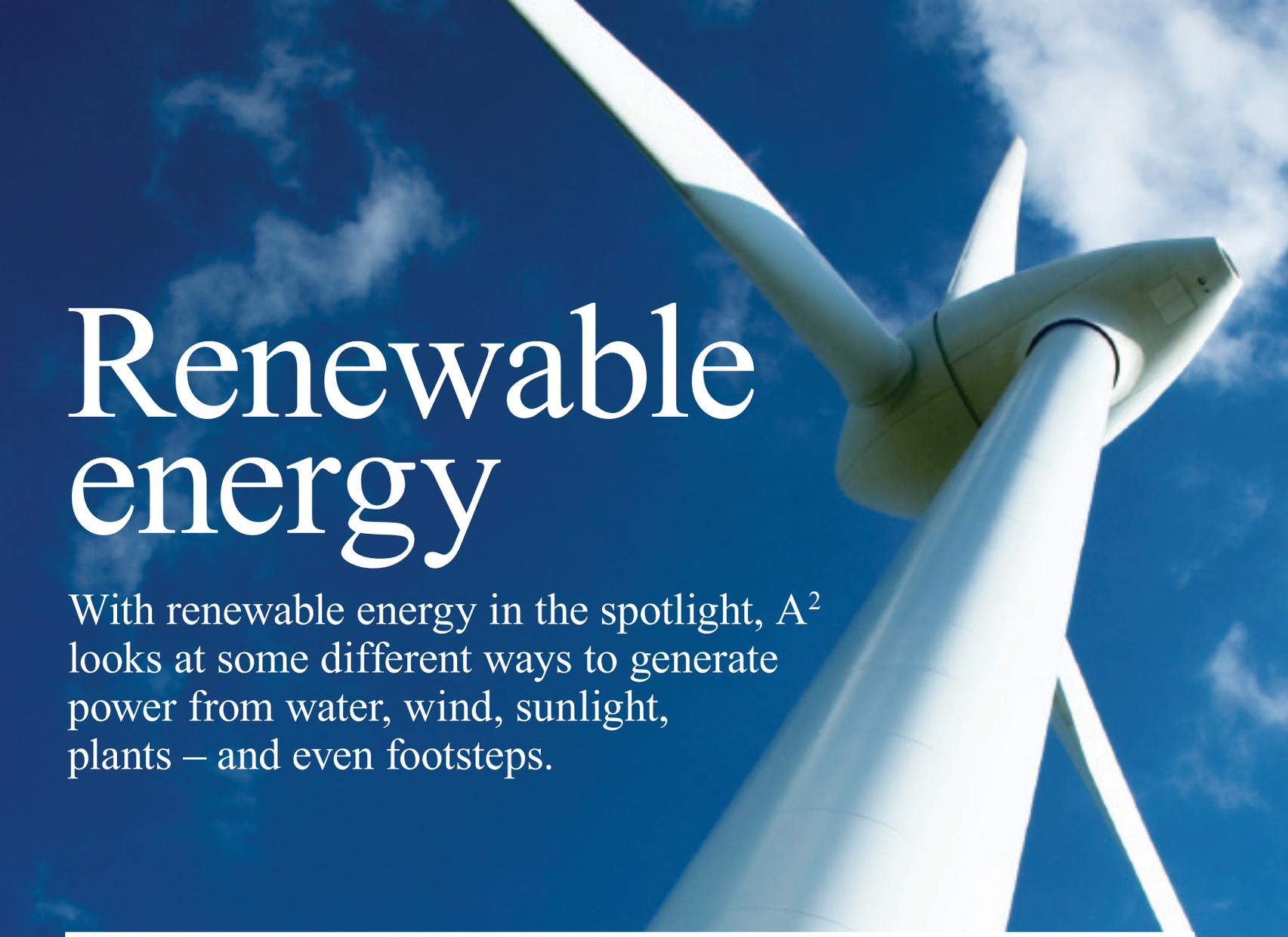
"We need a national map, drawn up to common standards and open to everyone, to help identify the best opportunities for low-carbon heat across the country. And, with the deadlines for reducing emissions drawing nearer, we need it now."



The London Heat Map

"Arup's heat mapping has provided a vital, reliable source of information for distributed energy projects across the capital."

Martin Powell, Director
London Development Agency



Renewable energy

With renewable energy in the spotlight, A[2] looks at some different ways to generate power from water, wind, sunlight, plants – and even footsteps.

Marine

Wave
What - Using the movement of waves to generate power.

Why - Waves are immensely powerful and have great potential for generating electricity. But they also present challenges for energy generating equipment. Systems must withstand the constant battering. And suitable locations for harnessing wave energy, such as the Pentland Firth in Scotland, are often far from where the energy is needed, making distribution inefficient. Despite this, the future of wave energy looks positive – a report from the Carbon Trust shows marine energy could supply up to 20% of the UK's electricity needs.

Where - As an island, the UK has the potential to tap into a significant amount of wave energy resource. One wave farm currently under development off the south-west coast of Shetland aims to generate enough electricity to meet the average yearly demand of approximately 13,000 homes – offsetting 25,000 tonnes of carbon dioxide each year.

Tidal flow
What - Using the flow of the tides to generate power.

Why - Although tidal flow power faces similar challenges to wave energy, tides are more predictable. Engineers look for fast, powerful, predictable tides. Lochs, estuaries and other places where the sea narrows amplify tidal range and generate the most tidal energy.

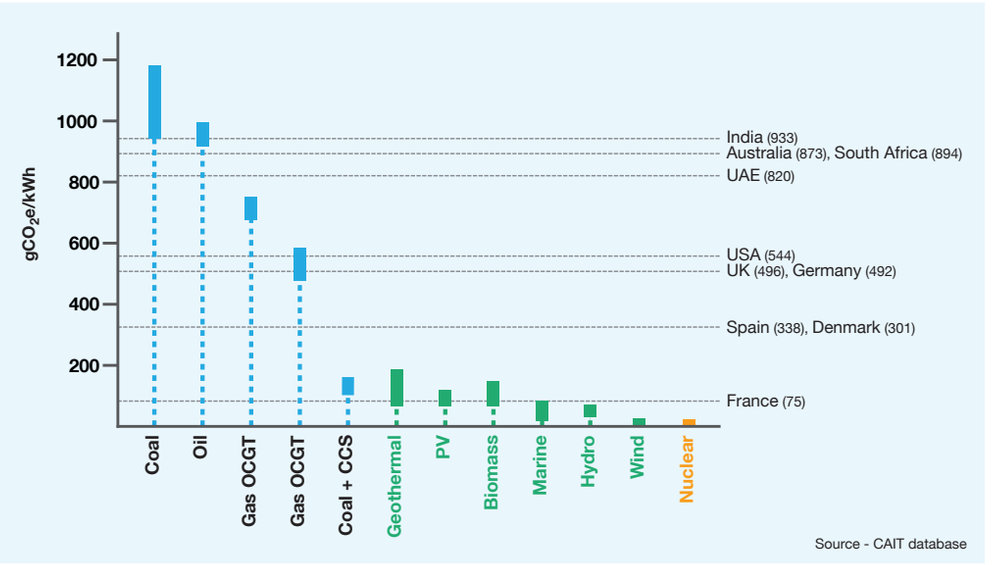
Current reports suggest that although up to 3,000GW of tidal energy is available to the UK, less than 3% is located in areas that are suitable for power generation. Even so, it is estimated that tidal energy could meet over 30% of the country's energy needs. Tidal flow power could make an important contribution to this.

Where - Strangford Lough, Northern Ireland, is home to the world's first commercial tidal generator. The SeaGen project delivers over 6,000MWh into the UK grid every year. An installation seven times larger is planned for a fast-flowing patch of open sea – known as The Skerries – off the Welsh island of Anglesey.

Tidal range
What - Impounding tidal flow behind barrages in estuaries. When the tide drops, the water behind the dam is released through turbines to generate electricity.

Why - Tidal range power can generate predictable amounts of renewable energy at predictable times in the tidal cycle. It is not subject to the unpredictable intermittency which is a feature of wind energy.

Where - A tidal range power plant has operated successfully in La Rance, France, for 45 years. Its peak output of 240MW is enough to power 4% of the homes in Brittany, France. A similar scheme has been proposed for the Severn estuary in the UK. Here, the barrage would produce enough renewable energy for three million homes – more than 5% of the UK energy demand.



Relative carbon intensity of renewables

Biofuels

Wood chips and wood pellets
What - Chips of wood between one and five centimetres long and pellets of compressed sawdust up to three centimetres long.

Why - You can use wood chips and pellets to generate either heat, as you would a gas boiler, or combined heat and power (CHP). Although they can be cheaper than gas on a like-for-like energy basis, the capital cost of boilers is three to four times higher than gas-fired equivalents.

Wood chips are less expensive than wood pellets to produce (you just need a wood chipper). But pellets have a higher energy density because they have a lower moisture content and more consistent quality.

Provided you replace the trees and don't transport the fuel long distances, burning wood chips can save a lot of CO_2 compared to gas – emissions are around 80% lower per unit of heat produced. However, it can be difficult to source and store the large volume of fuel needed and to keep it dry.

Where - The Eden Project in St Austell, Cornwall, burns wood chips in a biomass boiler to produce 60% of its heating. The majority of this fuel is grown locally.

Algae
What - Growing algae and extracting the oil to use as a fuel.

Why - Algae could be the only way we can swap fossil fuels for biofuel without reducing the land available for growing food, and the approach enjoys a lot of political support.

Algae grow much faster than crops like palm oil and sugar cane, which are conventionally used to produce biofuel. And the high-quality oil extracted has the potential to replace crude oil for uses such as aviation.

Investment in research and development to improve the efficiency of algae biofuel production promises to make it commercially viable on a large scale. There is plenty of political support for its development.

Where - Algae farms have been operating around the world for over 30 years in countries such as Mexico, India, Israel, Japan, Thailand and the USA. Most are 100 acres or less and there are many more small-scale pilot projects. Expect to see more large-scale farms in the near future.

Wind

Offshore
What - Generating electricity from wind by building turbines out at sea.

Why - Wind speed is generally 20% stronger offshore, where it can pass uninterrupted over long stretches of relatively flat ocean. Offshore turbines have less visual impact than onshore ones, which often attract objections. Also, there are plenty of suitable locations available offshore.

However, maintenance costs are considerably higher than on land. The towers and the sea bed need protecting to prevent the turbines' foundations being eroded. They also need to be connected to the shore using large cables, a process which requires careful engineering.

Where - Currently, Europe has over 1,500MW of generation installed. And the UK has one of the best offshore wind capacities in the world, with an estimated potential of 986TWh per year. Just over 500MW of generation is already installed, with plans in place for a further 32GW by 2020.

The planned London Array wind farm off the Kent and Essex coasts would see up to 341 turbines installed over a four year period. When fully complete the project would generate up to 1,000MW of electricity. This is enough to supply 750,000 homes – around a quarter of Greater London, or all the homes in Kent and East Sussex.

Onshore
What - Generating electricity from turbines at windy locations on land.

Why - Onshore wind energy is currently the lowest cost form of renewable electricity generation in the UK. The range of onshore wind farms varies, from small domestic turbines up to those producing hundreds of megawatts.

Where - Wind energy is increasingly used as an embedded form of generation, where the energy is used at source – wind turbines integrated into buildings, for example. This avoids transmission losses and makes investment in the technology more worthwhile.

Solar collectors, Colston Hall

In the UK, Arup has helped Yorkshire Water install two turbines at its Loftsome Bridge Water Treatment Works. These meet around a third of the site's energy needs and contribute to the company's target of generating 10% of its energy from renewable sources.

Solar

Photovoltaics (PV) and solar thermal
What - Using sunlight to generate electricity and heat.

Why - Harnessing some of the sun's immense energy and converting it to electricity using photovoltaics PV would reduce fossil fuel consumption. PV systems are very low-maintenance and can last for 25 years or more. They're ideally suited to towns and cities, where they can be incorporated into the facades and roofs of buildings. However, over 80% of the world's PV systems rely on silicon. This makes them one of the most expensive ways of generating renewable electricity.

Solar thermal heat panels are relatively cheap and easy to fit to roofs. They can supplement other systems by meeting 30-40% of domestic hot water needs. Although more expensive than flat panels, evacuated tube systems – effectively see-through thermos flasks – prevent heat loss through conduction or convection, take up less space, and can achieve much higher efficiencies.

Concentrated solar thermal uses mirrors or lenses to focus sunlight, heat liquid, make steam and drive turbines to generate electricity. A relatively low-cost option, in Spain and the US solar concentrating technology promises to generate energy at around grid prices in under ten years. But this simple concept relies on brilliant sunshine and there must be a backup system to keep the turbine running in cloudy weather. It also needs a lot of water and this can be hard to find in sunny areas.

Where - The BedZed development in London uses PV to generate electricity for residential use. In Manchester, PV was added as a facade to the CIS Tower during a retrofit, demonstrating its potential for commercial space. And solar power is becoming increasingly widespread – in the last year alone Arup has advised on the potential acquisition of over 160MW of grid-connected PV projects across Europe.

Geothermal

What - Using natural heat from the Earth's crust and mantle to generate electricity and heat homes.

Why - Heat from deep in the Earth can be transported to the surface by groundwater. In tectonically active and volcanic areas, water at more than 200°C (392°F) is found in faulted rocks. This can be recovered from boreholes thousands of metres deep and used to drive turbines to generate electricity. Even away from tectonically active regions, there are areas of granite where water at around 100°C (212°F) can be recovered from shallower depths and used for district heating.

Where - Geothermal energy can be tapped at tectonic plate boundaries around the world and areas underlain by certain types of granite. In Australia, plans are underway to exploit high temperature granite deposits at depths of about 5km. Similarly, the south west and north of the UK have geothermal potential and exploratory drilling is planned in these areas.

Intermediate temperature geothermal energy sites have been developed throughout Europe for district heating. In the UK, Arup has studied potential sites in Belfast, Manchester and Newcastle.

Hydropower

What - Using the flow of water through a height drop to drive a turbine.

Why - Hydropower is currently the world's largest source of renewable electricity. According to the International Energy Agency (IEA) it accounts for 16% of worldwide supply. As well as large-scale projects, smaller hydropower schemes have great potential.

The technology for these is simple, robust and reliable with low maintenance costs. This makes them ideal for off-grid developments in rural areas and developing countries. And – compared with other renewable technologies – hydropower generation provides a relatively constant supply of electricity. But output can depend on the weather – particularly with run-of-river schemes, which are likely to generate less power during dry months.

Where - Hydropower is viable wherever there is a suitable flow and head (the vertical distance the water falls). At Esholt Wastewater Treatment Works in Yorkshire, UK, Arup identified the opportunity to use a 10m fall to generate electricity using a hydro-turbine. Using Archimedian screws, the turbine generates energy equivalent to £110,000 per year.

In the UK, the recent introduction of Renewables Obligation Certificates and Feed-in Tariffs means many smaller hydropower schemes have become attractive investment opportunities. A number of former mill sites are now being redeveloped for hydro-electric generation.

For further information about renewable energy please email steve.saunders@arup.com or simon.power@arup.com

Hungry giants

Data centres consume huge amounts of energy and there are opportunities to make them a lot more efficient.

Back to the future

Changing attitudes to energy will shape tomorrow's world

Illustration © Dawn Gardner

How can we hope to understand an issue as big as energy? Dr Chris Luebkeman, director of Arup's Foresight and Innovation team, offers his insight into the factors affecting the past, present and future of power.

"In our work at Arup, I like to think of extremes," says Luebkeman. "What if energy were free? Or what if the cost triples? What would our cities look like then? What would it mean for how we live our lives?"

"Over the years I've learnt three things in particular," he continues. "Change is constant, the future is fiction and participation is what shapes our world. The way we use energy has changed tremendously and it will do so again – leading to a very different future. But this future will be shaped by us and we have the opportunity, and responsibility, to change the world for the better."

Luebkeman gives an example of a change that might result from future efforts to conserve energy. "Imagine if you had an allowance for resources like energy and water on your hotel bill," he says. "You could save money by using less – or have to pay more if you use more. Hotels could make this part of their loyalty schemes, rewarding people who save energy over the year because it is good for business and the world."

Generational understanding

This example leads Luebkeman to the first of his key talking points on energy: generational understanding. "Older people might not like the idea of a hotel monitoring their energy use," he says. "But twenty-somethings would get into it, enjoying tracking their usage and that of their peers both near and far."

"It shows you have to consider what is normal – in terms of access to energy – for each generation," says Luebkeman. "Our grandparents expected to put a sweater on in the winter, now we expect to heat our homes and offices so we can wear shirtsleeves all year round. In the near future, sweaters might come back into fashion."

Accessibility

Geography also affects people's expectations of energy, argues Luebkeman. "You can think of access to energy as a pyramid," he says. "There is a brown agenda at the base of the pyramid and a green agenda at the top. The brown agenda is about getting access to energy, it's fundamentally about development. The green agenda is about getting access to clean energy. Our greatest challenge is to merge these two."

"Access to energy, information and intellectual resources has previously been unevenly distributed around the world – with areas such as Africa poorly served," Luebkeman continues. "But this is now rapidly changing as growing accessibility to all three is enabling the brown agenda to be green."

"For me, this is illustrated by one story in particular," he says. "A few years ago at TED, a conference for the world's most fascinating thinkers and doers, I had the pleasure of meeting William Kamkwamba. He's the Malawian teenager who transformed his village by building electric windmills out of junk."

"At just 14 years old, William built an electricity-generating windmill from spare parts, working from rough plans he found in a library book. He knew that there had to be another clean, simple way to help his family and community. Increasing accessibility means the clean energy enjoyed by William's village may soon be more widespread in areas like this."

Connectivity

Of course, you can't think of energy in isolation. Modern societies depend on energy for everything from telephones to well pumps and transportation. They are, Luebkeman explains, all connected by energy.

It's another attitude to energy that has evolved over time, he points out. "My grandparents had a single telephone in the house and used it infrequently," Luebkeman remembers. "I grew up relying on analogue phones powered from the phone line itself. Today my daughter is devoted to her mobile phone, relying on energy to power her handset and the network that supports it. If the power went out, my grandparents still could make a call. This is no longer the case."

Reliability

Energy is connecting more people but the reliability of the power we depend on is far from certain. "We expect our energy to be reliable," he says. "But in most parts of the world seamless movement of energy and information remains the exception rather than the rule."

"I visited South Korea recently," he continues. "In Seoul, you can watch cable television on your phone while you're on the metro. You can pay for things with cash, your credit card, your transit card or your mobile phone. People there are accustomed to the fact that energy provides them with a reliable flow of accessible information."

Luebkeman found this – and the greeting that awaited him back in the UK – particularly interesting. "Sorry mate, cash only," said the taxi driver at Heathrow Airport.

"Countries like South Korea and India are developing modern, reliable energy infrastructures," he says. "They may soon be able to leapfrog countries that are currently more developed but whose energy infrastructure is ageing and is not being modernised."

Changing attitudes to energy and issues surrounding accessibility, connectivity and reliability clearly pose problems for us all. To those who predict a painful future of expensive, unreliable energy, Luebkeman has this response.

"I'm an optimist and I believe in people," he says. "We're adaptable and we'll figure it out. Besides, I'm quite looking forward to the day when people wear sweaters again."

Your carbon policy timeline

Navigate through the policy maze with Arup's guide to emissions, energy and efficiency legislation

Inside this edition of A² is your copy of Arup's new carbon policy timeline. Covering emissions, efficiency and energy, the timeline helps businesses respond to policy drivers by planning low-carbon investment.

"The timeline illustrates key aspects of UK carbon policy and the driving mechanisms designed to achieve those policies," explains Arup energy consultant Mark Anderson. "Organisations can use this to understand what they should invest in and by when."

"Take a director of a high street banking chain, for example," says Anderson. "They could be responsible for an estate and will need to understand their financial exposure to these mechanisms – the penalties they could face if their buildings aren't energy-efficient."

"At the moment, the bank might expect to get back most of its Carbon Reduction Commitment (CRC) payments. But the recent government spending review has indicated that no CRC payments will be recycled back to consumers. So the bank will need to become increasingly energy-efficient or face higher costs."

"Coupled with core business pressures, there's a lot for organisations to weigh up," Anderson continues. "We hope the timeline will help people understand and respond to impending changes. It offers a snapshot of current policy, supporting organisations as they examine the UK government's electricity market reform consultation."

Responding to policy

To start responding to carbon policy, Anderson advises businesses to understand their current situation and then take simple steps to reduce their emissions. "Putting it bluntly, you need to plug the hole in your bucket before you start filling it with water," he says. "Conventional energy-saving measures are a good, cost-effective starting point."

"After that, you'll find that policy drivers are taking us beyond the level of carbon reduction that can be achieved by energy efficiency and management alone. Meeting these more ambitious targets often requires investment in combined heat and power (CHP), renewable energy, and business and operational change throughout an estate."

Incentives and investment

"At Arup, a lot of our energy-consulting work is in this area – because the question of carbon is inseparable from the issue of economics," explains Anderson. "How will the mechanisms affect us? What are the incentives for us to invest in low-carbon technology? The timeline helps businesses answer these investment questions and, with our help, determine what the appropriate procurement options are."

"For example, we're currently working with a global pharmaceutical company on a biomass CHP plant," he says. "We're projecting the commercial feasibility over time, allowing for incentives, and looking at how the development will help their Carbon Reduction Commitment. We're also working with teaching hospitals and universities to help them determine how best to respond across their estates."

Public sector targets

Anderson and other members of the Arup energy team are also working to include policy drivers affecting public sector organisations in the timeline. "The fundamental drivers for local authorities, higher education organisations and the NHS are the same as for businesses," he explains. "But they have their own, tailor-made reduction targets."

Using the process shown in the timeline, Arup has helped Lancaster University and other organisations meet their reduction targets. Projects include developing site-wide energy metering and management systems; installing large-scale wind turbines (planning permitting); and refurbishing energy centres and heat distribution networks to incorporate CHP plants. Together, these have the potential to produce 50% of an estate's electricity requirements from low-carbon sources.

"Using the timeline, Arup helps organisations come up with intelligent procurement strategies to plan their investment effectively," concludes Anderson.

For further information regarding legislation please email neil.shaw@arup.com or mark.anderson@arup.com

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