

Unlocking the potential of hydrogen

EY Energy Law Services



An aerial photograph of a dense tropical forest surrounding a large, winding river with turquoise-blue water. A small boat is visible on the water. In the bottom left foreground, there is a prominent, rounded island covered in lush green trees.

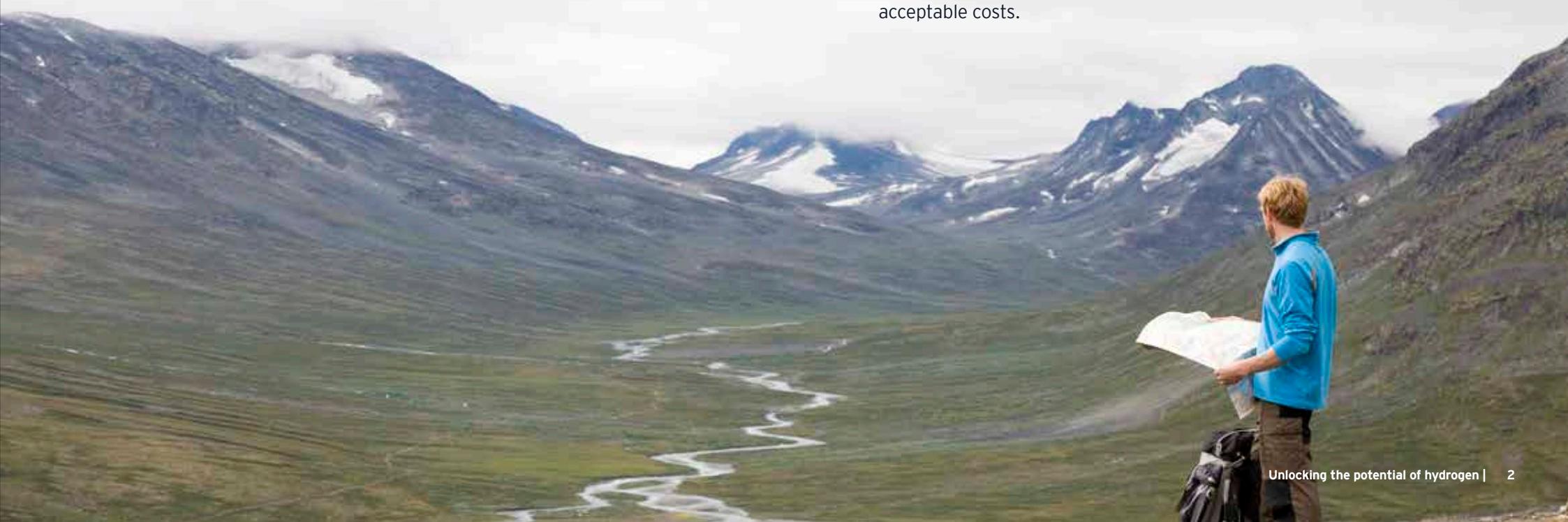
Hydrogen

Why hydrogen may hold the key to the transition to net-zero

Falling costs of renewable power generation, particularly wind and solar, have enabled many countries, including the UK, to significantly decarbonise their electricity generation sources. However, the decarbonisation of heating, heavy industry (including both process fuelling and reliance on petroleum and natural gas for chemical feedstocks), heavy transport, aviation and shipping remains a significant challenge.

Low carbon hydrogen (whether produced without carbon emissions or involving carbon capture technology) is seen by many as a viable answer. Governments, investors, industry bodies and organisations are moving at pace to identify when, where and how to invest in low carbon hydrogen. From Canada to Chile, from Australia to the EU, governments have been rolling out their hydrogen strategies, recognising hydrogen as a key component of their future energy mix which will enable economy-wide decarbonisation and transition to 'net-zero'.

In the context of the energy transition, an important advantage of hydrogen lies in its ability to store large amounts of energy over long periods of time at competitive costs (compared with current battery technology). This potentially provides a cost-effective solution to seasonal imbalances between renewable generation and energy consumption, and the possibility of extending the application of renewable energy to the 'hard-to-abate' sectors such as industrial and domestic heat, aviation and shipping at acceptable costs.



Hydrogen – what's in a colour?

Green Hydrogen

Hydrogen can be produced by splitting water (H_2O) into hydrogen (H_2) and oxygen (O_2) using electricity. If the electricity used comes from a renewable source such as wind or solar then the hydrogen production process is carbon-free, and the product is known as 'green' hydrogen.

The process of electrolysis (or electrolytic hydrogen production) requires an electrolyser. The electrical power source is connected to two electrodes. Hydrogen rises at the cathode and oxygen rises at the anode. A membrane prevents the hydrogen and oxygen product gases from mixing.

There is a range of electrolyser technologies, differentiated by their electrolyte materials and the temperature at which they are operated. Alkaline electrolyzers are currently the most developed technology but solid oxide electrolysis (SOE) cells, which operate at a high temperature, are considered to be a particularly promising avenue of future development. Whilst they are not yet commercially viable, SOE cells could reduce the overall cost of green hydrogen by reducing the amount of electrical energy required for electrolysis. In high temperature electrolysis, a significant amount of the energy required is provided as thermal energy (heat). That thermal energy could come from a number of different sources, including waste industrial heat.

According to the UK Committee on Climate Change, if all hydrogen required to achieve net zero by 2050 were produced by electrolysis, the UK's annual electricity generation would need to double (from current annual consumption of ~300 TWh).¹

Grey Hydrogen

Steam methane reforming of natural gas (SMR) is currently the cheapest and most widely used form of hydrogen production. The SMR process involves a thermochemical reaction of natural gas and steam at between 700–1100 °C, in the presence of a (typically nickel) catalyst. This produces an endothermic reaction that breaks up the methane molecules in the natural gas to produce hydrogen and carbon monoxide. The carbon monoxide can then be saturated with additional steam to undergo a water gas shift reaction and produce additional hydrogen.

Hydrogen produced from SMR is known as 'grey' hydrogen and is not low carbon as the process produces a significant by-product of carbon dioxide.

Blue Hydrogen

If the carbon dioxide by-product can be captured and stored permanently in disused oil and gas fields or naturally occurring geological storage sites (or captured and used, for example in chemical processes) the hydrogen produced from SMR becomes known as 'blue' hydrogen. The carbon capture and storage (CCS) process is therefore essential for hydrogen produced by SMR to be considered as low carbon hydrogen.

In the short term, commercial-scale hydrogen production is likely to be primarily blue hydrogen owing to the significant electricity demands of green hydrogen production.



1. Committee on Climate Change. *Net Zero the UK's Contribution to Committee on Climate Change*.

Enabling conditions for deployment of low carbon hydrogen at scale

The proportion of low carbon hydrogen (green and blue) in global hydrogen production is currently negligible, i.e., less than 0.7% (according to the International Energy Agency).² Most of the prospective end-users of hydrogen as part of the transition to net-zero do not currently use hydrogen. Production and application of low carbon hydrogen at scale would require the presence of a range of enabling conditions. These may include:



Supportive policy and regulations

Low carbon hydrogen is not at present price competitive with grey hydrogen and other alternative fossil fuels. Prospective end-users which do not currently use hydrogen as feedstock or fuel may need to incur conversion costs to switch to hydrogen. Demand-side support policy could incentivise them to do so. This may take the form of financial support such as grants and carbon contracts for difference (CCfD) or compulsion to decarbonise such as minimum quotas. Both the EU and the UK are looking at reforming their emission trading schemes (ETS) with a view to increasing carbon pricing whilst avoiding carbon leakage.

A strong offtake arrangement

In the absence of a liquid wholesale market, any low carbon hydrogen project is likely to depend on a long-term offtake arrangement with a credit-worthy offtaker. Early adopters of low carbon hydrogen are likely to be businesses which already use hydrogen as feedstock such as refineries and petrochemical companies and can switch to the low carbon version with minimal conversion costs or end-users which are able to switch to using hydrogen as part of their regular asset replacement programme e.g., a local bus fleet. The design of a low carbon project will need to take into account the strength of the offtaker to mitigate the stranded asset risk. This is particularly important before there is a solution to long-distance hydrogen transportation as there might not be an offtaker for the hydrogen produced other than the specific end-user co-located with the hydrogen project or located within the same industrial cluster.

Upscaling of technologies

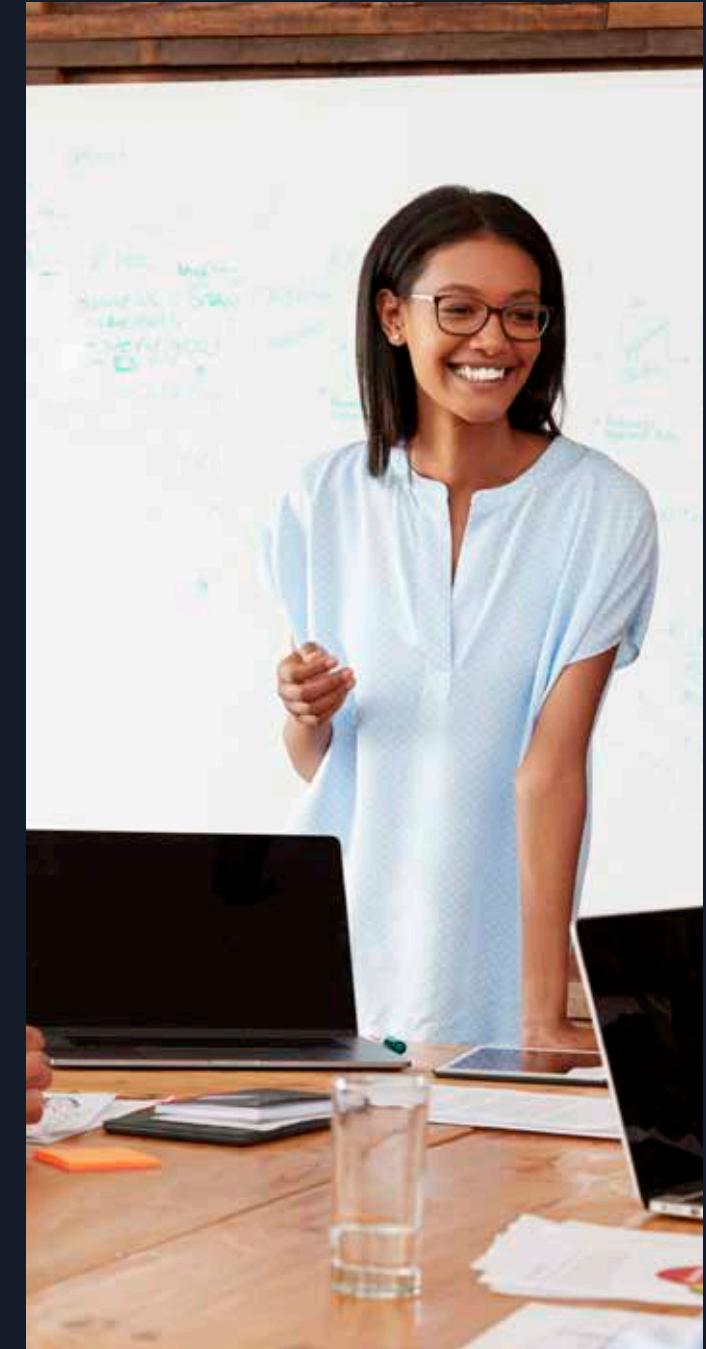
The core technologies used in producing low carbon hydrogen such as electrolyzers (for green hydrogen) and carbon capture (for blue hydrogen) have yet to achieve 'market maturity' for production at scale. The success of pilot projects currently under development will have demonstration effects for the market. In the meantime, risk allocation with contractors and operators could potentially be a matter of complex negotiation and careful consideration.

Stability of input

The costs of renewable energy account for some 60% of the production costs of green hydrogen whereas the variable operating costs for blue hydrogen production are driven by the costs of natural gas. Long term supply contracts such as corporate power purchase agreements (PPAs) or gas sale and purchase agreements (SPAs) could help ensure a reliable supply of feedstock at predictable prices.

Finding the right model

At this stage, the viability of any low carbon hydrogen project is likely to be closely linked to the successful commissioning and operation of any interfacing projects such as any industrial or municipal facilities being built or retrofitted to use hydrogen or the hydrogen transportation network servicing the project. A green hydrogen project may rely on a captive renewable generation facility for its power supply. The potential project-on-project risk increases the challenge in the design of project structures (for example, whether these inter-related facilities should be developed as an integrated project or separate projects). The degree of alignment of interests between sponsors and the impact on project bankability would be key considerations. In some cases, a tolling arrangement could be used to isolate the project from risks associated with other segments of the value chain.





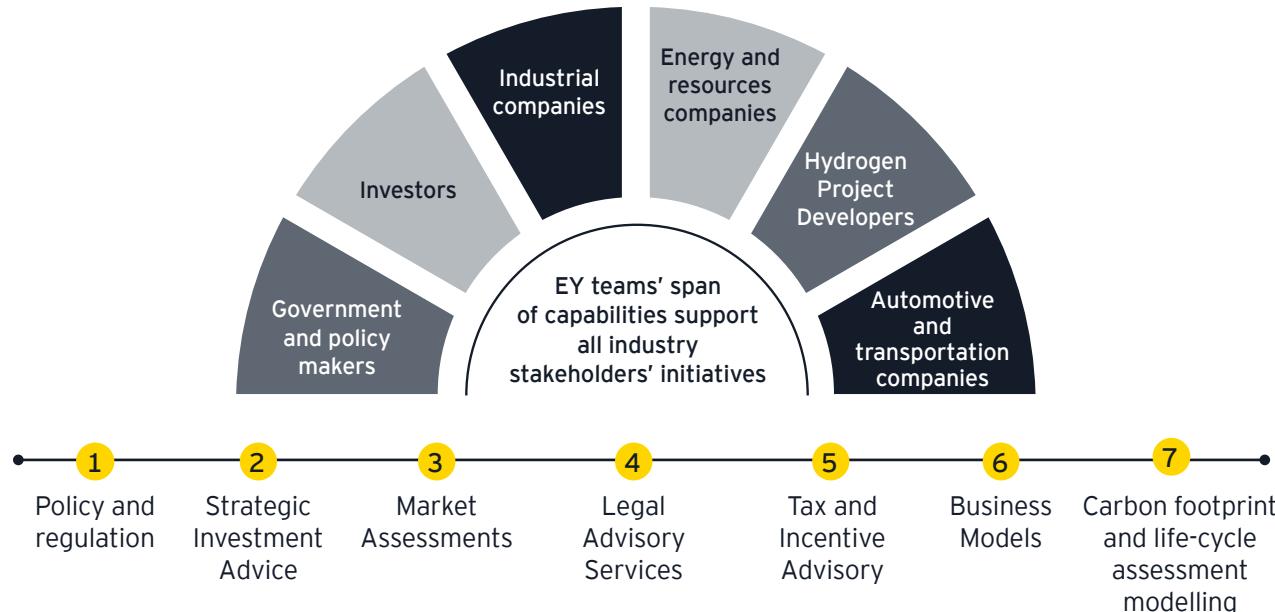
EY

in hydrogen

EY in hydrogen

- For decades, the key question was whether hydrogen would play a significant role in future energy markets, or whether alternative options would dominate.
- The importance of hydrogen is no longer in doubt, with its potential to enable decarbonisation across power, heat and transport, especially in harder to reach applications, and its role as an energy store, now recognised.
- Governments, investors, industry bodies and organisations are now moving at pace to identify when, where and how to invest in hydrogen.
- EY teams are working with these groups, both in the UK and around the world, to support the improvement of strategies and investments in hydrogen to increase potential benefits to society and investors.
- EY teams have already been supporting more than 30 clients in developing their hydrogen policy and strategy, building out light, heavy duty and industrial H₂ applications and investing across green and blue hydrogen production.
- Bringing together experienced legal, business, tax, regulatory and modelling professionals, EY teams are well placed to support businesses around the world on today's key questions on hydrogen.

Capability Suite



- Today's key questions**
- What are the key components to make hydrogen business models economically viable now and in the future?
 - What are the applications, technologies and market participants which will be first in the hydrogen build out?
 - What support mechanisms should governments provide to incentivise investment at scale in hydrogen?
 - What are the respective roles of blue and green hydrogen in driving scale, cost reduction and decarbonisation?
 - What are the risks of early investment in hydrogen and how can these be mitigated?
 - What should organisations be doing now to get ready for hydrogen investment and deployment?



Why EY Energy Law services in hydrogen?

Helping build the world's tomorrow

Experienced EY Energy Law professionals provide sector-focused legal advice on all constituent components for the development and financing of low carbon hydrogen projects – from regulatory advice, construction and supply contracts including PPAs and offtake arrangements to project models and financing structures.

The nascent nature of the hydrogen sector presents vast business opportunities as well as complex challenges across its value chain. This fast-developing landscape is driving governments and market participants alike to innovate, adapt to new market structures and develop appropriate regulatory frameworks and business models in order to stay at the forefront in this dynamic and increasingly important sector.

EY Energy Law professionals are part of the EY global Power and Utilities and Global Renewables service offering, bringing together a worldwide network of professionals to anticipate trends, identify their implications and help our clients develop workable business models and create a competitive advantage.

EY Energy Law services – hydrogen

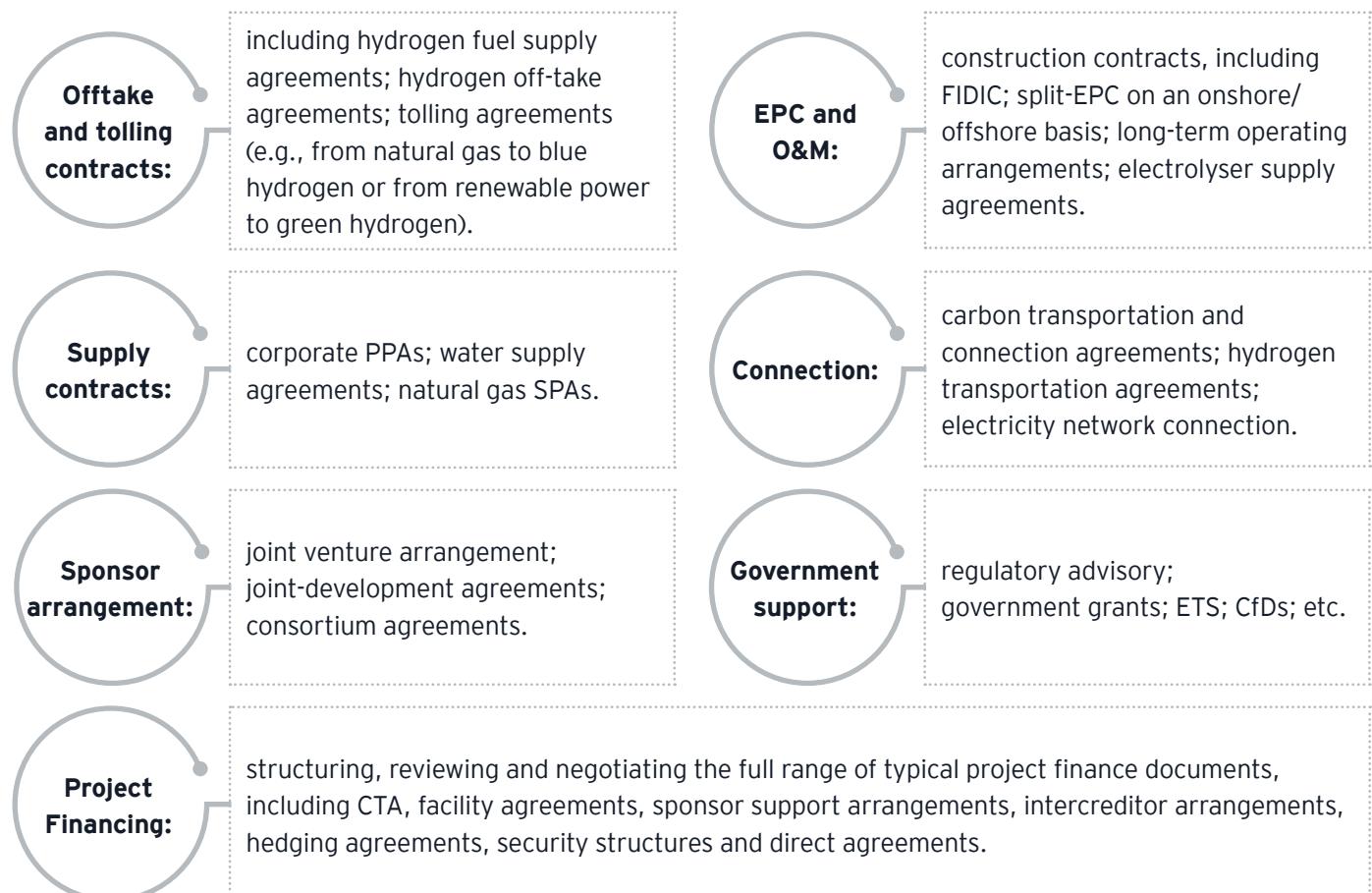
EY lawyers have a thorough understanding of the full range of issues driving the development of the low carbon hydrogen sector, drawing on our experience in the global energy, power, natural gas and commodity markets. We have advised on numerous transactions in both the primary (greenfield development and financing) and secondary markets.

EY lawyers have particular expertise in project development and financing, mergers and acquisitions, and sub-contracting arrangements such as EPC, O&M and equipment supply.

EY lawyers are engaged around the globe and on highly complex and structured projects.

EY Energy Law professionals have many years' experience of acting for clients throughout the energy sector, including developers and project sponsors, lenders (including commercial banks, multilaterals and development finance institutions), contractors and equipment suppliers, investors and funds. We have advised on energy projects across the world, with experience on transactions in the UK, Europe and in emerging markets.

EY teams provide a comprehensive range of services for clients covering **all building blocks of a successful hydrogen project:**



EY Energy law services at a glance

EY Energy Law services offering:

Experienced energy sector lawyers recognised as leading professionals in their fields

Commercially aware, industry specific legal advice

Integrated cross-border legal advice using EY Law's **2400+ lawyers in 90+ jurisdictions**

EY teams were highly commended in the Energy Legal Services Provider of the Year category at the Petroleum Economist Awards 2020.



At EY, our purpose is **building a better working world**. The EY Law Energy service offering was born of our commitment to serving clients with lawyers offering the full range of practice skills together with true industry expertise.

EY clients include international energy companies, project sponsors, governments and their national oil companies, leading commodity traders, utility companies, EPC contractors and banks.

Legal 500 has listed team leader **Charles Morrison** in its 'Hall of Fame' for Oil and Gas lawyers and partner **Dimitri Papaefstratiou** as one of London's leading individuals for both Power and Oil and Gas.

We provide advice across the sector, including **Power and Utilities, Future Energy and Oil and Gas**.

Core practice areas

- ▶ Project and infrastructure development
- ▶ Financing
- ▶ Mergers and acquisitions
- ▶ Joint ventures
- ▶ Regulatory advice
- ▶ Storage and transportation arrangements
- ▶ Gas and LNG sales arrangements
- ▶ Product sales and trading
- ▶ EPC and O&M arrangements

EY Law services – combining global reach with sector-focused knowledge

EY Law teams are driven by people and powered by technology, with multidisciplinary teams that help solve business, not simply legal, problems and identify potential risk, uncover value drivers and generate cost savings on a truly global scale.

Legal Advisory – the **practice** of law

90+
jurisdictions
offering legal
advisory services

2,400+
lawyers providing legal
advisory services

Legal Operations – the **business** of law

8
global delivery centres
across Europe, India
and the US

1,100+
technology-savvy,
multilingual
professionals

24/7
follow-the-sun legal
managed services
delivery model

The background image is a vibrant, aerial photograph of a modern city at night. The scene is dominated by a complex network of elevated highways and overpasses, their curves illuminated with bright white lights. The city is densely packed with buildings of various heights, their windows and facades glowing with a mix of warm yellow and cool blue lights. In the foreground, a large, curved building with a glass facade reflects the surrounding lights. The overall atmosphere is one of a bustling, advanced urban environment.

Key contacts



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Working across assurance, consulting, law, strategy, tax and transactions, EY teams ask better questions to find new answers for the complex issues facing our world today.

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