By Jeremy B. Bentham

FUTURE CITIES
in a Resource Constrained World

The world's fast-growing population is urbanising rapidly. As such, over the forthcoming decades, population growth and the resulting increase in energy use will likely be focused in cities, creating both challenges and opportunities.

Challenges associated with rapid urban growth include resource pressures on energy and water supply, as well as the diminishing ability of the natural environment to absorb human-induced pollution and waste. Conversely, opportunities arise from a city's ability to quickly and effectively aggregate business model changes, and the capacity to impact maximum numbers of people with targeted and smart levels of investment.

Much has been written about the rapid growth of cities in recent years. Of note, a joint analysis by Shell and Booz & Company, entitled *Future Cities in a Resource Constrained World*, examines various scenarios that cities of the future might experience. It is upon this analysis that this article is based.

A Changing World and the Importance Of Cities

The world's population is projected to grow to nine billion by 2050. By then, approximately 75% of people will be living in cities, compared with today's 50%. Energy use will therefore concentrate in cities, increasing from 66% of the world's energy use today, to nearly 80% in 2040. Emissions associated with this increase will also grow in the forthcoming decades.

Today, there are approximately 600 cities with a population greater than 750,000 people. However, the average city population is far greater than this figure, standing at 2.5 million. There are currently 21 megacities with populations exceeding 10 million residents. By 2025, the average population in cities will be three million, and there will be 29 megacities worldwide. Geographically, the greatest growth in urban population will occur in China, India, the United States, Nigeria, Bangladesh and Brazil.

It is also worth noting that the growth of resource use in cities is set to increase at a rate greater than population. This is due to the impact of increasing prosperity, which drives energy use per person.

Cities are important, not only for the number of people they house and the resources they require, but because their scale has the potential to make them effective places within which to address issues of resource constraints. Increasingly, essential services – including water, energy, air and waste management – are being addressed at the city level, rather than at national or regional level. Currently, cities impose their own policies and regulations regarding social, environmental and economic development. They are responsible for developing infrastructure and mitigating the effects of pollution, power and water shortages, and climate change-related weather events.

A prime example of a city that takes ownership of all of the above areas is the Danish city of Copenhagen. Since 2011, the city has committed to purchasing only electric and hydrogen-electric cars for municipal use. It aims to become the first carbon-neutral capital in the world by 2025.

> **Energy usage in cities is dictated by a number of drivers. These include climatic conditions, economic activity, geography, income disparities, population and urban design.**

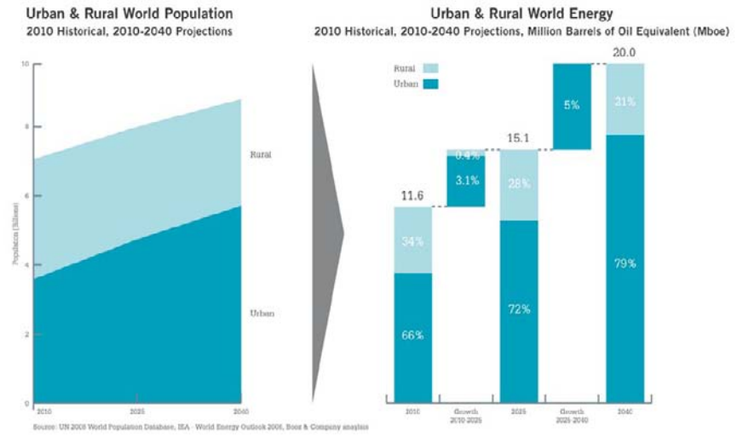

Exhibit 1: Global population and energy consumption growth forecasts

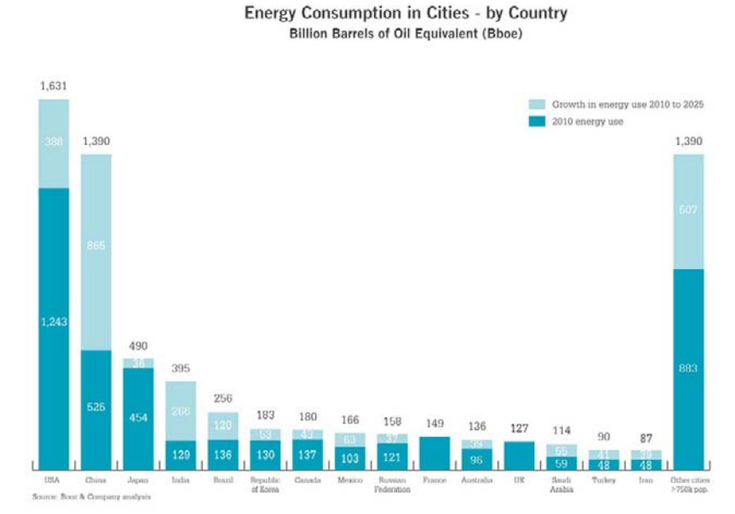

Exhibit 2: Energy use in cities with over 750,000 inhabitants by country

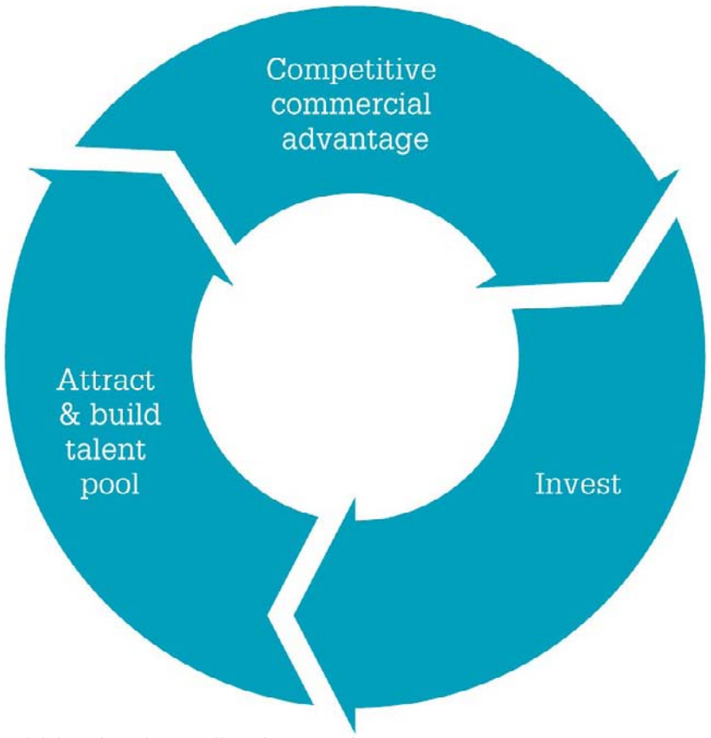

Exhibit 3: The City Growth Virtuous Cycle

ADVANTAGE
Early sources of **advantage**:
- Trade hubs
- Cluster of expertise
- Special economic zones
- Ongoing development of commercial advantage resulting from virtuous cycle

INVESTMENT
Companies invest to capitalise on these advantages:
- Expanding production
- More efficient technology
- New products service industries

Government invest infrastructure, enabling more **efficient business** operations and improving **amenity**:
- Transport, services, amenities, communications, education

ATTRACT TALENT
- Jobs and wealth opportunities **attract labour** from outside the city - increasing labour pool and size of home market
- Increasing **education** and up-skilling build **talent** and **entrepreneurism**
- Increased opportunities for skilled people to **network** boosts **innovation**

Drivers of City Development

Cities grow through a cycle incorporating three steps, as illustrated above.

City development begins with a city's competitive advantage. This can include the presence of a trading hub due to geographical location, a gathering of specific expertise, or the presence of policies that promote and regulate economic development.

In turn, investment capitalises on this competitive advantage. Private investment from companies expands trade and production, improves the efficiency of operations, and develops new products and services. At the same time, public investment in infrastructure is necessary to facilitate efficient business growth and improve the liveability of the city. Public investment includes transport infrastructure, services such as water and waste management, amenities including parks and facilities, and educational institutions.

The resulting jobs and amenities attract, educate and retain labour within the city and grow the talent pool of the home market for resident companies. An increase in opportunities for people to network, additionally, boosts innovation.

The cycle repeats itself, with companies, entrepreneurs and the city government continuing to develop the city's commercial advantages. As a result of further investment, and an increase of skills and talent, the city's GDP grows, accompanied by more amenities and opportunities for individuals.

However, growth can slow or even reverse for a number of reasons. As cities grow to a significant size, marginal diseconomies – such as pollution, crime and congestion – can begin to outweigh the benefits of all of the above. In other instances, a city's competitive advantage may erode as industries that once made them great begin to decline under open market competition, or, investment by the government or private firms simply ceases. When these occur, a city's growth cycle will either slow, stop or reverse.

Drivers of Energy Usage In Cities

Energy usage in cities is dictated by a number of factors. These include climatic conditions, economic activity, geography, income disparities, population and urban design.

Of note, other things being equal, cities with large populations generally use more energy than those housing fewer people. Likewise, cities that are economically prosperous use more energy than those in decline. In a city that is booming, people use more energy through increased ownership of vehicles, the control of indoor temperatures (through air-conditioning or heating), and greater usage of appliances.

In addition, different city layouts drive different levels of energy usage. According to a joint study published in 2010 by the World Wildlife Fund and Booz & Company, called *Reinventing the City*, energy use in cities with suburban sprawl is much higher on a per capita basis than cities with greater density. This is due to a combination of greater transportation needs and higher household usage driven by larger properties.

This combination of factors driving energy use creates six city archetypes. These vary from prosperous communities, sprawling metropolises and developing mega-hubs (such as Amsterdam, Houston and Buenos Aires, respectively) that are low-density; underdeveloped urban centres (such as Marrakech and Panama City) that are medium-density; and, urban powerhouses and underprivileged crowded cities (such as Hong Kong and Lagos, respectively) that are high-density. This is demonstrated by the chart in Exhibit 4.

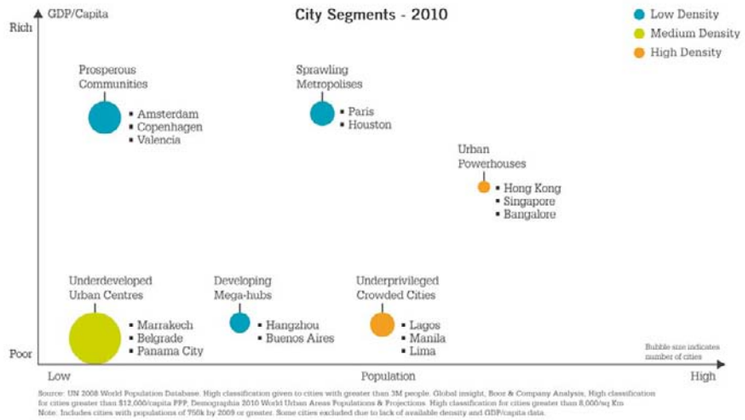

Exhibit 4: City archetypes based on energy usage (and examples)

Currently, absolute energy usage is concentrated in two of these city archetypes, sprawling metropolises and prosperous communities. These include relatively low-density cities with high GDP per capita, typically in the United States and Europe.

Development Pathways

In addition to the above archetypes, six pathways have been identified that allow cities to develop from one archetype to another. For cities with high GDP per capita, the pathways include urban decline, where sprawling metropolises become prosperous communities, and the transition to mega-city, where sprawling metropolises grow even further. For cities with low GDP per capita, there are four pathways with which to develop. These include industrialisation and modernisation, controlled urbanisation, slum proliferation, and late stage growth. This is demonstrated in Exhibit 5 below.

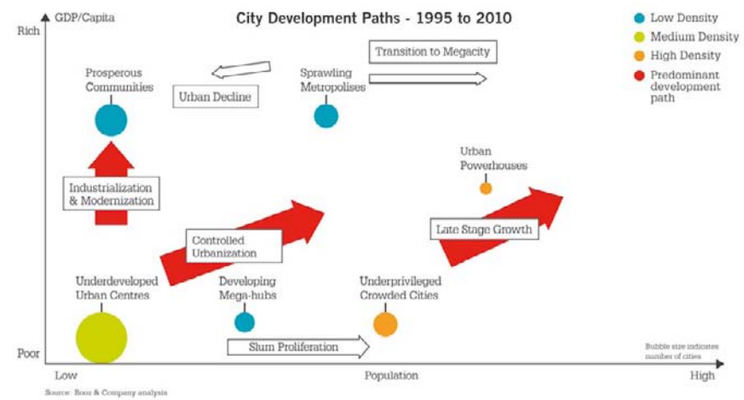

Exhibit 5: City development pathways

Over the forthcoming decades, three pathways will dominate world city growth, particularly in the emerging markets: industrialisation and modernisation, controlled urbanisation and late stage growth.

From an absolute energy use growth perspective, late stage development and controlled urbanisation, driven by a combination of consumption per capita growth and population growth, are expected to dominate over the next 15 years.

The Urban World In 2025

By 2025, the number of urban powerhouses will more than double, with 14 new powerhouses emerging as major cities due to India and China becoming wealthier. Consequently, total energy use in this city archetype will, accordingly, increase.

By this time, there will be fewer underprivileged, crowded, cities in the world – a total of about 30 – as cities across Asia grow wealthier and become urban powerhouses. Yet, there are expected to be more sprawling metropolises – about 50 cities by 2025 – as some cities grow wealthier without creating policy conditions to promote urban densification.

The number of prosperous communities is, too, expected to increase from 127 to approximately 150, as smaller local cities, predominantly in Asia, become richer. However, it is difficult to forecast the total number of underdeveloped urban centres by 2025, as cities continue to develop rapidly and unpredictably in emerging nations.

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Stresses On Cities

Cities around the world face a plethora of stresses, many of which relate to their particular climate, geography and economic status. However, there are a number of universal issues that all cities will face.

In both the short and long term, end-user energy prices will prove problematic to cities of all kinds across the globe. Prices will increase due to a range of factors, including higher demand, fiscal restructuring, emissions pricing, renewable portfolio standards, and increasing commodity fuel costs. Adding to these fundamental drivers of price are volatility and uncertainty around fuel costs, weather, and emissions legislation.

In a number of developing nations, energy price rises are borne by the government, which subsidises energy – an exponentially increasing burden as prices, population and demand per person all rise. Ending such subsidies will prove challenging for emerging market governments and could result in civil unrest.

Cities also face the universal problem of attracting adequate infrastructure investment. With increased loads, increasing peaks of usage, and greater weather extremes, infrastructure assets are under growing pressure. Cities with infrastructure established in the 1960s and 1970s – or earlier – have assets that are at the end of their design lives, at a time when the ability to pay for replacements is low and the disruption impact of replacing an asset being used at capacity is high.

In developing cities with limited financial resources, finding new ways to pay for the vital assets necessary for ongoing economic development in a time of global economic slowdown is a major challenge.

An additional challenge the cities of tomorrow face is that of public amenity. With wealth comes greater public expectation, in terms of liveability. This is partially served through increasing environmental standards and resident's requirements for more technically advanced solutions, which come at a cost premium. For example, low-carbon power is more expensive than coal-generated power, yet many cities choose the former.

In wealthy cities, there is much opposition to infrastructure projects that paradoxically enhance general living – such as roads, wind farms, and sewage treatment plants – yet directly affect surrounding residents, visually and in terms of noise pollution.

Some cities will also need to address the impact of climate change on water supply. This applies to developed cities as much as it does to those from emerging nations.

The world's cities are increasingly becoming the epicentre of human living. How city leaders manage their energy resources will become ever critical in enabling economic and social growth, as well as environmental preservation. With city populations set to double over the forthcoming decades, resources will be stretched to breaking point. How today's policymakers plan for this will be key to the successes – or failures – of tomorrow's cities.

For more information, please visit www.shell.com/scenarios

1. **pg 64: Rapid urbanisation brings the challenges of pressures on resources.**
   Photo courtesy of Shell.
2. **pg 65, above: Exhibit 1 shows the growth forecasts of global population and the corresponding energy consumption.**
   Image courtesy of Shell.
3. **pg 65, below: Exhibit 2 shows the energy consumption in cities that have a population of more than 750,000 inhabitants.**
   Image courtesy of Shell.
4. **pg 66: Exhibit 3 shows the growth cycle of cities.**
   Image courtesy of Shell.
5. **pg 67, above: Exhibit 4 shows the six city archetypes based on energy usage.**
   Image courtesy of Shell.
6. **pg 67, below: Exhibit 5 shows the city development pathways which allow cities to develop from one archetype to another.**
   Image courtesy of Shell.
7. **pg 68: The growing number of urban powerhouses, will increase energy usage in this city archetype.**
   Photo courtesy of Shell.

Jeremy B. Bentham has been in the energy business for more than 30 years. He is a graduate of Oxford University, where he read physics. He joined Shell in 1980 following post-graduate experience at the California Institute of Technology. He also holds a masters degree in management from the Massachusetts Institute of Technology, where he was a Sloan Fellow from 1990 to 1991. Since January 2006, he has been responsible for Shell's Global Business Environment team, which is best known for developing forward-looking scenarios to support strategic thinking and direction-setting.