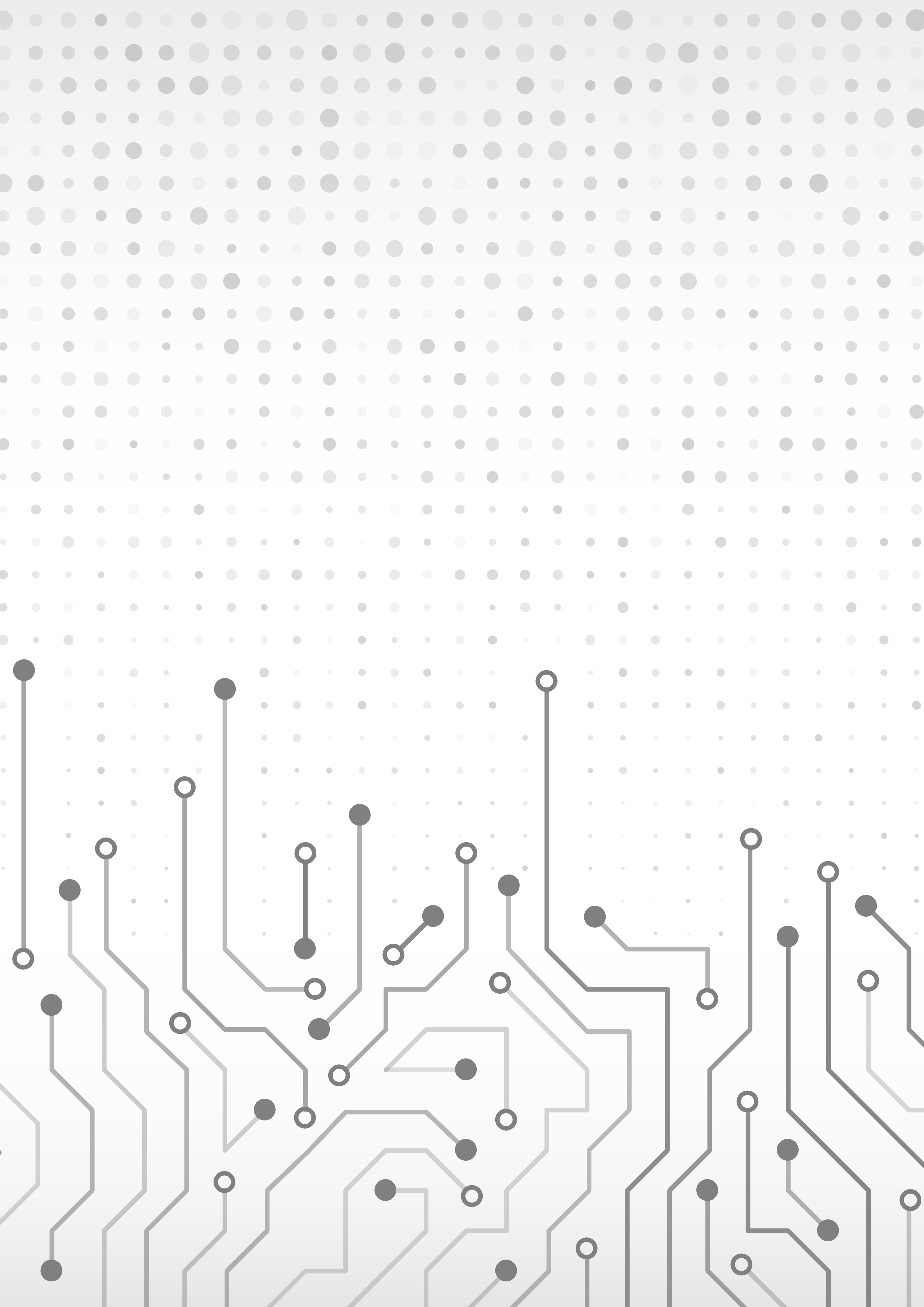
darmagazine i16

January 2019

The Smart Revolution: Reimagining Cities



darmagazine i16
January 2019

In this issue

The 16th issue of Dar Magazine will give readers insight into the latest highlights of Dar Group's far-reaching initiatives, from leading some of the region's most ambitious projects and experimenting with the industry's latest trends to optimising systems and striving for environmental preservation.

Our special feature showcases Dar's involvement in one of the most significant enterprises in the Middle East: the once-in-a-generation effort to build Egypt's state-of-the-art New Administrative Capital. Penspen takes readers to West Africa, into the heart of its mission to promote wider access to reliable electricity. Elsewhere, Maffeis Engineering S.p.A. discusses the challenges of constructing the landmark centrepiece of Dubai Expo 2020, and Dar undertakes the massive Kuwait National Bridge Assessment Project.

Dar Group's efforts to meet the challenges of an increasingly vulnerable global environment take centre stage once again with Dar London exploring concerns over rising sea levels. Parallel to that, long-time contributor John Davey reflects on the latest updates to the World Bank's Environmental and Social Framework.

Currie & Brown continues to inspire a revolution by using data analytics to provide construction clients with recommendations that optimise operations and save up to millions of dollars; Dar offers up its latest experiment in machine learning; and, concluding this volume, the peerless Perkins+Will presents a pioneering, high-performance building design studio.

As ever, we hope you enjoy reading this issue.

The Team


Person_Without_Helmet_0.63

Contents

Author
Ahmad Debbas

Expertise
Information Technology

Company
Dar

Location
Beirut, Lebanon

Artificial Intelligence and Deep Learning:

Transforming the Architecture, Engineering, and Construction Industry

A field like no other

Artificial Intelligence (AI) algorithms have been around since the 1950s when American computer scientist and psychologist Frank Rosenblatt created the perceptron algorithm, an early type of Artificial Neural Network (ANN) that stood as the first self-learning algorithm. The dream was to create an intelligent machine that can simulate human thought processes and learn independently: that machine would then open up a field with infinite possibilities.

However, for decades afterwards, the grand promise of AI was confined to the realms of science fiction as the scarcity of data and computing power rendered these promising early learning algorithms useless. Then, the introduction of the World Wide Web, social media, monitoring devices, and smartphones triggered and fuelled a historically unparalleled surge in data collection and availability, one that is still growing exponentially. Coupled with major advancements in algorithms and a meteoric rise in computing resources, this data explosion propelled AI into a reality that excites many and instils fear in some.

Coupled with major advancements in algorithms and a meteoric rise in computing resources, this data explosion propelled AI into a reality that excites many and instils fear in some.

AI permeates the modern economy. It is projected to have a disruptive impact on all industries. Moreover, rapid technological advances in analytics, robotics, and digitisation have already enabled the emergence of unprecedented business innovations.

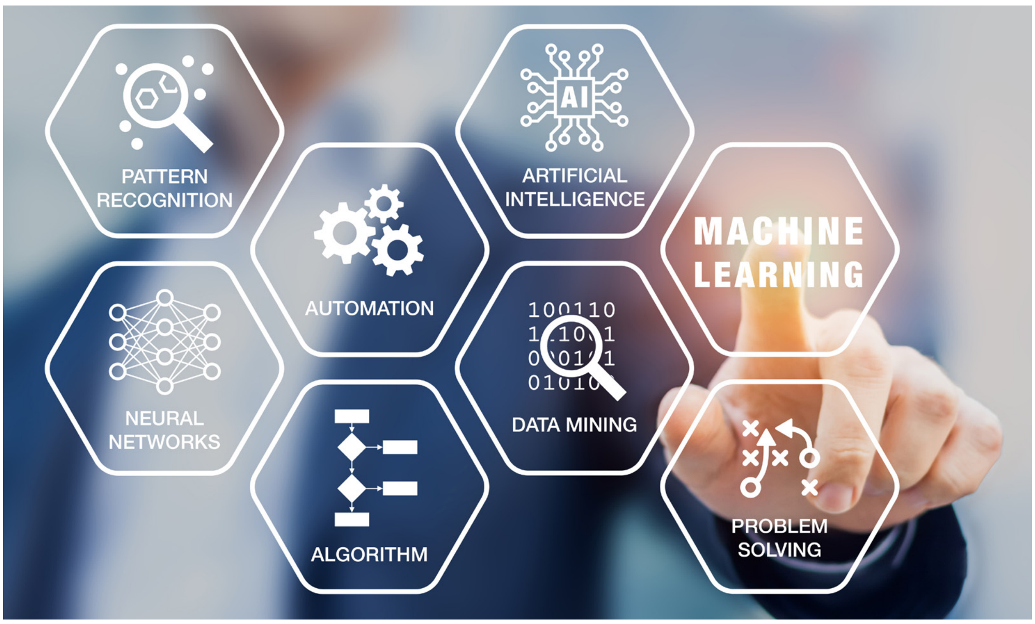
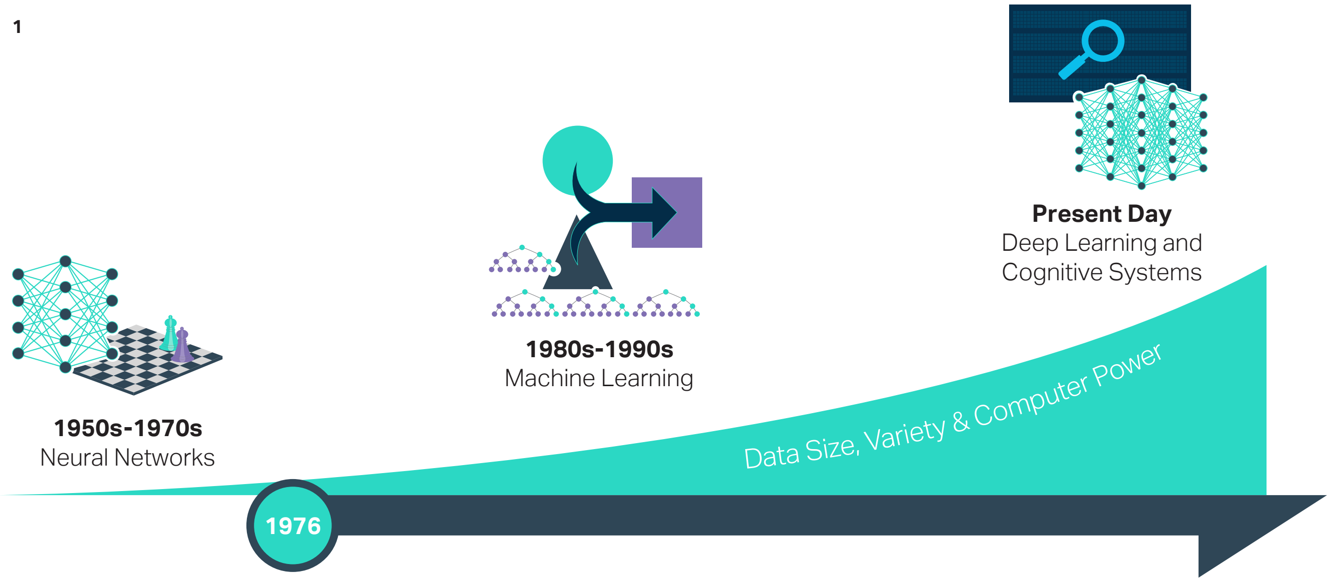


Figure 1 A timeline projecting the history and progress of AI.

Figure 2 Image classification error rates trajectory.

1



Artificial Intelligence, what's with the hype today?

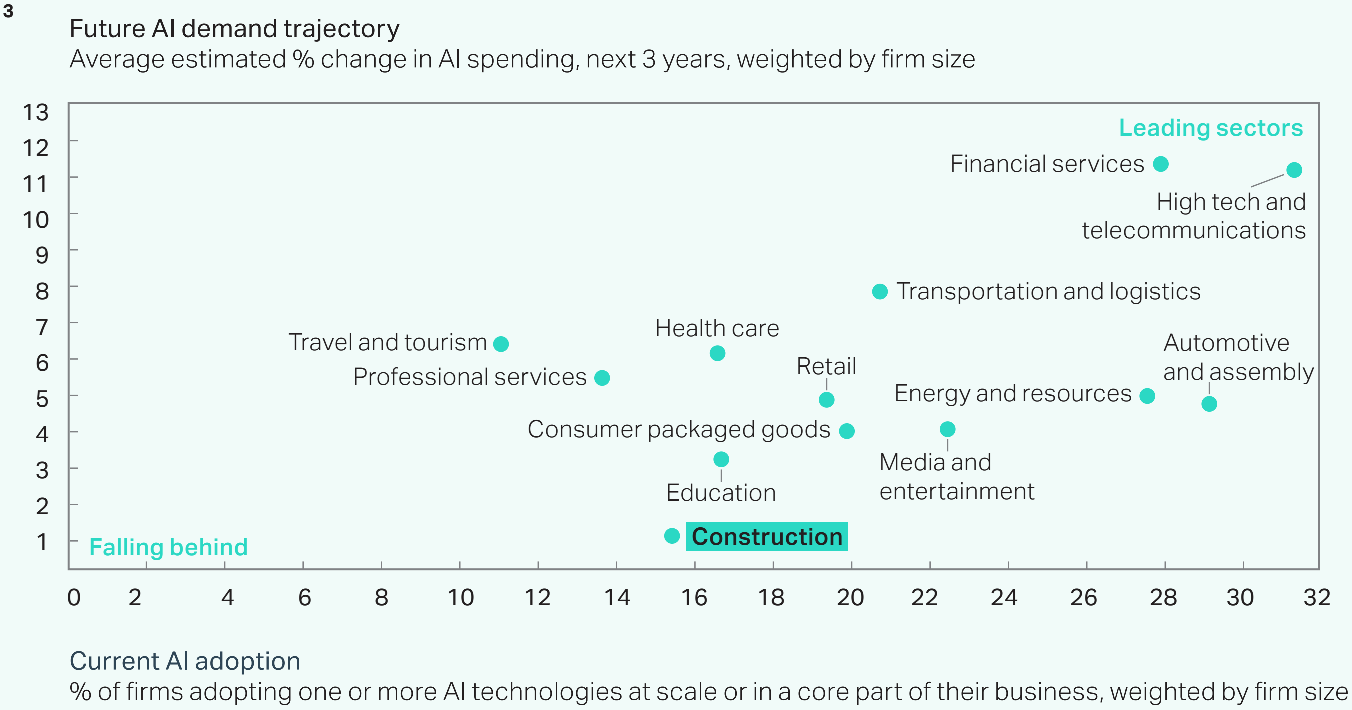
AI and data are inextricably linked: in simplified terms, machine learning occurs when enormous amounts of data are crunched and analysed through specialised algorithms and the machine then gains the ability to independently recognise patterns and make inferences and predictions. The more rich and heterogeneous the data, the more accurate the machine's predictions will be. For example, recommendation engines on Netflix use AI algorithms that analyse enormous amounts of data from the ratings and viewing patterns of millions of users to predict what a particular viewer is likely to enjoy and offer personalised recommendations for movies or series. At the moment, AI can be found in a wide range of applications from recommendation engines on Amazon and Netflix to Google's self-driving cars to smart assistants, like Siri and Alexa, which are mastering natural language processing. In some areas like image classification and object recognition, AI has become more accurate than humans as it has witnessed an exponential drop in error rate (Figure 2). Soon enough, AI will be in just about every product and service we buy and use.

AI, however, is posing an incredible challenge. Enterprises and governments must face the challenge of finding innovate ways of leveraging this remarkable technology if they hope to remain competitive and stay on the leading edge of their industry or practice. Yet, many decision makers remain baffled as to how they can capitalise on the enormous datasets they have through AI and deep learning.

This leads us to the question: what will be the impact of AI on the Architecture, Engineering, and Construction (AEC) industry? What kind of transformation will organisations of this sector undergo while capitalising on data? Over the past three years, Dar has embarked on a big data transformation journey in search of answers. Today, we aim to capitalise on our big data strategy for the sake of implementing the AI roadmap and methodology envisioned by Dar.

2

3



4

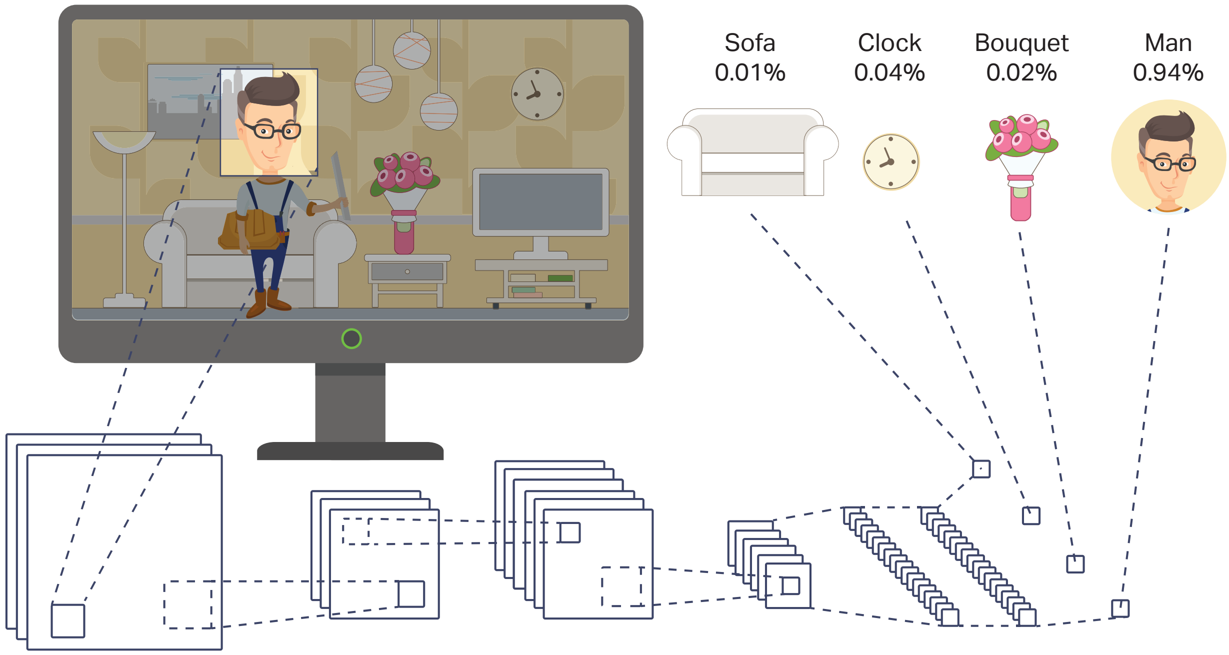


Figure 3 A McKinsey study showing sectors leading in AI adoption.

Figure 4 A Convolutional Deep Learning Model.

Figure 5 Interconnected layers of a Convolutional Deep Neural Network.

Figure 6 Labelling training image datasets.

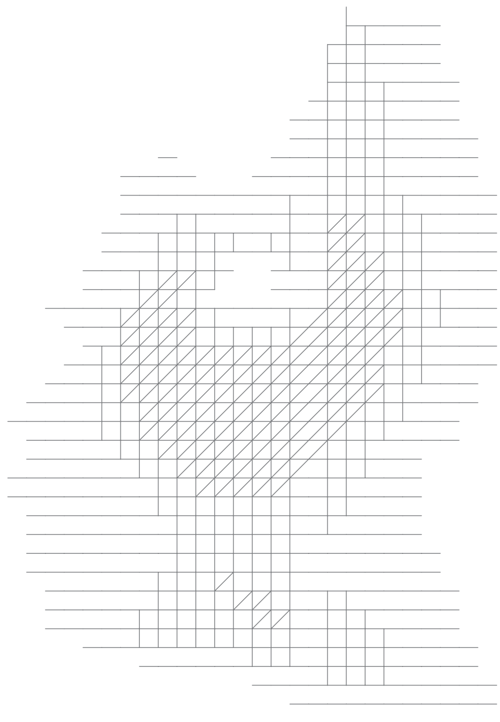
Far behind: AI in the AEC Industry

Needless to say, AI in the AEC industry is still in its infancy. Indeed, a study by McKinsey (Figure 3) shows how this industry is falling behind in AI and how it features in the lower spectrum of industries disrupted by the technology.

Ever the visionary, Dar sees this as an excellent opportunity to be among the leaders and pioneers disrupting the AEC industry with Artificial Intelligence. In fact, Dar has no choice but to be an innovative player in the AI landscape as it will be difficult to catch up should the competition gain the edge here.

Dar must tackle AI in an educated approach by carefully evaluating areas in which this technology can introduce innovation and growth and understanding where it cannot yet provide value. For this purpose, the Information Technology department has been investing in developing the skills and expertise needed to springboard Dar's upcoming AI journey.

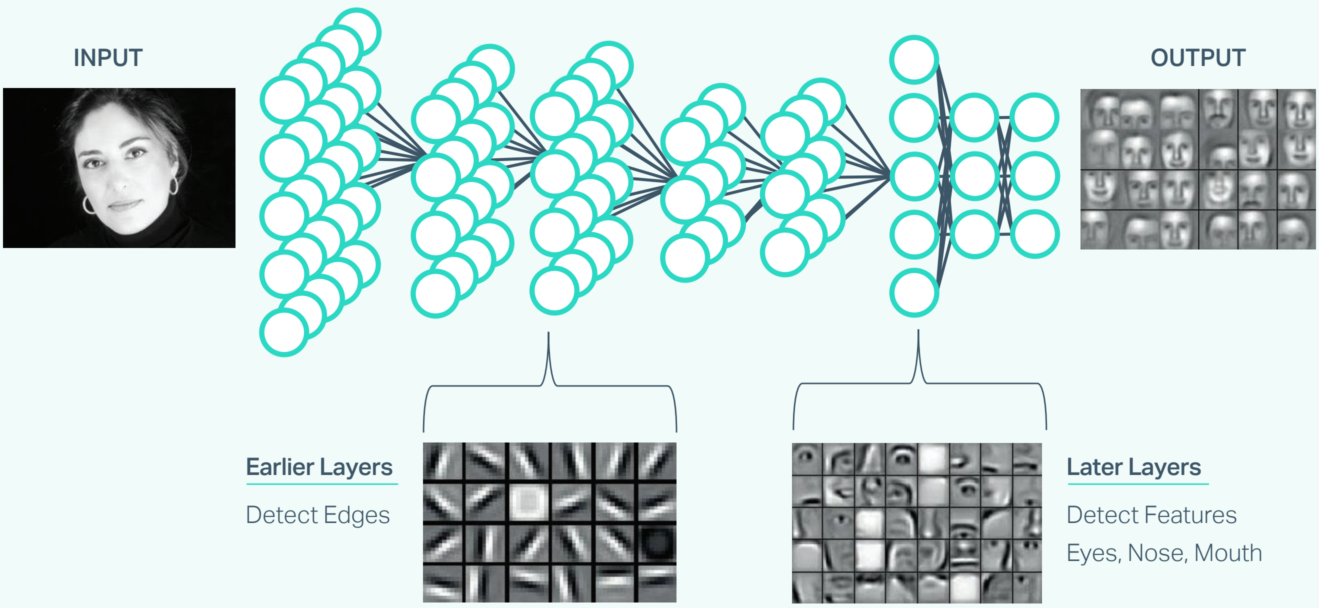
Deep learning for construction site safety



As a result of deploying drones and Internet of Things (IoT) devices on the project sites it supervises, Dar possesses an abundance of image and video datasets compiled on construction sites. This wealth of data presents an attractive opportunity to train and develop an AI model capable of detecting events on construction sites deemed hazardous or not complying with safety standards and measures. For this purpose, Dar decided to capitalise on progress made in deep learning and object detection in other industries to create a deep learning model tailored for the construction industry.

Deep Learning is a type of artificial intelligence capable of processing image and video datasets. More specifically, Convolutional Neural Networks (CNN) composed of interconnected layers of software-based calculators known as neurons are used in such cases. A CNN is a multi-layered neural network with special architecture designed to take images as input and extract increasingly complex features of the image in each layer in order to be able to classify the image and determine the output.

5



6

The Deep Learning Model trained in Dar was designed based on the reference architecture of YOLOV2 (You Only Look Once), a state-of-the-art object detection Convolutional Neural Network capable of processing 40-80 frames per second with a mean average precision rate (mAP) of 78.8%. To train this model, we invested significant time and effort in the data preparation stage, in which we had to gather images and label each object we wanted to detect. We decided to annotate the images with three labels: Helmets, Persons With Helmets, and Persons Without Helmets (Figure 7).

7

8

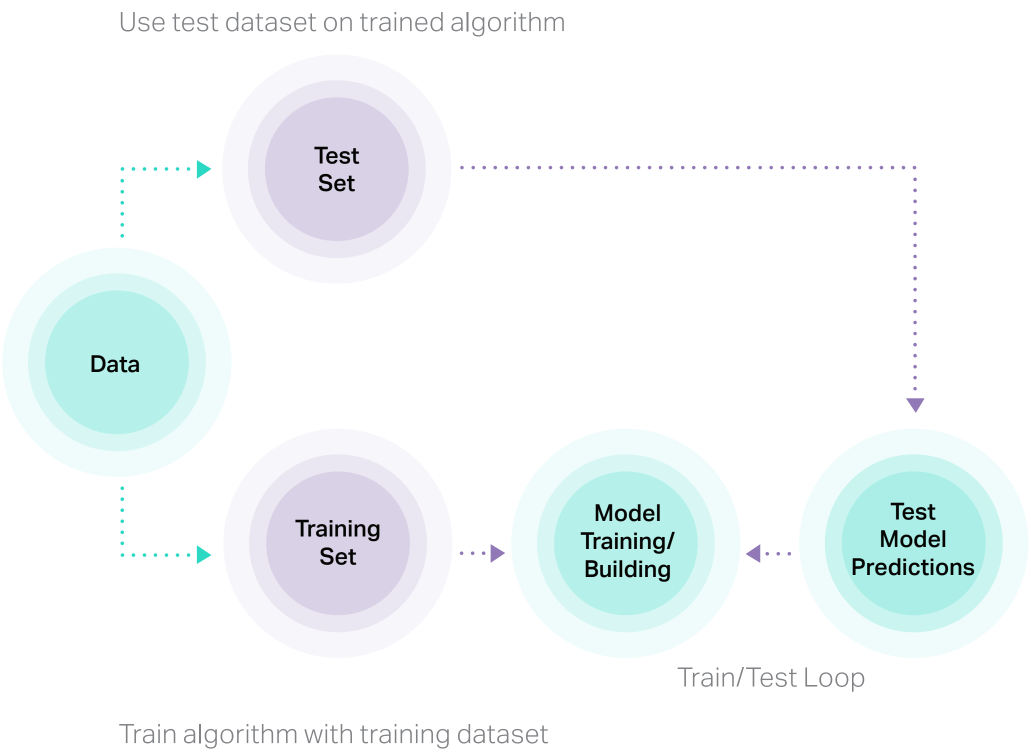


Figure 7 The output of an AI model trained in Dar to detect workers not adhering to safety policies on construction sites. In this frame, the machine detects an employee not wearing his safety helmet.

Figure 8 Training, testing, and validation workflow.

We trained the designed Convolutional Neural Network with thousands of similarly labelled images. The training process entailed splitting the data sets into three categories: training, testing, and validation data. We first trained the model on the training datasets and then tested and validated it using the testing and validation datasets. The training process took three days and stopped when the error rate did not improve in three consecutive iterations.

The result was an AI model capable of detecting labels it was trained on (Helmets, Persons With Helmets, and Persons Without Helmets) in new images and videos it receives from drones and IoT devices.

What is next?

Moving forward, Dar is to deploy this AI model and feed it real-time videos and images from cameras and drones installed on construction sites operated by the company. The process will require infrastructure with computing resources strong enough to allow the AI model to process videos and images rapidly and in real-time. This involves the deployment of a GPU-accelerated hardware and software solution that delivers breakthrough performance and efficiency tailored for AI needs.
Dar's object detection AI model for construction site safety has room for improvement. We can further train this model on more labels that are relevant to safety protocols in construction sites, labels such as gloves and vests. An even greater aspiration is to train the model to learn employees' repeated work patterns and detect threats coming their way. This will significantly improve construction site safety conditions and adherence to safety policies as the AI model will detect hazardous events in real-time and report them to the right personnel.

Through this enterprise and through various similar initiatives, Dar strives to search for innovative applications of AI and machine learning in the AEC industry, with the aim of solidifying its position as a global leader and continuing to provide its clients with the best and most up-to-date services available in the market. ◆

Author
Daniel Cash

Expertise
Data Analytics

Company
Currie & Brown

Location
Portland, Oregon, USA

Data Analytics: An Unexpected Catalyst for the Construction Industry Modernisation Movement

Trace problematic issues and inefficiencies in the construction industry back to their sources, and you will find quite a few of them originate in a troubling reluctance to keep up with the times. This is particularly true of concerns related to labour productivity. In most industries, labour productivity has been rising for the past half century. In our own, it has been frozen almost flat since the 1950s.

1

Figure 1 Building site.

A powerful yet dormant industry

This standstill is driven, in part, by the fact that the construction industry has not found ways to latch onto and benefit from the revolutions in technology that have transformed other sectors of the economy, such as banking or manufacturing. In such industries, all processes have been redefined and optimised by technology. Take the process of transferring money, for example. Twenty years ago, that process required a handwritten check sent via the postal service and a subsequent physical trip undertaken by the payee to the bank. Today, the entire transaction can be conducted on a mobile phone, in a matter of minutes at most. The construction industry should be continuously looking to redefine its own processes to find similar optimisations.

There are management issues as well. Favouring tradition over change, the construction industry continues to employ a highly conservative business model and is often suspicious of innovation. This highly cautious – "it's always been done this way" – approach is not without benefits to certain parts of the industry. Many projects are paid per man-hour worked, with profit guaranteed each hour, so it simply is not in some people's interest for construction processes to become less labour intensive.

The price of conventional thinking in the 21st century

Traditional approaches, however, can raise serious issues. In the United States, labour shortage means that projects – especially those in the data centre and semiconductor industries – often cannot be completed on time or within budget. Moreover, labour expenses usually comprise the lion's share of the project's total cost. That means prices charged to project owners may rise to a point where they are unsustainable. Such costs can fundamentally change the nature of the contract. In the case of data centres, for example, this cost inflation can render the entire build unprofitable, forcing relocation to another, cheaper location and/or a compromise on quality. These constraints should motivate owners to create an environment more conducive to productive labour.

Minor adjustments, exponential benefits

Yet, how is such an environment to be created? A critical, initial step is to fully understand and quantify what exactly is making people unproductive, both at an individual level and at a company level. Once this understanding has been established, both the owner and the contractor can work towards trying to rectify the situation.

There are numerous examples of how simple awareness can help boost performance and cut costs. The Currie & Brown team recently delivered a project for a household name which required contractors to work at a manufacturing facility. At that facility, a poorly implemented security protocol was costing the contractor two productive man-hours every day. In our report, we highlighted the fact that the client had not included the cost of this hold-up in his project calculations, enabling members of the management team to change protocols and and save money. If we had not had the data to quantify this cost, changes would never have been made.

Another example involved the delivery of a large, expensive piece of hardware for another project. Rather than planning the installation in advance, the client only asked the electricians to install the hardware on the day it arrived. Since the client had not given any notice, the electric firm classed the job as an emergency callout and charged accordingly. Such extra cost was completely avoidable as the hardware had been ordered months before. Using Currie & Brown's data

Figures 2 & 3 Data centres.

analytics tools, the team was able to quantify the cost of these transactions and others in dollar terms and to present the manufacturing group clients with business-critical information about how much they could save by altering their procedures. These recommendations were immediately embraced by the client, and they resulted in measureable savings to installation costs of subsequent tools.

Blind spots

Such problematic issues are by no means unusual. Project owners often fail to visualise the true costs of poor financial management or fail to benchmark themselves against their competitors or their industry in general. It is not uncommon for them to assume the price offered to them is the market rate and accept it.

One reason for this is the fact that, in large companies, lines of management and reporting may be blurred. Different departments may have different budgets and skill sets. Internal communication could be quite poor. On the other hand, many professionals simply do not realise or appreciate the impact their decisions, or lack of decisions, can have on construction costs. To cite just one example, the cost implications of mid-project design changes are often not considered. This type of uncoordinated approach can have huge consequences.

All of this reinforces the mantra that cost analysis and understanding of the real-world financial implications of construction and labour costs are key. This isn't rocket science. Industry-standard price books are published by trade organisations: these books list the hours a worker should need to complete a particular task. By analysing this information, consultancies such as Currie & Brown can tell clients if and by how much they are deviating from these industry standards and advise them accordingly.

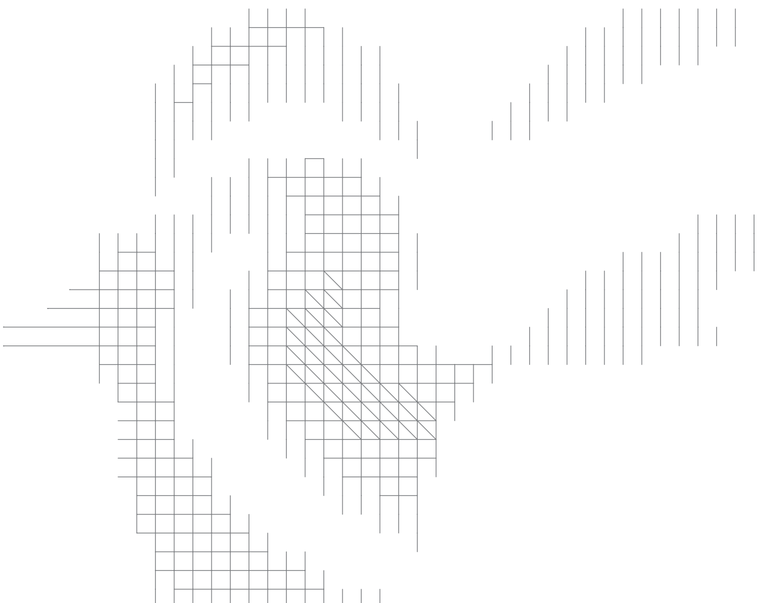
The sheer volume of data available can pose a challenge, but this is precisely where Currie & Brown's software really delivers value. We break items down by material and labour type, which enables us to benchmark the project against its peers and against industry norms. This analysis helps highlight the areas in which inefficiencies are occurring.

Moreover, such analysis can be performed quickly and comprehensively across an entire scope of work, allowing us to identify the most cost-effective vendors even before a project begins. Variances in pricing can be quite massive, so savings resulting from this one activity may be substantial. In some instances, this type of data crunching can identify a differential of more than 30% which equates to millions of dollars in savings!

Shifting the paradigm

It is astonishing — given the potential cost reductions that this kind of service generates — that many project owners carry on making decisions and taking actions exactly as they did before. If they were making profits anyway, they simply may not care about construction savings. Their priority is the customer, not the infrastructure. Making a change often requires a cultural shift as well as energy and focus, and getting those things in place in large companies can be quite challenging.

Still, our analytics tell a compelling story, one that hopefully more and more clients will hear and come on board with. With a bit of gentle education and hand-holding, project owners will come to see beyond the complexities of the raw data we present and understand exactly what all that information means to them. There is a hill to climb, but the financial benefits and boosts in productivity that data analytics can bring are simply too great for clients to ignore. They just need to recognise that the gulf between the thinking of the 1950s and the practices of the 21st century is nowhere near as wide as they may still believe. ◆



Plugging Africa's Energy Gap – With Gas

Author
John Downer

Expertise
Oil and Gas

Company
Penspen

Location
UK

Just not enough electricity

The facts concerning the lack of electricity in Africa are shocking.

More than a century after the light bulb was invented, most of the African continent remains cloaked in darkness after nightfall. School children often cannot read after dusk, businesses cannot grow, clinics cannot refrigerate medicines or vaccines, and industries are left idle. This dire reality is hampering economic growth, affecting jobs, and limiting livelihoods. Outside of South Africa, power consumption averages 124 kilowatt-hours per person per year, or just about enough to power one light bulb per person for six hours a day. In Sub-Saharan Africa, only one fifth of the population has access to electricity compared with one half in South Asia and four fifths in Latin America.

To exacerbate matters, the slow rate of progress in electrification means that most African countries will fail to reach universal access to electricity even by 2050. The cost of producing power in Africa is about twice as expensive as elsewhere in the developed world. Moreover, the intermittent and unreliable nature of the available electricity has led to an over-reliance on inefficient, expensive, small-scale, oil-based back-up power generators that produce electricity that is even more expensive. It has been estimated that a spend of US$ 41 billion per year is needed to address these multiple and deep-seated problems.[1] *

* For footnotes across the article, please refer to page 21.

Figure 1 Pylons.

Figure 2 High voltage tower.

That there is a direct and important relationship between energy and economic growth is a modern axiom. According to the World Economic Forum: "Without heat, light, and power, you cannot build or run the factories and cities that provide goods, jobs, and homes, nor enjoy the amenities that make life more comfortable and enjoyable. Energy is the 'oxygen' of the economy and the life-blood of growth…"[2]

Of the forms of energy, the International Energy Agency (IEA) has stated: "Electricity demand growth in emerging economies remains strongly linked to rising economic output."[3]

This is especially the case with Africa, where the largest infrastructure deficit is to be found in the power sector.[4] Whether measured in terms of generation capacity, electricity consumption, or security of supply, Africa's power infrastructure delivers only a fraction of the service found elsewhere in the developing world.

The 48 countries of Sub-Saharan Africa (with a combined population of 800 million) generate roughly the same amount of power as that of Spain (with a population of 45 million).[5]

Akinwumi Adesina, who took over as president of Africa's lead development lender, the African Development Bank, in September 2015, plans to dedicate his tenure to solving what he sees as the biggest hindrance to economic growth and development on the continent: the energy deficit.

Adesina has said that this flagship project aims to raise US$ 55 billion of investment to close the energy deficit in the next decade. According to the International Renewable Energy Agency (IRENA), the continent will need to add around 250GW of capacity between now and 2030 to meet growing demand which implies that capacity additions will have to roughly double to around 7GW annually.

Hopeful signs

There has been considerable encouraging progress in some parts of Sub-Saharan Africa in bringing together neighbours to support collaborative efforts and responses. In the region of West Africa and for the 15 countries forming the Economic Community of West African States (ECOWAS), there is already a community of nations with aligned policies on key areas, including energy, along with good physical evidence of installed energy projects responding to the challenges. These projects include the West African Power Pool (WAPP), which distributes electricity among nations across the West Africa region, and the West African Gas Pipeline (WAGP), which transmits gas from Nigeria to Togo, Benin, and Ghana.

Penspen has recently worked with ECOWAS to study options to improve energy supply to the region and, through this study, has been at the forefront of assessing energy demand and supply issues as well as developing new concepts designed to radically improve the supply and diversity of energy.

Principally, our recent study has examined ways to expand the benefits from gas delivered by the WAGP system to each of the ECOWAS countries beyond those already connected, and to reach an additional 11 countries in West Africa, some of which are the poorest in the whole continent.

It is acknowledged that improvements to Africa's supply of energy also need to try and address global issues affecting energy production. This means that when increasing energy supply, solutions need to embrace renewables alongside traditional responses that develop energy from other sources. Whilst there is a natural tension between renewables and traditional methods, there is great scope to advance both in a collaborative way that avoids a binary choice, which denies one the benefit of the other.

Figure 3 A worker works inside a pipe on a pipeline construction.

Figure 4 Gas pipeline panoramic.

More electricity but from what source?

It is well documented that rising levels of Greenhouse Gas (GHG) emissions in the atmosphere are driving climate change.

Power generation plays a significant role as a source of GHG emissions. For example, in the United States, most of the emissions from human-caused (anthropogenic) GHGs come primarily from burning fossil fuels - coal, hydrocarbon gas liquids, natural gas, and petroleum - for energy use. In 2016, emissions of carbon dioxide (CO_2) produced as a byproduct of burning fossil fuels for energy were equal to 76% of total U.S. anthropogenic GHG emissions (based on global warming potential) and about 94% of total U.S. anthropogenic CO_2 emissions.[6]

The global rise in CO_2 levels and temperatures has led to responses such as the Paris Agreement, whereby the central aim is to limit global temperature rise this century to well below 2 degrees Celsius above pre-industrial levels and to pursue efforts to limit the temperature increase even further to 1.5 degrees Celsius.

To meet their Paris Agreement commitments, governments have focused on achieving greater energy efficiency and using more low-carbon energy sources for electrical power generation.

Policies targeting energy efficiency have been steadily increasing in recent years and have had significant impact. For example, globally 31.5% of final energy consumption was subject to mandatory energy efficiency policy in 2016, up from only 14% in 2000.[7]

Using natural gas in parallel with renewables can significantly reduce the carbon footprint of power generation, through both greater efficiency and lower emissions.[8] For example, natural gas-fired Combined Cycle Gas Turbine (CCGT) plants are a form of highly efficient energy generation technology that combines a gas-fired turbine with a steam turbine.

They generate about half of the amount of CO_2 compared to burning coal to produce the same amount of energy. This, coupled with the greater efficiencies of these gas-burning electricity production plants, has led to dramatic declines in the use of coal-fired production.

CCGT plants work well alongside renewable power plants because of these benefits. Renewable power plants generate electricity supplies from wind, solar, and wave power, while CCGT plants provide a base load supply and take up the slack in energy production from these variable renewable sources.

The economics of this partnership are also positive. Taking account of the impacts of subsidies and the effects of carbon costs, CCGT energy costs compare well with those of renewables (based on a U.K. location) as shown in the following table.

Levelised cost estimates for projects using established technologies commissioning in 2020, technology-specific hurdle rates, $/MWh[9]

	CCGT	Biomass Conversion	Offshore Wind	Large Scale Solar PV	Onshore Wind > 5MW
Predevelopment Costs	0	3	7	8	5
Construction Costs	9	7	95	68	57
Fixed O&M	3	8	31	12	13
Variable O&M	4	1	4	0	7
Fuel Costs	46	94	0	0	0
Carbon Costs	25	0	0	0	0
TOTAL $/MWh	**86**	**112**	**137**	**87**	**82**
Cost in $/kWh	**0.09**	**0.11**	**0.14**	**0.09**	**0.08**

Hence, in the debate about energy generation, the role of gas-fired CCGT will remain a critical resource providing reliable, efficient base load generation to support a full suite of renewable technologies.

Getting gas in Africa to where it's needed

Africa is fortunate to possess an abundance of natural gas reserves. Indeed, substantial further reserves, such as the sizable discoveries offshore in Mozambique and Tanzania, have recently been added to the continent's portfolio. In West Africa, the Greater Tortue field off the Senegal-Mauritania maritime border contains over 50Tcf of resource potential – split roughly in half between the two countries – and sufficient for 30-50 years of production.

This adds to the gas reserves of Nigeria, estimated at 184Tcf, the ninth largest in the world.[10] Gas is therefore available in West Africa, but as a product it requires transportation by either pipeline or LNG to reach a market.

The work by Penspen for ECOWAS — supported by local Dar Group offices in the West Africa region — has studied the functioning and operation of the existing WAGP system, and considered where and how it could be expanded to reach the whole of the ECOWAS region not currently part of the WAGP.

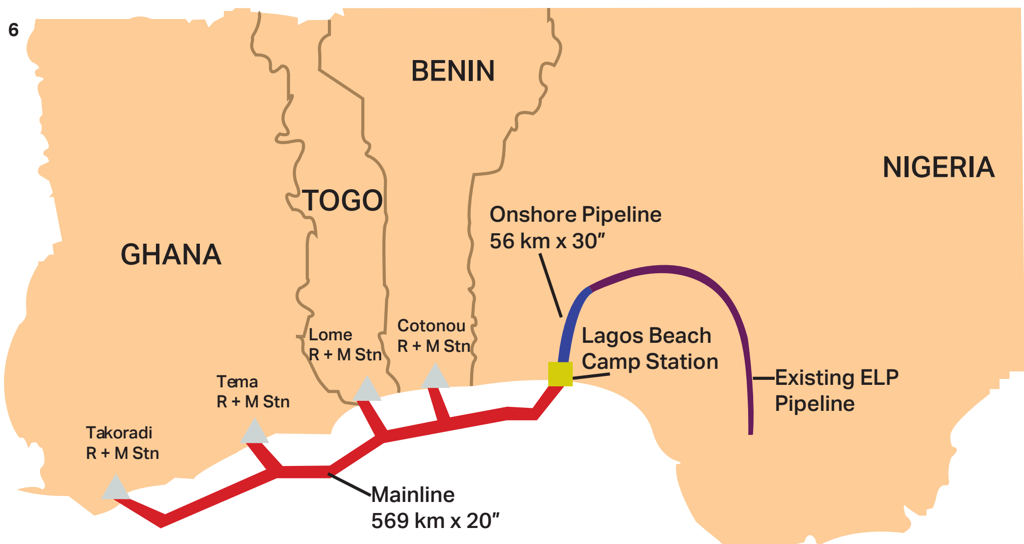


Figure 5 HDR of offshore jack-up rig in the middle of the sea at sunset time.

Figure 6 A schematic overview of the existing WAGP system.[11]

Figure 7 A modern CCGT thermal power plant.

Figure 8 Proposed ECOWAS gas transmission network.

7

8

There is potential to reach a further 11 countries with a combined population of over 240 million.

Penspen has researched, developed, and costed a concept for a gas system network of over 5400km that will reach these countries[12] through an ambitious ring main pipeline network of up to 36" diameter. The promotion of a ring main concept means that the necessary compression requirements are minimised through efficient flow, and there are considerable benefits for security of supply where any interruption can be minimised by flow in the other direction. It also allows offshore gas fields to utilise a new mode of transportation and encourages the development of stranded or marginal fields.

Ultimately, the pipeline system will bring energy in the form of natural gas to regions which are energy poor. This will provide these countries with the feedstock for CCGT plants, enabling them to make a step towards change in the provision of electrical power. They will also be able to use natural gas as a feedstock for certain energy intensive industries, such as cement and fertiliser manufacturing, and to power transport through compressed natural gas (CNG).

All of these benefits offer great hope of mobilising significant economic growth in the region but are critically dependent upon having the energy to fuel it.

The development of such an energy system would bring direct employment for many during the lengthy construction phase and thereafter for operational and maintenance staff employed by the holding company. Studies on the use of gas in Sub-Saharan Africa have identified some of the key potential benefits likely to accrue, although it is acknowledged that there are also many contingent challenges. These are summarised in the following table:

Roles for Gas-to-Power in Sub-Saharan Africa[13]

Application	Local Conditions Influencing Adoption of Gas-Fired Power
Replace liquid fuels	When liquid fuels are used to generate baseload or mid-cycle electricity, gas from domestic production or pipeline imports is likely to offer significant cost savings.
	When liquid fuels are used for peaking or backup generation, the viability of gas may depend on locating the peaking plant near the source of gas production. Otherwise, the cost of underused pipeline capacity could negate fuel cost savings.
	Using imported LNG to replace HFO or diesel is likely to be unattractive unless high utilisation rates can be achieved.
	For small, inland markets, pipeline gas is unlikely to be economic, and liquids replacement will depend on transmission grid capacity.
Displace coal	When gas at LNG export parity competes with coal at international prices, gas is often cheaper as a baseload solution, even without taking carbon into consideration.
	When domestic coal prices are below international levels, the competitiveness of gas is likely to depend on its availability at less than international prices. This can make sense for a producing country when reserves are insufficient to support an LNG project, or when reserves exceed LNG requirements to such a degree that the opportunity cost of gas is driven down to petrochemical levels.
	The competitiveness of gas versus coal improves dramatically when strong carbon reduction policies are in place, through either self-imposed caps on emissions or the incorporation of carbon pricing into least-cost generation decisions.
	Gas competes very effectively against coal as a mid-cycle (e.g. 50% - 70% load factor) solution across a wide range of fuel prices.
Complement to hydropower	Even where abundant hydropower potential exists, and where they are the least-cost long-term generation option, gas-fired plants can be attractive: • when hydropower will operate at mid-cycle load factors • when implementation and drought risks in the hydropower program are high • when the minimum efficient scale of hydropower greatly exceeds incremental market growth

The longer-term benefits of increasing the supplies of natural gas will be immense in providing, at last, a means to increase the availability of electricity, so that a population of 367 million people in West Africa will be able to switch on a lightbulb for longer than six hours a day and make a start to plugging the huge energy gap in Africa. ◆

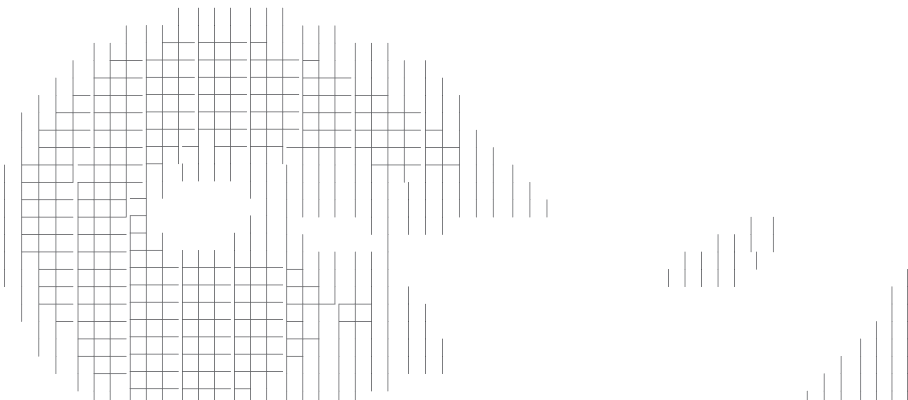


Figure 9 Starting to plug the huge energy gap in West Africa.

[1] World Bank Group; Fact Sheet: The World Bank and Energy in Africa.

[2] World Economic Forum; Energy for Economic Growth – Energy Vision Update 2012; Energy: The Oxygen of the Economy; Peter Voser; Chief Executive Officer, Royal Dutch Shell.

[3] IEA; Global energy and CO_2 status report - 2017.

[4] World Bank Group; Fact Sheet: Infrastructure in Sub-Saharan Africa.

[5] World Bank Group; Africa Infrastructure Country Diagnostic; 'Fast Facts Energy'.

[6] U.S Energy Information Administration; 'Where Greenhouse Gases Come From'.

[7] IEA; Global energy and CO_2 status report - 2017.

[8] A full discussion on the importance of the role of natural gas in addressing the climate change challenge can be found in our previous article; "Supporting the Paris Agreement Emissions goals" Darmagazine (Issue 15) https://dar.com/content/publications/i15/#page/27.

[9] Notes:
1) Source of data - BEIS 2016 Electricity Generation Costs, Table 2 (adapted);
2) Conversion used £/$ 1:1.3 for £/MWh to $/MWh;
3) CCGT using H Class GT;
4) Offshore wind - from U.K. Round 3; Onshore wind – U.K. location.

[10] bp-stats-review-2018-natural-gas.

[11] The West African Gas Pipeline Company limited (WAPCo); http://wagpco.com/

[12] Capo Verde subject to further study.

[13] Harnessing African Natural Gas; A New Opportunity for Africa's Energy Agenda?; Energy and Extractives Global Practice; The World Bank.

Authors

Mohamed Zaki

Essam Abdou

Expertise
Bridge Inspection, Assessment, and Testing / Bridge Design

Company
Dar

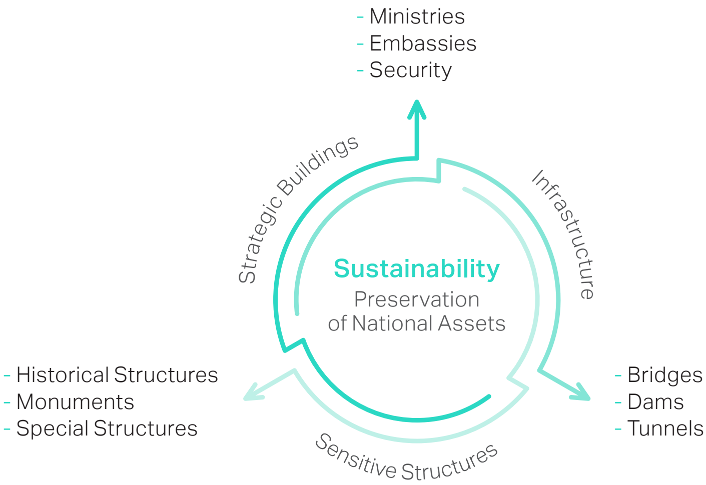
Location
Cairo, Egypt

Dar and Kuwait's National Bridge Assessment Project:

A Mammoth Undertaking

Bridges are incredibly valuable national assets: they connect communities, ease urban life, and - for millions of people - form vital pathways to economic progress and social opportunity. In many countries, however, bridges were constructed decades ago, and most have not received proper maintenance over the years. This is a dangerous issue. In the very best case scenarios, bridge failures are inconvenient setbacks. The worst of them are catastrophic tragedies. It is crucial for public safety, then, to continuously investigate the structural adequacy of these bridges. This article provides insight into how Dar leveraged state-of-the-art bridge maintenance technologies to successfully undergo the massive Kuwait National Bridge Assessment Project.

1



For decades, clients and communities around the world have trusted Dar not only to create, design, and build their most ambitious projects but also to lead the way in efforts to preserve, maintain, and sustain precious structures of national, cultural, social, or historical value (Figure 1). We believe investing efforts in preservation and maintenance not only significantly increases a structure's lifespan but also reduces its life time cost and boosts the sustainability of surrounding communities.

Due to this belief and due to its dedication, reliability, and technical excellence, **Dar was asked to take on the Kuwait National Bridge Assessment Project, an enormous enterprise that covered 350 roadway bridges and over 100 pedestrian bridges spread over the six governorates of the state of Kuwait.** Dar's mission comprised the inspection, assessment, and rehabilitation design of these bridges in order to verify and upgrade their performance against current codes and loads.

During this project, Dar's specialised team successfully utilised Dar's own Bridge Management System (BMS): such systems are usually provided by international organisations such as the American Federal Highway Administration (FHWA). The project provided Dar with an opportunity to successfully implement its own customised, pioneering, and state-of-the-art BMS system with Bridge Inspection and Assessment System (BIAS) software. The Dar BMS was quite comprehensive, covering everything from inspections, testing, and rating operations to the successful design of the rehabilitation works necessary for each bridge. During this project, Dar's specialised team came

Figure 1 Preservation of National Assets chart.

Figure 2 Boubyan Bridge.

Figure 3 The DAR-BMS system flowchart.

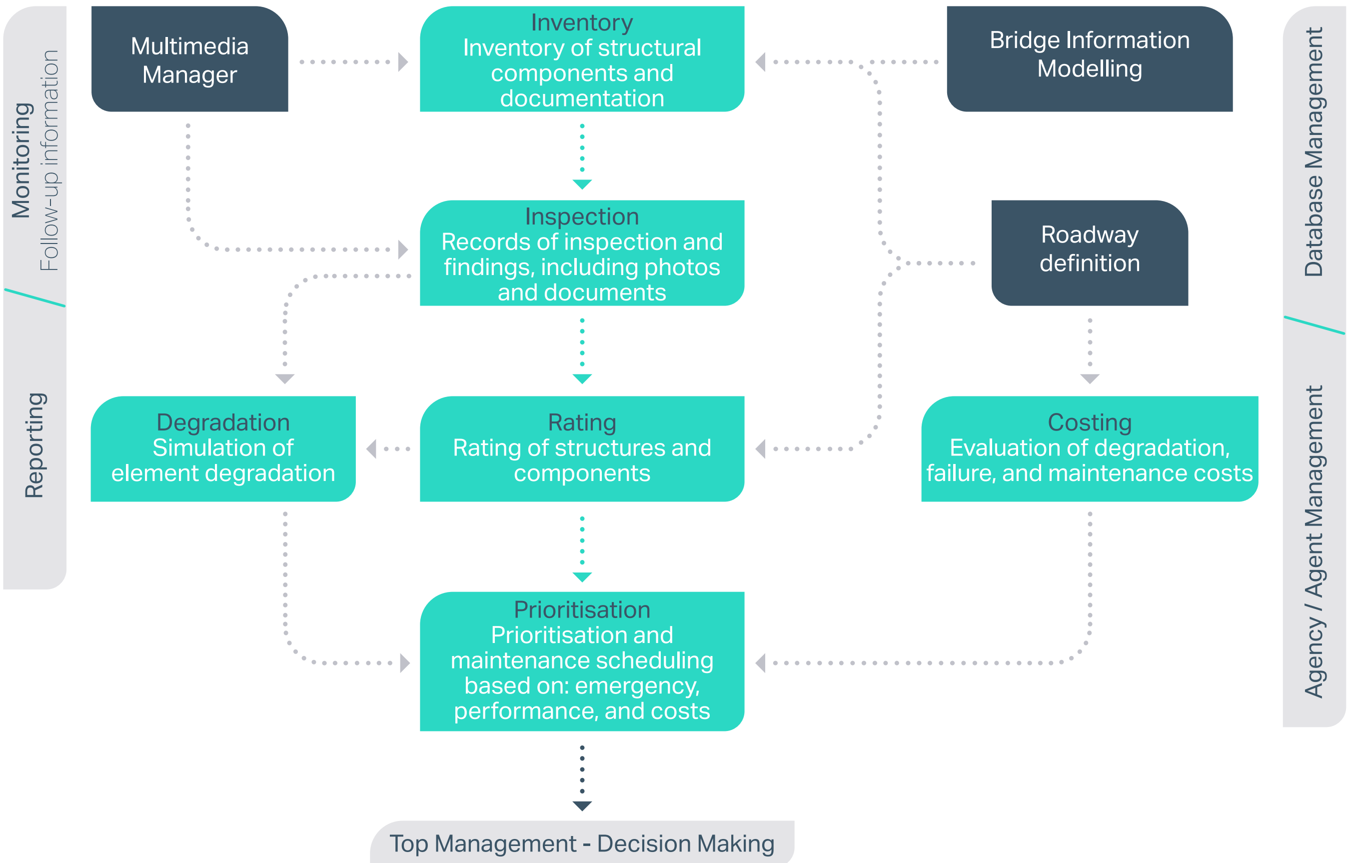
across almost every type of bridge available: pre-stressed box girder concrete bridges, steel plate girder bridges, segmental bridges, and others. The team even worked on Kuwait's Boubyan Bridge, the historically iconic 2.4 km structure that links the main land to the Boubyan Island (Figure 2), noting that this bridge was bombed during the Iraq-Kuwait war.

2

Dar's BMS experience

The Dar-BMS, with its BIAS software, is a comprehensive bridge management system that provides bridge owners (authorities) full control in terms of monitoring and managing their bridge assets. The process is initiated by the electronic archiving of as-built drawings and construction documents using the system's 'inventory' module. Then, the inspection processes are recorded and structural rating is performed. Afterwards, associated costs and budget requirements for bridge maintenance are estimated. This system is particularly advantageous in that it is fully customisable and may be tailored to satisfy the particular needs of any specific client. The system is also applicable to both old and new bridges.

3



Bridge inspections, testing, and condition rating

The specialised team Dar has assembled is comprised of well-trained and well-equipped engineers, who are capable of conducting incredibly precise inspections of all related bridge elements and recording their findings on specially designed electronic inspection forms and checklists incorporated within the Dar-BMS system.

The teams were assigned to inspect specific elements in each bridge according to carefully designed inspection plans. A systematic coding and numbering system was adopted for the bridge elements. All the inspection forms were based on the AASHTO MBEI 2013 and its 2015 interim, with special additions and modifications made by the Dar team to suit the purposes of this project.

The inspection processes themselves included - but were not limited to - hands-on inspection of bearings, expansion joints, concrete cracks, spalls, rebar corrosion, delaminated regions, and other critical defects. Each defect was measured and evaluated on-site and recorded on the system. Recording of on-site inspection observations used some or all of the system's capabilities which include voice recording, photographing using inspection tablets, video recording, and text input. Dar's team also used drones to inspect inaccessible locations. Figures 4 to 6 show examples of inspections carried out by Dar staff members.

All of the data acquired was then processed within the DAR-BMS system, and a health index was calculated for each element that was related to the magnitude of a certain defect. Consequently, a component rating was obtained according to the National Bridge Inventory's guidelines.

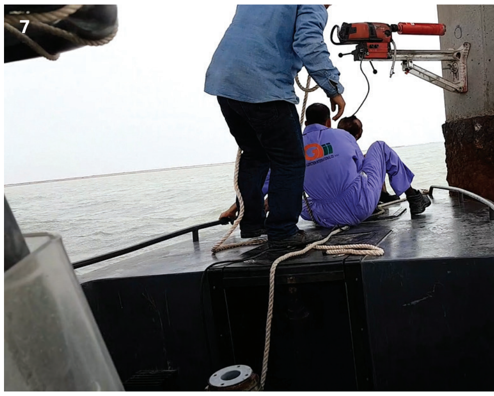


Figure 4 Inspection by drones.

Figure 5 Hands-on inspection of bearings.

Figure 6 Underwater inspection at Boubyan bridge.

Figure 7 Core test in waterway.

Figure 8 Example of pull off test for repair laminate.

Figure 9 Carbonation test for a core sample.

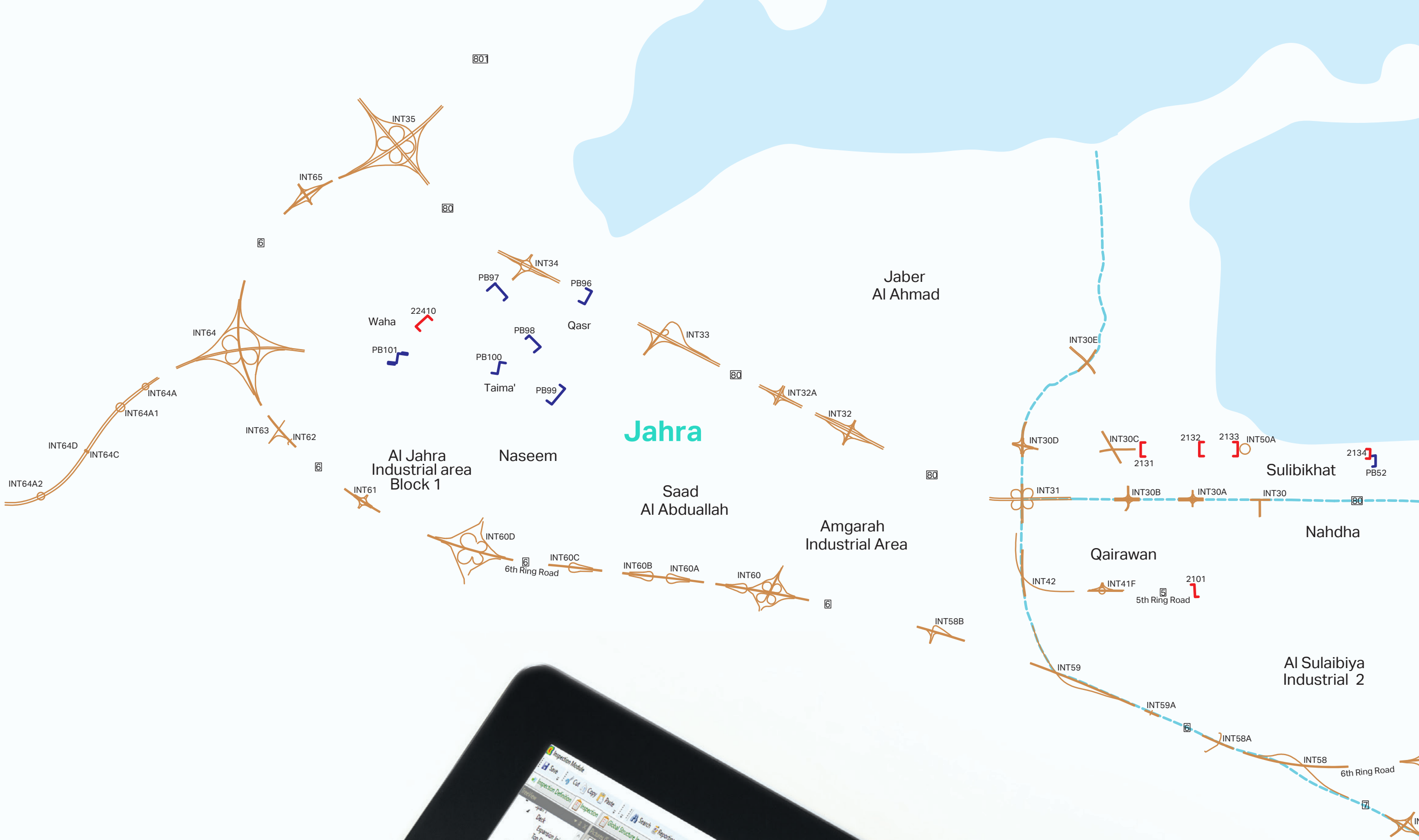
9

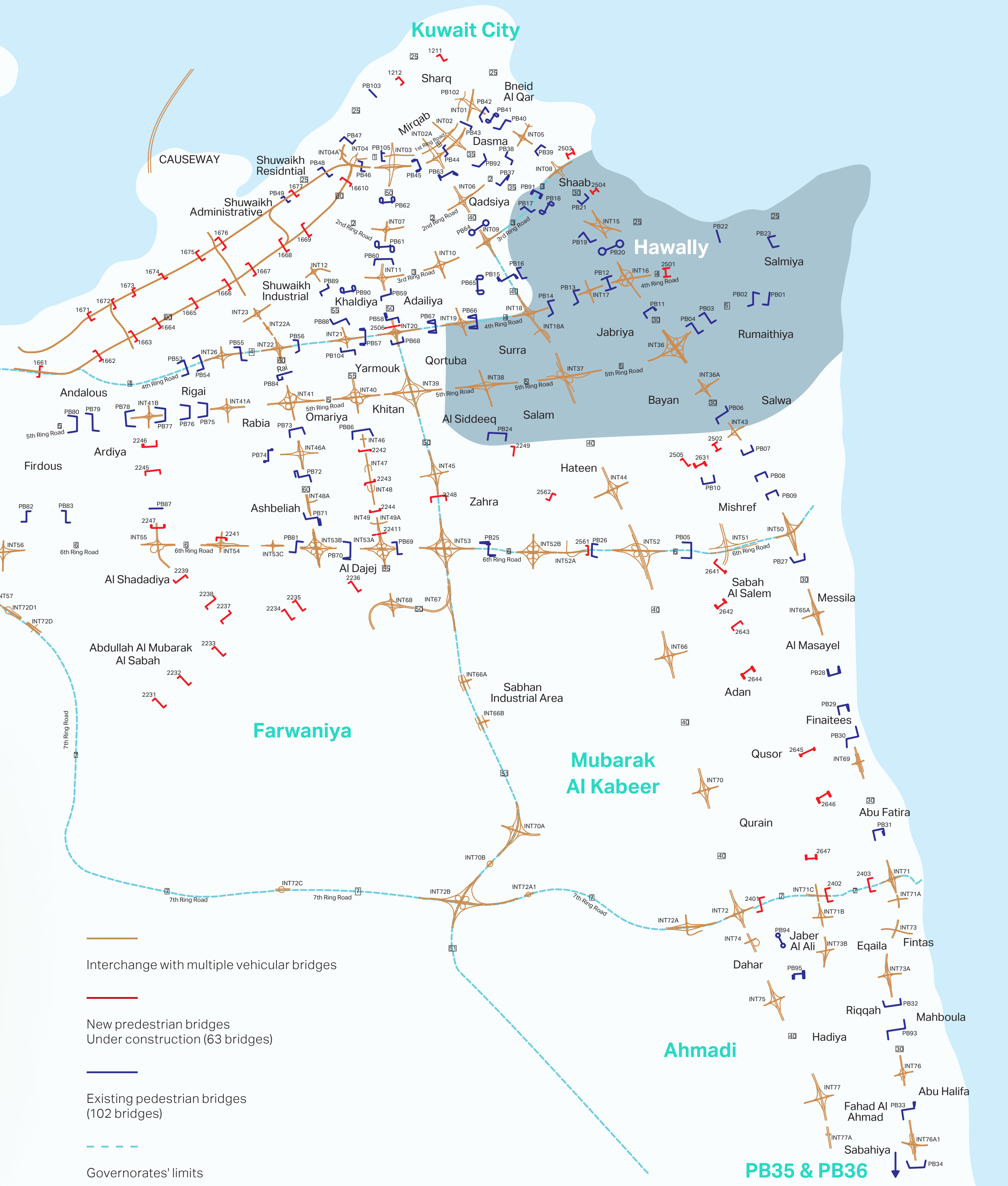
The in-depth inspection operations went hand-in-hand with tailored, site-specific physical testing campaigns: the inspection teams planned, designed, and executed the appropriate tests for each bridge. Those ranged from simple Non-Destructive Testing (NDT) techniques to semi-destructive core extraction to possibly destructive proof load tests.

The team conducted many tests within this wide range of techniques, tests that suit the requirements and conditions of the Kuwait project and the specific structure of each individual bridge. It is worth mentioning here that **DAR now has its own accredited NDT inspectors.** The NDT they conducted for the steel bridges included Magnetic Particle Testing (MPT) for weld crack detection, Ultrasonic Testing (UT) on steel masses for detecting cracks and separations in welds and bearings, Brinell hardness leeb testing, coating thickness measurement, and bolt torque calibrations. On the other hand, NDT conducted for concrete bridges included chloride ion penetration tests, carbonation tests, chemical analysis of sulphate contents, and half-cell potential tests for determining probability of corrosion. In addition, CAPO tests and semi-destructive core tests, for which rebound numbers of hammer tests are correlated to form a full test matrix, were conducted. More advanced methods, such as dynamic modal testing, were also applied. Figures 7, 8, and 9 show samples of conducted tests.

The specialised team Dar has assembled is comprised of well-trained and well-equipped engineers, who are capable of conducting incredibly precise inspections of all related bridge elements.

Elements of all existing bridges on all interchanges on the map were inspected on site and findings were documented electronically on the DAR-BMS site tablets within special input forms which include digital photographs, video captures, voice recordings of inspectors' personal observations, and inspection text input directly on site.




Kuwait City
Sharq
Bneid Al Qar
Mirqab
Dasma
CAUSEWAY
Shuwaikh Residntial
Shuwaikh Administrative
Qadsiya
Shaab
Hawally
Salmiya
Shuwaikh Industrial
Khaldiya
Adailiya
Jabriya
Rumaithiya
Surra
Yarmouk
Qortuba
Andalous
Rigai
Rai
Rabia
Omariya
Khitan
Al Siddeeq
Salam
Bayan
Salwa
Firdous
Ardiya
Hateen
Mishref
Zahra
Ashbeliah
Al Shadadiya
Al Dajej
Sabah Al Salem
Messila
Al Masayel
Abdullah Al Mubarak Al Sabah
Sabhan Industrial Area
Adan
Farwaniya
Finaitees
Qusor
Mubarak Al Kabeer
Abu Fatira
Qurain
Jaber Al Ali
Eqaila
Fintas
Dahar
Riqqah
Mahboula
Hadiya
Ahmadi
Abu Halifa
Fahad Al Ahmad
Sabahiya
PB35 & PB36
4th Ring Road
5th Ring Road
6th Ring Road
7th Ring Road
Interchange with multiple vehicular bridges
New predestrian bridges
Under construction (63 bridges)
Existing pedestrian bridges
(102 bridges)
Governorates' limits

10

Original Condition State	New Condition State			
	1	2	3	4
1	95.77	3.01	0.16	0.07
2	0.00	98.99	0.56	0.45
3	0.00	0.00	91.81	8.19
4	0.00	0.00	0.00	90.14

Load rating and sufficiency rating

Subsequently, the in-depth inspection results were substantiated by calculations in order to verify the structural adequacy of the inspected bridges. Figure 12 shows a structural model of the Boubyan Bridge. Load ratings - which indicate the loads that can be safely utilised by a specific bridge for an indefinite period of time - were conducted as appropriate, based on the site inspection and testing results. Incorporating the load rating, the condition rating, and traffic and roadway information into the Dar-BMS system in turn enables the automatic generation of the sufficiency rating, a score that indicates a bridge's ability to meet the traffic demands and safety requirements for the routes it carries. This rating also includes the bridge's essentiality to the public and to user experience comfort impact. Sufficiency ratings are developed as per the national bridge inventory guidelines of the FHWA and form the basis of repair prioritisation.

11

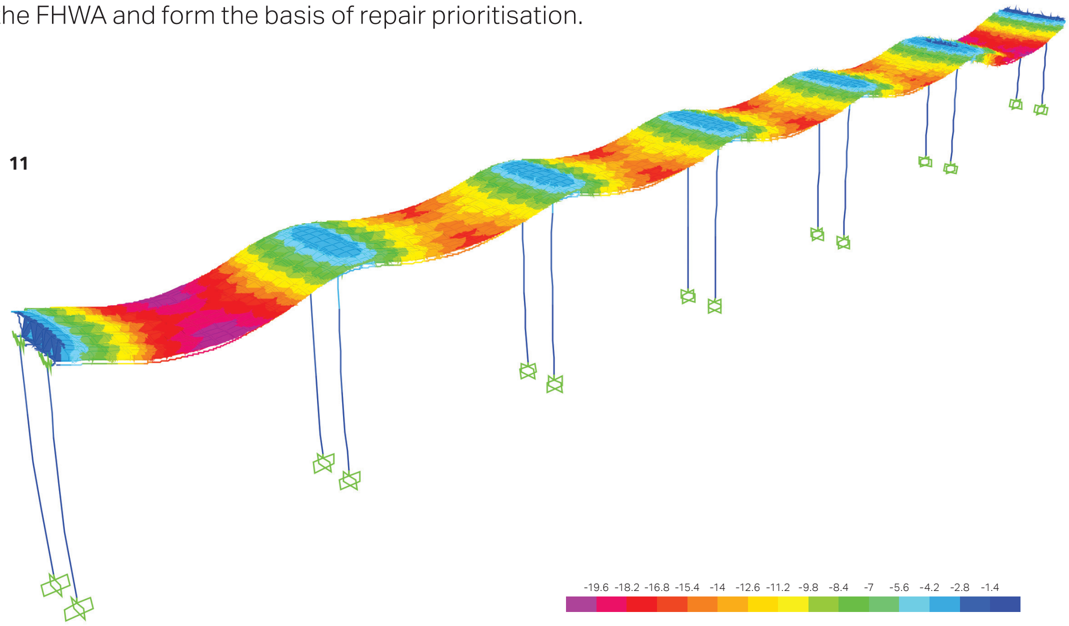
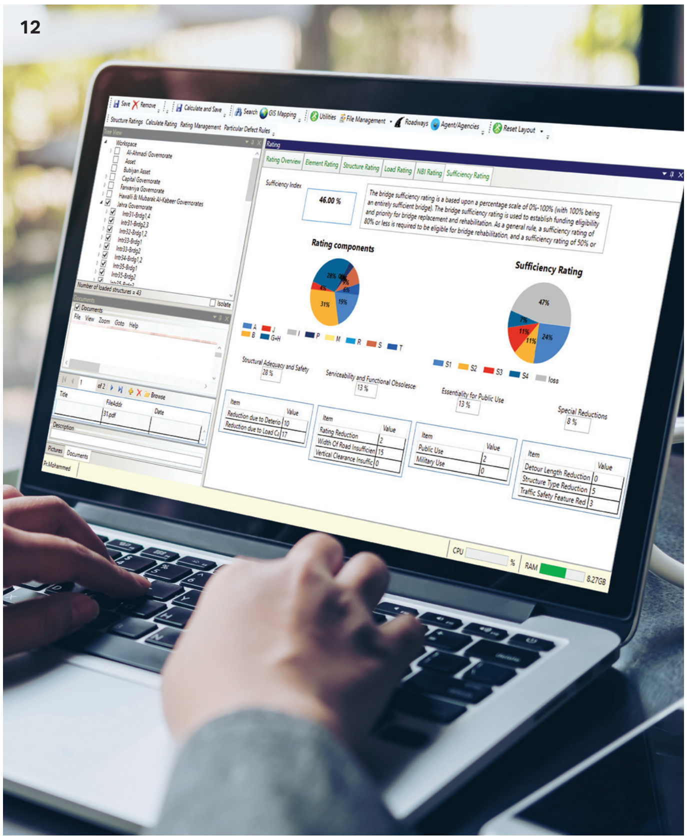


Figure 10 Degradation models built in the system.

Figure 11 Structural model of Boubyan Bridge.

Figure 12 Sufficiency rating.



12

Degradation, costing, prioritisation, and maintenance planning

Dar's specialised team used its expert opinion and judgment to forecast the future deterioration of each element defect. These forecasts were used to form the degradation and transition matrices in the DAR-BMS system platform. They provide the probability of transition, through a specific number of years, from a defect condition state to another more severe or less severe condition state. Figures 10 and 11 offer glimpses at screenshots of the rating and degradation modules. In turn, the degradation and transition matrices forecast a bridge's condition after a certain number of years, a forecast made based on analysis of previous observations from inspections and information on prevailing environmental observations. Different repair techniques can be introduced to the system, and the forecast would be re-run to take account of each of those techniques and that technique's impact on each defect. Through such simulations, several scenarios with different budgets can be visualised and evaluated, which opens the way for cost balance comparisons to be made.

On the basis of those, the DAR-BMS produces a final prioritisation plan for bridges with respect to their specific maintenance needs and budget constraints: the optimum maintenance plan.

Dar's new capability in BMS

All of this work was completed within the dedicated project duration of 24 months. Conducting detailed inspection and extensive testing campaigns on over 450 bridges of different types, sizes, and requirements has allowed Dar's inspection team to gain significantly vast experience and invaluable technical know-how. Dar now has its own wide team of accredited NDT inspectors. The DAR-BMS has been applied and verified, and it has proven capable of enabling bridge owners to fully visualise and understand the conditions of their assets and fully control their effective management. This stands in stark contrast to the lack of information and vision before the onset of any such project.

Dar's wealth of knowledge in this sector can easily be used for the benefit of other countries with similar bridges and weather conditions, in the Gulf region, the wider Arab world, and all different regions with similar needs. Dar is capable of providing a BMS that may easily be tailored to satisfy client needs and of conducting all required operations from inventory building, detailed inspections, testing, rating, degradation forecast, and prioritisation to the effective design and supervision of repair and rehabilitation. ◆

Authors

Fabio Ceccato

Robert Damian Vochescu

Expertise
Structural Engineering

Company
Maffeis Engineering S.p.A.

Location
Italy

Engineering a Historic Centrepiece: Dubai Hosts the World at Al-Wasl Plaza

In just under two years, the world's brightest minds will converge on Dubai for Expo 2020. This historic and universal exhibition, touted as a celebration of human ingenuity, is held once every five years. Under the banner of "Connecting Minds, Creating the Future," Dubai will be hosting the first Expo ever to be held in the Middle East, Africa, and South Asia region. Expo 2020 promises to bring countries, corporations, NGOs, and millions of visitors together to showcase innovative ideas and create opportunities for international dialogue and collaboration. Construction on the Expo site has already begun in earnest, and Italian engineering company Maffeis Engineering S.p.A. of Dar Group is playing a lead role in one of the site's most impressive centrepieces.

The central square of Expo 2020's new complex will be the Al Wasl Plaza. The name itself is significant in numerous subtle ways: Al Wasl is both the ancient name of Dubai and the Arabic word for connection. The word is incredibly fitting for a plaza that will host Expo 2020, an event that has taken up connections as its flagship theme. The name also gained additional significance with the organisers' promise that they will leverage the latest innovations technology has to offer in order to make the destination one of the most connected places on the planet.

Al Wasl Plaza, then, has a responsibility to symbolise the word as a whole and is intended to serve as a glorious embodiment of the connection between the host country's rich past, its ambitious present, and its future. The huge trellis dome, which is designed to cover the entire central square and act as the central hub of the entire universal exhibition, is built with this vision in mind. Its grid reproduces an ancient ring recovered in Dubai during an archaeological expedition, but the rest is as futuristic as possible. The entire 67.5 m dome will be covered with high-tech fabrics, and, depending on scheduled events, holographic images in movement will be projected on the insides and outsides of the walls of the 13,000 m^2 square on which the dome is set.

With a weight of more than 2265 tons and an indoor space of 724,000 m^3, the Al Wasl Plaza is truly a pharaonic and iconic project. According to Adrian Smith and Gordon Gill architects, a huge garden will be placed under the Al Wasl Dome. The lawn and water games, designed in the royal style of Caserta, are among the few concessions to esterophilia. The rest, beginning with the numerous colonnades of palm trees guiding tourists as they travel, will recall the riches of the landscape of Dubai.

A modern Duomo, the Al Wasl Plaza will be the setting for the lay liturgy of the opening and closing ceremonies of Expo 2020 and for the festivals of the individual countries taking part in the event. It will also be a place to rest, a cool shelter sustained by the air conditioners which will work continuously to avoid turning the structure into a greenhouse under the desert's scorching sun. In short, it will be the heart of Dubai's universal exhibition.

724,000 m³
indoor space

67.5 m
dome height

2265 tons
Plaza weight

13,000 m²
area for projection of holographic images

An Italian touch: Cimolai- Rimond and Maffeis Engineering S.p.A.

This pulsating heart will be built through a partnership between two Italian companies: the Milanese Rimond and the Pordenone-based Cimolai. Maffeis Engineering S.p.A. of Dar Group completes an Italian trio and will make its own contribution to the mammoth task of transforming this pharaonic project into reality, by designing the method statement and the dome's connections.

Making the dangerously impossible possible: method statement design and analysis

The enormous opening dome takes over 130m of the central Plaza area and reaches a height of 67m. It consists of S460 quality pipes arranged in a motif of rings interconnected to each other to form a dome. The tube diameters are standardised at 508mm while thicknesses range from 10mm to 50mm. The pipes are calendared and welded together so the structure appears smoothly continuous and free of interruptions. The behaviour of the structure is that of a dome, supported on pot bearings that allow rotations in all directions.

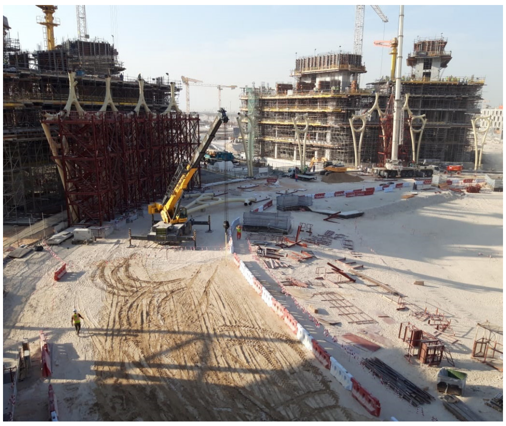
To counter potential risks on this sensitive project, the structure's method statement was designed to address three critical issues: the resilience of existing concrete substructures, residual locked-in stresses, and the enormous dimensions and complexity of the trellis structure itself.

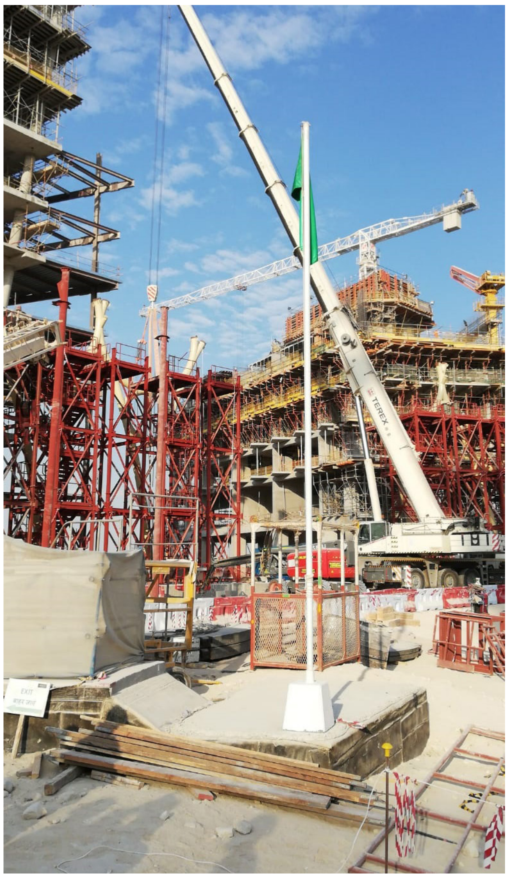
The first of the aforementioned problems is linked to the task of scouring the limited site area for suitable and acceptable locations for each of the crane operations. In fact, all the backfilling was taken up by existing concrete substructures, and these substructures had not been designed to withstand the critical, if temporary, conditions imposed by crane operations. Therefore, all concrete substructures had to be verified for each of the liftings performed by the crane. Moreover, the crane movements were optimised to mitigate the impact on the concrete substructures. Temporary props were avoided whenever possible in order to reduce construction costs.

Another difficult task was designing the method statement in such a way as to minimise the residual locked-in stresses and deformations. This task was a critical one. The service stresses are very high in the structure's original design condition to begin with, so there is very little margin for extra stresses caused by the erection phases. To counter this problem, the Maffeis Engineering S.p.A. team conducted piece-by-piece analysis with staged FE models. The team recommended that, during the erection sequences, all pieces be supported by temporary towers. These removable works, which could easily be disassembled later, are connected to the structure by means of frictionally tightened slotted connections. As an added precaution, checks and verifications of the residual stresses are conducted for each erection phase.

The most particular and sensitive issue that affects the design of the method statement is that of the complexity and the large dimensions of the trellis structure. For context, it is important to note that the structure consists of an outer part and an inner part. The outer part, called Ring 1, reaches a vertical height of 45 m. As the bottom part with the biggest thickness, Ring 1 is the heaviest part of the structure and needs to be erected as a large and high lattice structure. To accomplish this erection, a customised bracing system had to be especially designed and developed.

The inner part, Ring 2, is first erected at ground level as a 'small' dome with a height of 25 m. Once the ring is complete, the project proceeds to the most peculiar stage: lifting Ring 2 in its entirety onto Ring 1. This incredibly delicate phase requires all the skills and know-how from the Cimolai team combined with every ounce of the detailed knowledge and high-grade analysis skills of the Maffeis Engineering S.p.A. design team. Yet, a solution was found. The elevation of Ring 2 is executed through the means of 18 strand jacks, supported by vertical main columns. These columns are enormous pipes (1200x15mm), fixed to the ground on a concrete slab and fixed at the top to Ring 1. The lifting itself and the subsequent regulation phase that is performed to align and connect Ring 1 and Ring 2 are both performed under strict weather control and monitored by a continuous precision topographic survey.





Connection design and calculation

The Maffeis Engineering S.p.A. team was also responsible for the design of the steel pipe connections that form a prominent feature of the trellis structure. The connections are made up of calendared pipes, welded one on the other until they merge tangentially into one.

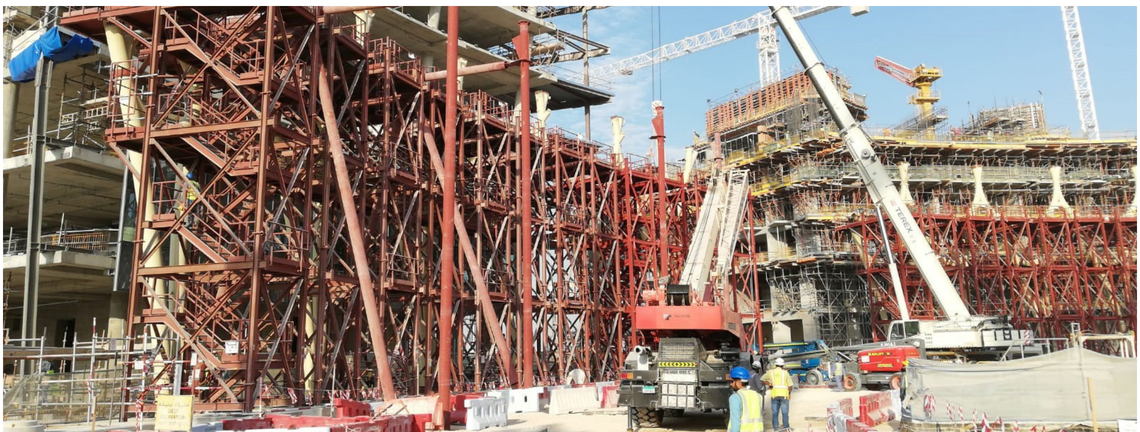
The challenge is an interesting and complex one. Consider more than a thousand connections that seem at first glance similar to each other but are actually different in their calendaring radii, the thickness of their profiles, and their internal straining actions. Moreover, the design must aim to minimise the request for internal steel plates and, above all, minimise the size of the welds or the effective throat thicknesses. Since the project is characterised by kilometres of welds, successfully minimising the size can have an enormous impact on the final cost of the entire structure. Standard codes do not provide tools to deal with connections of such complexity, so the connections — by virtue of their particularity and specificity — have to be studied and analysed individually.

In order to complete such extensive analysis properly and efficiently, Maffeis Engineering S.p.A. developed and leveraged a model with marvellous computational power. The required analyses were conducted with computational approaches oriented towards automation, approaches that represent state-of-the-art innovations in the world engineering panorama. Automatic procedures were developed to generate detailed Finite Element Method (FEM) models of the nodes. The main phases were essentially:

- reading and defining the input (identifying mapped actions and nodes, internal action at the connection, and so on);
- constructing geometry aimed at structural calculation and faithful to the criteria of manufacturing;
- creating finite element calculation models; and
- analysing and post-processing results.

Even the calculation of the welding was carried out through automatic procedures. The algorithm used is able to identify the intersections between different profiles and recognise the longitudinal development of the welds. It even calculates the forces acting on them for the purpose of designing, optimising, and verifying the welding procedures necessary for the realisation of the diagrid connections.

The creation of the software dedicated to the analysis of the connections of the trellis nodes was made possible by the union of multi-disciplinary competencies. Indeed, with the enormous amount of analysis necessary, engineering and designing connections was far from the only concern. In fact, the main challenge was developing, managing, and controlling the automatic generation procedure. Programming the necessary software and creating the codes – work specifically developed in Python and C# – were continuous tasks throughout the duration of the activities. The programming was aimed first at managing the problem of the 3D surface modelling for structural calculation (specifically the problem of parametrisation of complex geometries) and, also, at post-processing the stresses indicated by the analyses in order to automatically calculate welds. In such cases, the work of reviewing and checking the results — conducted in accordance with pre-established tests, documented, and carried out in a recurring way in accordance with ISO 9001 quality standards — is extremely important. A design of the procedure itself ultimately allowed the creation of a fast live-link between the conditions input (always sensitive to changes and updates) and the analysis and post-processing phase of the results. This has meant that, in addition to providing efficiency and excellence, Maffeis Engineering S.p.A. was able to guarantee respect for the tight deadlines to which the design activity was subject. ◆



Special Feature

Egypt's New Administrative Capital:

A City of Unbound Opportunity and Unrestrained Potential

City wide facts and figures

715 km²
City wide Area

6.5 million inhabitants
Expected Population by 2050

2 million jobs
Expected Job Opportunities by 2050

21
Number of Residential Districts

Phase 1 facts and figures

170 km²
Phase 1 Area

2.7 million inhabitants
Expected Phase 1 Population

8
Number of Residential Districts

200 million m²
Total Built Up Area of Phase 1

2.5 million m²
Ministerial and Financial District Area

3.9 million m²
Ministerial and Financial District Built Up Area

0.8 million m²
Central Business District Total Area

1.8 million m²
Central Business District Built Up Area

16 million m²
Mixed Use Corridor Total Area (Capital Park)

16 million m²
Mixed Use Corridor Built Up Area (Capital Park)

38 million m²
Residential Districts Total Area

47 million m²
Residential Districts Built Up Area

Location and size

The New Administrative Capital is strategically located 45 km east of downtown Cairo and sits between two highways linking the site to the Suez Canal Development Corridor, the Port of Ain Sokhna, New Cairo, and the industrial city of the 10th of Ramadan.

Covering a total land area of 700 km^2, the planned New Administrative Capital is comparable in size and scale to the City State of Singapore or the Country of Bahrain. By itself, the first phase of the New Administrative Capital (currently under construction) has a land area of 170 km^2 which is comparable in size to Washington DC.


10TH OF RAMADAN CITY
SHOROUK CITY
MADINATY CITY
Suez Road
Capital Park
10 km
CBD
Ministerial & Financial District
PHASE 1
NEW ADMINISTRATIVE CAPITAL
Sokhna Road
Regional Ring Road

The Required Birth of a New City

Author
Dan Horner

Expertise
Planning & Urban Design

Company
Dar

Location
London, UK

The population of Greater Cairo has doubled within the past few decades, which has led to overcrowding, congestion, and untenable pressure on the city's urban infrastructure systems.

In response to such pressures, the Government of Egypt envisioned the birth of a new city, one that can sustainably accommodate physical growth while simultaneously strengthening and diversifying economic growth.

That city materialised at the Egypt Economic Development Conference in 2015. Under the auspices of President Sisi, the Minister of Housing - Mostafa Madbouly – announced

Figure 1 Capital Park - Downtown district.

Figure 2 Dar Egypt's director of operations, Yehia Zaki, during the Egypt Economic Development Conference 2015.

the launch of the New Administrative Capital project, a once-in-a-generation enterprise that aims to alleviate Greater Cairo's increasing densification and establish a new growth hub for future generations. Within the same year, the construction of a new road corridor leading from Cairo to a newly designated 70,000 ha site was inaugurated.

Aspiration and vision

The decision to move government ministries, parliament, and civic institutions to the New Administrative Capital has demonstrated the Government's unwavering commitment to the project. Such conviction, combined with early investment and the construction of new roads and infrastructure, has acted as a strong catalyst to attracting major private investment and stimulating economic growth.

By the time the project reaches completion in 2050, an estimated resident population of 6.5 million people will live in 21 newly constructed residential districts, each of which will be centred on sustainable landscapes, community facilities, and a diverse range of accommodation types — all aimed at providing a high standard of living for the typical Egyptian family. The New Administrative Capital is also projected to generate and accommodate over 2 million synergistic job opportunities for all income-levels and cultures, particularly the country's growing youth population. The Government recognises that exemplary housing has a profound effect on the health, welfare, and economic wellbeing of its population. The availability of houses at different price points and tenures is therefore critical in order to ensure accessibility to all income groups – especially young professionals and members of the middle class who are increasingly finding themselves priced out of the Cairo housing market.

New communities will be supported by 500+ medical facilities, 1500+ academic institutions, commercial centres, cultural hubs, and even a new international airport.

The New Administrative Capital is a bold vision, but it is a vision that is both feasible and implementable and is currently being delivered on the ground, day by day. The New Administrative Capital possesses the unrestrained potential needed to shape a better standard of living for millions of Egyptian families: it is a once-in-a-generation opportunity to secure long-term sustainable growth and drive the nation forward.

This opportunity, with its exceptionally ambitious and incredibly rare nature, has aroused a strong sense of national pride and support for the project - which in turn has resulted in many Egyptian businesses and companies investing from a very early stage. Such national momentum and support has consequently led to significant (and growing) international interest and investment.

A country with a great past has a bold and bright vision for its future - the New Administrative Capital is an embodiment of that prospect and a major step forward in achieving it.

Capital Park

On behalf of the Egyptian Government, Dar has prepared a masterplan for the commercial backbone of Cairo's New Administrative Capital: the Capital Park development corridor.

Covering an area of 16 km² and with a planned built up area of about 16,000,000 m², Capital Park is comprised of three distinctive commercial zones: Gateway, Downtown, and Central Business District (CBD). The districts are centred upon a world-class Central Park, larger than the size of New York's Central Park and bookended by a new Grand Mosque to the west and Africa's tallest tower to the east.

Capital Park's gateway location between major highways and rail networks enables the zone to function as the commercial artery for the New Administrative Capital and its neighbouring communities. By the time it is completed,

3

4

Capital Park is expected to have generated over 450,000 permanent employment opportunities and to be home to a residing population of over 180,000 people. The Central Park alone is expected to attract more than 2 million visitors a year.

Within its role as 'main consultant,' Dar is undertaking master planning services for the whole Capital Park corridor as well as detailed architectural and engineering design services for the CBD, which is earmarked as the first phase of construction and has site preparation works in progress.

Capital Park is set to become a symbol of Egypt's rich culture and progress, delivering a series of smart urban districts which are resourceful, resilient, and forward-looking. These will include: contemporary business environments, focused on attracting investment, generating new employment

5

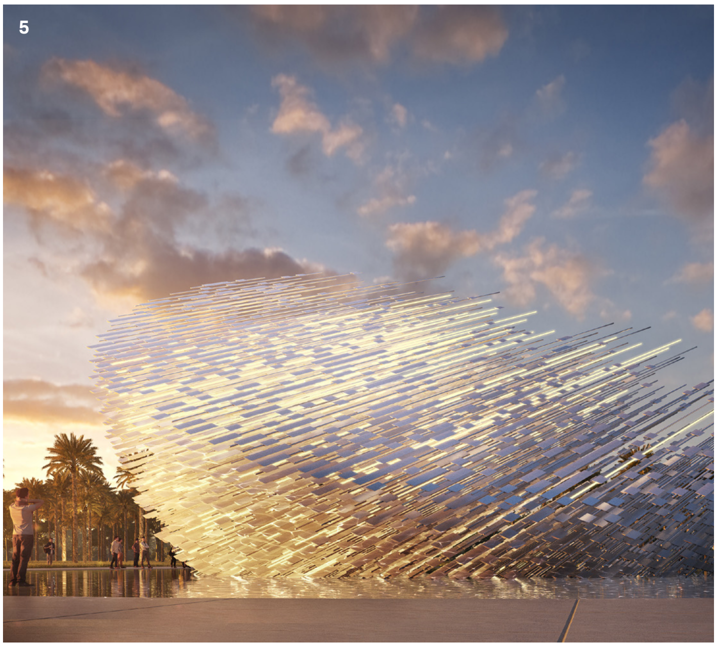


Figure 3 Downtown Parkside apartments.

Figure 4 Central Park Lake.

Figure 5 Central Park Art Sculpture.

Figure 6 Central Park event space.

Figure 7 Central Park.

opportunities, and propelling economic growth; residential communities that will facilitate and promote a high standard of living for all citizens; and civic spaces that bring communities together and promote healthy urban lifestyles.

State-of-the-art infrastructure and transportation systems will enable rapid internal and external connectivity for the thousands of commuters visiting the New Administrative Capital, via inter-city monorail, light rail, tram, and electric bus networks.

The unprecedented Central Park spans over 10 km in length and 4 km^2 in size – making it one of the largest urban parks in the world. Its design has been shaped by site features, topography, and hydrology to ensure that it works in harmony with its natural environment. The park will also host a wide variety of world-class recreational and leisure amenities. These include botanical gardens, sporting clubs, children's learning centres, major event spaces, and a series of art features and installations, all of which will be easily accessible through a network of tree lined pedestrian and micro mobility routes.

The Central Business District (CBD) is an international business and financial centre and a highly efficient and attractive place of work, which, once completed, is set to become one of the New Administrative Capital's most iconic and internationally recognisable districts, with landmark high-rise towers that will serve as a symbol of Egypt's cultural and economic progress.

The **Downtown District** is the recreational and cultural heartland that forms the core of the New Administrative Capital's offerings in retail and hospitality. In this District, museums, galleries, theatres, and cinemas sit alongside high-street shops, shopping arcades, and department stores.

The western **Gateway District** is planned as a centre for enterprise, innovation, research, and development, integrating innovative, high-tech, and entrepreneurial businesses with technology and medical university departments. Its proximity to the major highway network also makes it the appropriate location for logistics, light industry, and big-box retail uses.

Bringing together master planning, project management, and construction supervision for a project of this scale under a single consultant presents a rare opportunity to implement a clear and distinctive vision. Capital Park is the backbone of the new city and will be the catalyst for economic growth.

The first phase of construction is CBD East, which will set the standard in intelligent infrastructure and sustainability, through green building design, resource management, and renewable energy.

CBD East

The Central Business District East "CBD East" is set to become the New Administrative Capital's most iconic and internationally recognisable district.

The comprehensive planning and design of all aspects of the new District by Dar and sister Dar Group companies offers an opportunity to create a highly interconnected and intelligent urban environment which enhances efficiency, safety, security, and liveability for its inhabitants.

To achieve this vision, Dar is working with its sister company Perkins+Will to create a cohesive architectural, aesthetic, and material language that will provide a dialogue between each building typology while still allowing each individual structure its own distinctive character.

An instant landmark and a focal point of the entire project is an iconic sculptural tower with an illuminated crown inspired by the Obelisk of Luxor. Rising nearly 400 meters, it will be one of the tallest buildings in Africa and will offer 100,000 m^2 of Category A office space as well as a 5-star hotel. Simply stated and elegantly proportioned with refined details, it will convey a sense of strength and stability.

A symbolic pedestrian axis running east-west through the centre of the entire CBD emulates the Nile Valley, connecting all components into a cohesive whole. As it meanders through

the CBD East, the main pedestrian spine — which links the Iconic Tower to an important sculptural element located at the far eastern end of the site — features the use of water and planting to recall the Nile Valley. This important promenade passes through the central plaza of the multi-use elliptical building with its façade of closely spaced vertical aluminium sunscreens reminiscent of tall reeds found along the Nile river banks. Within the plaza, the walkway itself divides and merges, again referencing the Key of Life. A sunken garden oasis provides optimum shading and retail opportunities for a variety of food and beverage venues.

On the northern edge of the district, six distinct office towers of various heights and exterior expressions flank the expressway, offering passing motorists impressive and spectacular views of CBD East.

To the south, five uniquely shaped residential towers are located adjacent to the Green River Park and will allow residents the opportunity to enjoy clear unobstructed views in several directions.

Throughout the district, open arcaded podiums front onto the roads, creating a well-defined and active streetscape environment. The podiums create synergy between the office, housing, and retail elements whilst offering the public and office workers opportunities to shop, eat, and socialise. All podium roofs are to be planted with low water consumption succulents, providing insulation to the spaces below and a pleasant environment for potential outdoor use.

Set amongst the high rise buildings will be a sequence of world-class public spaces, which will ease pedestrian navigation and flow and create a truly unique urban experience. Landscaping of these spaces will include natural grasses and other plant and tree species native to Egypt, all of which will be set within an organised composition of paving throughout the site.

This high-profile project will showcase world-class architectural design and incorporate state-of-the-art urban infrastructure systems, platforms, and innovations. Once implemented, the autonomous and self-reliant district is poised to set a new international standard in 'smart city' design.

Figure 8 CBD East Central Boulevard.

Figure 9 Central Plaza and Iconic Tower.

Figure 10 CBD East Pocket Park.

Ministerial and Financial Districts

The new Ministerial District is symbolic of Egypt’s past, present, and future. Designed to reflect elements of Egyptian culture and heritage, it is nevertheless unmistakably contemporary and built to accommodate the sophisticated needs of a large and modern workforce.

Once complete, the District is expected to accommodate over 100,000 employees, who will be able to commute to their workplaces via a network of interconnected monorail, light rail, and tram systems. The district is centred upon a monumental linear park that will not only be an exquisitely designed civic space but will also feature a procession of prominent civic buildings - including a new gallery, museum, central library, and exhibition centre.

Dar’s role in the design and delivery of the District covers master planning, project management, and construction supervision. Construction of the District is well underway, with the first ministries due to be operational towards mid-2019.

Adjacent to the Ministerial District is the newly planned Financial District, which will accommodate the headquarters of Egypt’s largest and most influential banks and financial institutions along with a series of hotels, shopping centres, restaurants, and cafes. Dar is the lead design consultant for this District and for the newly introduced Central Station District to the west which will act as a major transportation interchange for the wider area.

These three interlinked Districts (Ministerial, Financial, and Central Station) are required to set new standards of urban development and quality of life for their users: their success is seen as instrumental to the overall success of the New Administrative Capital.

Figure 11 Capital Park Development Corridor.

Figure 12 Ministerial district.

"The New Administrative Capital city will provide outstanding services and a high quality of life for the citizens of Cairo and the surrounding area. The new city will also create a variety of job opportunities, as part of a comprehensive development framework.

Once the capital is complete, it will be vital to continue to upgrade the infrastructure and provide constant maintenance, to very high standards, across the various projects, and to provide ongoing high-quality services for citizens, to guarantee a sustainable city."
Abdel Fattah El Sisi, President of Egypt

Dar helping deliver a generation-defining project for Egypt

Dar is honored to be entrusted by the Government of Egypt in helping define and shape the country's most significant development projects. Working in close partnership with the Government and the private sector, Dar is helping deliver a new world-class city that is reflective of the rich history and heritage of the nation and symbolic of a higher quality of life for future generations.

The firm's multi-level involvement in the New Administrative Capital demonstrates, once again, the sheer breadth and excellence of the services this firm offers and its world-class capabilities in delivering projects of this scale and stature.

CBD East Skyline

Development Headlines

Site preparation works for the Central Business District have commenced. The district will feature the tallest tower in Africa, a monumental structure with a height of 385 m.

The construction of the Governmental District, which will feature 34 ministerial buildings, the parliament, and the cabinet, is well underway, with the first ministries expected to become operational by mid-2019.

Ministerial district and construction

Authors

Ahmed Abd El
Fattah El Shenawy

Jad Succar

Expertise
Electrical and
Telecommunications
Engineering

Company
Dar

Location
Cairo, Egypt
Beirut, Lebanon

Building a Smart and Resilient City

The New Administrative Capital is envisaged to set a benchmark in sustainable and Smart City design: it will feature state-of-the-art infrastructure, transportation systems, green building design, resource management, renewable energy, and innovative industries, all of which will set a new standard for Egypt's future urban growth.

This New Administrative Capital will embrace an ethos of sustainability born from Egypt's great history and tradition in

1

Figure 1 CBD East towers.

innovation and self-reliance. The new capital will not only take advantage of the sustainable technologies of today, it will also research and develop the technologies of tomorrow through newly founded innovation and education hubs.

ICT: The fundamental enabler of the Smart New Administrative Capital

The core objective of the technology infrastructure for a Smart City is to provide, in real-time, a comprehensive view of the current operation of every aspect of the city's infrastructure, from its power distribution lines to its traffic lights.

Smart infrastructure systems are differentiated from traditional systems by their ability to make intelligent planning decisions through three main processes: collecting data, anticipating problems, and coordinating resources. The technology has, as its backbone, a large Internet of Things (IoT) platform and is empowered by a set of services. By harnessing the power of Information and Communication Technologies (ICT), the New Administrative Capital will be able to collect enormous amounts of data about itself from various strategically placed IoT sensors and field equipment. Then, the information will be efficiently transmitted through fixed and wireless communication means and ingested across various data analytics, which analyse data in order to obtain a fuller understanding of what is happening and predict what is likely to happen. This contributes to the manual actuation or automation of actions that can dramatically optimise processes and boost reliability, efficiency, and resilience.

New Administrative Capital Smart City facilities

At the core of the New Administrative Capital Smart City vision lie the critical infrastructure facilities required for proper day-to-day operations. These include:

- Data Centres – for city-wide operations
- Command and Control Centre (CCC) – for city-wide Smart City service operations
- City Operation Centre (COC) – for city-wide safety and security monitoring and operations
- CBD Main Control centre – for CBD safety, security, and Smart City service operations

Safe City operation

The Command and Control Centre (CCC) will be the main control building for the New Administrative Capital Safe City, focusing mainly on the safety and security of the city's residents and providing the Ministry of Interior with necessary and effective public safety solutions such as:

- Incident detection
- Emergency response
- Evidence collection

Unified infrastructure management

The City Operation Centre (COC) will enable the seamless integration and swift coordination of data received from the various Smart City services; the presentation of this data to the operators; and the execution of automated and user-managed actions throughout the city. It will host the Smart City platforms which will use open Application Programming Interfaces (APIs) to integrate the different Smart City ecosystems, and provide functions such as device management, data analysis, real-time decision making, and so on.

The city dashboards will provide a holistic view of city operations, enabling city stakeholders to manage data from various sectors such as lighting, parking, traffic, waste management, Wi-Fi, and others.

The New Administrative Capital's COC will open opportunities for city operators to further develop and apply new and future industry trends such as Artificial Intelligence (AI), blockchain, data warehousing, machine-to-machine communication, connected cars, and many others.

Data centre services

Within the CCC and COC facilities, city cloud data centres will be provided to host all the city-generated data and applications and to enable different services such as:

- Infrastructure as a Service (IaaS)
- Platform as a Service (PaaS)
- Software as a Service (SaaS)
- Virtual Private Cloud (V.P.C)
- Virtual Private Server (V.P.S)
- Managed Hosting

CBD Main Control Centre

Another critical infrastructure facility will be the CBD Main Control Centre. This centre will allow the facility management to have local monitoring capabilities for the district outdoor video surveillance systems and smart services. It will also provide full visibility over the data aggregated from the towers Integrated Building Management System. This Main Control Centre will be interfaced to the CCC and COC facilities.

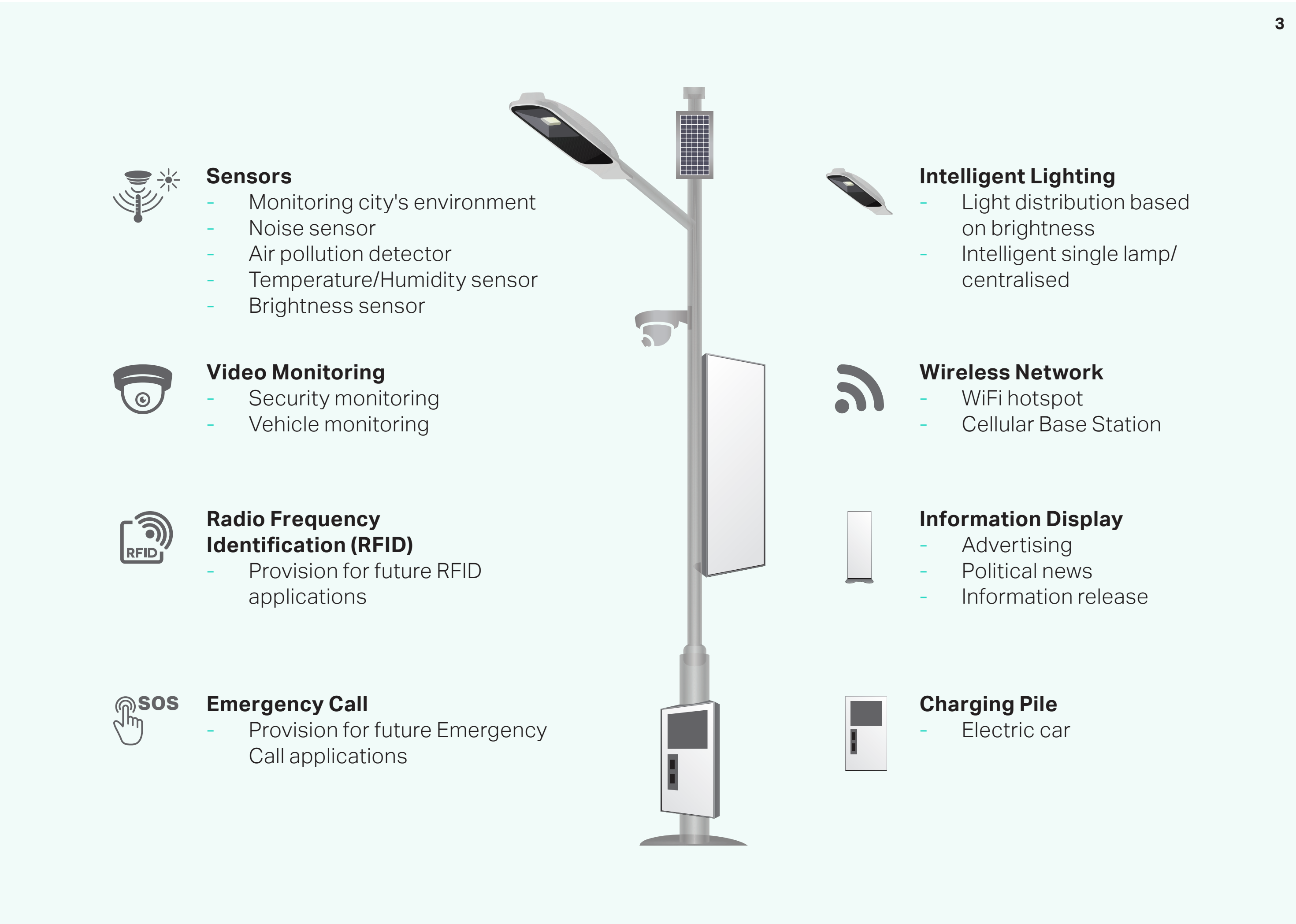

2

CBD Smart City services

As a new development, CBD has a tremendous opportunity to adopt and benefit from the ultimate Smart City concepts. Following the stakeholders' vision and guidelines, CBD is applying a rich menu of Smart services, including the following:

1. Smart Pole Services (emphasising infrastructure, environmental, and energy pillars):

- Smart Lighting Poles will offer a high level of safety and security within CBD roads and public spaces. Furthermore, by developing a Smart Lighting Management System, CBD will benefit from a lower cost of operations and a higher level of control. The multifunctional lighting poles will provide both a platform for higher return on assets through integrated digital banners and room for futuristic smart applications via integrated IoTs and devices (Digital Signage, weather sensors, Wi-Fi, video surveillance, public safety fixed units, and others).



2. Video Surveillance Systems (emphasising security pillar):

- A video surveillance system will be designed to effectively monitor and secure buildings and outdoor communities and to provide situational awareness and efficient security risk mitigation.
- Once deployed, video surveillance will be a transformational powerhouse in the CBD Smart City. When equipped with state-of-the-art video analytics, it can serve to extrapolate information, empowering authorities to provide tailored smart services for improved safety and, thus, leading to a decrease in crime levels. This service will also be the foundation for many features – including smart queue management and traffic control and management systems – that, if deployed, will enhance visitors' experiences.

Figure 2 CBD East.

Figure 3 Example of Smart Pole including Smart services.

3. Intelligent Transportation Systems (ITS) (emphasising transportation pillar):

- Provision for future implementation of city wide planned ITS services is considered in the main roads. The use of ICT in transportation and traffic management systems will improve the safety, efficiency, and sustainability of transportation networks, reducing traffic congestion and enhancing commuters' experiences.

4. Smart Grid (emphasising infrastructure pillar):

- By optimising supply and demand for the district, the CBD Smart Grid will promote clean, sustainable, economic, and commercial benefits for users and authorities who will be armed with increased control over the electrical network.
- From a technical point of view, CBD's Smart Grid transmission and distribution systems, integrated with the latest energy management technologies, will give the district's power supply a high level of reliability and resilience.
  All electric grid components (meters, transformers, distributors, etc.) will be connected to both the COC and the CBD Main Control Centre.
- Similarly, all valve chambers and water meter chambers will be connected to both the COC and the CBD Main Control Centre.

5. Smart Parking (emphasising transportation pillar):

- Smart Parking is another vital component of a Smart City. The service will provide real-time parking space management by using sensors to monitor parking spot availability and by guiding users to available spots through mobile applications. Smart parking will optimise the time drivers spend manually searching for the optimal parking lot and spot and can be expanded to encompass a complete suite of services such as online payments, remote spot reservation, parking period notifications, and overstay violations.
- All parking bays are provided with parking guidance systems enabling the efficient use and management of every parking slot within the CBD.


4

5

6. Photovoltaic System (emphasising energy and water pillar):

- Photovoltaic systems will be provided in the CBD Central Utility Complex (CUC) to emphasise green and energy efficiency concepts within the district.

7. Smart Irrigation System (emphasising energy and water pillar):

- Connectivity to the irrigation system controllers is provided through a Smart Irrigation System.

8. Quad Play Services (emphasising infrastructure pillar):

- Ranging from fixed line connectivity to Internet Protocol TV (IPTV) services, all quad play services will be guaranteed to tenants via the Fiber To The x (FTTx) infrastructure.

9. Smart Meters (Utilities Management) (emphasising infrastructure and energy and water pillars):

- By deploying Smart Metering, the CBD utilities infrastructure will offer a host of benefits to both consumers and authorities. Such benefits include facilitating bill management, improving consumption management, enhancing network planning, offering real-time insights, and performing predictive analytics.
- All units will be provisioned with Smart Utility Meters communicating via Power Line Communication (PLC) and connected to the COC for remote monitoring and management capabilities.

10. Building Management System (BMS) (emphasising infrastructure, security, and energy and water pillars):

- Integrated BMS will be leveraging building systems integration under one platform, enhancing user experience and facility staff operation.


6

Egypt going Smart

Through aspiring to develop and build new Smart Cities, Egypt is primarily focused on creating a society that will offer its members an enviable quality of life, attractive living environments with ample opportunities for progress and growth, and healthy lifestyles.

At the very heart of the New Administrative Capital, the CBD – a pilot Smart City – is precisely one such example. It seeks to promote a lively and innovative environment for its individuals, businesses, and stakeholders. Through the anticipated embedded digital technology and the optimised sustainability models, CBD's residents and visitors will benefit from a myriad of personalised experiences, an unparalleled quality of life, an increased sense of belonging and safety, reduced costs, more information, and a limitless array of services to select from. ◆

Figures 4 & 5 Example of a Smart Parking system.

Figure 6 District Main Control Centre arrangement.

Author
John Davey

Expertise
Environmental
Consultant

Company
Dar

Location
Beirut, Lebanon

Higher Standards, Newer Commitments: The World Bank's Updated Environmental and Social Framework

Environmental Assessments evolved in the 1960s[1] and have now been mandatory almost everywhere for a couple of decades. Over that time, environmental concerns have continued to change. Consequences of climate change, the scourge of plastic in our oceans, and the devastating health impacts of poor air quality are better documented and feature more urgently and prominently in people's minds than ever before. Social concerns have also changed, with issues such as forced migration, human trafficking, modern slavery, and gender-based violence featuring prominently in today's daily news bulletins.

International funding institutions such as the World Bank and International Finance Corporation have taken on the responsibility of tackling these issues and have provided their own high standards for environmental assessment. These institutions have kept abreast of contemporary concerns with updates to their Safeguard Policies and Performance Standards, which consequently have come to be considered best industry practice. These policies tackle both environmental and social issues. Yet, even these high standards will lose their efficiency if they do not continue to reflect the rapidly evolving scene.

[1] Primarily after the 1962 publication of Rachel Carson's Silent Spring, which eventually led to the establishment of the US EPA in 1970.

Raising the bar for social progress and environmental health

In 2016, the World Bank set out to refine its EA requirements. On the basis of wide-ranging operational experience, industry dynamics, and extensive consultations, it has now issued its new Environmental and Social Framework (ESF). This framework comprises a Vision for Sustainable Development; an Environmental and Social Policy for Investment Project Financing; and — most significantly for those involved in day-to-day project execution activities — a set of ten new Environmental and Social Standards (listed below). These standards will replace many of the previous social safeguard operational policies. Some policies — those dealing with private sector activities, international waterways, and disputed territories — will remain in place while the new standards set out the revised requirements for the identification and management of environmental and social issues.

The purpose of these revisions is to continue to reduce poverty and boost prosperity in ways that are sustainable and beneficial to both the environment and the public.

Starting 1st of October 2018, the new ESF will be applied to all investment projects seeking funding from the World Bank. It is not retroactive, and established projects will be granted a seven-year changeover period during which they can work their way through the system.

The disingenuous might dismiss the new standards as more of the same. Indeed, if World Bank Environmental Assessments are part of your staple diet — as they are for the Dar environmental teams working in Beirut, London, Doha, and Amman — the new framework will seem very similar. The new upgrades, however, were put in place to maintain higher standards, and seasoned environmentalists will welcome the framework's innovative approach to project financing approval and its vigorous focus on contemporary environmental and social issues.

New World Bank Environmental and Social Standards

ESS 1
Assessment and Management of Environmental and Social Risks and Impacts

ESS 2
Labour and Working Conditions

ESS 3
Resource Efficiency and Pollution Prevention and Management

ESS 4
Community Health and Safety

ESS 5
Land Acquisition, Restrictions on Land Use and Involuntary Resettlement

ESS 6
Biodiversity Conservation and Sustainable Management of Living Natural Resources

ESS 7
Indigenous Peoples and Sub-Saharan African Historically Underserved Traditional Local Communities

ESS 8
Cultural Heritage

ESS 9
Financial Intermediaries

ESS 10
Stakeholder Engagement and Information Disclosure

Safeguarding the world's most vulnerable

For those unfamiliar with the Bank's procedures, the devil is in the detail. Vigorous adherence to key human rights, transparency, accountability, consultation, participation, non-discrimination, and social inclusion is, of course, a given. Greater detail is expected on labour living and working conditions, workers' and community health, occupational health and safety, and for both workers and the public, a vigorous and transparent grievance redress mechanism. Impacts on disadvantaged and vulnerable groups must also be considered, mitigated, and managed in even more vigorous and transparent ways so as to give them full access to project benefits. Less emphasis is to be put on the care of such groups; more on the provision of opportunities for self-support.

In another vein, stakeholder engagement, long a vital feature of World Bank-related projects, must be — and must be seen as — a programme continuing throughout the life of a project: from project initiation through design to construction and beyond.

Preserving environments and ecosystems

In addressing climate change, projects must promote climate resilience and adaptation, manage living natural resources and water in a sustainable manner, and assess the related transboundary and global risks and impacts.

Provision for biodiversity is also strengthened with a precautionary approach requiring detailed clarification of how risks and impacts affecting critical and natural habitats will be mitigated. Biodiversity 'offsets' are now considered a last resort measure. The ESF recognises ecological systems, ecosystem services, and natural capital. Borrowers will be expected to estimate a project's gross greenhouse gas emissions.

These requirements are but a taster of the new ESF's technical approach to environmental and social issues. Adaptive management remains the key to ensuring that appropriate and timely responses to developing and changing issues can be provided throughout the project cycle.

A framework for commitment

What many will regard as the most notable change is the introduction of an Environmental and Social Commitment Plan (ESCP) to complement Environmental and Social Impact Assessment / Environmental and Social Management Plan (ESIA / ESMP) documentation.

The value of the ESCP is that it:

i. consolidates the measures and actions necessary for environmental and social compliance within a specified timeframe;
ii. serves as a tool with which to identify environmental and social risks, impacts, and mitigation measures; and
iii. provides a comprehensive outcome for timely disclosure prior to project appraisal.

The ESCP will take account of the findings of the environmental and social assessment, the Bank's due diligence, and the outcomes of stakeholder engagement. Most importantly, the ESCP will become part of future legal agreements between the Bank and Borrowers, with relevant sections incorporated into contracts with contractors and sub-contractors. Where there are gaps between the Borrowers' national environmental and social requirements and the Bank's requirements, Borrowers will upgrade their national requirements before funding is approved.

Rising to the challenge

The World Bank's new Environmental and Social Framework is an exciting development in both environmental assessment and project management. National agencies – such as the Department for International Development (DFID) in the United Kingdom, the Japan International Cooperation Agency (JICA), and the Kreditanstalt für Wiederaufbau (KfW) in Germany – are in the process of realigning their environmental and social requirements to follow suit. Meanwhile, at the time of this writing, Dar's environmentalists have already incorporated some of the new requirements into recent project appraisals in Angola, and our teams eagerly await the opportunity to implement them further on future projects. ◆

Author
Yazan Saleh

Expertise
Civil Engineering

Company
Dar

Location
Dubai, UAE

Designing Construction Waste Out of the Equation:

Green Building for the United Arab Emirates and Beyond

*To say the United Arab Emirates' construction industry is a first-rate, world-class industry is almost an understatement. With large-scale, ambitious projects constantly on the rise, this particular industry has quickly become one of the world's most significant and competitive. Yet, trailing after this remarkable achievement is a deeply problematic legacy: the price of success is an approximate average of six million tonnes of waste generated every single year in Abu Dhabi alone.[1] * To put this alarming number in context, consider that, in any given year, the waste left behind by this one industry can be single-handedly responsible for up to 75 % of the waste generated by the entire emirate.[2]*

Recognising the danger, the United Arab Emirates (UAE) introduced comprehensive Green Building regulation in 2009 and has since emphasised the importance of mitigating environmental pollution by reducing construction waste. Still, the UAE construction industry has a responsibility to consistently adopt the best and most up-to-date practices for avoiding waste. The challenge is an exciting one: success would have a long-term transformational impact not only on the industry itself but also on the entire country. This article will discuss the critical role played by the team at design stage in mitigating construction waste and will explore green building tools and methods that can be incorporated at that stage to optimise resource management.

*** For footnotes across the article, please refer to page 69.**

Figure 1 "ITM Building Guide: How to Minimise Construction Waste" by ITM Co-operative Limited, September 2014. Copyright by ITM Co-operative Limited, September 2014.

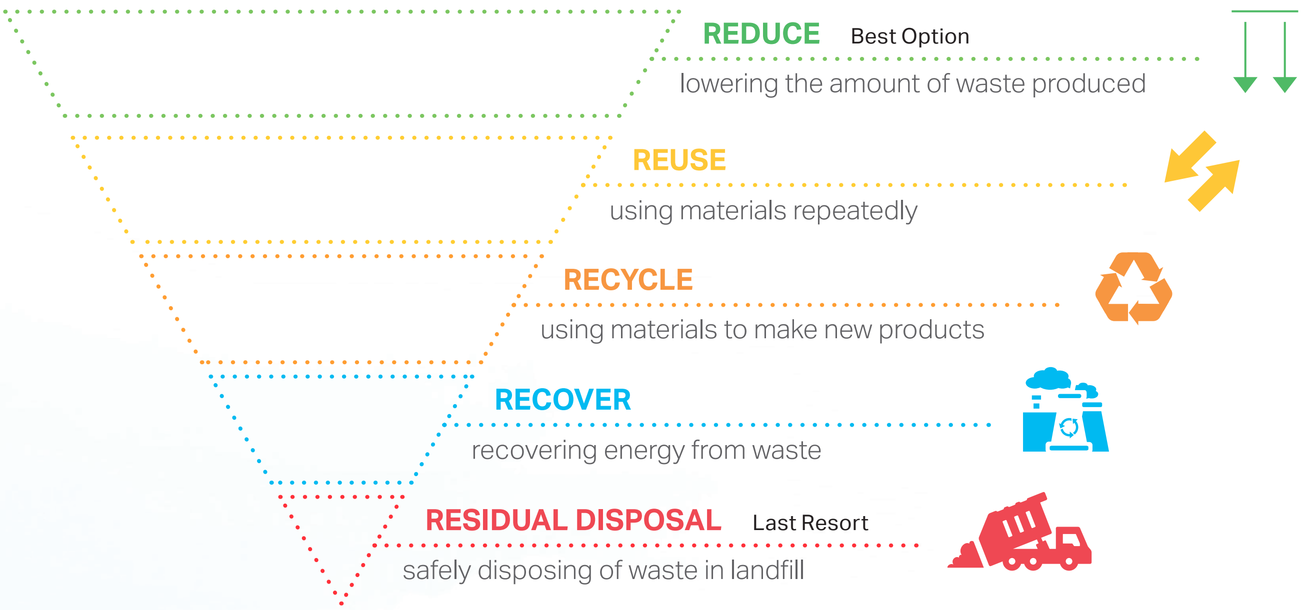
Tracking waste to the source

A critical first step towards mitigating construction waste is investigating its sources, of which, as it turns out, there are several. Significant amounts of waste are directly related to the construction methodology and management, the architectural design, and the specified material itself. Unfortunately, the list of common culprits is quite extensive: inefficient designs, sudden design modifications, frequent deviations from - or lack of - a sequential plan, inaccurate estimates regarding quantities of required materials, poor storage, inefficient management and supervision, and ill-equipped workers. Table 1.0 provides a more comprehensive list of the origins and causes of construction waste.

There are two types of construction waste: material waste and time waste. Both are generated through direct and indirect processes. Material waste is direct waste: it usually results from ordering incorrect quantities, producing more material than is required, or making inaccurate measurements. Manufacture errors and defects as well as inappropriate site storage procedures also produce material waste. On the other hand, time waste is one of the indirect forms of waste: it comprises the waiting and stopping periods, varying orders and information, delays, shortages in necessary equipment, and failure to adhere to planned activities. Both material waste and time waste have considerable, negative environmental and financial effects.

More detailed investigations yielded deeper insight. Various research initiatives and studies have estimated that 33% of construction waste enters into a project purely in its design stage. This is especially true when architects and designers do not consider the implementation of waste reduction and minimisation techniques an integral part of the design phase.

To reduce construction waste, then, architects and stakeholders must introduce and implement principles of sustainability and green building design **even in the earliest stages of designing a construction project.** Doing so will help designers reduce and overcome the negative effects of construction waste. When properly incorporated, green design principles have been shown to boost material and resource management, optimise construction waste management, elevate energy efficiency, and increase water conversation. Green design tools that could be implemented at the design stage include value engineering and management, construction and demolition waste management plans, supply-chain management, and the highly effective “Designing out Waste” tool, which was developed by the UK’s Waste and Resources Action Programme (WRAP).



1

Use the SR waste hierarchy to prioritise your waste minimisation options in order of priority: waste reduction (or prevention) is always the best option, followed by re-use then recycling and recovery and, as a last resort, residual disposal in a clean fill or landfill site.

Optimising the Design Stage: Fundamentals of Green Building Design Principles

The design stage, then, is both the essential initial step towards sustainability and a priceless opportunity to protect the natural environment from the construction industry's potential hazards. Therefore, designers at every stage of the design process should carefully consider any option that could potentially limit a project's waste yield.

In the options appraisal stage, for example, the developer could urge the client to consider refurbishing an existing asset instead of redeveloping it, or using existing space more efficiently, or even designing new works that are flexible and can be adapted to future changes in needs.

Moreover, forecasting waste and identifying top opportunities for waste reduction and reuse must be considered critical components of the early design stage. Designers could focus attention on the most promising opportunities for waste reduction and reuse. Those could include using in-situ materials through remediation and stabilisation; reprocessing materials for reuse on-site (for example, utilising demolition and excavation arisings or balancing cut and fill); employing off-site construction; and pursuing alternative design solutions.

In the later design stages, attention must be focused on identifying the five to ten products with the highest forecasted waste rates and on bringing these rates down to good practice levels. Matching product and design dimensions could help, as could standardising the choice of components across a project and selecting materials and components with high durability. Where appropriate, seeking early contractor involvement in identifying and vetting low waste solutions can also be enormously beneficial.

To further advocate for sustainable designs, designers must quantify the forecasted waste and its cost, estimate achievable savings from specific actions, and capture the waste/cost estimates in a Construction Waste Management Plan (CWMP) that originates in the early design stage. Those estimates must be included in the contractor tendering process, which allows tender prices to take account of design decisions and potential savings.

2

The guide presents a simple three step process for applying the Designing out Waste principles in projects:

Figure 2: Reproduced from "Designing out Waste process: Implementing Designing out Waste in construction projects" produced by Waste And Resources Action Programme (WRAP). Copyright by the Waste and Resources Action Programme.

Figure 3: Information from WRAP's "Designing out Waste: A Design Team Guide for Buildings."

The "Designing out Waste" tool for minimising construction waste.

The "Designing out Waste" tool is one of the construction industry's best techniques for minimising waste: it emphasises avoiding, eliminating, and reducing waste at the earliest stage and at the resources for construction stage. Through workshops and extensive brainstorming sessions, the design team, including experts from different design and construction disciplines, uses the "Designing out Waste" tool to formulate a waste reduction action plan (Figure 3). This plan is then implemented from the design stage right up to the last stage in the project's life cycle (Dajadian & Koch, 2014).

3

1 **Design for Reuse and Recovery:**
Whenever possible, the designer should consider either using available materials generated from the existing building or recycling the waste or debris of on-site materials and utilising these assets to design and build the new project. If reusable materials are not available, the designer might be better off using 'new' materials that contain high levels of recycled components. Design for reuse and recovery is facilitated by visiting and inspecting the site and conducting site analysis prior to the start of the design stage.

2 **Design for Off Site Construction:**
The trend towards prefabricated construction not only plays an essential role in reducing waste, it also enhances the construction's performance. Off-site manufacture and prefabrication cover everything from modern timber and light gauge steel framing systems, tunnel form concrete casting, and pre-caste concrete to modular and volumetric forms of construction.

3 **Design for Materials Optimisation:**
By minimising excavation, standardising materials and components across a project, and coordinating dimensions properly, designers can boost material resource efficiency. Without compromising on design choice or project needs, designers can use less material and, thus, produce less waste in the construction stage.

4 **Design for Waste Efficient Procurement:**
Designers can also help mitigate waste by vetting contractors and stipulating in contractual clauses that the contractor understand principles of waste reduction and work in an environmentally friendly manner.

5 **Design for Deconstruction and Flexibility:**
With the help of material scientists, designers can focus on understanding the life cycle of materials: specifically for how long they can be reused, recycled, or reduced during the building's life cycle and maintenance.

Origins of Waste	Cause of Waste
Contractual	- Errors in contract documents - Contract documents incomplete at commencement of construction
Design	- Design changes - Design and construction detail errors - Unclear, unsuitable specifications - Poor coordination and communication (late information, last minute client requirements, slow revision and distribution)
Procurement	- Ordering errors (i.e., ordering items not in compliance with specification) - Over allowances (i.e., difficulties in ordering small quantities) - Supplier errors
Transportation	- Damage during transportation - Insufficient protection during unloading - Inefficient methods of unloading
On Site Management & Planning	- Lack of on-site waste management plans - Improper planning for required quantities - Lack of on-site material control - Lack of supervision
Material Storage	- Inappropriate site storage space leading to damage or deterioration - Improper storing methods - Materials stored far away from point of application
Material Handling	- Materials supplied in loose form - On-site transportation methods from storage to the point of application - Inadequate material handling
Site Operation	- Accidents due to negligence - Equipment malfunction - Poor craftsmanship - Time pressure
Residual	- Waste from application processes (i.e., over – preparation of mortar) - Packaging
Other	- Weather - Vandalism

Table 1.0: Origins and causes of construction waste. Reproduced from "Waste Management Models and Their Applications on Construction Sites" by S. Dajadian and D. Koch, 2014, International Journal of Construction Engineering and Management, Vol. 3 Nº. 3, p.93. Copyright 2014 by Scientific & Academic Publishing.

Adoption of BIM for waste management

Another highly effective implement that can be incorporated into the design stage is the Building Information Modelling (BIM) system. BIM facilitates adequate collaboration and effective communication: it can play a major role in ensuring that all stakeholders are actively involved in decision-making from the conception of the building project and throughout its entire life cycle.[3] With regards to waste management in particular, BIM is beneficial in that it enables the creation of a federated model that could be assessed and updated by all members of the project team. It engenders design coordination, task harmonisation, clash detection, and process monitoring of all construction waste management activities.

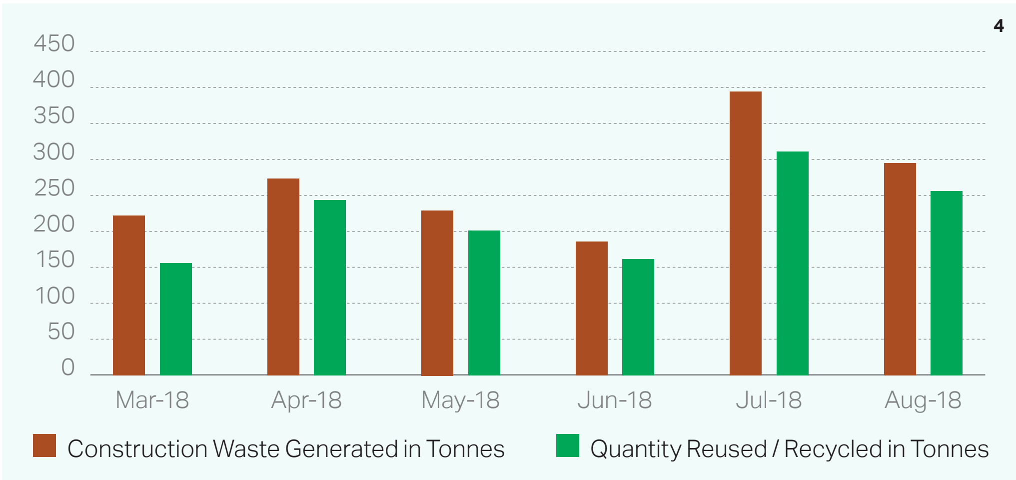
Hospitality project: a successful case study

A study was carried out on the waste percentages of one of the largest hospitality projects in Dubai, a Dar project with a total built-up area of 70,000 m^2. The result showed that the current waste recycling rate is 84% (Table 2.0, Figure 4), which is meeting the Green Building objectives.

Quantity of Construction Waste in Tonnes			
Month	Generated	Reused/Recycled	Percentage
March 2018	220.00	160.00	72.73%
April 2018	275.95	240.95	87.32%
May 2018	228.93	198.93	88.90%
June 2018	185.23	165.23	89.20%
July 2018	390.00	318.00	81.54%
August 2018	292.43	254.73	87.11%
Total	1592.54	1337.84	84.0%

Table 2.0: Waste management summary

Figure 4: Waste diverted from landfills.



Frontiers for the future

The UAE construction industry is growing year after year. If not monitored, controlled, and minimised through design and construction processes, the volume of construction waste produced can begin to have devastating effects. Government bodies have been proactive in tackling this problem, issuing various guidelines and regulations for the construction industry with the following as primary goals:

- Consider material optimisation at design stage
- Target zero construction waste at design stage
- Segregate waste for reuse / recycle. ◆

[1-2] From "Waste Statistics 2017." Statistics Centre Abu Dhabi (SCAD).

[3] Eadie, R., Browne, M., Odeyinka, H., McKeown, C., & McNiff, S. (2013). BIM implementation throughout the UK construction project life cycle: An analysis. Automation in Construction, 36, 145-151.

Author
Colette Connolly

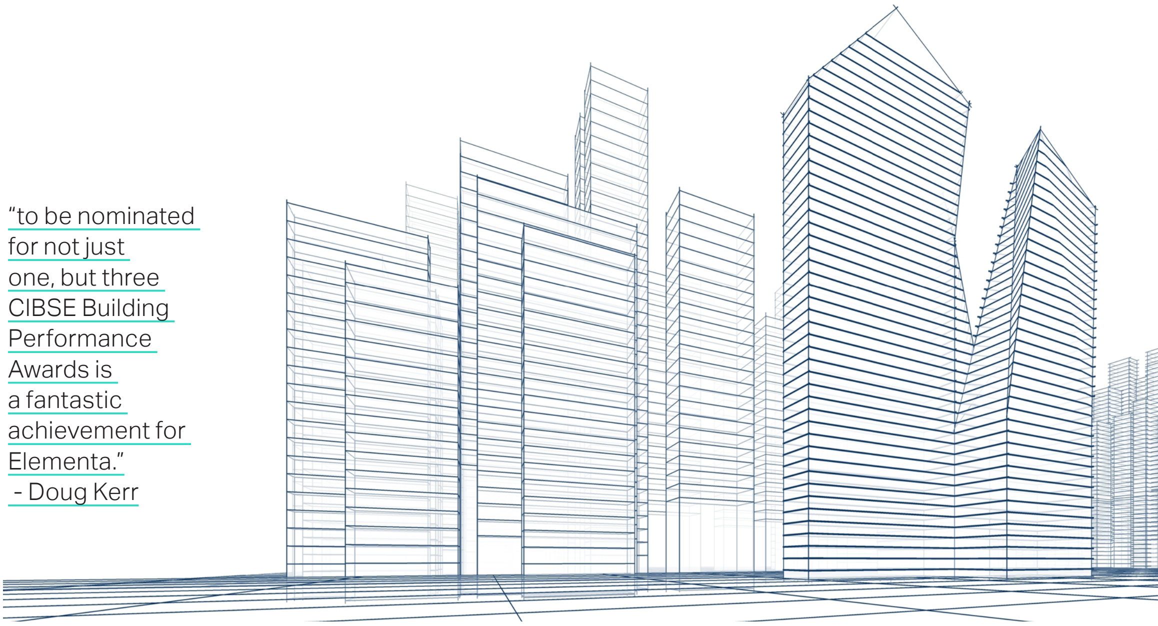
Expertise
UK Marketing Manager

Company
Elementa Consulting

Location
London, UK

Trust, Nurture, Inspire: Extraordinary Elementa Hits New Heights in 2018

"to be nominated for not just one, but three CIBSE Building Performance Awards is a fantastic achievement for Elementa."
- Doug Kerr



At the end of another challenging year, we at Elementa are proud to announce that our company has been recognised by leading institutions in the construction industry for its mission to challenge norms, fuel change, and push towards a more sustainable and environmentally friendly industry.

Mentoring the next generation of building pioneers

For the second consecutive year, Elementa has been named Employer of the Year for the medium category (51 - 300 employees) at the CIBSE Young Engineers Awards and crowned the overall 2018 winner across all categories (1 - 301+ employees). Driving support for young people throughout the industry, the awards recognise organisations that pro-actively champion the next generation of industry professionals within the building services sector, by showing commitment to empowering young people in the workplace or by supporting those employees through education and training.

Elementa's core values – trust, nurture, inspire – serve as an operational mantra which guides the company's responsibility to its young employees. Our engineers are at the forefront of leading developments, and sharing knowledge and mentoring the next generation is significantly important not only to our company but also to the wider industry.

The CIBSE judges lauded Elementa's passion and our ability to 'practice what we preach,' pointing to significant initiatives undertaken by Elementa at the beginning of 2018. These include launching a Next Gen arm to our established networking group, encouraging junior engineers to become STEM ambassadors, providing personal training allowances, and committing to take a junior member of staff to every major industry conference both in the United Kingdom and abroad.

Figure 1 Elementa's awarded certificates for CIBSE Employer of the Year.

Figures 2 & 3 Elementa staff members receiving the 2018 CIBSE Employer of the Year awards.

Figure 4 A selection of Elementa's CIBSE Building Performance Awards trophies.

Showcasing excellence in engineering

Elementa has also been shortlisted for three accolades at the prestigious CIBSE Building Performance Awards 2019 – awards offered in recognition of **the people, products, and projects that demonstrate engineering excellence in the built environment.** The awards focus on actual, measured performance not design intent or performance specifications.

First, Elementa is proud to be up for the Building Services Consultancy of the Year award for the fourth year in a row, having won the accolade in both 2017 and 2018. This award specifically commends consultancies that are meeting and exceeding clients' expectations with regards to building performance and actively spreading knowledge and best industry practice in this field.

Building Services Consultancy of the Year is not the only title Elementa is hoping to retain: the company has also been shortlisted once again for International Project of the Year, an award it has taken home for the last three years. This time around, Elementa's shortlisted project is its 'Silicon Valley Tech Office,' a confidential project for a well-known web-based client. The client company aimed to reduce energy consumption at its new office headquarters, and the building was designed to produce as much energy as possible from the roof via PV panels and to show continuous improvement in performance year on year. A typical building of this typology for a tech client in this climate can range anywhere from 65 to 80 kBtu/sf-yr. In the first year of operation, the building utilised 40 kBtu/sf-yr, half the amount utilised by the benchmark building. Moreover, in its second year of operation, it has been able to drive down energy consumption by another 25%, to 29 kBtu/sf-yr. The client aims to one day reach net zero energy.

Finally, Elementa is delighted to announce that Senior Engineer Clara Bagenal George has been nominated in the Building Performance Engineer of the Year category. This award recognises the important work done by building services engineers and celebrates their contributions to the performance of the built environment. Clara's most notable work includes establishing the London Energy Transformation Initiative (LETI) and gaining support from over 200 cross-industry professionals to help lead London to zero carbon emissions. Clara and the LETI group are now working directly alongside the Greater London Authority (GLA), and the majority of their recommended policies are included in the draft New London Plan.

Managing Director Doug Kerr proudly commented: "to be nominated for not just one, but three CIBSE Building Performance Awards is a fantastic achievement for Elementa. Our continued success over the last few years has been achieved through our passion and personal approach to delivering high-level service and it is an honour to see this recognised once again by CIBSE. We look forward to the results in February."

To complete an overview of the company's heartening performance this year, these nominations and awards are complemented by the publication of Building Magazine's Top 150 Consultants list — in which Elementa climbed 16 places since last year — and of the Top 50 Engineers list, in which Elementa improved its standing by five places. Elementa was also shortlisted for the Engineering Consultancy of the Year at the 2018 Building Awards, one of the industry's longest running and most prestigious award ceremonies.

New Year, New Objectives

Looking forward to the future, we at Elementa aspire to continue driving the initiatives and innovations that fuelled our thrilling success in 2018. ◆

Managing the Coast in the Face of Climate Change – Insights from Europe

Author
John McCawley

Expertise
Resources and Environment

Company
Dar

Location
London, UK

Coastlines: Battle lines in the fight against climate change

While the summer heatwave of 2018 in Europe, along with extreme temperatures and wildfires elsewhere, may not categorically be stated as climate change impact, it has been forecast that as a result of climate change, such events will become mainstream. The impacts of climate change will be numerous: the earth warms, ice melts, seawater expands, and- ultimately- sea levels rise.

This poses a very particular challenge. Worldwide, construction programmes of immense scale are supporting population and economic growth. Climate change is necessitating investment in coastal infrastructure to support these programmes and improve national resilience. Such initiatives require considerable resources, and the use of offshore dredged aggregates to shore up coastlines and raise design basements is playing an increasingly important role in meeting this demand.

All coastal projects that Dar associates with should consider the potential impacts of climate change and sea level rise and mitigate such impacts through appropriate design inputs. A recent Dar coastal project in the eastern Niger Delta (Ibom Industrial City, Akwa Ibom State, Nigeria) is one example in which discussions on the management of climate change impacts have been raised, and engineering design solutions are being recommended.

Dredged sediments shoring up the coastline.

The National Oceanography Centre, Southampton.

A critical coastline

With its extensive coastline stretching to thousands of kilometres, the United Kingdom must, by necessity, plan carefully to manage rising sea levels and address the vulnerability of its coast. Among the vital infrastructure around the UK's coastline and dependent on proximity to the sea are 52 ports handling 95% of incoming freight; 47 water and wastewater treatment facilities; and 19 nuclear power plants. The UK must plan for the resilience of this and new infrastructure over the coming decades, raising the basement level of new development as necessary and building effective defences. Increasingly, this is requiring dredged material from the ocean floor, which comes with its own potential for significant environmental and ecological impact.

Findings from the UK – The Dar London Environment Team

To explore the industry's latest studies on and insights into the environmental impacts of dredging offshore coastal sediments to shore up coastal projects, John McCawley and Tom Foster of the Dar London Environmental Management team — both with academic and professional backgrounds involving coastal geomorphology — attended a conference coordinated by the European Marine Sand And Gravel Group (EMSAGG). EMSAGG provides a forum for the exchange, dissemination, and consideration of information for all those with an involvement in marine sand and gravel, including its supply to coastal infrastructure projects. John and Tom were among EMSAGG delegates sharing experience and best practice at the National Oceanography Centre in Southampton, England. The EMSAGG conference, "Beyond the Horizon," recognised that improving European environmental performance in the acquisition of marine sand and gravel contrasts with increasingly poor practices internationally and was focussed on disseminating best practices to limit environmental impact.

Particularly notable presentations in relation to the environmental management of offshore sands and gravels were delivered by:

- Jaap Flikweert, Technical Director at Royal Haskoning DHV, who discussed beach nourishment practices in Europe with a specific focus on the Zandmotor in the Netherlands, a coastal protection project. Experience gained in this project is currently being considered with a view towards protecting strategic resources in the UK in a similar way. Studies of the Bacton Gas Terminal, on England's east coast, were especially discussed in this regard.
- Vera van Lancker of the Royal Belgian Institute of Natural Sciences, who discussed sediment mapping in the North Sea, in order to designate zones available for extraction and areas to be protected.
- Nick Everington of the Crown Estate, England, who discussed methodologies employed to map the sands and gravels off the south coast of England, identifying those areas that could be licensed for extraction as well as those areas requiring protection, for ecological and long-term sustainability reasons.
- Mark Russell of the Mineral Products Association who discussed global pressures on offshore sand resources, much of it illegal, growing from 30 billion tonnes / year today and forecast to be 50 billion tonnes / year by 2030.

The post ice-age erosion and deposition of sands and gravels into the North Sea and English Channel have provided valuable local mineral resources for the bordering countries. Knowledge of these resources, particularly that gathered over the past 40 years, has culminated in state-of-the-art seafloor mapping and designation of areas licensed for extraction and, equally, areas that are off-limits. The expense involved with such mapping has in part been financed by taxes levied on the sand mined by the dredging companies over time.

1

Figure 1 John McCawley with Mark Russell of the Mineral Products Association and Robert Langman of Marine Space (seafloor mapping).

The range of knowledge gained and contacts made by John and Tom will have a direct influence on the environmental assessment of the coastal infrastructure projects they are involved or will become involved in as part of the Dar team. As Dar continues to expand into the infrastructure markets of the UK and Europe, John and Tom will provide an important level of awareness of how these coastal environmental issues are managed in the UK and Europe. Discussions held with Mark Russell on unsustainable sand dredging practices globally were also of particular interest.

Broad outcomes from the conference included:

- a deeper knowledge of the ecological and sustainability impacts of dredging offshore sands and gravels and insight into how these impacts can be managed better;
- techniques employed to map and value seafloor sands and gravels, ahead of dredging;
- contacts with consultants with seafloor mapping and coastal management skills; and
- a follow up meeting at Dar's London office with Dirk Vennix, CEO of CIRIA (Construction Industry Research and Information Association) to explore ways in which CIRIA might be able to assist Dar in the UK.

The Future of Coastal Management in the UK

In October 2018, the UK issued guidance from the Adaptation Sub-Committee of the Committee on Climate Change (CCC) to report on the key climate change challenges facing the UK's coasts.

In 2019 the UK Environment Agency will be publishing its strategy for managing coastal erosion and flooding risks through to 2050. The CCC – Adaptation Committee, led by Professor Jim Hall, made the following observations and recommendations with regard to protecting England's coastline.

Living along the coastline of England has always carried a certain level of risk: the infamous 1953 storm surge killed 307 people in England and Storm Xavier in December 2013 caused over £1.6 billion (US$ 2 billion) of damage. Risks of flooding and coastal erosion have always existed along the ever-changing UK coastline, but the new report from the Committee on Climate Change uncovers how coastal risks are to increase in the future – and how the country is currently ill-prepared.

In England, 520,000 properties (including 370,000 homes) are located in areas with a 0.5% or greater annual risk of coastal flooding, and 8,900 properties are located in areas at risk from coastal erosion, without taking into account coastal defences. Direct economic damages from flooding and erosion are presently valued at over £260 million per year. Transport, energy, and waste infrastructure as well as cultural assets are exposed to coastal flooding and erosion. Approximately 7,500 km of road; 520 km of railway line; 205,000 ha of good, very good, or excellent agricultural land; and 3,400 ha of potentially toxic historic landfill sites are currently at 0.1% or greater risk of coastal flooding in any given year. Power plants, ports, gas terminals, and other significant assets are also at risk. Yet, at present, the benefits of protecting these different assets are not prioritised in the government's coastal defence spending.

Figure 2 Coastal protection is needed at the Bacton Gas Terminal, located on England's east coast.

The UK will almost certainly see 1 m of sea level rise at some point in the future, possibly within the lifetimes of children alive today, with further increases expected in the centuries thereafter. We must account for this change in long-term land use and coastal defence plans. The number and value of assets at risk on the coast has steadily been increasing. Houses, businesses, roads, railways, train stations, power stations, landfill sites, and farmland will all be affected by increased coastal flooding or erosion in the future. Many of these assets are protected by dated coastal defences and, so, are deteriorating in the face of rising sea levels and eroding coastlines. The strategies we employ to either defend or roll-back these assets need to be clarified, funded, and implemented.

Coastal environments naturally adapt to sea level rise by retreating landwards. Mudflats, wetlands, beaches, and sand dunes provide natural protection against flooding, while also serving as some of Britain's most important natural habitats. But on much of England's shoreline, the coast's natural protective mechanisms are being squeezed between rising sea levels and human development. We must re-emphasise the value of these environments and ensure that they play a larger part in our adaptation plans for the future.

The CCC Adaptation Committee found that despite the government and its agencies emphasising the need for a strategic approach to coastal management, policies and practices for England's coasts are not facing up to the inevitability of future change: plans do not reflect the realities of long-term change, are not joined up, and are not fully implemented. People who live on the coast are not engaged in the process of planning for future change and are not taking pro-active steps to adapt.

Sea levels will rise for centuries to come because of temperature increases linked to our past emissions, and robust adaptation plans are essential. The UK needs to decide which areas to protect and how much it is willing to spend to do so. Where protection will no longer be affordable or sustainable, action is needed so that assets can be relocated or decommissioned in a sensitive way. Taking pro-active steps now will save money in the future and help create a coastline that is naturally resilient to future changes.

The central government has a particular responsibility to ensure that risks are realistically assessed and to provide the frameworks and targets that will drive change. The CCC states that the actions in the recently published UK National Adaptation Programme (July 2018) do not adequately address the risks. The Government must develop specific metrics for coastal adaptation that will go alongside the UK 25 Year Environment Plan. The CCC also states that the 2019 update of the Flood and Coastal Erosion Risk Management (FCERM) Strategy should set out how and when the hard choices that have to be made on the coast are going to happen. The impacts of sea level rise will be with us — and will increase — for many years to come, and the UK Government needs to face up to these challenges now.

The CCC Adaptation Committee has made five key recommendations:

1. The scale and implications of future coastal change should be acknowledged by those with responsibility for the coast and communicated to people who live on the coast. Improved risk mapping (led by the Environment Agency) and more complete analysis of the full costs and benefits of coastal management options will provide the evidence needed to make realistic plans.
2. The local government and the Environment Agency need to be enabled to engage with affected communities and stakeholders.
3. The Department for Environment, Food, and Rural Affairs (DEFRA) and the Ministry of Housing, Communities, and Local Government (MHCLG) policy on the management of coastal flooding and erosion risk should specify long-term, evidence-based, quantified outcomes supported by the affected communities and stakeholders.
4. The government should make long-term funding/investment available in order to deliver a wider set of adaptation actions. Decisions about funding should be based on broader and more inclusive economic cases — ones that more thoroughly address environmental implications and social justice — than is the current practice. Places where continued investment in hard defences is uneconomic lose out but must still be funded in order to enable adaptation to the inevitable changes.
5. Plans to manage and adapt specific shorelines over the coming century should be realistic and sustainable in economic, social, and environmental terms. A coastline policy is required, one that clearly identifies areas that need to be defended in the long term, areas that should remain or be returned to a 'natural' environmental state, and communities that are currently unsustainable and require more strategic adaptation, such as relocation.

Towards a more resilient tomorrow

Through participating in the EMSAGG conference and through various similar initiatives, the Dar London Environment team continues to keep track of the latest trends and developments in this incredibly critical sector. The team will also leverage these insights to provide sustainable, environmentally friendly services and contribute to creating coastline enterprises that are resilient enough to stand for decades and centuries to come. ◆

Authors

Youssef Riachi

Marc Madi

Expertise
Mechanical
Engineering
Systems Optimisation

Company
Dar

Location
Beirut, Lebanon

Combined Cooling and Heating Systems:

New Horizons for Utilising Waste Heat

Dar's engineers and designers are perpetually engaged in optimising the systems they create and offer their clients: they scour the technological world, looking for ways to reduce energy use, promote efficiency, mitigate costs, and reduce greenhouse emissions. With every percent saved offering a significant advantage, these engineers take every system in a building — no matter how small — and attempt to find ways to boost its performance. This article presents an illustrative example: an attempt to test and introduce a cost-effective and sustainable supplement to traditional cooling and heating systems within a building.

Figure 1 Top view: large air conditioners.

An engineering challenge

Waste heat refers to heat generated as a by-product of other processes: heat that is not directed or utilised for beneficial purposes. For long periods of time, waste heat was just a by-product, a source of energy that cannot be tapped. Then, Combined Heat and Power (CHP) systems were introduced to tackle this engineering challenge, and they were quickly employed in large-scale centralised plants and industrial applications to recover waste heat and use it to produce power and heat simultaneously. The ground-breaking CHP systems had a significant enhancing effect on overall efficiency and opened up exciting possibilities for future exploration.

Combined Cooling and Heating (CCH) systems using heat recovery chillers are the next stage of this evolution and were conceived with the same basic principles in mind. Cooling processes – such as building air conditioning in summer – release heat, which is usually wasted and lost to the atmosphere, either directly through air cooled condensers or indirectly through water cooled condensers and via cooling towers. CCH systems were designed to potentially recover this waste heat and utilise it for heating necessities such as hot water production.

Such a system provides an effective solution to energy-related problems such as increases in energy demands, higher energy costs, energy supply redundancy, and environmental concerns. Indeed, CCH systems have turned out to be among the best means of improving energy efficiency, reducing operation costs, and limiting greenhouse gas emissions.

Like waste heat recovery systems in industry, CCH systems can be implemented on a large scale in different sectors. They have particularly promising potential if adopted in hotels, leisure facilities, and industrial processes in which there is a continuous and simultaneous demand for cooling and heating applications. The technical, economic, and environmental performance of a CCH system is closely dependent on the environment it is introduced in, the building, system designs, and energy management. Moreover, the implementation of CCH is constrained by such factors as simultaneous need for cooling and heating, temperature level required, equipment, and energy source cost. Each of these factors will impact the system's cost-effectiveness.

Testing ground for a CCH system

To explore this issue further, the authors of this article decided to conduct a techno-economic analysis of a CCH system using a case study of energy use in hotels set in hot and humid climates. The analysed case was that of the Iconic Hotel in Doha Port in Qatar: the site was chosen because the hotel's extensive cooling and heating demands are ideal for CCH applications. In such a setting, CCH systems could benefit from a full recovery potential, extending heat recovery to low and high temperature regimes with moderate additional initial cost. The project's objective is to minimise lifetime costs and optimise energy use.

From a technical viewpoint, the two major drivers of this study were the calculation of hourly heating and cooling loads and the power/fuel consumption for each of the system's components. For such purposes, comprehensive modelling is the first and most important step for the design and assessment of the CCH system. The economic viewpoint, on the other hand, includes conducting Life Cycle Cost Analysis (LCCA) to help determine the economic feasibility of the proposed alternatives.

Indeed, CCH systems have turned out to be among the best means of improving energy efficiency, reducing operation costs, and limiting greenhouse gas emissions.

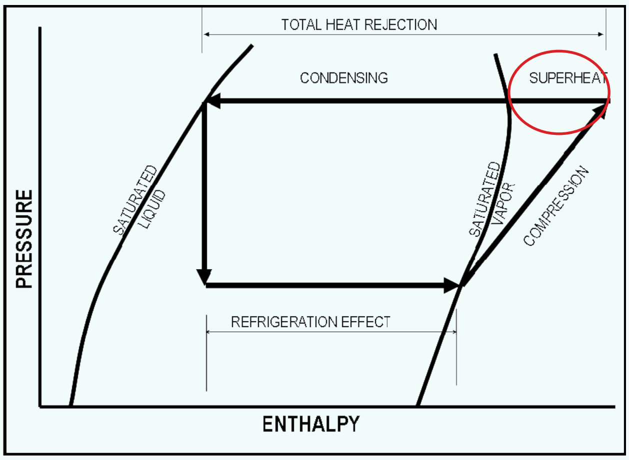
The results were quite significant: the economic study shows almost 20% decrease in overall life cycle cost when heat recovery chillers are used in the energy facility and the latter constitutes the major source of heat provision. The economic study also shows a net decrease in running costs when heat recovery chillers are implemented as compared to the base case of chiller-only and boiler-only systems: a decrease in running cost that may reach 26%.

Additionally, the environmental analysis shows a decrease of approximately 13% in CO_2 gas emissions throughout a system's entire life cycle.

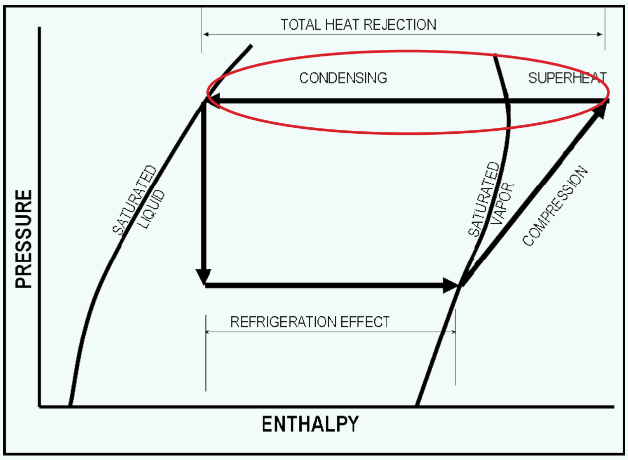
This study, outlined in sections below, will help decision makers promote recovery chillers as a substitute to fossil-fuelled boilers in similar applications with simultaneous heating and cooling demands.

The workings of a CCH system

One of the main components of a CCH system is a heat recovery chiller. The chiller aims to strike an optimum balance between cooling and heat recovery. It maximises the unit's efficiency by energetically recovering useful heat from the thermodynamic cycle, heat that would otherwise have been rejected and lost into the atmosphere. To accomplish this, an additional heat exchanger (usually brazed plate type) is mounted in series between the compressor and the condenser. Depending on the temperature requirement for hot water production, this exchanger will act either as a de-superheater for partial heat recovery (15 – 20 % heat recovered) or as a condenser for full heat recovery (90 – 100 % heat recovered).



2



3

Figure 2 Partial heat recovery on P-H Diagram.

Figure 3 Full heat recovery on P-H Diagram.

Figure 4 Methodology assessment.

In partial recovery mode, only a small amount of heat is available since only superheat is removed from the refrigerant, a process that represents approximately 15 % of compression work. High grade heat comes from de-superheating the refrigerant between the compressor and the condenser (Figure 2). To accomplish this, the heat exchanger (the de-superheater) is installed, with the refrigerant on one end and the fluid to be heated on the other. Not only does this process de-superheat the refrigerant, it also reduces the cooling water or cooling air required by the condenser. The size of the de-superheater is generally designed to meet the demand for hot water, and the high grade heat recovered from this process is beneficial for the production of hot water with temperatures between 60°C and 80°C.

In full recovery mode, on the other hand, the heat recovery exchanger performs as a full condenser (Figure 3). Larger amounts of heat are available since all the heat coming from the refrigerant condensing process is recovered. Low grade heat, recovered from the refrigerant being condensed, is provided with temperatures ranging from 30°C to 60°C. Full recovery mode brings the amount of cooling water or air required by the condenser down to nil.

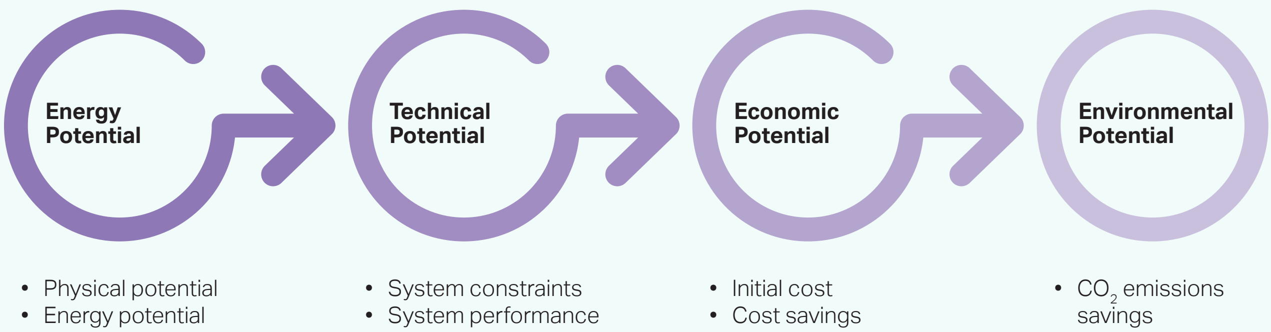
For the purpose of this case study, the CCH system employed commercially available recovery chillers to derive useful heat from cooling processes. The system has a possible chiller-only operation mode. Chillers to be considered are electrically driven compression types, while boilers are fuelled by Liquefied Petroleum Gas (LPG).

Methodology

During this study, a software developed in-house was adopted to provide comparison of energy utilisation efficiency in order to minimise both the fuel consumption and Life Cycle Cost (LCC) of the proposed CCH system. The LCC includes the capital investment, operation and maintenance costs, and fuel and power running costs.

The methodology proposed within the case study covered estimation of heating and cooling demands, simulation, analysis, energy study, and economic study.

Using an in-house software, cooling and heating loads are determined based on the outdoor climate data for Doha (Dry Bulb Temperature, Wet Bulb Temperature, and



4

solar fluxes) and the domestic hot water (DHW) set point temperature. Based on these temperatures, cooling and heating demands are determined on an hourly basis and constitute the main inputs for the recovery chiller system capacity.

The DHW set point temperature plays a major role in determining the heat load profile as it constitutes the major part of the total heat load throughout the year. The DHW temperature leaving the recovery chiller is also crucial as that temperature determines the chiller's capacity and influences its efficiency and operation. For this reason, simulations are carried out on the domestic hot water based on its temperature as it leaves the recovery chillers. The temperature ranges from 40°C to 60°C: the maximum temperature is considered 60 °C since for higher temperatures, full heat recovery would not be possible unless two stage compression chillers are used, with associated high initial costs and large space requirements.

The calculation methodology is sketched out in the flowchart of Figure 5. First, the user has to introduce the cooling load and the desired domestic hot water temperature. Next, outside temperatures are introduced on an hourly basis. The simulator first determines the ideal hourly heat recovery capacity. It then calculates effective heat recovery capacity, taking into account constraints such as recovery chiller capacity, efficiency, and hot water temperature.

5

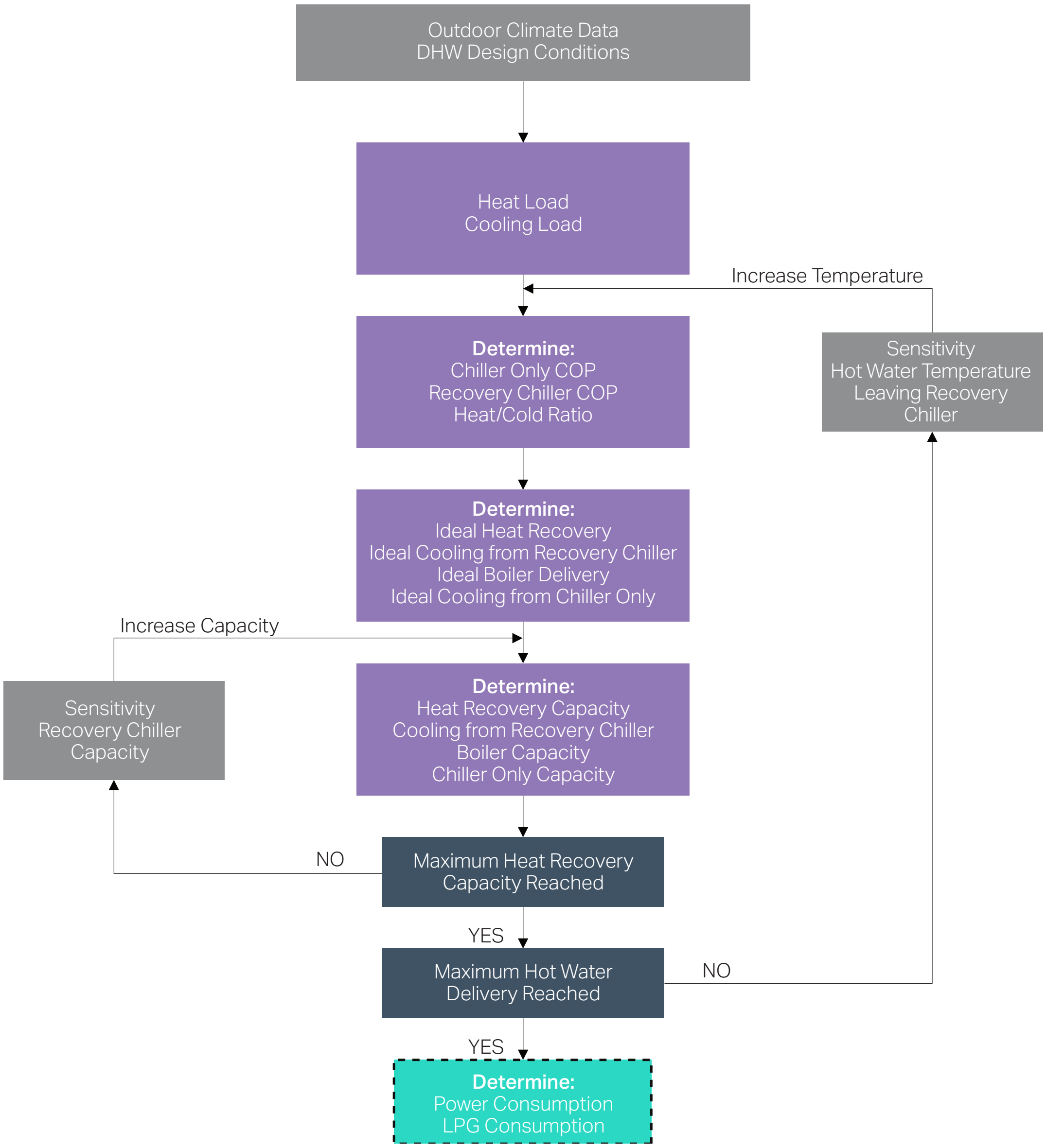


Figure 5 Flowchart showing sequences to calculate the power and fuel consumption.

Figure 6 Hourly cooling load profile.

Figure 7 Total and segregated heat load profiles throughout the year.

Figure 8 Break down of the annual heat energy demands.

Figure 9 Break down of the annual heat produced as a function of temperature of hot water leaving the recovery chiller.

Consequently, after determining the hourly heating and cooling capacity of each component (chiller-only, recovery chiller, and boiler) as a function of DHW temperature and recovery chiller capacity, the simulator will proceed to determine the hourly power and fuel consumption as a function of DHW temperature and recovery chiller capacity.

Simulation and analysis

The study took into consideration a range of recovery chiller capacities along with different DHW temperatures, in order to analyse the costs incurred by the required equipment and the impact on energy savings: in other words, to perform a sensitivity analysis and an economic feasibility study through an LCCA.

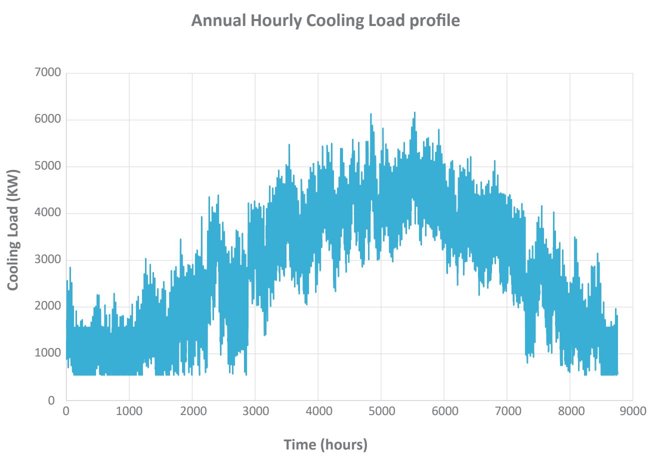
In order to analyse the feasibility of the CCH system specifically for the hotel under analysis, it is necessary to depict the hourly variability of heating and cooling demands as extensively and accurately as possible. In this case, hourly unitary heating and cooling demands were obtained by simulating the hotel building data over a period of one year (8760 hours). This modelling yielded several insights.

Heating and cooling demands estimation

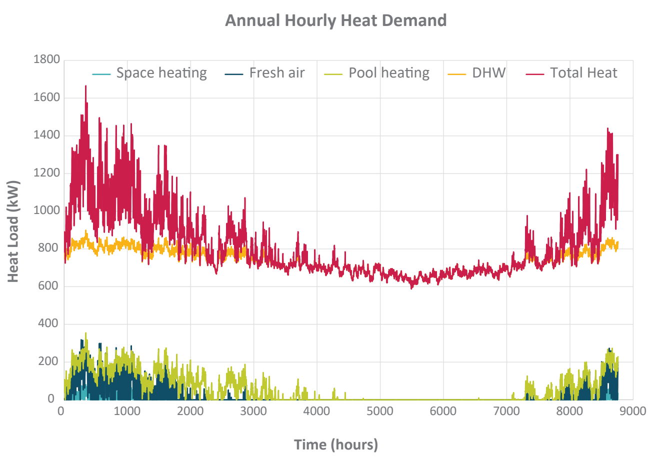
The total cooling demand comprises the estimated cooling load for the Iconic Hotel. Figure 6 depicts the hotel's cooling load demand throughout the entire year: the peak cooling load reaches 1,754 TR (6,167 kW) in August and the minimum cooling load is approximately 154 TR (541 kW). Cooling, then, is needed during the entire year: due to internal heat gains, even in winter when outside temperatures drop below 15°C. The result is that the annual cooling energy required to meet the demands of the Iconic Hotel reaches 23,400 MWh, the equivalent of 3,797 EFLH.

On the other hand, the Iconic Hotel's total heat demand comprises the estimated energy required for space heating, pool heating, fresh air heating, and pre-heating domestic hot water. Figure 7 depicts the heat load during the entire year. The heat required for space heating is concentrated in the months between November and March, with an annual demand of approximately 22.8 MWh. Moreover, heat energy necessary for pool heating is required throughout the year, with the exception of the summer months, for a total annual demand of approximately 510 MWh.

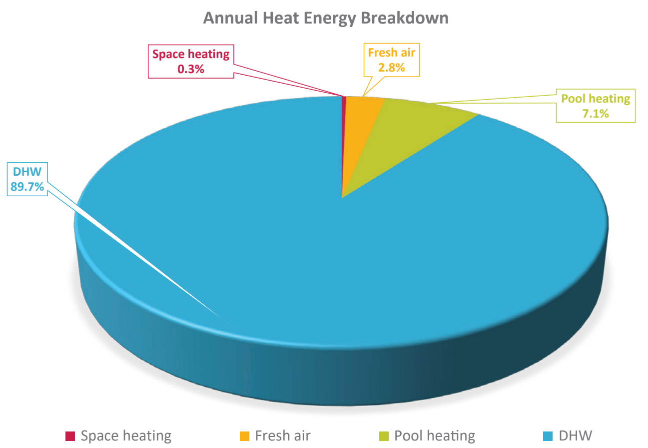
6



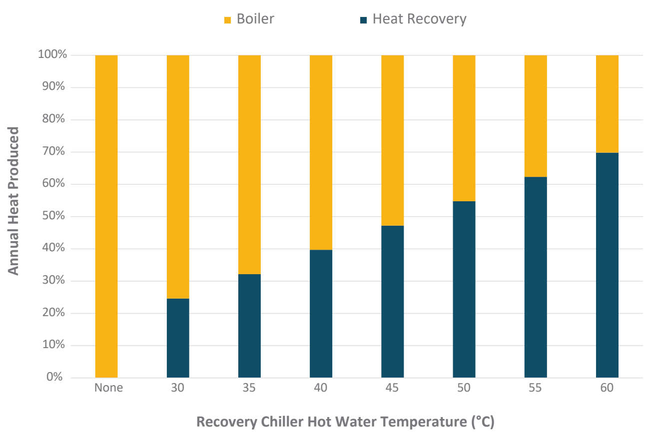
7



8



9



Heat energy for domestic hot water production is required all-year round. With an annual demand of approximately 6,431 MWh, domestic hot water production constitutes up to 89.7% of the annual heat required, with the rest divided among space heating, fresh air heating, and pool heating (Figure 8).

The temperate of domestic hot water leaving the boiler is set at 80°C. The potential heat recovery will depend on the water temperature leaving the condenser recovery chiller. Figure 9 shows the heat recovery potential as a function of DHW temperatures independent of recovery chiller capacity.

Energy analysis

CCH systems vary from site to site with different cooling options, rated size ranges, load characteristics, and operational objectives. The heating and cooling plant used in this study includes LPG boilers, recovery chillers, and cooling-only chillers. The cooling demands are satisfied through a combination of air cooled chillers-only and air cooled recovery chillers while the heating demands are met by the air cooled recovery chillers and boilers fuelled by LPG. The boilers are used as supplementary heating equipment to be employed when the recovered heat is insufficient to achieve the higher heating levels required by some of the hot water systems serving kitchens and laundries.

The sizing of the different elements was carried out after considering several aspects including peak loads and performance variations triggered by operating conditions. The following assumptions are considered for system simulations:

- Boiler efficiency: 90 % (condensing type)
- Boiler capacity: 980 kW (2 x 50 BHP)
- Recovery chiller capacity: 2 x 175 TR
- Chiller COP: Function of operating conditions (Figure 10)
- Temperature of water leaving the heat recovery chiller: 40°C to 60 °C
- Ratio (heat /cool) recovery chiller: Function of operating conditions (Figure 11)
- Cooling – only chiller capacity: 4 x 350 TR

With respect to defining the system's techno-economical parameters, the following items were taken into consideration:

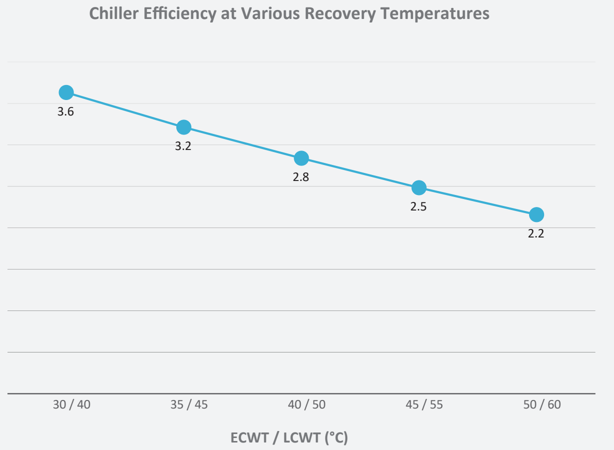
- the capacity and efficiency of each of the components;
- the estimated investment, operation, and maintenance costs; and
- the utility costs for LPG and electricity.

Heating and cooling output profiles

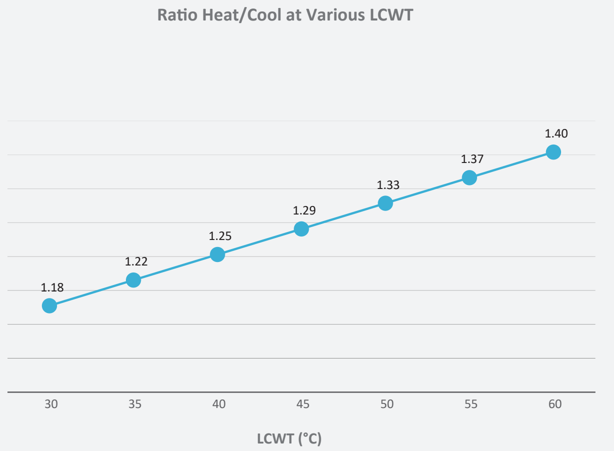
From the simulation, the following figures are calculated on an hourly basis and used to perform the economic study:

- the heating produced by the recovery chillers,
- the cooling produced by the recovery chillers,
- the power consumed by the recovery chillers,
- the cooling produced by the cooling-only chillers,
- the power consumed by the cooling-only chillers,
- the heating produced by the LPG boiler, and
- the LPG consumed by the LPG boiler.

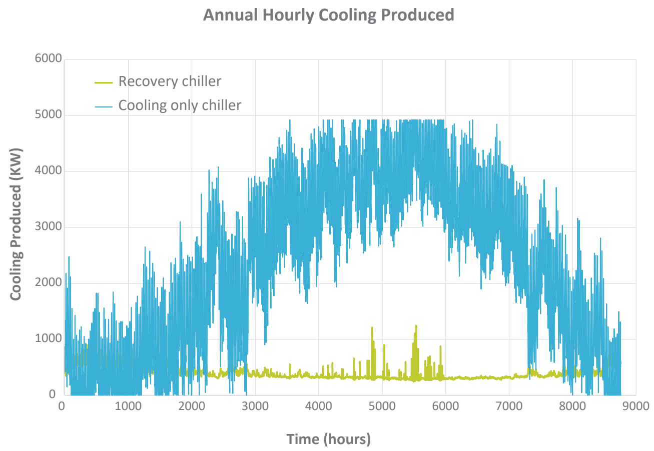
10



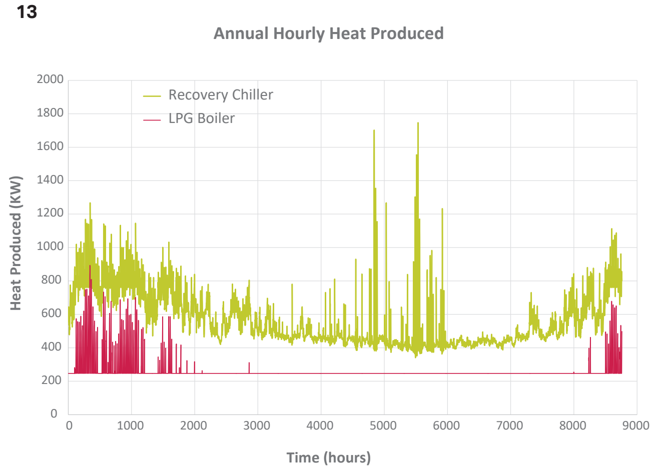
11



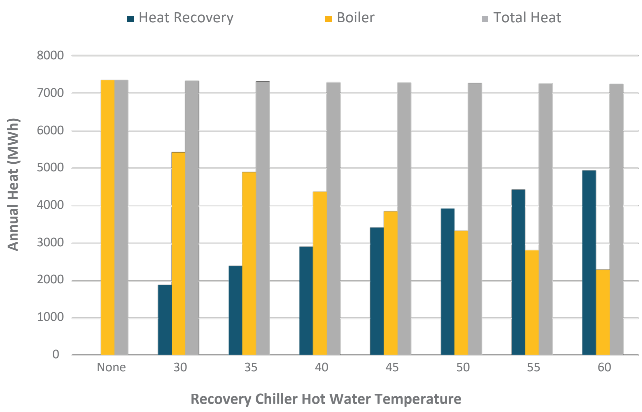
12



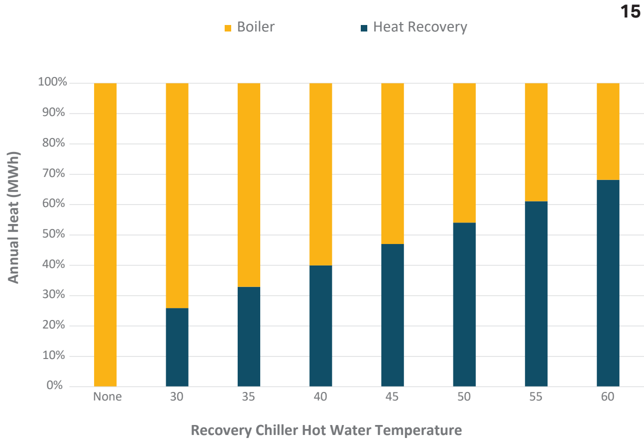
13



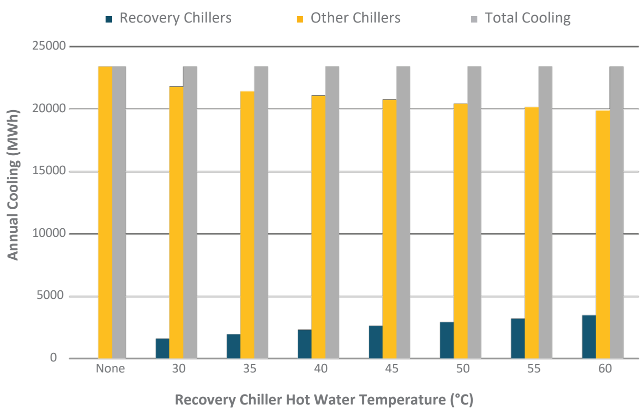
14



15



16



17

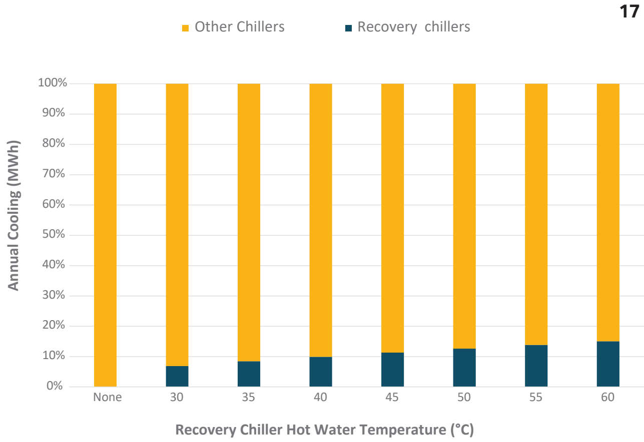


Figure 12 depicts the hourly cooling capacity produced, throughout the year, by both the recovery chiller and the cooling-only chiller for water leaving the condenser with a temperature of 60°C. The recovery chiller's cooling capacity will be directly related to the demand for heating. The cooling-only chillers will secure the cooling demand until they reach their maximum capacity. If or when that happens, the recovery chiller can over-produce by releasing its extra heat into the atmosphere (peaks in green shown in Figure 12).

Figure 13 depicts the hourly heating capacity produced, throughout the year, by the recovery chiller and the LPG boilers for water leaving the condenser with a temperature of 60°C.

Figures 14 and 15 show that, as the temperature of the hot water leaving the recovery chiller rises, the chiller produces more heat. At 40°C, the annual recovery chiller heat produced is 45%. That amount reaches 68% when the temperature is 60°C.

Figure 16 shows the annual cooling produced by recovery chillers and cooling-only chillers as a function of the temperature of the hot water leaving the chiller while Figure 17 shows the partition of this energy. When the hot water leaving the chiller has a temperature of 40°C, the annual contribution of the recovery chiller is 10%. That number reaches 15% when the temperature is 60°C.

Figure 10 Recovery chiller efficiency.

Figure 11 Recovery chiller heat / cool ratio.

Figure 12 Hourly cooling produced by recovery chillers and cooling-only chillers.

Figure 13 Hourly heating produced by recovery chillers and LPG boilers.

Figure 14 Annual heat produced by the recovery chiller and the boiler as a function of the temperature of the hot water leaving the recovery chiller.

Figure 15 Partition of heat produced by the recovery chiller and the boiler as a function of the temperature of hot water leaving the RC.

Figure 16 Annual cooling produced by recovery chiller and cooling-only chillers as a function of the temperature of the hot water leaving the RC.

Figure 17 Partition of cooling produced by recovery chiller and cooling-only chillers as a function of the temperature of the hot water leaving the RC.

Economic analysis

In order to perform the economic study, Life Cycle Cost Analysis (LCCA) was used to evaluate the system and compare the different options. The LCCA is a summation of all associated costs including capital investment, non-energy operation and maintenance costs, and energy costs associated with power and fuel. For the purpose of this case project, the lifetime of the system is assumed to be 15 years, and the discount rate is assumed to be 0%. In order to simplify the analysis, the inflation rate for operation and maintenance costs and for energy costs is considered 0%.

Table 1 below presents the costs associated with this case study, including cost of equipment, operation and maintenance costs, and energy running costs.

Table 1: Costs considered in the study

Component	Unit	Investment Costs
Chiller only	QAR/kW	730
Recovery chiller *	QAR/kW	1,100
Boiler	QAR/kW	420
Component	**Unit**	**Annual Maintenance Costs**
All above-listed units	% CAPEX	4%
Energy cost	**Unit**	**Current price**
LPG	QAR/kWh	0.091
Electricity	QAR/kWh	0.12

** Recovery chiller + additional auxiliaries*

Then, the feasibility study is carried out: it comprises technical and economic analysis of recovery chiller heating capacities ranging from 0 to 2000 kW and for temperatures of hot water leaving recovery chiller ranging from 40°C to 60°C. The running cost and the running cost savings as a function of these two variables are presented in Figure 18.

The results clearly show a decrease in energy cost (for LPG and electricity): savings can reach 17% when the temperature of hot water leaving the recovery chiller is 40°C. When that temperature is 60°C, savings in energy cost exceed 26%.

Figure 19 clearly shows a significant decrease in lifetime cost (combined CAPEX, OPEX, LPG, and electricity costs). Savings can reach 13% when water leaving the chiller has a temperature of 40°C. When that temperature is 60°C, the savings in lifetime costs reach 20%.

Increasing the recovery chiller's capacity can also boost the amount of heat and cold the chiller can produce. However, savings in running cost reach a saturation threshold due to the fact that heat produced by the boiler will always be needed for 80°C hot water production. Peak savings are reached in the range of 800 to 1000 kW chiller heat capacity: for larger capacities, lifetime cost savings start to decrease due to the large increase in CAPEX and to fewer savings in running costs.

Figure 18 Running cost and running cost savings as functions of recovery chiller capacity and temperature of hot water leaving the recovery chiller.

Figure 19 LCCA over 15 years as a function of recovery chiller capacity and temperature of hot water leaving recovery chiller.

Figure 20 CO_2 emissions and CO_2 emission savings per year as a function of recovery chiller capacity and temperature of hot water leaving chiller.

Environmental analysis

For the environmental analysis, the following CO_2 emission rates are considered:

- LPG CO_2 emission rate: 0.22 kg/kWh
- Electricity CO_2 emission rate in Qatar: 0.596 kg/kWh

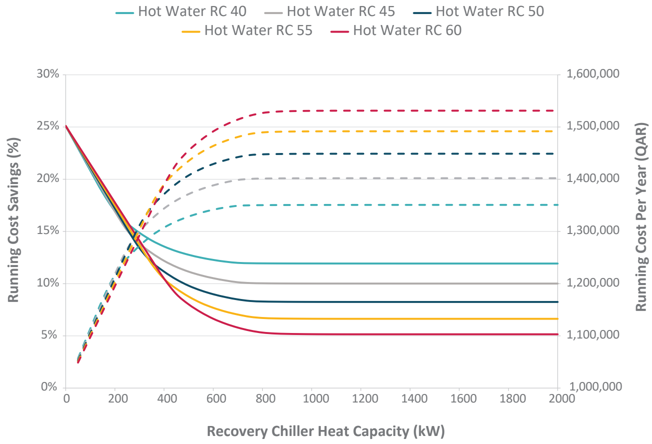
Recovery chillers also have excellent implications on the environment. Figure 20 clearly shows a decrease in CO_2 emissions when part of the LPG boiler's work is conducted by heat recovery chillers. Adding a recovery chiller to the utility plant can reduce CO_2 emissions by 11% and 13% for water temperatures of 40°C and 60°C respectively. Even though electricity in Qatar has higher specific CO_2 emissions than LPG-specific CO_2 emissions, utilising a recovery chiller will decrease greenhouse gas emissions even more due to the chiller's dual performance and higher energy conversion factor for heat pumps.

Discussions and conclusions

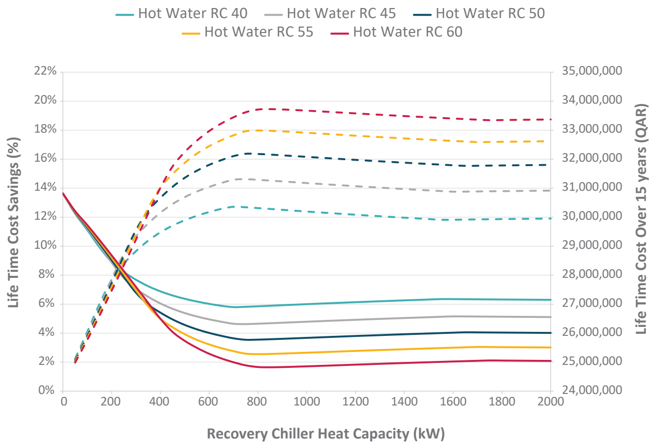
This case study proposed a CCH system designed to lower the contribution of LPG boilers. A modelling and optimisation method — one that takes energy balances, power, and heating and cooling demands into account — was developed and performed using in-house software in order to determine the cooling/heating system's optimal operation conditions. The study demonstrated that utilising such a system in a setting similar to the Doha Iconic Hotel leads to significant life time cost savings and to reductions in greenhouse gas emissions.

Energy recovery systems are widely recognised as efficient systems with great potential to achieve important energy and economic savings. As an environmentally friendly solution, this type of system is rightfully gaining wider recognition as a technology to be promoted. ◆

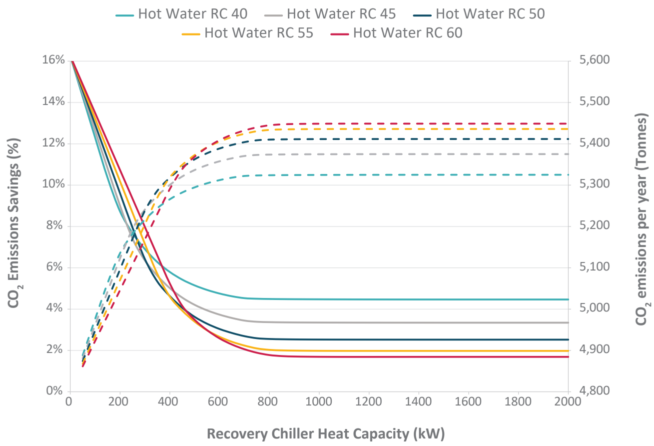
18



19



20



Author
Devin Kleiner

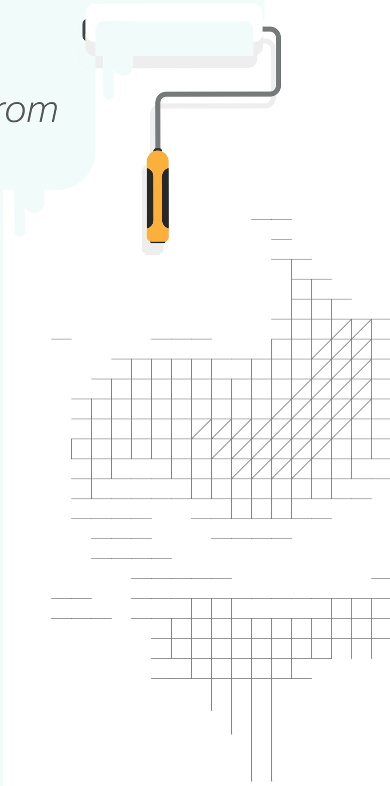
Expertise
LEED AP Building
Design + Contruction

Company
Perkins+Will

Location
Seattle, USA

Co-Piloting Seattle's Living Building Pilot Program

Can we shape a building in such a way as to optimise its experiential, environmental, and economic performance? With exciting advances in computing power and with state-of-the-art modelling and design tools recently developed by Perkins+Will's labs, the answer is a resounding yes. Architects marshalling these technologies are able to determine – from the earliest stages and with astounding precision – how each of their design choices could potentially influence a building's performance. Before they ever break ground on a new project, architects will be able to make their buildings more sustainable, reduce cost and construction waste, optimise energy intake, and so much more. To lead the way in this incredibly promising field, Perkins+Will has partnered with the University of Washington's Department of Architecture and Center for Integrated Design to offer a graduate design studio in which students can engage in research-informed practice and learn to use tools to design buildings with optimal performances.



With the aim of breaking new grounds in architectural achievement, the University of Washington's Department of Architecture, Martin Selig Real Estate, WSP, and Perkins+Will collaborated to create a high-performance building studio for the 2018 Winter Quarter.

Influencing architectural pedagogy

The University of Washington (UW) Department of Architecture is leveraging this design studio as part of its own pilot for its Masters of Architecture curriculum. In particular, the department is shifting its requirements for the program's final year in order to provide students with a culminating experience, one that allows them to apply the insights gained from a seminar course to the discoveries that arise in a research-focused design studio.

First, students take a seminar course in which they research topics ranging from energy performance targets and innovative water technologies to code requirements for complying with Seattle's Living Building Pilot Program (LBPP). Then, the design studio gives them the opportunity to apply all insights gained from the seminar.

The Perkins+Will research-based design studios in 2017 and 2018 were structured similarly. Feedback from instructors and students to the UW Architecture Department's curriculum committee helped shape the curriculum change that will be officially implemented as of the 2019-2020 academic year.

Building a research-informed practice

This graduate design studio also serves as a testing ground for Perkins+Will's research-informed practice. Partnering with the UW Department of Architecture and Center for Integrated Design provides a unique opportunity to share cutting-edge tools developed within the firm's Research Labs and to receive precious feedback from students and instructors, feedback that will help developers enhance each tool's functionality and usability.

Design Space Construction (DSC)

With steady advances in computing power and design tools, it is easier than ever to use simulation during the early phases of design to inform the entire trajectory of a project. Design Space Construction (DSC), a process and tool developed by Perkins+Will's Process Lab, allows students and architects to track the effects of design options and choices.

The DSC tool is built in a visual scripting language called Grasshopper, a plug-in for the 3D modelling software program Rhino 3D. The close relationship between the modelling program and the DSC tool is integral to reducing the common barriers for simulation. To facilitate understanding and interpretation, the DSC tool's simulation results are visualised in a Parallel Coordinate Plot (PCP), an overlay of line graphs.

In the early phases of a project, this visualisation method is particularly beneficial because it provides teams with a side-by-side comparison of normalised variables and with an opportunity to weigh – using measurable data – the merits of each design option. The DSC tool also allows teams to test how performance variables such as heating and cooling loads, daylighting, water use, and first and lifecycle costs correlate to development decisions including height, window area, and floor area. This data-driven feedback is then displayed visually in a comparative graph which, in turn, increases the likelihood that performance metrics will inform the project's design.

Inside the studio

Students in the University of Washington's graduate design studio were tasked with evaluating design decisions in the context of their experiential, environmental, and economic impacts as measured by compliance with Seattle's LBPP. The LBPP appeals to developers by incentivising specific sustainable design thresholds with additional height and density. Though still in its pilot phase, the LBPP is quickly gaining traction and is, as such, a natural fit for graduate students about to enter the workforce and help advance Seattle's sustainable built environment and design profession.

The students' assignment was to apply the LBPP to a planned high-rise project in Seattle's Belltown neighbourhood and to use performance data to shape the building.

1

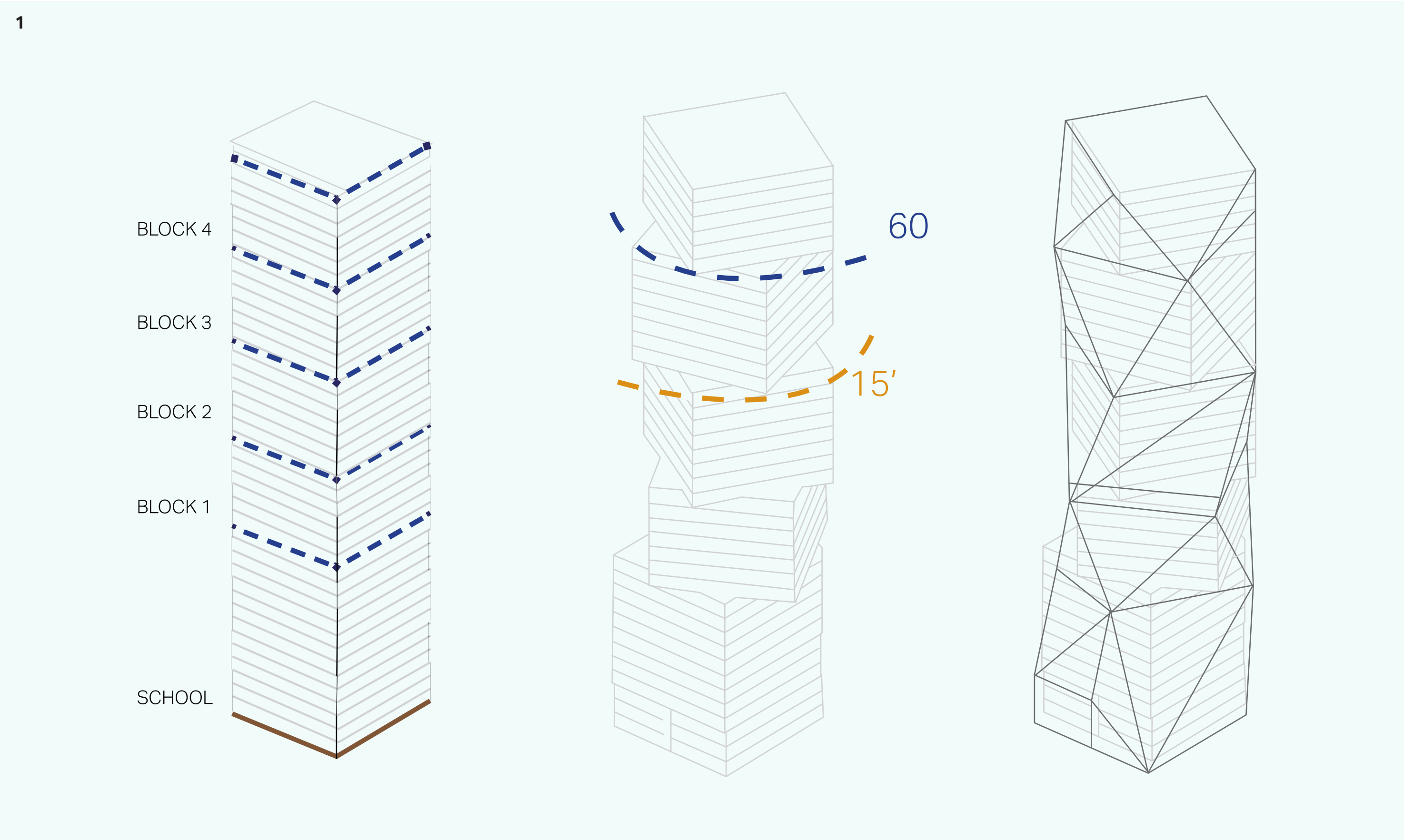


Figure 1 Student diagram showing step-by-step evolution of proposed building form.

Figure 2 Student diagrams showing performance-based design decisions.

Figure 3 Parallel Coordinates Plot (PCP) comparing performance metrics between student projects.

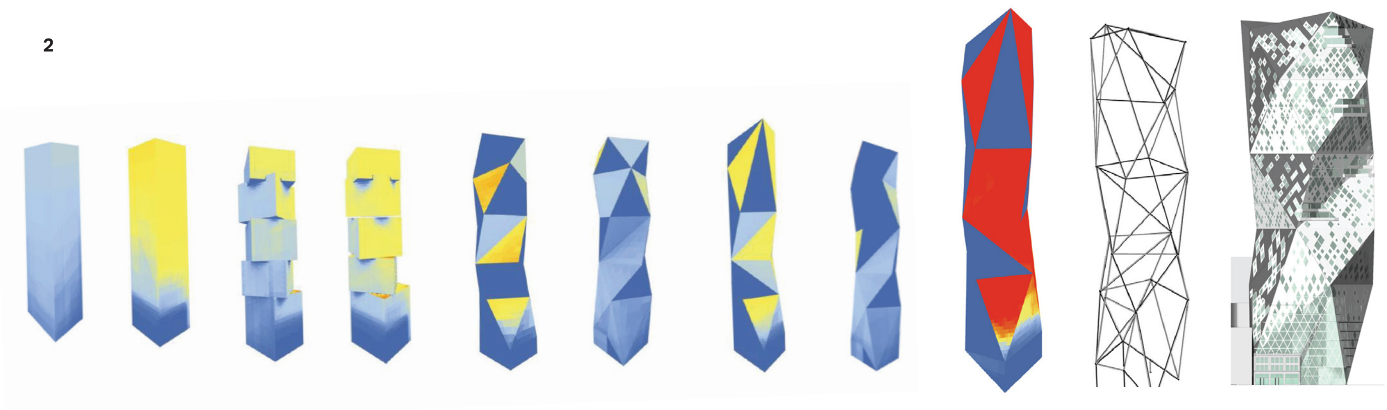
Figure 4 Parallel Coordinate Plot (PCP) comparing performances of alternative designs.

Applying a performance-based design process

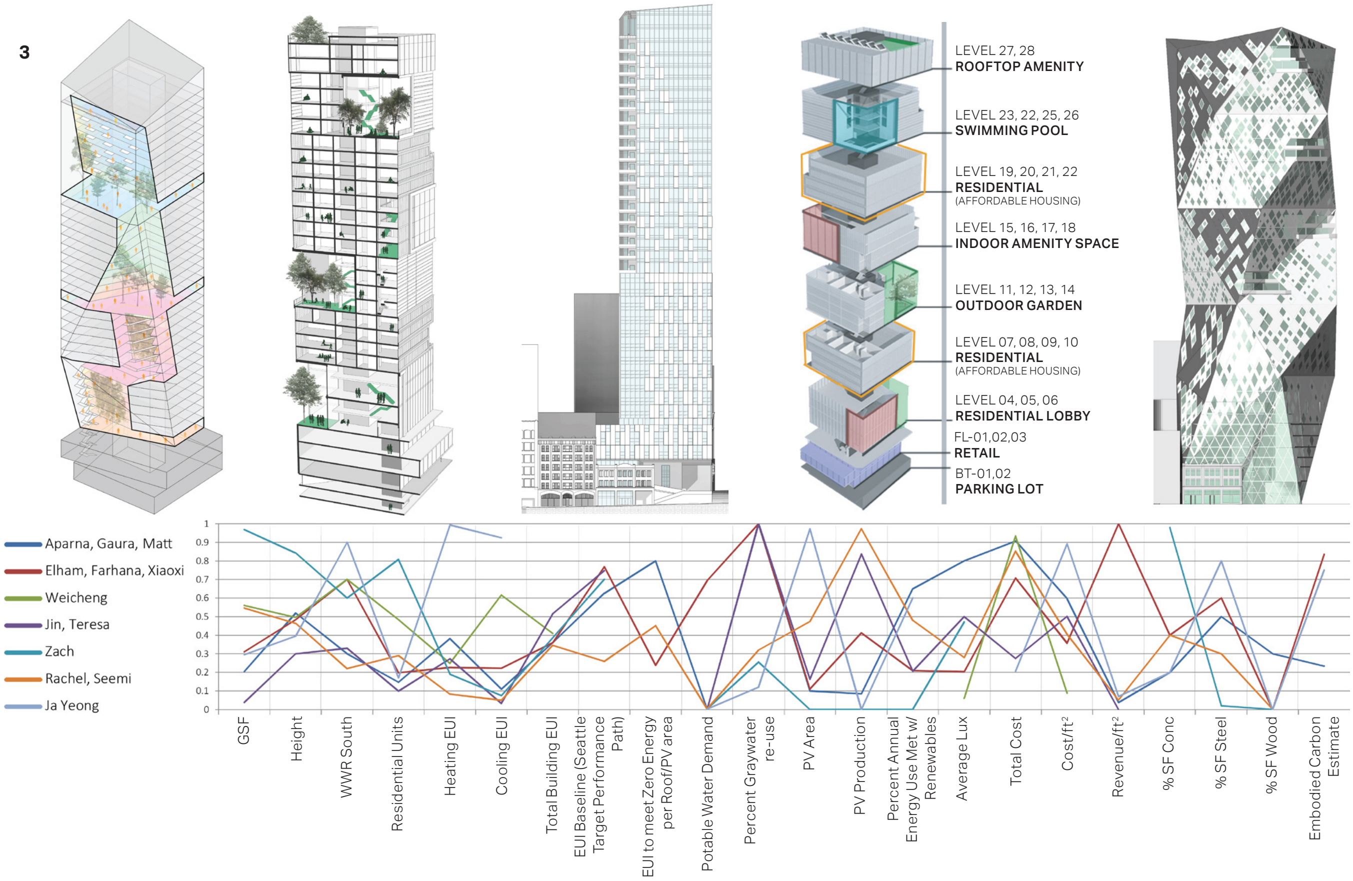
Students approached this design task with a focus on building performance. They oscillated between computer simulation and building form to balance variables such as solar heat gain, daylighting, views, heating and cooling loads, natural ventilation, and human experience both inside and outside the building. Seemi Hasan and Rachel Meyers, who together formed one of several student teams working on the project, explored how rotating and faceting a tower's shape could mitigate solar heat gain and increase the energy generated by solar panels integrated into the building's façade, while also considering views and aesthetics.

Hasan and Meyers also used computer simulation to measure solar irradiation (the amount of solar radiation falling on various surfaces, shown in blue, yellow, and red in the diagrams below), researching numerous design options for optimising the faceted shape of the building to maximise daylighting and energy performance. DSC allowed them to generate possible designs and monitor the relative impact of each on performance-based metrics throughout the evolution of the project.

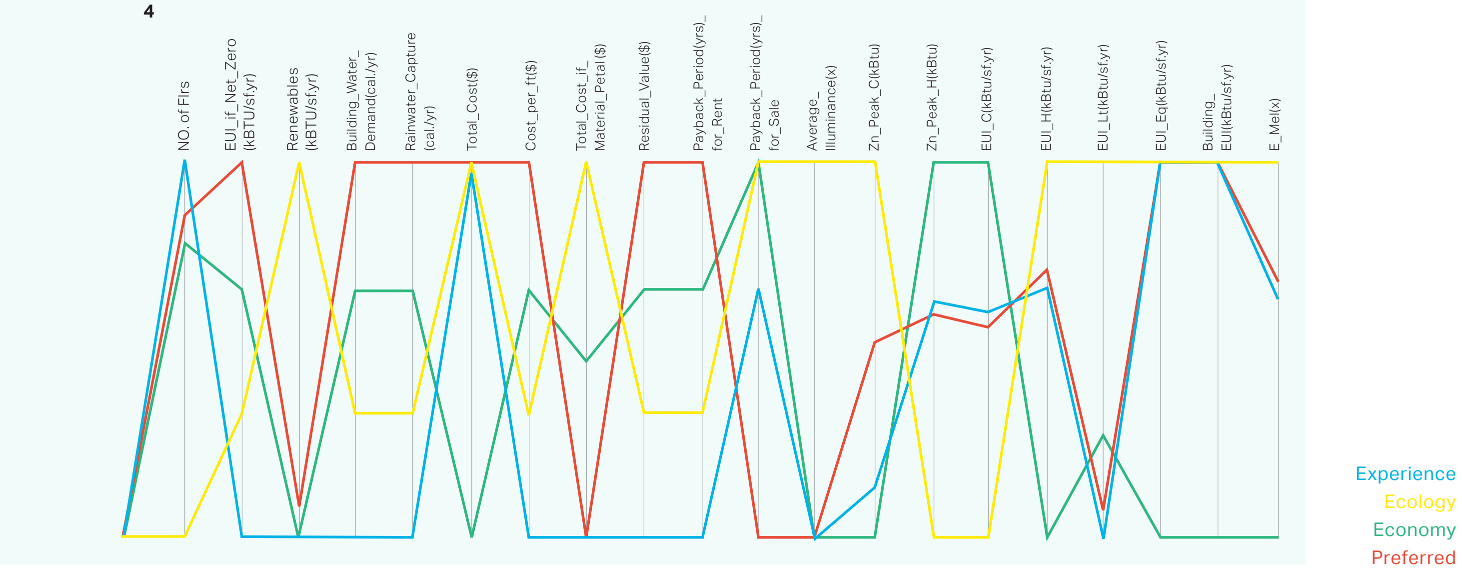
2



3



4

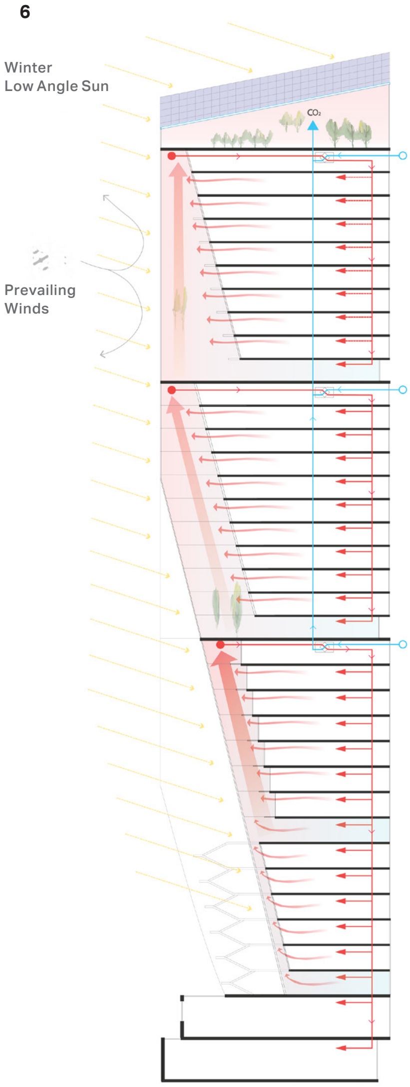


Immersing in practice-informed research

During the ten-week studio, students benefitted from having the data-driven feedback translated into comparable graphs. Figure 3 shows a PCP comparing the performance metrics of the student projects with renderings showing the wide variety of designs that resulted from the research. A PCP can also be an effective way to show various design options within a single project. For example, the PCP in Figure 4 illustrates how students Xiaoxi Jiao, Elham Soltani, and Farhana Haque compared four different schemes, with the red line representing what would become the preferred scheme. Rather than orienting the building to minimise solar exposure, this group explored increasing solar gain to drive natural ventilation throughout the building by using a large atrium to create a stack effect. The team worked with the instructors to augment the DSC tool with an additional simulation to measure the effects of natural ventilation. The customised version of the tool allowed the group to explore how changes to the atrium at different times of year would influence daylighting and peak heating and cooling loads in the offices and apartments adjacent to the atrium.

5

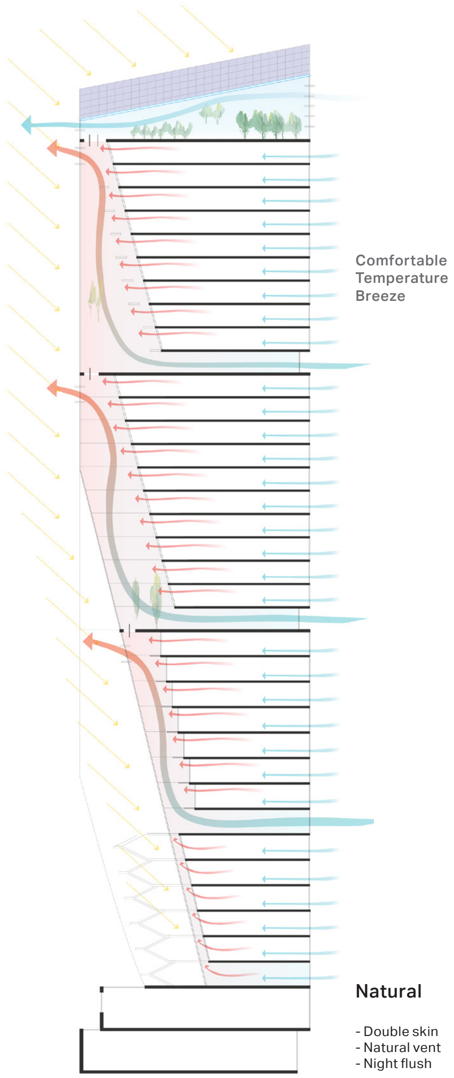
6



Heating Mode (40°F Outdoor)

Figure 5 Student renderings of proposed design.

Figure 6 Student diagrams of sustainable systems in winter (left) versus summer (right).



Throughout the quarter, student groups continued to explore a wide variety of design options with the aim of striking a balance between performance and beauty. While the various groups had different objectives and approaches, a unified goal was focusing on an iterative process and developing a narrative. The DSC tool allowed students to create a narrative based on their findings and to make sure their design changes were working towards their performance goals.

The partnership between Perkins+Will and the University of Washington, co-pilots for Seattle's LBPP and the architecture program curriculum, is creating its own narrative, helping students shape the sustainable future of the architecture profession. The potential transformation of architectural design in both academia and the profession is evidenced by what we at Perkins+Will heard from those stimulated by this innovative graduate design studio.

The academic chair called the studio "one of the most interesting and formative educational experiences students have had." Students themselves added that the program "challenged us to think of the building as a system." Still, the most enthusiastic quote came from the client, who called the studio "brilliant," adding, "I have never seen anything like this." We hope that we will all see more of this type of architectural education soon. ◆

Seeking your stories

We're always on the lookout for new stories. If you work for one of the Dar Group companies and think you have an interesting idea for this magazine, **get in touch** at **darmagazine@dar.com**. We'll help you get it published.

DARGROUP

darmagazine would not be made possible without the contributions of Dar Group professionals from around the world and the diligence of our team of editors and designers.

For more information, please visit **www.dargroup.com**

dar

PERKINS + WILL

T.Y.LIN INTERNATIONAL

PENSPEN

R&H Rail (Pty) Ltd

ipa ADVISORY LIMITED

L&B Aviation Planning at the Leading Edge

d2 consult international

Ross & Baruzzini

CB Currie & Brown

Maffeis Engineering Engineering and Consulting

INTEGRAL GROUP

PFAL Project Finance Advisory Ltd.

gpo group

Please recycle this magazine.

darmagazine supports methods and policies to guarantee the sustainable management of forests. Our pages are printed on uncoated and acid free paper that is made with 100 percent bleached pulp E.C.F. manufactured from trees.

If you prefer to subscribe to the online version of darmagazine, please send an email to darmagazine@dar.com.

For further information,
please visit us at dar.com
darmagazine@dar.com

dar.com