

Megatrends – what do they mean for infrastructure planning?

December 2014





Modern, reliable and affordable infrastructure is a key driver of economic growth – and of living standards. Estimates of the world’s infrastructure investment requirement over the coming decades run into the trillions of dollars. While developed countries will want more, and more sophisticated, infrastructure systems, developing countries still need the basics – water, energy, sanitation and basic access to education and health facilities.

There are some obvious challenges at a macro level – having the right type and variety of commercial models to deliver the projects, the availability of capability and, most importantly, affordability. Yet, is there a need for a fundamental shift in the way that infrastructure assets are planned, developed, procured and operated? Is it really just about delivering more?

What do these megatrends mean for infrastructure? Do they mean that we’ll need more of it? If so, will it be affordable? Will more infrastructure come at the expense of scarce resources and environmental health? Or can we be saved by technological breakthroughs? Here, we discuss four challenges to be addressed.

We argue that the impact of the global ‘megatrends’ – changes that will transform the world over the coming decades – will change the approach to infrastructure investment decisions. Megatrends, as identified by PwC, are described in the breakout box on page 5.

Infrastructure systems

Health



Education

Energy



1. Distributed assets – local solutions for modern people

Technological advances and the desire for resource efficiency make the case for moving the infrastructure needed to sustain life (energy, water and food) closer to the demand. Increased urbanisation improves the economics of having such assets ‘embedded’ in our living and working environments.

Energy supply is an easy example. In Australia, the major sources of energy are typically far removed from end users. For example, around 90 per cent of Victoria’s electricity is generated by the four large coal-fired power stations located in the Latrobe Valley, around 150 kilometres from central Melbourne, with Melbourne being home to 75 per cent of the state’s population. Long transmission distances require large capital investment in networks and result in large energy losses through transmission. Moreover,

Victoria’s generation from old brown coal-fuelled power stations is among the most greenhouse gas (GHG)-polluting on the planet.

Yet, there is an existing and proven low-GHG-emitting technology that can be located in heavily populated areas, and that can deliver base-load electricity (unlike solar and wind), as well as heating and cooling to residential district heating and cooling schemes, or to clusters of commercial buildings. Combined heat and power (CHP or cogeneration/trigeneration) – fired by natural gas, waste or biomass – can reduce GHG emissions by about 60 per cent compared with grid-delivered brown coal electricity, can avoid additional expenditure on transmission and distribution networks, and can improve the security of energy supply by being isolated from grid interruptions. Such distributed energy systems are well utilised in parts of Europe and North America

where, admittedly, the economics are improved by the cold climate; however, the main obstacle in Australia is the lack of government sponsorship.

In the past, central planning of the energy network was the domain of integrated, state-owned electricity entities, but disaggregation and/or privatisation of the electricity systems across each Australian state has resulted in individual generators, network providers and retailers, each concerned about their own commercial interests, without any incentive to develop options that will erode their existing businesses.

Local city councils have attempted to step up to the plate. Sydney City Council had plans for a major distributed energy scheme with an aim to supply 70 per cent of the city’s electricity needs by 2030, but now these plans have been scaled down to a small fraction of the original intent.

A number of other city councils across Australia have lacked success in this space. Arguably, local government needs assistance from higher levels of government to deal with the complex commercial, legal, regulatory, policy, market, planning, technical and risk issues inherent in distributed energy generation and reticulation projects.

Moreover, individual private enterprises are not able to lead market development in an effective way due to the need for government sponsorship and the need to pull together government bodies, private businesses and private residents to participate in the scheme.

2. Multi-use infrastructure assets – killing many birds with one stone

A basic knowledge of 19th- and 20th-century Western history (particularly United States and Australian history) tells us that infrastructure development ran in tandem with the settlement of a country and the evolution of technologies. The model was: wear some rough roads from A to B, then build a railway from A to B, then build a telegraph line from A to B, and then eventually build some electricity transmission lines, possibly along the same route.

Now, we live in an age of multiple proven infrastructure models and sophisticated emerging technologies. A linear adoption is no longer necessary or appropriate. A current project in the United States (supported by the United States Government and General Electric) is a neat case in point. The plan is to build roads from super-strong glass and solar cells to generate electricity. If the technology

was applied to all of the country's roads, it would produce more than three times the country's energy needs, using renewable energy instead of coal. This example is real, with prototypes currently being installed in parking lots. The solar road idea, in its simplest form, is the building of an infrastructure asset that provides both a transport function and an energy generation purpose. Yet, the development of the project has led to the consideration of other functions, including light-emitting diodes (LEDs) to illuminate the road lines, heating elements to resist ice and snow and the potential to recharge electric vehicles while moving.

While the solar road may sound futuristic, we already have an increasing focus on ensuring that infrastructure investment is efficient and can serve multiple purposes where possible. Think schools with community facilities, hospitals with health hotels, public housing with integrated private housing, integrated transport, communications and energy transmission corridors.

3. Closed systems – moving towards resource efficiency and zero waste

Where industrial processes consume resources such as water and energy, and produce waste products, there is an opportunity to use new technologies to reduce the impact on the environment. As with multi-use infrastructure assets, increasingly connected thinking is required to deliver innovation and efficient outcomes. Agriculture is a field where we can significantly reduce the 'leakage' of resources. Let's think about it: key agricultural

inputs include water, energy and fertiliser; key outputs include food products, plant waste and animal waste. Arable land occupied by farms would otherwise be natural forests or grasslands.

In a closed system, crop waste and animal litter could be used to fuel an anaerobic digester to generate energy to power irrigation systems and to heat greenhouses for growing hydroponic vegetables. The anaerobic process would also produce fertiliser as a by-product. In addition, part of the farm could be devoted to forestry as a carbon-farming initiative to restore environmental balance.

What does all this mean for infrastructure planning? There is a growing body of research and development recognising that natural systems are incredibly efficient (inherently environmentally optimised!) and provide the best basis for designing man-made systems. It is usual for infrastructure projects to need to comply with environmental regulations, and there might be particular environmental objectives; but how is it best to incentivise, recognise and reward the design of infrastructure systems that do not result in any environmental externalities?

4. Rapidly changing and complex technologies – the future is your friend... or is it?

Where the required infrastructure output is an information technology (IT) service, the pace of technology change and the risk of inefficient resource use and early obsolescence can loom ominous. Large-scale IT projects pursued by governments (and also by the private sector) have been prone to very long development times, very large cost overruns and often sub-optimal outcomes. The problematic overlay is that the rate of project development can be outpaced by the rate of technology development. This can result in a completed project that is dated and unwieldy at the outset.

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What is a megatrend?

In 2014, at PwC, we worked with our clients to determine the big changes disrupting their organisations, and the economy as a whole. We've distilled what we learned into five megatrends that have a major influence today, and will have a major impact over the coming decades:

1. demographic shifts (ageing populations)
2. shifts in global economic power (from West to East – think China and India)
3. accelerating urbanisation (denser cities)
4. climate change and resource scarcity (at what cost?)
5. technological breakthroughs (what's next?).

Megatrends 1 and 2 have obvious implications for infrastructure in the future. There will be a significant increase in demand for aged care and health facilities, and the shift from West to East will result in a major geographic shift in the concentration of investment. The implications of these shifts will be wide-reaching; however, in this article, we focus on the joined implications of megatrends 3, 4 and 5 – urbanisation, environmental challenges and the opportunities presented by emerging technologies. Following, we provide a brief description of these megatrends.

Urbanisation

In the 20th century, the world's urban population grew from 220 million to 2.8 billion, with growth expected to reach almost five billion by 2030. Urbanisation means an increased concentration of required infrastructure services – including transport, energy, water and waste disposal. Australia is already the most urbanised country in the world.

Climate change and resources

The scientific consensus with climate change is clear, yet the political prevarication and social equivocation continue to provide a drag on action; however, it is inevitable that the march of environmentally friendlier practices will continue. No-one disputes the sense in not littering or not pumping untreated sewage into our waterways or not using asbestos to build our homes; however, not so long ago, these were accepted practices in Australia. In addition, to combat the scarcity of resources, such as water, energy, minerals and forests, we should expect an increased focus on recycling, multi-using and reducing waste.

Technological breakthroughs

The pace of development, change and proliferation of smart phone devices is visible evidence of the current rate and implications of technological change. We all know the world is changing,

but what sort of technological breakthroughs might impact future infrastructure development? Some possibilities, which are under development, include:

- artificial intelligence: the rapid growth in the processing power of computers is enabling analysis of data using increasingly complex models to solve problems in ever more ingenious ways – enabling smarter, more informed investment decisions
- wireless energy transfer: early technology has been developed that can beam energy from a power source directly into a device without the need for wires. Consider the implications of a world where nothing needs to be plugged in anymore
- solar fuel: a technology that creates liquid fuel using only sunlight, carbon dioxide and non-potable water is currently being developed. It mimics the process that plants use to produce energy through photosynthesis, allowing the sun's energy to be kept in liquid form. The implications for renewable energy storage could be revolutionary.

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Moreover, IT projects often fail or deliver sub-optimal outcomes due to a lack of an effective interface between the commercial and technological streams of thinking. For those who are not IT experts, the field can seem like a bewildering array of esoteric concepts – clouds, racks and platforms. This can result in the subject matter experts (the technology specialists) having a much greater say in the project development than what may be the case with a road, school, or hospital. While the opportunities might be exciting, bland commercial questions might rightly override technical considerations – for example, what do budget, cost and risk say about building on top of legacy architectures, rather than starting from scratch with greenfield infrastructure?

It is easy to see why an increasing convergence of technology and commercial thinking is needed in the development and delivery of IT projects. Procurement and contractual models that enable and encourage flexibility will become increasingly valuable.

What does it all mean?

The sponsorship void – policy and planning

Late last year, Sydney City Council made a very detailed submission to the 'Inquiry by the Public Accounts Committee into Cogeneration/Trigeneration in NSW'.

It makes clear how industry and technological changes can create voids

in the policy, legal and regulatory frameworks needed to enable valuable (and environmentally friendly) investment. The challenge for governments is to move quickly enough to allow and, indeed, encourage investment in new infrastructure systems that would otherwise be technically and commercially viable.

Open development processes

Traditionally, governments have determined the need for infrastructure assets. Moreover, projects are normally developed on a departmental or portfolio basis – that is, it might be an energy project, a waste project or a water project. Once a decision has been made, a tender will be issued, seeking bids. The tender process may allow for add-ons to the core infrastructure asset requirement, but the process isn't designed to and doesn't easily accommodate the design and delivery of true multi-use assets.

What are the alternatives? Governments can become much more joined-up in their thinking, through interdepartmental think tanks or whole-of-government agencies with a mandate to develop infrastructure concepts without constraints by sector.

The private sector is also well positioned – perhaps even better positioned – to develop infrastructure ideas that leverage technologies and know-how to merge the delivery of multiple service needs. The private sector may also possess certain assets (such as

land or existing infrastructure) that governments would not normally factor into their infrastructure planning.

So, should the private sector be encouraged to develop concepts for government? One approach is through a structured tender process, where the private sector's ideas and asset contributions are sought to solve a broad requirement. For example, if a government wants to improve the quality and quantity of the stock of social housing, they could put out a tender that essentially says, 'Based on the government's existing housing stock, we invite private-sector parties to propose ideas and unique contributions that you may be able to make'; however, this leads to the dilemma of 'comparing apples with oranges' – that is, comparing two or more proposals that are radically different and achieve different outcomes. While this can be overcome, it is at odds with the typical approach of presetting evaluation criteria that align with very specific service outcome objectives.

This leads to the question of unsolicited proposals. Some governments have established processes for considering unsolicited proposals. The Victorian Government released a new Unsolicited Proposal Guideline in February 2014. It emphasises that the proposal 'must have a degree of uniqueness [including] a unique idea or IP, being in a unique position or having ownership of strategic assets integral to delivering the proposal'. Should this sort of



approach be used to more proactively seek and harness private-sector ideas to inform the infrastructure planning process? It could encourage private sector innovation and participation in the wider scope of planning and delivering infrastructure assets. This would be attractive to the private sector as an outlet for testing ideas and as a means to avoid some of the costs and risks inherent in usual competitive infrastructure bid processes.

Real options and flexibility

So how do we move from a history of 'lumpy', one-dimensional investments in infrastructure projects to a more measured and progressive approach, which takes advantage of multi-sector thinking and innovative technologies to accommodate change?

Traditionally, the value and benefits of infrastructure projects have been measured and compared in terms of net present value (NPV). In structuring and valuing projects going forward, governments may be well advised to augment this with a real-options valuation approach, aimed at capturing the increasing value of flexibility and management of risk in a fast-changing world. Real options are the project-based equivalent of financial options (that convey the right, but not the obligation, to buy or sell a security at a future point in time).

The value of real options may arise from the inherent operational

flexibility of different infrastructure configurations, or from being able to delay investments until more information is obtained, or from the up-front building in of the ability to modify or add to the asset in the future.

An interesting and relevant application of real-options thinking is in planning water infrastructure and operating strategies in a world of climate change uncertainty. The Blue Nile project in Ethiopia considers new multi-purpose dam alternatives along the river. The approach incorporates flexibility in design and operating decisions – including the selection, sizing and sequencing of new dams, and reservoir operating rules. The analysis relies on a simulation model that includes linkages between climate change and system hydrology, and tests the sensitivity of the economic outcomes of investments in new dams to climate change and other uncertainties. The real-options framework has been valuable in identifying dam configurations that will deliver robust to poor outcomes and that are sufficiently flexible to capture high upside benefits.

Back home in Australia, it is easy to see that real options could be incorporated into the commercial design of road, rail, utility and health infrastructure assets. Making an unwieldy one-off, long-term investment decision appears increasingly at odds with the rapid evolution of analysis tools, technologies and user demands. Do the

traditional business case and decision-making processes need to transform to accommodate the potential of the present and future? Does there need to be an evolution of the public-private partnership (PPP) model? PPPs are beneficial because they take a long-term view of the optimisation of the build, operation and maintenance of an asset within a set of predefined parameters. However, PPPs do not represent a fluid model for long-term asset expansion or evolution, with uncertain add-on dates.

Summary thoughts

The future looks like an exciting place. For infrastructure development and delivery, it will be a time of much activity and rapid change. Innovative thinking (both in government and the private sector) will be required to achieve the best outcomes. Governments need to be aware of where there might be obstacles to investment. Collaborations of public and private intelligence will be increasingly fruitful, and the flexibility to respond to changing circumstances should carry a high premium. The megatrends will march on regardless. Infrastructure development needs to be supported by the commercial models that best exploit the opportunities that those trends present.

This article was published in the December 2014 edition of Infrastructure Partnership Australia's 'Future Build' magazine.

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