

KEYNOTE PAPER

NZAAR-KN-17-43 PLENARY SESSION

King Abdullah City for Atomic and Nuclear Energy: Designing a City for the Post-Petroleum Era

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OPENING OF THE EXTENDED ABSTRACT

From 2007 to 2014 the author was the Head of Eco-Masterplanning with the London-based practice of Llewelyn Davies Yeang – Architects and Planners. The firm produced a number of masterplans in Qatar, Libya, Turkey and India and in 2009 was invited to create an Ecomasterplan for King Abdullah City for Atomic and Renewable Energy. The ruling family in Saudi Arabia, increasingly aware that oil is a finite product wished to explore ideas for a future city that would function when the country's oil wells run dry. They hired 12 international consortia paying each US \$1.2million to produce designs. LDY headed one of the consortia and elected to design a city for a population of 250,000. This was not a move born out of immediate need for Saudi Arabia has proven reserves of 266 billion barrels according to government estimates submitted to the Organization for Petroleum Exporting Countries ('Annual Statistical Bulletin', OPEC, 2015). If these figures are correct, Saudi Arabia's reserves will last for another 70 years at an average production rate of 10.2 million barrels per day reported for 2015. Nevertheless it was regarded as prudent by the Saudi authorities to plan ahead. Research Question How would a city in Saudi Arabia function after the oil reserves of the country are expended? Methodology The methodology can be summarised as 'Research by Design'. A team of 55 specialists was assembled. LDY in London and Kuala Lumpur collaborated with Buro Happold Engineers in Riyadh and London.

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NZAAR-KN-17-43

KING ABDULLAH CITY FOR ATOMIC AND NUCLEAR ENERGY – DESIGNING A CITY FOR THE POST-PETROLEUM ERA

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Research Question

How would a city in Saudi Arabia function after the oil reserves of the country are expended?

Methodology

The methodology can be summarised as 'Research by Design'. A team of 55 specialists was assembled. LDY in London and Kuala Lumpur collaborated with Buro Happold Engineers in Riyadh and London. A team comprising 19 city planners, architects and 3D modellers was allocated to the project; 10 engineers from Buro Happold gave specialist advice on energy, water supply, transportation, security and waste. Eighteen academics from the architecture and engineering department of Umm al Qahr University in Mecca provided local knowledge. Specialist advice on landscape/ecology came from Dr. Mike Wells of Biodiversity by Design attached to the University of Bath UK while the UK National Nuclear Laboratory supplied expertise on a nuclear reactor. Michael Guerra, an expert on hydroponic food production was employed. Models were built in London and 3D animation was produced in Shanghai

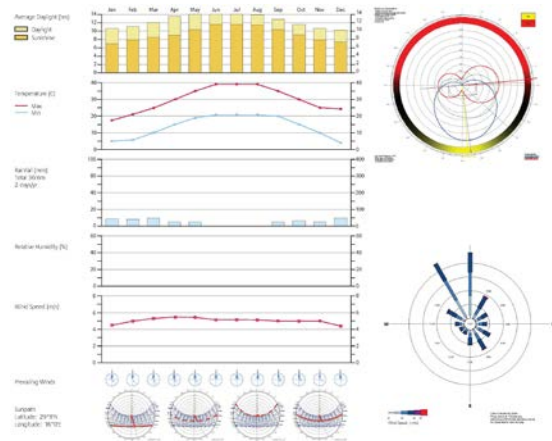
The Site

The site of the new city, to be known as King Abdullah City for Atomic and Renewable Energy (KA-CARE) was 30 km South West of the capital Riyadh and 800 Km from MECCA. The site is on the edge of the Greater Riyadh Authority Masterplan in an area designated as an Environmental Reserve

The Saudi Arabian landscape is typically sandy desert with rocky outcrops. There is heavy rain for a brief two-month period each year and landscape in the wadis (valleys) flourishes for a brief period.

Seemingly barren land bursts into flower in these two months. The site lies on the western extremity of the Wadi Hanifah catchment area

The topography shows a system of valleys running east from a high ridge. The valleys are dry for the greater part of the year and are eroded by torrential rainfall for a brief period.



The climate analysis is crucial. There is over six hours of sunlight every day, High daytime temperatures contrast with cool night time temperatures. It is extremely dry with rainfall only in December and March. Wind speeds are low and mostly from the north. The analysis indicates sufficient hours of sunlight for solar power, but wind speed is marginal for wind energy. Water supply is a problem. Taking all the data and analysis together the land that is suitable for development was identified.

The design team identified an optimum size for a city. We took a sample of cities around the world and used some subjective criteria. We asked what size a city must be to have a general hospital, a university, an industrial base etc. We arrived at the figure of 250,000. It is roughly the size of Oxford or Milton Keynes in the UK or the projected population of Putra Jaya in Malaysia.

LDY in London and sister company T.R. Hamzah & Yeang in Kuala Lumpur

pioneered an ecological approach to masterplanning which sees the process as the benign and seamless integration of four strands of eco-infrastructure into a system. These are categorised as: the green eco-infrastructure being nature's utilities and the creation of viable new habitats; the blue water-management infrastructure being close-loop water management and sustainable drainage; the grey engineering eco-infrastructure being eco-engineering systems and utilities; and the red infrastructure being the human society, lifestyles and legislation.

The design team next generated options. It was interesting to observe the methodology of the team members from different cultures, some seeking to follow precisely the analysis outlined above, others seeking to impose a formal plan on the landscape similar to Edwin Lutyens in New Delhi or the plan of Canberra in Australia by Walter Burley Griffin or indeed the masterplan for Putrajaya in Malaysia. Others sought to impose an orthogonal grid on the site in much the same way that colonial powers imposed grids on new cities.

Other options emerged most of them avoiding the deep valleys to the North West while some sought to cut and fill to create flat plateaus on which to build. In all 18 options were explored. The options were evaluated using EMAT (Eco Masterplanning Assessment Tool) devised by LDY. It awards points for each feature in the Green, Blue, Red and Grey Infrastructures. The Preferred Option was one emphasising ecological connectivity. It indicates a 7km long city along the ridge line with projections to the North West along smaller ridges, and on the flat terrain below the ridge to the south West.

A land use plan was devised to be achieved in seven semi-autonomous phases built on the high ridge, the lower plateau and on the

scarp slope separating the two. The Green infrastructure was developed – urban oasis habitats, urban pocket parks, areas where native habitats are restored and areas for crop cultivation. Learning from Wadi Hannifah, weirs and dams were proposed to capture water and reduce erosion.

Biodiversity targets were set in collaboration with the Institute of Biodiversity by Design at the University of Bath in the UK. Birds, mammals and butterflies were identified and vegetation designed to attract these species.

The size of a neighbourhood or district is determined by the distance a child can walk to school or an adult can walk to a market or mosque. The optimum distance is plotted on this plan and we eventually settled upon 45 neighbourhoods and eight neighbourhood centres.

Generally the dwellings are inward orientated to a courtyard with small openings on the public façade which conforms to a model for the hot dry climate in the Middle East. Recreation and leisure was considered in some detail again based on the principal that facilities should be within walking distance.

The economy of the new city is research based. The main ‘street’ of the city is a sheltered environment with electric powered vehicles and a Light Rail Transit System. The source of materials for the construction of KA-CARE was carefully considered with a view to reducing transport costs and with view to recycling materials.

The Energy Equation

The key question was how to create energy for the city without petroleum. Seven methods are employed.

- 1 A Solar Chimney
- 2 Solar collectors
- 3 Photo Voltaic arrays

- 4 Biomass or Waste to Energy
 - 5 Wind Turbines and
 - 6 Geo-Thermal Plant
- Plus a small Nuclear Power Plant.

The most obvious feature of the plan aerial view is a solar chimney where a 1 km radius array of reflectors directs the sun's rays to a tall chimney, heating it up and thereby ensuring wind speed at the base driving power-generating turbines in addition to providing domestic hot water.

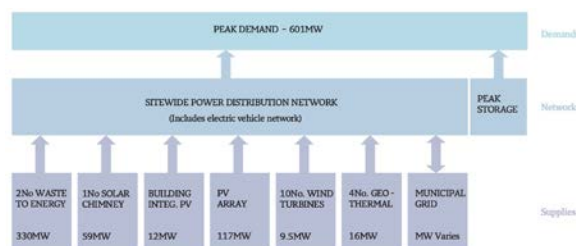


And the problem of car parking was addressed. There are to be no petrol-powered cars in the city and all cars that arrive at the outskirts are parked in deep silos at one or other of the four entrances. Residents of the city must then use public transport in the form of a rented electric car, an electric bus and electric light rail system is proposed – the latter being connected to the centre of Riyadh in the future. A logistic distribution system was evolved which also uses electric vehicles.

Buro Happold worked with the architectural team to supply the engineering solutions that would ensure the city will operate without petroleum. The proposed Nodal Split was – Private Hire Electric cars 20%, LRT 35%, BRT and bus 35% and walking/cycling 10%. This contrasts with the current situation in Riyadh where 89% of transport is by private car. The main transport entrances

to the new city were the locations for parking silos. Petrol driven cars are parked in one of the four silos at the entrances to the city. Cars are parked and retrieved automatically. An LRT system connects the principal entrances and the central concourse.

All waste is collected by a pneumatic waste system. 3,500 tonnes of waste is collected weekly and used for waste-to-energy. There is a 73% reduction in landfill. In simple terms 2 No. Waste to Energy plants produce 330 MW, One solar chimney produces 59 MW, Building Integrated Photo Voltaics produce 12 MW, PV Arrays produce 117 MW, 10 No. Wind Turbines produce 9.5 MW and 4 No. Geo Thermal plants produce 16 MW. The Peak Demand is 601 MW.



A small nuclear reactor is embedded in the research complex. The nuclear reactor is based on a similar reactor at Halden in Norway. But nuclear energy has not been counted in the calculation and is regarded as a bonus.

Water supply for the city comes from stored rainwater, recycled water and ground water. Careful management of water systems ensures that requirements will always be met.

The total construction cost of the city was estimated by Davis Langdon to be 193

Billion Saudi Riyals. The design team presented the masterplan at a three-day event in Riyadh. All twelve teams were able to witness the different solutions. It was a learning experience and LDY's methodology and solution was highly commended.

KA-CARE did not proceed. On 25 January 2011 President Mubarak of Egypt was deposed. In March 2011 the insurrection against President Assad's regime in Syria began and it continues to this day. On 20th October 2011 President Muammar Ghaddafi of Libya was captured at Sirte and executed. The whole Middle East imploded with the rise of ISIL (The Islamic State in Iraq and the Levant) and the invasion of Iraq culminating in the setting up of a caliphate in Mosel. The Saudi government turned their attention to other matters and KA-CARE was put on hold.

But the lessons learned are of global significance. The vital question is what will the world do when oil runs out? What plans are being made to live in a world without petrol? What will Malaysia do when there is no petrol to power cars. Some estimates suggest Malaysia has oil reserves that will last until 2040 (just 23 years).

Reference

- [1]. Llewelyn Davies Yeang and Umm al Qahr University Mecca, *King Abdullah - City for Atomic and Renewable Energy* (KA-CARE). LDY, London 2010.