A world of nuclear experience

PwC global nuclear capability – capital projects and infrastructure
We have a world of hands-on nuclear experience ...

... from policy, structuring, finance and construction to operations, life extensions, decommissioning and waste management

Whether it is engineers, physicists, project managers, asset managers, forensic, tax, accounting, IT and operational specialists, or finance, deals or regulatory specialists, we have people with extensive real-life experience from inside the global nuclear sector and we are able to blend that with our experience with major capital projects in other sectors. We are playing an established part in many industry developments and are well placed to add value, enhance the capabilities of your team and help take you to the next level.
Introduction

Nuclear science plays an important part in modern life, from power generation to the production of radioisotopes for medical, industrial and agricultural use. Nuclear power is an important source of low carbon, baseload electricity, helping to combat climate change and increase security of supply, and nuclear medicine is vital for the diagnosis and treatment of disease.

Few capital or infrastructure projects are more challenging than nuclear projects: their demanding scale, cost and complexity; their immense national and international significance; intense public and regulatory scrutiny; plus the responsibility to decommission and manage nuclear waste. Even smaller-scale projects, such as the development of small modular reactors, face these challenges.

The worldwide nuclear industry is in the middle of a three-fold challenge of extensive new build, increased efforts to manage and extend the life of an ageing global fleet, and the widespread decommissioning of the oldest plants, all within the context of high competition for resources and ever-increasing energy demands.

This brings particular challenges. How can finance be raised to build new power stations? How can projects be structured and developed to the satisfaction of investors while meeting the highest levels of safety, security and safeguarding? Will the supply chain cope with the increased demands upon it? How can the industry continue to reduce the risks of non-proliferation (including converting research reactors from highly enriched uranium (HEU) to low-enriched uranium (LEU)) and better manage fuel and radioisotope production? How can the performance and duration of existing assets be improved? What is the solution to the long-term management of radioactive waste?

Considerable investment is being made in nuclear power, whether it be in new build, life extension or decommissioning. Electricity output from nuclear is forecast to increase by two-thirds by 2035, led by China, Korea, India and Russia.¹

PwC is on hand to support your nuclear projects. We are involved in many major current projects and can assist throughout the nuclear power lifecycle – from strategy and financing through to decommissioning and disposal of radioactive material. We continue to work with our clients to develop and implement solutions to the issues faced by the modern nuclear industry.

Our team includes people with direct hands-on experience of planning, developing, operating and decommissioning nuclear facilities. We can provide a wide range of skills, from structuring to regulatory, engineering to business services, financing to IT. Our starting point is matching your needs with our nuclear sector expertise, knowledge, professional objectivity and rigour.

We believe in having a continuing dialogue – listening to your priorities, understanding your business issues and delivering great work together.

Working together
PwC and the nuclear sector

At a glance – why PwC

- Strong global network to help our clients succeed
- An experienced workforce with broad capabilities and a deep commitment to our global nuclear clients. This investment positions us to anticipate our clients’ needs and respond with a quality of service that sets us apart

- Our nuclear team is experienced across the nuclear cycle from uranium mining through to new build through to decommissioning and waste management
- Strength and depth across the nuclear sector with real knowledge and experience of the nuclear market

- Knowledge of government organisations and industry bodies and their priorities
- Hands on approach to developing your organisation and supporting its capabilities

- Lasting value for our clients, bringing together a customised mix of skills
- Combining a creative mindset and problem-solving experience of our specialists from the financial (funding, tax and accounting), technical (IT, mechanical and civil engineering) and commercial disciplines, with the precision, structure and analytical capabilities

“ What do I do when I need to talk to someone and get advice? I call PwC. That’s why I hired them. ”
– Head of nuclear power programme, major utility company

With PwC you get an adviser with experience across the nuclear lifecycle. It’s experience that can be vital in giving you an independent view of what lies ahead.
Countries that are not members of the Organisation for Economic Cooperation and Development (OECD) are providing much of the impetus behind nuclear power growth. Of the 73GW under construction in 2013, about 80% was in non-OECD countries.*


PwC takes the experience we have gained from our direct involvement in past and current nuclear projects and other major capital programmes to help governments and companies move more efficiently and effectively through the complex lifecycle of a nuclear project.
Helping your nuclear capital projects …

PwC works with owners, operators, technology providers, investors, financiers, governments, regulatory bodies and other industry stakeholders in every region of the world to assist with the decisions, planning and implementation of major nuclear capital projects (see Map 1). PwC provides top-level advice on reform and strategy or hands-on delivery of the resulting change programmes.

In addition to having hands-on experience of nuclear programmes around the world, we are involved in many different ways in the nuclear industry. We are active members of a number of industry organisations (including the World Nuclear Association). Members of our team are designated and recognised as Experts by the International Atomic Energy Agency.

They are invited to attend organisations such as the International Framework for Nuclear Energy Cooperation (IFNEC), the OECD’s Nuclear Energy Agency and OSPAR to debate industry issues and changes. They also work for regulators, carrying out state utility commission reasonableness and nuclear safety requirement reviews for the US Nuclear Regulatory Commission.

Map 1: People with experience of the projects that matter

Our team has experience with prominent nuclear power projects in major markets around the world, including in more than a dozen countries.
PwC – working with you

Management of risk is key to any stakeholder in any large project. Being an established member of the nuclear industry, we understand the risks and the project governance requirements needed to achieve a successful project. We are able to offer a wide range of services to help meet the specific challenges faced by different stakeholders. For example:

Governments
• Choice and design of policy frameworks and funding mechanisms
• Design and delivery of specific regulatory policy
• Feasibility advice and analysis
• Risk modelling and independent reviews

Investors and financiers
• Market risk assessment
• Portfolio risk screening and improvement
• Financial support and appraisal
• Commercial and contracting structuring and strategy

Owners and operators
• Liaising with and supporting relationships with regulators
• Establishing and developing owner and operating entities
• Performance improvement for existing nuclear organisations
• Contract management and commercial structuring

Contractors and developers
• Contract performance
• International and national regulatory impact
• Procurement and sourcing
• Localisation review and assessment

Vendors, service providers and suppliers
• Contract and commercial frameworks
• Company frameworks and legal entities
• Labour and human resources
• Procedural support

Many projects are ground-breaking, especially after the lull in nuclear new build in many parts of the world. It is essential that ground-breaking does not become confidence or bank-breaking.
Policy frameworks, strategy and financing

Policy stability and certainty is a necessary foundation for the financing, security, safety and safeguarding of nuclear projects. This is all the more so given the risks associated with the long construction period and complexity of developing new nuclear projects. In many countries the challenge is even greater given the long period that has elapsed since previous nuclear projects were completed or, in some instances, because it is the first project of its kind.

Effective policy and strategy at the outset can do much to offset the risks associated with any new build project. Governments have a role to play in boosting the confidence of the market by demonstrating policy stability, a strong rule of law and established regulations that can underpin such a large financial investment. They can also support the industry by ensuring electricity wholesale markets are fair, supporting nuclear power as required with specific mechanisms, and by ensuring that the planning, licensing and permitting processes are clear. It is also important that the roles and responsibilities of different actors through the lifecycle, from planning to decommissioning and waste management are appropriate and well defined.

Investors, owners, operators and contractors all need to understand the regulatory and market context and what it means for the structuring of the project, the return on capital and on operations once the project is developed. The strategic rationale for the project – its market and portfolio fit, its contribution to growth and shareholder value, its timing and the type of partnership arrangements – needs to be very clear. Financing is a major challenge, especially during construction when the project is vulnerable to cost overruns and extensions of time. A stable and robust political and country environment is absolutely essential for the raising of finance.

Working together – AREVA, Belgium Nuclear Forum and PwC

For two major nuclear stakeholders in France and Belgium, PwC conducted an independent study about the socio-economic impact of the nuclear industry in both countries. Based on a specific methodology developed by PwC, these studies delivered benchmarked figures of the economic added value (at regional and national scales) of reactor design/construction/operation phases, as well as a quantification of the jobs generated all along the nuclear value chain. Some context evolutions were also assessed with respect to their environmental, economic and price competitiveness impacts.
How PwC can help

Getting policy, legal and regulatory frameworks right

PwC can help governments and industry players alike develop policy and regulatory frameworks that take full account of the reality of nuclear capital projects. It is essential that all relevant experience and evidence is taken into account so that policy and rule-setting does not result in unintended consequences for projects and operations. We advise on implementation and compliance with up-to-date international standards, regulations and agreements. We assist with the review and design of specific policies and mechanisms and conduct the necessary analyses and scenario modelling, as well as building factual data about economic added value and job dynamism created across the value chain. Finally, we help companies gain a full understanding of the regulatory context and assist in regulatory submissions.

Getting strategy right

Understanding risks and how best to mitigate them lies at the heart of developing a robust strategy. We help by assessing the market and business needs that are required to feed into strategic planning.

This entails conducting market assessments, including supply chain readiness and advising on the right structuring of the project to balance the risks of various stakeholders while meeting the requirements of regulators, investors and financiers. We also conduct risk assessments for organisations looking to move into new territories or emerging markets and for governments looking to develop a nuclear strategy or nuclear industry.

Market entry strategic advice in Europe

We advised a technology provider on the national regulatory framework, electricity sector size and structure, supply chain infrastructure and existing competition. We reviewed the financial statements of the target organisation and details of key costs, preparing a summary of the key commercial and financial risks identified during the diligence process.
**Getting funding and financing right**

PwC helps with financial risk assessment and the modelling of different scenarios as well as value for money (VfM)/affordability assessments and revenue/demand forecasting. We develop commercial structures to help obtain the required credit rating – taking into account financing, tax and accounting considerations. We also provide support for financing competitions, help our clients negotiate financing documents and balance financial strategy and regulatory requirements.

**Getting the structuring and incentives right**

PwC provides analysis of financing options available, advises on risk distribution, allocation modelling and incentives assessment, and assists with equity participation support, including the potential role of a technology provider. We can also help with economic impact assessments and evaluations using qualitative and quantitative measurement and options appraisals. This can enable you to look at the financial impact of different ways of delivering projects – for example, alternate financial structures, financing terms and refinancing.

**Focus on structuring – balancing regulatory risk with financial risk**

The need to attract both financing and investment and revenue security (funding) to enable increased nuclear new build has prompted many nations to review their nuclear regulation requirements.

The impact of regulation on the commercial structuring must be considered, balancing financial risk with regulatory risk. In particular, whether regulators will permit the separation of the owner and operator, as is allowed in territories such as the United States; and regulatory decisions on the nature of the operator, such as whether it is permitted to be a thinly resourced entity, relying on sub-contracting of services and associated risk.
Working together – Teollisuuden Voima Oyj (TVO) and PwC

We were advisers to TVO in Finland on the approach to private sector funding for nuclear development. Finland has a high dependency on energy to fuel its paper and forest industry. TVO is a non-listed public company founded in 1969 to produce electricity for its shareholders at cost price. It operates on mutual principles for its industrial and energy utilities shareholders.

Deliverables
PwC’s involvement on the funding strategy followed its decision for major nuclear power expansion. Once the investment option had been decided on, we were asked to assist in looking at the economics of nuclear generation at the prevailing market conditions and how TVO could put together a funding package to get the new power station built. Our work included:

• Assistance in developing a financial model for the NPP
• Analysis of funding alternatives
• Commenting on project implementation agreement in preparation for discussions with shareholders and other interested stakeholders.

Not only was this one of the largest single investments in Finnish industrial history so far, but the mutual operator model was unique for Finland. The project also came after a long period when there had been no new nuclear build in Finland. Many observers felt it would be difficult to put together a funding structure for a new nuclear power station in a competitive electricity market that investors were unfamiliar with. These difficulties and the issue of effective financing and management of nuclear waste costs were overcome.

Each entity needs to look hard at individual capabilities for delivering the project, which, in turn, will have an impact on the nature and extent of the relationships. It’s important to consider and manage early the challenges that arise in projects where there is a complex equity mix of investors. In some cases, there is likely also to be some M&A activity, where, for example, the parties to a consortium decide to exit. PwC’s specialised deal, JV structuring and financing advice is there to help with all these issues and to deliver value through quantitative analysis, rigorous implementation and leading-edge structuring techniques, carrying out pre-acquisition due diligence, and supporting tax-efficient deal structuring and post-deal integration.
Project assessment and development

Sound project definition and effective decision-making at the outset of a capital project are critical to a successful outcome. The ability to influence project success and enhance value is greatest at the start of any project. Conversely, the cost of variations, changes and delays dramatically increases throughout each successive project stage.

The quality of decision-making in the early stages of a project is especially critical in the nuclear industry where the capital costs are high, the timescale is long, and governance and compliance with regulatory requirements are crucial to progress.

Robust project appraisal needs to be matched with appropriate financial and structuring arrangements. The various structures in the market include (i) vendor equity with ECA (Export Credit Agency) and commercial debt financing, (ii) build-own-operate (BOO) with financing model, (iii) Exceltium, (iv) Mankala and (v) government financing. These structures can be adapted to meet the requirements of all stakeholders including developers, lenders, governments and regulators.

A key to a successful nuclear project is balancing the financing and regulatory requirements to make sure the highest regulatory standards are met while developing a project that investors are eager to support.

How PwC can help

Project feasibility advice and analysis

PwC prepares cost-benefit analysis, market analysis, bankability and regulatory compliance assessments. We also look hard at projected project costs, revenues, capabilities, and the risks and sensitivities surrounding these. We have specialists who focus on project financing, corporate financing, financial feasibility, cash flow modelling and can use statistical methods to measure and describe budget risk in probabilistic terms. We also develop feasibility studies to assess a proposed project considering not only the financial returns but also the political and country environment, the suitability of off-take arrangements, the siting of the project, the localisation requirements and the local capability, including the suitability of the supply chain.
Business case development and supporting advice

PwC helps with funding and approval requirements including detailed business case development and supporting documentation. We can conduct testing and qualitative review of the project business model, taking into account its public policy rationale and the inputs required from the provision of public infrastructure. We assist with the development of power purchase agreements, contracts for difference or similar off-take arrangements.

Assessing financing arrangements

PwC has hands-on experience of a number of the nuclear financing models in the market and has specialised knowledge of the various structures being adopted including vendor financing with ECA and debt support, BOO, Mankala and Exceltium and variations on these structures. PwC also advises on the regulatory requirements of the operator (thick or thin) and adaptation of the project structures according to the local requirements of the regulators. It is important to develop a robust structure through the project development stages – using financing resources such as ECAs, risk allocation and supporting contract structures, and recognition of electricity markets to secure early rate recovery in regulated markets or off-take agreements in merchant markets.

Regulatory strategy and compliance

Managing the development of a nuclear project in line with regulatory frameworks is a key element of a nuclear installation. Being fully aware of the impact of regulation is essential for managing costs. Unforeseen requirements can add significant time and cost. PwC helps with the framing of regulatory strategy and modelling different financial and incentive options, as well as supporting the development of healthy relationships with regulatory bodies.

Photo courtesy: Sanmen Nuclear Power Company Ltd.

The Passive Containment Cooling Water Tank (PCCWT) is an important part of the passive safety system at the Sanmen Nuclear Power Station in China. It contains water that helps to cool the plant in the event of an emergency.
Working together – Nuclear Power Corporation of India (NPCIL) and PwC

We advised NPCIL on the design and development of a structured joint venture strategy roadmap to aid in expanding nuclear power in India to 63 GWe by 2032.

We assessed the capital required by NPCIL for executing the capital expansion plan needed to reach its target; mapped and projected internal resources generation; conducted an equity commitment gap analysis; evaluated the funding options for both debt and equity; formulated an investment decision framework and JV partnership model; considered the commercial and tax implications of JV structuring and technology sharing; and conducted a benchmarking study of nuclear compared to other fuels (for affordability) up to 2032.

Capability and readiness assessments

Does your organisation have the capability required to manage a large nuclear capital project? Similarly, is there sufficient supply chain capability? We can help you take a realistic and hard-nosed look at all the things that are required to meet localisation, regulatory and organisational requirements based on our many years of global experience.

In our experience of nuclear projects, we have found important capital project readiness gaps. It might be people gaps, process failures or insufficient attention to the amount of integration required. We can then help you decide the most appropriate way to address capability shortfalls and prioritise remedies.

Establishing the asset management bedrock

Effective and efficient enterprise asset management (EAM) is a vital foundation for addressing the safety, asset maintenance and renewal, and capital investment challenges facing companies. We can help you think about asset management early on in your nuclear project planning.

Planning in advance of the contract stage regarding issues such as how you will get the data prepared and transferred can save a lot of money and headaches. If aspects are overlooked, they can be expensive and difficult to remedy.

New opportunities, new challenges: small modular reactors

Small modular reactor (SMR) architecture offers the possibility of reactors that would offer quicker and more flexible deployment of nuclear power. For example, they could provide a new source of cleaner generation at older coal-fired generation sites or at existing nuclear sites. A number of barriers remain and SMRs will need to show they deliver in terms of safety, availability and cost competitiveness. If they can, they could become an important part of the generation mix.

But ‘small’ doesn’t mean the capital project management challenge will be any less onerous. New designs bring new risks and uncertainties with associated implications for estimating and contingency. No matter how much testing has been done in trial mode, there is always the likelihood of eventualities occurring in actual deployment and operations that were not predicted. PwC is able to help companies to balance the various risks, not just of technology development but also of licensing, commercialisation, corporate relationships, structuring and financing in a robust programme delivery framework.
Project procurement and delivery

Successfully delivering a nuclear project across its lifecycle requires strong project management and processes as well as a thorough contracting strategy. The delivery must stand up to intense internal and external scrutiny and demonstrate that the operator is both the ‘controlling mind’ and ‘intelligent customer’ that regulations require it to be. It must also be able to handle the complications of nuclear permitting, licensing and construction along with the difficult transition from start-up through to operations and final decommissioning and delicensing.

A clear and transparent strategy, which is bought into, is critical for procurement and delivery of a nuclear project; without it the project will unravel. Any approach must clearly lay out the framework and accountability for project execution, oversight and assurance. Readiness and capability assessments for both the contracting organisation and the supply chain must be carried out. The supply chain contracting strategy is also critical. How do you establish a strategy that is win-win all round? What is the optimal incentive structure? How do you share risk?

A key consideration is when to start and how to phase the project. A lot of nuclear projects start without detailed engineering design or strategy. Some of this may be inevitable, but it runs the danger of creating a ‘catch up game’ where the construction phase experiences productivity and efficiency problems because it is waiting on engineering design, or the decommissioning phase being more timely and expensive because of the lack of advance planning.

How PwC can help

Matching the contracting strategy to the balance of risks

The project contracting approach and commercial terms need to balance risks and rewards among project participants and clearly set out accountability for specific performance parameters while maintaining the operator’s ‘intelligent customer’ role.

We can help you devise a contracting strategy that fits with your risk appetite and capabilities and draws not only on our nuclear industry experience but also on the successful practices we have observed in the global engineering and construction environment. We can help you analyse and assess the market and understand the advantages and disadvantages of the different delivery options and contract commercial terms, highlighting how the risk profile created by your contracts affects your future staffing and management approach.
Establishing effective governance and control

Project governance is an active and ongoing role. Combining our nuclear, engineering, project management, regulatory, financing, accounting and consulting experience, PwC helps clients manage contracts and requirements, identify issues and risks, establish timely risk mitigation plans and escalate issues when management attention is required. In nuclear, this requires a comprehensive suite of control tools and procedures to address detailed planning and scheduling, active change management, cost controls, risk management, quality controls, safety management contract administration and regulatory compliance. It also requires detailed control analytics that regularly analyse performance parameters and report timely, relevant and accurate metrics to senior management and project stakeholders.

With PwC you get an independent and objective viewpoint with no vested interests.
Meeting the unique challenges of new nuclear build

For a US new nuclear build, PwC’s team was selected to provide hands-on execution and advisory help, supporting the company through a myriad of construction-related tasks and issues including financing, regulatory matters, schedule analytics, continual projections of end costs, and the numerous challenges associated with managing contracts worth billions of dollars.

The project consortium faced the challenge of a shortage of new nuclear build expertise. The PwC team was able to add considerable experiential know-how. Our team included people with substantial engineering and project management experience, including direct experience of previous nuclear projects.

Keeping scope, schedule and costs under control

PwC has developed a variety of analytical tools to help project participants assess scope, schedule and cost performance throughout the project lifecycle. This is based on our experience of nuclear projects and other mega-projects across the globe. With control analytics, a project management team can proactively analyse the performance of a project and its associated risks through the use of modelling tools and techniques to identify those risks that have the highest potential for significant adverse project execution consequences.

These tools include quantitative risk assessments (QRA) using stochastic models to quantify project risks and forecast cost to complete project elements and estimate contingencies. QRA helps establish data trends and metrics and can analyse risks over tens of thousands of computer-generated iterations using probabilistic methods of analysis to aid decision-making. We also perform detailed schedule analytics, providing management deeper insight into schedule trends and early warnings of schedule risks.

Being a trusted adviser to your project management team

We can be on hand to continually evaluate your project management controls, capabilities and documentation and provide recommendations for process improvements. With the breadth and depth of our experience on nuclear and other major capital projects throughout the world, we can compare your practices to other successful industry practices and highlight where effective practices on other projects could be adapted to your situation. With PwC, you gain a specialist’s outside eye, offering support and challenge when needed, enabling you to identify and correct oversights and make changes in time to keep your project on course and reduce disruption.
Capital project oversight
PwC’s capital project specialists provide clarity to the programme board and stakeholders on the performance of their business-critical projects and gives confidence in the messages that your project team is communicating. This allows senior management to make informed decisions predicated on robust data. It also flags projects showing signs of distress, allowing you to take remedial action before issues escalate and become critical. The key risks and critical success factors are mapped, allowing management to understand and influence the in-life performance and activate the appropriate levels of management intervention where necessary to maintain the project performance. Lessons learnt are captured for use on other projects in the company’s portfolio.

Getting projects back on track
The history of large-scale capital projects is littered with high-profile examples of projects going off course and the nuclear sector is no exception. Prevention is better than cure, but if a project does go wrong, PwC can help with project recovery, disputes and investigations. Timely and appropriate action can help contain problems. We can help identify issues early through review and health checks, assess and select corrective options, support in any renegotiation of commercial or contract terms, or help if more drastic turnaround action is required, such as restructuring, contract re-let and negotiation.

Never underestimate uncertainty
People tend to underestimate uncertainty. In the early stages of a project everyone is optimistic and can underestimate the possibility of things going wrong. People assume (wrongly) that adding in a contingency figure and some float will make all the issues go away. Sometimes this is compounded with people not wanting to tell management bad news. PwC can be objective and not pull any punches. We can come in and give a much more independent view than the parties that are directly involved.

The beauty of QRA analysis is that, by breaking down schedules into discrete chunks, you can see much more easily and much sooner when things start to go wrong.
... all the way through the nuclear lifecycle

**Operations, maintenance and upgrades**

The transitions from construction to commissioning and then to operations requires careful planning and management. Good interfaces are needed between the different contractors and the operator. Even when operational, capital project challenges for nuclear installations’ owners and operators remain very real.

In a number of locations, significant capacity is being maintained by plant upgrades and life extensions. The technical and economic feasibility of replacing major reactor components, such as steam generators in pressurised water reactors (PWRs), has helped extend operating lifetimes to 60-plus years. The prospect of small modular reactors coming online provides another source for the expansion of nuclear power at existing sites, as well as at a wider range of locations.

The nuclear industry is faced with the demands of maintaining the viability of an ageing reactor fleet. This challenge is complicated by evolving regulatory requirements, including those arising as a result of recent natural disasters that have challenged plants to retain integrity beyond design basis. These events have spurred a re-evaluation of previously conducted seismic and flooding risk analysis.

**How PwC can help**

**A smooth handover and start-up to operation**

Ultimately, it is the operator’s responsibility to be able to prove that what was designed is what was built, and what was built is what is being operated, and to have actively evaluated, controlled and documented any changes. Systems and processes to manage this need to be considered and selected earlier in the project lifecycle than many realise.

In addition, effective process, systems and people are needed to manage the transition from construction to operation and, ultimately, to decommission the plant. These will need to meet the needs of stakeholders as well as adequately addressing specific business, cultural or project characteristics and imperatives. PwC works with our clients to create and improve existing process, systems and staffing, and support successful and sustainable implementation.

"We were already a successful nuclear operator but needed to move to the next level to demonstrate that we can compete with the best globally. We needed deep expertise and strong programme management to enable a successful and on-time transformation. We would have struggled without PwC’s help, guidance, encouragement and experience. We believe that we are better positioned to grow our business with our new management system.

– Deputy general manager, nuclear power station"
Working with investors – China’s Daya Bay nuclear power station and PwC

Daya Bay is one of the largest operating nuclear complex in the world. PwC assisted the Daya Bay Nuclear Management Company (DNMC), and its holding company, China General Nuclear (CGN), to implement SAP’s ERP and EAM solution at three existing power plants for six operating reactors. This solution will help provide Daya Bay’s management with financial and enterprise asset management, coordinating everything from daily plant operations, maintenance, supply chain and financials.

The project was completed in less than 18 months. The full original project scope was completed on time and on budget. The business scope included end-to-end finance, costing, supply chain management, work management, asset management, plant operations and blocking, and HR time entry. The solution is the foundation upon which CGN can manage its fleet of five other nuclear sites (20-plus units) currently under construction.

CGN needed to be able to demonstrate leading business controls, practices and transparency to participate in financial markets and adhere to global nuclear safety standards. The project was able to deliver clear and verified reporting into a complex multitude of processes, organisations and tools. Further, when another system integrator failed, DNMC was in the unenviable position of having to restart a project from the beginning. The new project included a team of PwC US ERP/EAM specialists integrated with a team of PwC China consultants with further support from our Global Development Center (GDC) in Shanghai.

Nuclear refits, upgrades and life extensions

These are large capital projects in their own right with their own complications. Every day a facility is off the grid involves cost and potential liabilities. Is the infrastructure there to support the new technology that is being implemented? Are stumbling blocks being foreseen, such as metric sizing replacing imperial sizing and the limitations of very fine tolerances on the equipment that is being maintained? What are the implications of a regulatory world that has moved on? Is the asset register comprehensive enough to provide the answers that are needed? Does your team have the agility required to meet your business needs? PwC has a strong multidisciplinary capability to help you meet the project management and governance challenges that arise. These challenges include managing the interfaces between various project participants, overseeing risk management, and tracking costs and schedules.

Effective enterprise asset management

Are the methods used to optimise the plant’s performance and reliability the best they can be? Developing a reliability repository for the design is an important step. PwC helps companies develop and use reliability centred maintenance (RCM) analysis rigorously to assess all facets of plant reliability. PwC also works with clients to achieve PAS55 and ISO 55000 accreditation, supporting your goal of fully realising the benefits of certification. We advise on a range of performance improvement techniques to help you to achieve outstanding operational performance from your asset and your people. By carefully managing assets across your portfolio of plants, your organisation can improve utilisation and performance, cut capital costs, reduce asset-related operating costs, extend asset life and improve your return on assets.
Ongoing operational support

Throughout the operating life of the plant there will be a variety of areas that are likely to require support and advice. PwC teams engage the firm’s global nuclear network to address client challenges related to refinancing and restructuring to protect investor returns within regulatory requirements, managing cybersecurity and other safety risks, and helping to manage operational performance of the business or supply chain to increase efficiency and improve plant procedures.

Enhancing your cybersecurity

Confidence in your digital operations is critical in the nuclear sector. But the nuclear industry, like others, is increasingly vulnerable to new and unprecedented cyber threats.

While the pace and magnitude of the risks have increased, the approach organisations use to manage them has not kept pace. We can help you test the strength of your current cybersecurity and industrial control systems, assess potential threats and prioritise risks. We can also help with forensics and incident response should a suspected breach occur.

We are conducting a number of projects around outage-based maintenance, helping companies manage and reduce costs, prevent delays and position them to enhance cost recovery.

We helped OPG improve capital project management by providing contract advisory services, a risk-governance review and compliance reviews. Our involvement enabled the project management team to evaluate their existing processes and procedures and determine any gaps that require attention. We interviewed the key project stakeholders and reviewed relevant project documentation to assess the effectiveness of the existing project controls and processes. We also reviewed applicable sections of key contracts, tested contractor and client compliance with the applications for payment portions of the contracts, and reviewed the client’s internal review and approval process.

The review focused on identifying key risk areas of the contracts and leading industry practices that could be implemented to address, manage or mitigate those particular risk areas. We identified opportunities for the client to increase the effectiveness of the project controls and governance environment related to the review and approval of the applications for payment that will continue over the duration of the project. We also identified areas of non-compliance and provided recommendations to enhance and improve their current plans.

Working together – Ontario Power Generation’s Darlington Nuclear Refurbishment Project and PwC

Ontario Power Generation’s (OPG) Darlington facility is a CANDU pressurised heavy water nuclear generating station with four reactors that first came into operation between 1990 and 1993. Refurbishment of the reactors is an aspect of their design and a requirement during operational service life. Refurbishment should allow Darlington to continue operating until approximately 2055.

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Waste and decommissioning

The management and disposal of waste during operations and downstream lifecycle steps, including interim waste storage, decommissioning and final waste disposal require major capital investment and infrastructure in their own right. The volume of projects is increasing as a growing number of nuclear power plants and other types of nuclear facilities reach the end of their operational lives. A number of countries are decommissioning more plants than they are building.

Like new build, this work requires stable regulatory frameworks and clear financing schemes. Governments have primary responsibility on developing national policies on waste disposal and eventual decommissioning of the nuclear power plant. In many countries it is the operators of nuclear installations that have the financial obligation for preparing and managing decommissioning and waste management. Operators also have responsibility for on-site waste management and how they decide to manage site closures, usually relying on specialist organisations that provide services related to the decommissioning activities.

These projects pose the same project management, financial, governance, contracting and regulatory concerns as large construction projects. They involve complex decision-making and trade-offs, and understanding of how various technical aspects can affect cost and schedule. For example, an increased focus on decontamination may reduce the volume and cost of radioactive waste disposal, but with increased labour costs and an extended schedule. Managing staff and local communities is a particular challenge during end-of-life preparation; ensuring that the organisation retains the skills and knowledge needed, keeping a focus on safety, while respectfully managing staffing reductions or transfers.

How PwC can help

Building in decommissioning from the start
Most new nuclear builds today require some form of ‘liabilities fund’ which is material to the initial financing, yet requires a good understanding of the end-of-lifecycle costs. It is therefore essential to understand the full nuclear lifecycle from both a financial and operational perspective in order to finance and manage decommissioning.

Project governance and control
Decommissioning brings with it all the challenges of safety, cost and long timescales that apply to the front end of the lifecycle. In some respects, the onus on effective governance and control frameworks is even greater because the work and associated costs are pre-agreed upon, and often ultimately the responsibility of the rate-payer. If the funding is insufficient or the work more complicated than planned, this could have a huge impact on stakeholders. PwC helps with a full range of governance, risk and control frameworks, independent reviews and other project management support.

At the back-end of the lifecycle there is a consequential reduced scope for any cost extension, making the level of risk and the need for strong control that much greater.
Developing and operating repositories

The development, construction and operation of nuclear repositories are capital projects in their own right. Structuring and financing requirements are considerable. Who will fund the development? What is the revenue stream? How can you provide genuine pre-estimates of costs for those who will use the facilities? PwC assists with these aspects and other relevant of repository projects.

Managing and delivering decommissioning

Decommissioning companies hire PwC to assist with their cost-level controls, explore financing considerations and establish strong governance. We also help clients who are concerned about funding to implement solid and relevant financial controls so they have confidence they are spending their investors’ money appropriately.

Regulatory strategy and compliance

Developing the regulatory framework and managing operations in compliance with it is key for waste and decommissioning activities. Being fully aware of the impact of regulation is essential for managing costs. Unforeseen requirements can add significant time and cost. PwC helps with the framing of regulatory strategy and modelling different financial and incentive options as well as assisting with compliance. With regulation in this area constantly evolving, PwC helps companies integrate their experience and perspective into the process of regulatory development.

Waste disposal strategy

Waste management and disposal is a critical element of any nuclear project with safety and security being paramount. What waste can be left on site? What can follow regular disposal routes? What can go to low-level waste sites? What has to be managed by the waste disposal organisation, and what are its requirements? Decisions on these can have a dramatic effect on project cost, and requirements can be very complicated. PwC assists with the development of waste disposal strategies and helps companies fully understand their impact.

Working together – National Radioactive Waste Management Agency and PwC

PwC was appointed by ANDRA as an independent adviser in the frame of the design phase of its large scale project for radioactive waste geological disposal facility (construction expected to start in 2020).

PwC is providing an analysis of the cost estimation established by the Agency to all project stakeholders and, notably, the waste producers (EDF, CEA, AREVA), who are responsible for financing.

The work for ANDRA on this worldwide project involves:

• Establishing the consistency of the whole project costs (construction and operating costs) and increasing confidence in the costing process
• Supporting risk management

Moreover, PwC supported the definition of a financing and organizational scheme meeting all identified challenges and analysed tax, legal, accounting and governance impacts for all stakeholders (Andra, Waste producers, French state).
According to a joint report of the OECD Nuclear Energy Agency and International Atomic Energy Agency, reactor demand for uranium is expected to increase between 53% and 113% over current levels and, although resources of uranium are more than adequate to supply the projected growth well beyond 2035, the actual market situation could be quite different.²

The nuclear fuel lifecycle entails significant and complex transportation planning. Uranium is mined and transported to facilities where it can be converted and enriched before the pellets are incorporated into fuel assemblies. At the back end of the fuel cycle, where reprocessing is permitted, there is further transportation of the spent fuel and the resulting waste and isotopes. Both ends of the fuel cycle are complex and need specialist skills, but the back end is the most challenging for the industry.

The enrichment, reprocessing and management of spent nuclear fuel are highly politically sensitive. Non-proliferation is fundamental to the civil nuclear supply chain. International agreements preclude certain countries from engaging in the enrichment and reprocessing stages of the fuel lifecycle, complicating the challenges of access to nuclear power.


In the medical sector there have been shortages of the key medical isotopes molybdenum-99 (99Mo) and its daughter, technetium-99m, leading the OECD’s Nuclear Energy Agency to create the High Level Group on the Security of Supply of Medical Isotopes to address the supply shortages. At the same time, all current long-term 99Mo-producing countries face the challenge of converting to using low-enriched uranium.
Advisory services to Uranium Corporation of India Limited (UCIL) for an international uranium-mining venture

UCIL is a public sector enterprise under the Department of Atomic Energy and plays a very significant role in the country’s nuclear power generation programme. We were asked to provide advisory services for a joint venture (JV) partner search to identify and execute international uranium mining opportunities.

We assisted in the search for a potential JV partner who would be in a position to sign a memorandum of understanding (MoU) with UCIL while satisfying the terms and conditions laid by down UCIL and keeping UCIL’s interests safe in accordance with applicable laws. We prepared pre-MoU documents to highlight the financial interest of UCIL while defining all the roles and responsibilities of the parties entering into MoU. We helped to formulate the JV partnership model and provided a critical analysis.

A MoU was prepared for UCIL leading to the preparation of an agreement and legal vetting of the agreement signed between UCIL and private companies. We also assisted in the presentation of the draft final agreement to the Government of India to get its approval.

How PwC can help

Fuel strategy

Each developer and operator of a nuclear power plant needs to consider carefully the best fuel strategy for their particular project. Much will depend on the country in which the power plant is situated, the type of reactor being deployed, whether the country can enrich and reprocess uranium, and the extent to which it wants to develop an ‘in-country’ nuclear industry. With new plant, developers may want a fuel strategy for the period of any debt financing and, thereafter, swap and change their fuel strategy as the market develops. Owners and operators of older plant may want simply to buy fuel from one supplier. No matter where you are in your project, PwC helps you develop fuel options to suit you and your project over its lifecycle.

Uranium mining

PwC is a leading adviser to the mining industry. We have over 1,500 mining professionals across the globe, assisting across the stages of the mining lifecycle, from exploration to mine closure to rehabilitation. Our CP&I services for mining include: capital project assessment approval and monitoring; assistance with preparation of feasibility studies, including mining and processing methods; preparation or review of financial and operating models; project funding advice and negotiation support; and fairness opinion on entity economic valuation.

Transportation

Transportation of nuclear materials, particularly at the back end of the nuclear fuel cycle, is a sensitive area. Countries falling outside the Paris and Vienna Conventions do not always follow the same rules on operator liability for third-party incidents. Materials shipped through international waters largely fall outside the international conventions. A number of countries will not allow ships carrying nuclear materials to dock in their ports. PwC assists with transportation strategies, regulatory advice (including carbon emissions) and the funding of vehicles for transportation.

Independent adviser to the enrichment industry

PwC acted as an independent adviser in the valuation of a company operating in the uranium enrichment business. PwC delivered a fairness opinion based on:

- an energy and uranium enrichment market analysis
- a review of financial projections and underlying assumptions
- a discounted cash flow valuation analysis
- a sensitivity analysis on key value drivers such as electricity/ore prices, estimated dismantling costs and pension/retirement benefits
A world of services
Compendium of PwC nuclear CP&I services

Whether it is engineers, physicists, project managers, asset managers, forensic, tax, accounting, IT and operational specialists, or finance, deals or regulatory specialists, we have people with extensive real-life experience from inside the global nuclear sector. We assist clients in both the public and private sectors to plan, manage and deliver large scale capital projects. The following is a sampling of the services PwC offers to help clients.

Strategy, regulatory and policy
Regulatory drivers and policy advice
• Policy and strategy development for public sector clients
• Analysis and advice on legal and regulatory frameworks

Market/business needs and strategic planning
• Market assessment, including supply chain readiness
• Structuring projects to balance the risks of various stakeholders while meeting the requirements of regulators and investors and financiers
• Funding (who pays) and financing (time-shifting of costs incurred) options appraisal
• Targeted feasibility and sustainability assessments of individual businesses and markets
• Revenue and demand forecasting
• Benchmarking/market testing
• Strategic advice through investment planning process
• Risk assessment for organisations looking to move into new territories, including emerging markets
• M&A support, including financial and commercial due diligence and funding options
• Joint venture support

Project assessment and development
Project feasibility advice
• Cost-benefit analysis
• Market analysis
• Bankability
• Regulatory compliance

Analyse project costs, revenues & capabilities
• Project financing
• Project feasibility analysis (financial)
• Cash flow modelling
• Use of statistical methods to measure and describe budget risk in probabilistic terms
• Capital project delivery
  – Assessment of non-financing project costs (capital costs, O&M)
  – Project feasibility analysis (technical)
  – High-level organisational capability assessment

Develop financing strategy & funding sources to be used
• Funding options (sovereign support, project/corporate financing and export credit)
• Building financial models to reflect the funding solution
• Financial risk assessment and scenario modelling
• Value for Money (VfM)/affordability assessment
- Develop commercial structures to obtain required credit rating
- Detailed tax and accounting structuring
- Running funding competitions
- Negotiation support of funding documents
- Balancing financing strategy and regulatory requirements

**Investment appraisal**
- Analysis of financing options available
- Risk distribution, allocation modelling and incentives assessment
- Equity participation support, including the potential role of a technology provider

**Cost-benefit analysis**
- Economic impact assessments and evaluations using qualitative and quantitative measurement
- Options appraisals looking at the financial impact of different ways of delivering projects, for example, alternate financial structures and financing terms

**Business case development and supporting advice**
- Project purpose, funding and approval requirements including detailed business case development and supporting documentation
- Project business model assessment including testing and qualitative review and feedback
- Country localisation (adapting business processes to meet local regulations and standards)
- Alignment with international leading practices and standards (WANO, IAEA, INPO and others)

**Project procurement and delivery**

**Procurement**
- Commercial support on justification process
- Euratom and procurement process compliance
- Sourcing and procurement strategy and process (including evaluation methodology)
- Consideration of any localisation requirements and potential ensuing risks to the project
- Procurement approach development – wrapped EPC or EPCM with multiple supply contacts
- Commercial advice on EPC and other contracts
- Support on scoping the RFP for vendor support – EPC or EPCM with equity and financing involvement
- Developing risk-sharing mechanisms
- Vendor assessment and tender process support
- Regulatory requirements – SQEP and/or permitting requirements assessment
- Support the development of a nuclear industry including technology transfer and market strategy
- Support the development of fuel strategies
- Final business case assessment

**Delivery**
- Reducing investment/selling participation
- Independent costs assessments
- Development and assessment of decommissioning plans

- Development and assessment of decommissioning funds
- Licensing support
- Operations readiness reviews
- Operational process design and enhancement
- Baseline assessment of project control environment
- Project governance structure
- Supply chain and logistics planning
- Systems assessment, design and implementation (e.g., SAP)
- HR assessment and succession planning
- Independent project adviser throughout project execution
- Cost to complete modelling
- Quantitative risk assessments
- Programme and project management (including project risk management & project assurance)
- Ongoing regulatory and (where applicable) cost recovery advice
- Dispute avoidance and resolution
- Continuous process improvement
- Document and information management
- Reporting and external communications
- Construction fraud assessments
- Supporting the transfer from developer to licensee/operator

**Operations, maintenance and upgrades**
- Refinancing
- Restructuring
- Managing or reviewing decommissioning liabilities and funds
- Supporting new investors or investors who wish to exit the project
- Assessing LTMA, O&M arrangements
A world of nuclear experience

• Assessment of fuel strategy
• Develop process for technology and other transfer
• Independent valuation reviews
• Operational financial model development
• Detailed scheduling and logistics support
• Enterprise asset management (EAM)
• People and change management
• Benchmarking and peer reviews
• Document preservation and warranty maintenance
• Retirement unit management
• Reliability-centred maintenance (RCM) design and implementation
• Materials management systems design and implementation
• Operational improvements and cost reduction
• Facility lifecycle assessments
• Supply chain improvements
• Maintenance and nuclear fuel contract reviews and audits
• Tax compliance and performance improvements
• Operational fraud assessments
• Project uprate assessments

• Steam generator and auxiliary equipment replacement programme support
• Life extension support

Cybersecurity

• Design, implement and/or perform quality assurance of information technology for safe and productive nuclear power plant operations
• Develop and implement cybersecurity strategy
• Cybersecurity testing (e.g., penetration testing and verifying operational segregation)
• Security of industrial control systems
• Threat intelligence and incident response/forensics
• Compromise discovery (identifying if highly sophisticated attacks are evident on networks)
• Crossborder cybersecurity and data protection legal advice from PwC Legal (and the ability to undertake any of our cybersecurity services under legal privilege if required)

Waste and decommissioning

• Assessment of decommissioning plans
• Establishing decommissioning and waste funds
• Management or reviewing decommissioning and waste funds
• Business evaluation for investment/divestment
• Disposal strategy
• Procurement strategies
• Negotiation advice and support
• Restructuring and regulatory impact
• Asset valuations
• Decommissioning cost modelling and benchmarking
• Corporate finance advice
• People and change strategy
• Environmental impact assessments
• Lifecycle assessments
• Tax strategy and advice including future of green taxes, mining taxes, R&D taxes and IP location optimization
• Supporting the policy, structuring, financing, construction and operation of repositories and other disposal facilities
On hand wherever you need us worldwide

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