Ladies and gentlemen, good evening, and welcome to the Royal Academy of Engineering.

Our profession, engineering, underpins the progress of humankind. For thousands of years engineers have unlocked the natural resources of the earth for the benefit of humanity. Engineers have given practical application to scientific endeavour – driving economic growth and bringing billions out of poverty.

In the future, it will be engineers using the earth’s resources in new ways who continue that progress, solving the great challenges we face today.

But for engineers to succeed, they must play more than a supporting role – they must be at the forefront of society, as leaders capable of driving change, not following it.

That’s why I am delighted to see you all here this evening, as some of the best engineers of your generation, on your way to becoming the leaders of tomorrow.

This evening I want to discuss what it means to be a leader, and how being an engineer equips you for that role. In particular, I want to talk about the leadership role of engineers in marshalling two vital resources: water and energy.

But before we begin, I’d like to point out that this evening is part of our celebrations of the 35th anniversary of this Academy.

Slide 2 - The Academy

In 1976 the founding fellows met at Buckingham Palace for the inaugural meeting of what was then the Fellowship of Engineering. This is them in the photograph. Among them are Prince Philip, Earl Mountbatten and 128 other distinguished engineering leaders including Barnes Wallace, the inventor of the bouncing bomb, Ove Arup, the great architectural engineer and George MacFarlane, the pioneer of radar.

Their vision was about how engineering can best be promoted for the national benefit, for progress in wider society and for the future of humankind.
I have had the pleasure and the privilege of serving as President of the Academy for the last five years. Next month, I hand over to my successor, Sir John Parker, and I want to briefly reflect on how we are working to realise the vision of our founding Fellows.

**Slide 3 – Academy’s Work**

Through its Fellowship, the Academy has been working to foster a much better understanding among the public and opinion formers of what engineers do and can achieve.

We are helping to create an education system that inspires and encourages young people to choose a career in engineering.

And we are supporting the kind of research and ideas that businesses can profitably turn into wealth.

There is still a long way to go, but I think we have made real progress towards the vision of our founders.

Above all, engineers are increasingly recognised by policymakers and society as essential to addressing the grand challenges that we all face.

One of the greatest of those challenges is providing adequate supplies of water – the first arena for engineering leadership that I want to discuss this evening.

**Slide 4 – Pont Du Gard**

The need to marshal natural water resources to serve humanity was behind some of the very earliest engineering. For the engineers of ancient China, the Roman Empire, and the Islamic Golden Age, water supply was the pre-eminent challenge.

In this photograph, for example, we see the glorious Pont Du Gard. Spanning almost 300m, 50m above the ground, and weighing 50,000 tons, it was constructed by the Romans 2000 years ago, and is still standing today.

At its peak, it carried 200 million litres a day to the citizens of Nimes – feeding the prosperity and development of that city. The strength of Rome’s empire relied, in many ways, on the ingenuity of her engineers.

In the intervening millennia, engineering our water supplies may have become less glamorous, but it is no less important to our health and prosperity.

The achievements of today’s water engineers are just as impressive as those of their Roman forebears.

**Slide 5 – Desalination Plant**

Here, for example, is a desalination plant in Barcelona that uses reverse osmosis to provide drinking water to over a million people.
With projects like these, engineers manage to provide clean drinking water to almost six billion people on earth, a breath-taking achievement for humanity.

But big challenges remain.

Most shocking is that almost one billion people still live without a safe supply of water.

That is not an insoluble problem: it is technologically possible to provide clean water for everyone. But many communities do not have the financial resources or the political structures needed to implement solutions.

That means engineers have to create innovative systems that are not only technically adequate, but that are deliverable given the financial and social resources available.

**Slide 6 – Rainwater Catchment**

In many cases, that means building small-scale water systems that are cheap to deploy and easy to repair: systems such as this rainwater collector in Kerala, which can easily be built and maintained by local communities without external assistance.

To an engineer it is second nature to design systems like this, systems that meet multiple constraints – technical, social and financial.

That is also a crucial skill for a leader – whether delivering drinking water to a village in rural India, or tackling larger-scale projects, the first step must always be to understand the context of the project and, in particular, the resources available.

Doing so allows you to define the purpose and the strategy of your organisation.

**Slide 7 – Water Constraints**

Providing access to those without water is not the only challenge that water engineers face.

Even greater is the problem of water scarcity – many regions have an adequate supply network, but do not have enough water to keep it flowing.

In this map the area of each nation reflects its total water consumption. As is obvious, consumption across the globe is grossly unequal.

The average American citizen, for example, uses more than 10 times as much water as the average citizen of Zambia.

The problem is most acute in developing countries, where population is growing most rapidly, and lifestyles are becoming ever more water intensive.

**Slide 8 – Water Poverty Diagram**
In many of those countries a pattern of water stress is already emerging.

Irrigation for agriculture, which underpins many developing economies, has to compete increasingly with new industries – particularly tourism and manufacturing.

Rapidly expanding urban populations add another pressure on water and sewerage systems. In pursuit of new jobs in new industries, the majority of the world's population now live, for the first time in history, in towns and cities.

And as a result of climate change, some of the world’s poorest regions are predicted to experience less precipitation, worsening problems of water scarcity.

Water scarcity has serious consequences – it retards economic development, it damages health and hygiene, and it leads to conflict in society as factions struggle over limited resources.

Addressing these challenges requires engineers to act not just as technical experts but as communicators – aligning diverse groups of policymakers, entrepreneurs and activists behind a project.

**Slide 9 – Jordan River**

Nowhere illustrates my point better than the nation of Jordan, one of the most water poor countries in the world.

I’ve seen myself how the once mighty River Jordan has been reduced by more than 90% to little more than a small stream in places – as in this photograph - thanks to the extraction of water by Israel, Jordan and Syria.

As a result, the Dead Sea, which is fed by the River Jordan, is falling by about a meter a year; and the six million inhabitants of Jordan's capital, Amman, receive water only once or twice a week.

**Slide 10 – Red to Dead**

In response, Jordan is undertaking a massive engineering project – constructing almost 1000km of pipeline to carry water North from the Red Sea: to replenish the Dead Sea, and to provide water for Amman.

The scale and complexity of this “Red-to-Dead” project is huge – it will eventually carry close to a billion cubic metres of water a year and cost up to 10 billion dollars. The technical challenges for engineers are vast.

But just as challenging are the political and environmental considerations. Engineers have to design a system that can win the agreement of Jordanians, Israelis and Palestinians – no mean feat.
And they must satisfy environmentalists that they are minimising the impact on the ecology of the Red Sea, the Dead Sea, and the Arabah valley in between.
The engineers working on Red to Dead are not just technicians and experts – they are *diplomats and negotiators*.

That ability is crucial to successful leadership: leaders must be able to align multiple parties – both internal and external – behind their strategy to achieve success.

In life there are few resources as important as water. But one other comes close – my second topic this evening and the focus of my career – energy. Energy is essential for heat, light, and mobility, as well as food, communication and consumer goods. It underpins economic growth and the spread of social progress.

**Slide 11 – Energy**

Throughout history, engineers have developed new sources of energy.

They started with biomass in the form of wood and feedstuff for working animals.

In the industrial revolution they started to unlock the vast energy trapped in fossil fuels: first coal, then oil and then natural gas.

And in the last few decades, engineers have introduced a new generation of energy sources: nuclear and renewables.

The unlocking of new resources has repeatedly revolutionised our economic, social and political lives, changing the way we work, live and travel.

**Slide 12 – Energy Demand**

But today we face a formidable challenge: to maintain the supplies of energy that underpin human progress.

Energy *demand* continues to grow strongly, driven by population growth and increasing prosperity.

The IEA estimates that the world will consume 40% more energy in 2035 than it does today.

**Slide 13 – Energy Concentration**

At the same time, conventional supplies are becoming increasingly concentrated in the hands of a few nations.

In this map the area of each nation is proportional to its oil reserves.

The level of concentration is immediately obvious. Three nations – Saudi Arabia, Iran and Venezuela - control more than 40% of global oil reserves; while Russia, Iran and Qatar control more than half of the world’s conventional natural gas.
In recent months, political events in the Middle East and North Africa and the subsequent rise in the price of oil have demonstrated how this concentration jeopardises our energy security.

**Slide 14 – CO2**

Meanwhile, as we strive to meet growing demand and guarantee energy security, we must also drastically reduce the greenhouse gas emissions of our energy production.

As engineers have unlocked energy from the earth, they have also unlocked carbon – with unprecedented and uncertain risks for our climate.

This chart shows the increase in atmospheric carbon dioxide since 1980, alongside the increase in global average temperatures.

It is a profound truth, only now being recognised, that we cannot grow first, pollute second, and clean up third.

So the challenge is great – to meet the world’s energy demand in a way that is affordable, secure and clean.

There is no easy solution. We have to make very difficult decisions involving uncomfortable trade-offs: because every source of energy comes with significant risks.

**Slide 15 – Shale Gas**

Take for example, natural gas.

Technological innovation has made it possible to extract natural gas from places previously thought impossible.

The most significant development has been a fall in the cost of a process called hydraulic fracturing - injecting water and sand into a well to fracture underground rocks and release the gas trapped inside.

That has made it economic to produce gas from shale formations. And thanks to these shale resources, the US is now self-sufficient in natural gas, an unthinkable prospect only a few years ago.

Elsewhere around the world shale gas presents an opportunity for countries to develop secure domestic supplies – such as at this site in Lancashire.

But shale gas, like every source of energy, has inherent risks.

In particular, the industry is struggling to win public acceptance for its use of hydraulic fracturing. Although historical evidence points to the safety of the process, many fear that it
could contaminate water supplies, and concerns have already led to bans in New York State and France, halting exploration in its tracks.

For that reason, we cannot rely too heavily on natural gas as a solution to the energy challenge.

**Slide 16 – Oil**

New sources of oil also have the potential to introduce variety to our supplies.

There are particularly promising resources in the deep-waters of West Africa, Brazil and the American Gulf of Mexico, where this gigantic Thunder Horse Rig is based. For some idea of the scale, its surface area is the size of three football pitches.

On land, Canadian oil sands and North American shale have tremendous potential. But at these frontiers there are significant risks.

There are operational risks: when people, systems or processes fail, as we saw with devastating consequences at last year's oil spill in the Gulf of Mexico.

There are political risks, which can be unpredictable, sudden, and deeply damaging. And there are strategic risks. Partnerships and acquisitions can rapidly turn sour even after the most rigorous due diligence.

What these risks have in common is that they cannot be eliminated. Exploring unchartered territories with innovative technology and untested partners is an inherently risky activity.

**Slide 17 – Nuclear**

Nuclear power is another important alternative, but the terrible events at the Fukushima power plan in Japan – shown here before the disaster – have cast its future into doubt. Germany, for example, plans to shut all its reactors by 2013.

In my view, that response is misguided. Abandoning nuclear power would likely mean increasing our use of coal – a far more dangerous source. Every year thousands of coal miners die in accidents and air pollution from coal causes hundreds of thousands of premature deaths.

But the catastrophic potential of nuclear power understandably generates fear, and makes public acceptance very difficult.

**Slide 18 - Renewables**

Alongside insecure fossil fuels and unpopular nuclear, renewable power looks increasingly attractive, both for its environmental benefits, and its ability to provide secure domestic energy.
Experience in the industry is growing and costs are falling. Over the last five years, annual investment in clean energy has grown fivefold to more than $250bn, and the price of solar cells, for example, has fallen by three quarters.

But despite that, renewable technology remains, in general, far more expensive than the conventional alternatives.

So, we face an energy landscape of tough choices, with expense and risk wherever we turn. Whatever sources we choose, we will be criticised by someone.

**Slide 19 – Energy Mix**

In the end, we will not find a single source of energy that solves all our problems. We will rely on a new *mix* of sources that balances the environmental and financial costs of different technologies, and that reduces risk through diversity.

In my view, fossil fuels, nuclear and renewables will all form part of that mix. Delivering a new mix requires a revolution in all aspects of our energy production and consumption.

In Saudi Arabia, for example, water desalination is responsible for more than half of domestic consumption – or 1 in every 50 barrels of world production. The Saudi government is now beginning the transition to solar powered desalination – realising that it makes both economic and environmental sense.

Transformations like that must take place across the world. And it will be engineers who drive that process.

Engineers will develop the technology to exploit the renewable resources at our disposal. Wind, wave and nuclear power are already providing exciting new opportunities for UK industry.

Engineers will build the systems to make fossil fuels plants cleaner and more efficient, and potentially to capture and store the carbon emitted.

And engineers will improve the efficiency of energy consumption across every industry – ensuring that our economic prosperity is sustainable in the long-term.

In every case, engineers have a unique skill that makes them invaluable: an ability to execute solutions with a grasp of both technical details and commercial reality.

That means not only understanding how a system works, but understanding how to implement complex change, how to manage risk and how to keep control of costs.

That capability must be at the heart of society if we are to deliver the new energy mix successfully and affordably. That is why engineers must act as leaders, not followers.

**Slide 20 - Leadership**
I believe leadership requires three core skills: the ability to define a vision that fits your context, the ability to align diverse parties to work towards that vision, and an ability to execute that vision efficiently.

Engineers, by the very nature of their training and their work, are equipped with these skills better than any other profession.

Every day engineers create plans to fit their context. Like those designing rainwater catchment tanks in India, they appreciate the resources available to them and the constraints they face.

Every day engineers align diverse parties to reach a common goal. Like those planning the Red to Dead project in Jordan, they understand how to communicate a vision with broad appeal.

And every day engineers execute solutions efficiently. Like those working on the energy systems of the future, they grasp how to manage risks and control costs.

**Slide 21 – The Future**

This is why I was so keen to speak to you tonight.

For too long, engineering has been seen by others, somehow as a supporting profession. I am afraid that too often engineers have gone along with that perception. When in fact, engineers, with their unique skillset, are leaders and need to be the drivers of change.

Most of you are in the early part of your careers.

As engineers, in whatever field, you have a unique and crucial role to play in transforming the natural resources of the planet into benefit for humanity - a role that has never been more important than it is today.

We live in a world more interconnected and intertwined than ever. That adds complication but it also multiplies opportunity: a leader in one place can make a greater difference than ever before.

Your challenge is to take this opportunity and make the most of it. Work with us, with your professional bodies. Equip yourselves with the skills and experience you need to become the leaders of tomorrow.

Ladies and gentlemen, now is your opportunity to share your ideas on how we, as engineers, can rise to this challenge.

Thank you very much.