1

Energy Networks and the Law: Innovative Solutions in Changing Markets

Donald N. Zillman, Martha M. Roggenkamp, Lila Barrera-Hernández, and Iñigo del Guayo

I. Introduction

This book discusses the role of networks in the energy sector, how these networks have developed, are being regulated, and what the impact can be of future market developments on network regulation. The energy sector is a vital part of most national economies and the networks are crucial for transporting energy resources from producers to consumers. However, networks are just one particular means of transportation and their current important role is the result of several technical innovations. In contrast to ships, trucks, and trains, which need drivers, networks (ie cables and pipelines) represent a mode of transportation that can be operated without direct human intervention. The sections below illustrate how the world of energy and networks has changed in little over two centuries.

Historian Pauline Maier has vividly recreated an important landmark in legal history in her study of the popular conventions in the United States that debated and ratified the Constitution of the United States.[1] Maier brings to life some of the little-known citizens who served as delegates to the conventions. Maier also provides a reminder of daily life at the end of the eighteenth century—a world in which modern energy was not present.

Maier traces the effort of two Massachusetts delegates to reach the state ratification convention in Boston. She laconically notes: 'It was no easy thing to get from Bath, an old shipbuilding center on the Kennebec River in Maine to Boston in January of 1788.' The trip required a journey of about 225 kilometers. Today the journey could be made in less than a three-hour drive on which the major concern would be traffic congestion.

In winter 1787–88, the best option was on horseback and the trip took six days. The other transportation option was by sailing ship. Wind and winter weather

[1] P. Maier, *Ratification: The People Debate the Constitution 1787–88* (New York: Simon & Schuster, 2010).

made that a challenging alternative. Even on the land route, water was a problem. Several major rivers divided the close-to-the-coast roads. At the rivers, ferry boats allowed passage, powered by a combination of human, animal, wind, and wave energy. Carbon-based energy (coal, petroleum, or natural gas) and/or electricity were decades in the future.

The six days of winter travel also required stopovers for food and lodging. Our two delegates satisfied their needs by staying with friends or relatives or in roadside inns. Here their energy source was wood, cut from the plentiful forests of Massachusetts of the time. The wood provided fireplace heat and heat for cooking sufficient to make travel survivable, if not pleasant.

Communications were difficult. The two delegates (lacking modern cell phones and computers) lost contact with their homes upon departure. Advice about political matters from home or news from Boston could have reached them only by carefully planned fast delivery by horse. This would have been both difficult and expensive.

The Massachusetts traveler of 1788 would have taken for granted that all energy was local. The horses and people who assisted his travel had likely never traveled more than 100 mile from the place of their birth in their lives. The wood that benefited the humans had been cut locally. The food that fed travelers and horses came from neighboring farms. Other products that came from human endeavor—blankets, saddles, plates, clothing—were likely to be of local origin. Distribution channels from raw material gatherers to product makers to consumers were basic and short.

This was the world of 1788, in one of the more modern parts of the globe, a world of very limited energy. It was also a world that would have looked familiar to the citizens of advanced civilizations of AD 1500 or 1066. Animal power, human power, wind, sunshine, water, and wood were the resources. Coal, oil, and natural gas played a very limited role. Also lacking were the benefits of that essential secondary source of energy—electricity. It is also worth remembering that the energy options available to the advanced nations of 1788 are the same that remain to between two and three billion people on Planet Earth in 2012.

The nineteenth, twentieth, and twenty-first centuries have been the centuries of energy. A remarkable combination of scientific discovery, engineering innovation, financial creativity, and political and legal initiative created what would have been unimaginable to our delegates of 1788. Oh, brave new world that has shaped the energy resources and networks that connect the world today!

II. Energy Sources and Networks

We begin our study of energy networks and the law with some background to energy itself. Much of this will be familiar to energy specialists. Our work as lawyers and teachers, however, persuades us that large proportions of the population, including professionals working outside the energy field, have little sense of the history of energy and its present scope. Energy knowledge extends little beyond the switch that turns on the electricity or the gas pump that fuels the car. We hope these

introductory pages will provide a useful perspective before we move to our discussion of the networks that allow energy to reach much of the population of the earth.

A. The history of modern energy

The world of 1788 depended mainly on renewable energy sources. Wood provided energy for heating and cooking then as it does today in many underdeveloped regions. The equipment available to produce these resources was often limited to spades and axes. Wind energy already required a more advanced technique as it involved the construction of a windmill. Renewable resources like wind, tidal, and solar energy have gradually been adapted to provide new uses by developments of science and engineering. The industrial revolution produced more advanced techniques, which enabled production in the (deep) subsoil. This led to a new energy era.

1. Coal

Modern energy progress started with our first great fossil fuel—coal. Coal is extracted by both underground and surface mining techniques. Once removed from the ground, coal needs further processing to remove impurities and to increase energy values.

While coal was known and used long before the Industrial Revolution, the needs of manufacturing, residential services, and transportation prompted a coal revolution over several generations in the late eighteenth to the mid-nineteenth centuries, with Great Britain leading the way. Coal replaced many uses of wood and wind. Transportation changed from sail to coal-fired vessels that could ignore wind directions or lack of wind altogether. Transatlantic travel times went from months to a week or two.

On land, the new invention, the railroad, was developed between the 1810s and 1840s and boomed within two decades. The horse was no longer the means of long-distance travel. Coal replaced wood as the locomotive's fuel. Eventually, coal replaced wood and falling water for the manufacture of products. Large factories powered by coal became symbols of industrial success. Wood further lost out in the residential and business heating and cooking realms.

By 1900 coal had become *the* modern fuel. A traveling urban politician of 1900—the heir of our 1788 delegates—would probably have left his coal-heated home to ride a coal-fired railroad to a large city prospering with coal-powered industries and lighted by coal gas-manufactured lighting. In the twentieth century other resources have to some extent replaced the primary position of coal. Coal's decline from the versatile fuel of 1900 has concentrated much of its use as the fuel to run industrial operations and electricity-generating plants. In advanced societies, the use of coal for transportation or residential and commercial heating has become rare.

Coal's undesirable attributes are considerable. Mining, whether underground or surface, is dangerous for workers and damaging to the surrounding environment. Burning of coal probably constitutes the most environmentally harmful use of a fossil fuel. Sulphur, particulate matter, and other releases from coal combustion

are harmful to humans and other life forms at both near and far distances. The release of CO_2 and other greenhouse gases make coal combustion one of the worst contributors to global warming.

The growth of coal gave rise to the first energy networks. Coal was not located close to or easily extractable by the ordinary citizen. Human ingenuity and wealth and hard physical labour were needed to locate coal seams, to extract and process the coal, and to ship it to the point of use. Coal can be shipped by truck, rail, barge, ocean freighter, or slurry pipeline. Often half a dozen separate business enterprises might be involved between the discovery and the ultimate consumption of the coal itself. The lumps of coal may have travelled hundreds of miles in the process. The sheer weight of coal can often make its transportation as expensive as its extraction.

2. *Oil*

King Coal in 1900 had already found a powerful challenger in an even more energy-potent fossil fuel—oil. Liquid carbon-based products had long been known. But the last half of the nineteenth century and the first half of the twentieth century saw oil's commercial emergence. Various attractive properties of oil began to make it the fuel of choice for powering water and rail transport, for many industrial purposes, and for residential and commercial heating. Oil also quickly captured two enormous markets: automobile and aeronautic transport. By 1950, transport was overwhelmingly powered by oil.

Oil retains its versatility into the twenty-first century, though some traditional uses are shrinking. Oil retains dominance in transportation, especially for motor vehicles, planes, and ships. Some nations and regions continue significant use of oil for residential and commercial heating and cooking. Industrial processes call on oil both for energy generation and for product component. Oil remains useful for electric generation, although economics often favours other fuels.

Oil, like coal, has its environmental harms. The Gulf Coast oil leak of 2010 provided a vivid reminder of how harmful and widespread an oil spill can be. Extraction and processing of oil presents a wealth of human health and environmental harms. Combustion of oil has a long history of environmental harms that have included smog in major cities and climate change worldwide.

Oil demanded even more networks than coal. Discovery and extraction of crude oil begins the oil cycle. The crude oil that comes out of the ground or from under the ocean needs refining to be usable for human purposes. In many instances this will require networks to get the oil from well-head to refinery to places of use. Pipelines can provide this service on land and in some shallow water situations. Discovery of rich oil deposits tended to be in locations far from the places where large amounts of refined oil were needed—the populated industrial cities of powerful nations. How to get the raw oil from rural Texas or the Dutch East Indies or the Caucasus, or later the Middle East, to its place of use became very important. A variety of networks emerged, from pipelines to long-distance tanker routes. For long-distance ocean shipments (think of moving crude oil from the Middle East to places of use around the world), supertankers take over. For shipments of smaller

quantities of refined oil on land, rail, truck, and barge can also contribute. Energy and energy networks became more international, with financial and legal problems often accompanying their creation.

3. Natural gas

A third hydrocarbon fuel—natural gas—was often found with liquid petroleum. For half a century or more, natural gas was regarded as more of a waste product, and a dangerous one at that, than as an attractive energy resource. The gas that was used for energy was manufactured from coal. However, as access to oil became more difficult, local gas fields became highly attractive. By the end of the Second World War natural gas had gradually carved out attractive markets for itself. These included residential and commercial heating and cooking, taking over roles previously served by wood, coal, and oil. Natural gas also plays a major role in industrial production of all sorts. As with oil, natural gas can be both energy fuel or product component. Electricity generation has increasingly adopted natural gas as the fuel of choice. Natural gas serves some transportation needs as well.

Natural gas is the emerging fossil fuel. While many discoveries continue to find natural gas associated with oil, many fields that produce only natural gas have been discovered and developed. Natural gas's reputation as the 'clean' fossil fuel has helped its attractiveness. Its production of pollutants (including CO_2) per unit of energy delivered is below either coal or oil. Nonetheless, combusted natural gas is a pollution source. Additionally, health and environmental problems arise from its extraction (particularly using new hydraulic fracturing technologies) and transportation (eg pipeline explosions).

The nature of a gas made its shipment and storage particularly challenging. Movement across land by pipeline created another networked fuel. In the last decades of the twentieth century, with the growth of environmental awareness, natural gas became a highly valued resource and pipelines made its use feasible. Natural gas is therefore the most networked energy raw material. Its form limits natural gas's ability to move in other than pipeline form. Most land-based gas movement from place of extraction to place of processing to place of end use is by pipeline. Where wide expanses of ocean need to be crossed, the natural gas can be converted to liquefied natural gas (LNG) and shipped to the place of use in special ocean tankers.

4. Electricity

The last decades of the nineteenth century saw the development of a wonderfully versatile energy source—electricity. Unlike the fossil fuels or other energy sources, electricity is not extracted from nature, ready to use for energy purposes with some processing. Electricity needs to be manufactured using one of the primary energy sources. Fossil fuel combustion, the uranium-based nuclear reaction, the power of falling water, sunshine, or wind that allows turbines and generators to operate producing the electricity that can provide heat or light, run an immense variety of industrial and business machines and residential appliances. The computer age that arose at the end of the twentieth century had its origins in the development of electricity at the end of the nineteenth century.

Fossil fuels provide much of the fuel for electric power. Although coal remains the primary source of electricity-generating capacity, natural gas has taken an increasing share of the electricity-generating market. Hydroelectric power—the capability of falling water to provide the motive power for electricity generation—is another most prominent source. The old waterwheel used to grind grain or pump water can now provide many megawatts of electric power. So too, the old windmill has found a modern use in onshore and offshore electricity generation.

The virtues of renewable and non-carbon releasing energy sources have increased the attraction of hydropower in recent years. The major use for falling water in the energy world is for electricity generation. Giant dams provide significant megawattage and produce a major portion of the electricity of some geographically favoured nations. However, new dam sites in areas needing large amounts of power are limited. And, despite its carbon-friendly nature, hydroelectric power imposes environmental burdens and risks that range from population disruptions to risks of dam collapse. Similarly, despite their 'green image', the construction of large-scale wind parks raise objections as they can be noisy and create horizontal pollution.

A major modern source for electricity generation is nuclear power. The discoveries of the first half of the twentieth century that led to the atomic bomb also made possible the generation of large amounts of electric power from the use of enriched uranium nuclear fuel. However, no energy source has raised more controversy over its human and environmental risks than nuclear power. Tough policy questions face investors, government officials, and the general public about the future of nuclear power. How should society balance nuclear energy's potential to generate large amounts of electricity largely free of CO_2 releases against the high consequences of accidents like Three Mile Island in the United States in 1979, Chernobyl in the Soviet Union in 1986, and Fukushima in Japan in 2011?

In general, electricity demanded a new kind of network—the long-distance transmission and local distribution lines that allow the controlled and safe transport of kilowatts of electricity from the place of generation to the place of use in home, office, or factory. Most of the renewable energy sources also need networks. Whereas biofuels that end up in liquid or gaseous form may need pipelines to get from place of creation to place of use, the primary modern uses of hydropower, wind, and tidal power are for electricity generation. Even though most renewable energy projects need to rely on electricity cables, it may well be that a different treatment of these cables is required, as renewable resources are often injected in the distribution grid instead of the transmission grid as usually is the case and thus potentially may lead to balancing problems.

B. Energy sources today

Let us now focus more comprehensively on the world of energy in the early twenty-first century. What are the raw materials of energy? How are they prepared for their end use as a source of energy? What are those end uses? What are the undesirable consequences of those processes of extraction, processing, and use? That big picture helps us to assess more specific network concerns.

The 2010 Key World Energy Statistics of the International Energy Agency (IEA) provides a useful starting point. Its Factsheet projects energy consumption to the year 2035—a date within the lifetimes of many readers of this book, or, at least, their children's. The new Policies Scenario of the IEA study projects an increase of 36 per cent in world primary energy demand from 2008 to 2035. The economically developed and energy-sufficient nations of the Organization of Economic Cooperation and Development (OECD) provide a small portion of that increase. Non-OECD countries account for 93 per cent of the projected increase. China alone provides 36 per cent of the total projected growth. Despite a variety of public policies directed at reducing the consumption of the three fossil fuels (coal, oil, natural gas), 50 per cent of the projected increase in energy consumption over the next quarter-century comes from those fuels.

1. Hydrocarbons

As of 2009 statistics, China is the dominant coal producer in the world by a wide margin. The United States ranks second but produces less than one-third of Chinese production. India, Australia, Indonesia, South Africa, and the Russian Federation are next in order. Both China and the United States consume most of the coal they produce. China, in fact, is the second leading importer of coal, trailing only Japan. Australia, Indonesia, and the Russian Federation are the leading exporters of coal.

Oil remains the dominant and the most versatile fossil fuel. Crude oil production (as of 2009 figures) takes place in most parts of the world. The Middle East leads, with a 30 per cent share of total production. The OECD nations follow at 22 per cent followed by the former Soviet Union (17 per cent), Africa (12 per cent), Latin America (9 per cent), and China (5 per cent). Within regions, however, there are wide disparities from country to country. The major producing nations in order are the Russian Federation, Saudi Arabia, the United States, Iran, China, Canada, Mexico, Venezuela, Kuwait, and the United Arab Emirates (UAE). Net exporters of crude oil are led by Saudi Arabia, followed by the Russian Federation, Iran, the UAE, Nigeria, and Angola. The United States (despite ranking third in production) is the top net importer of crude oil followed by Japan, China, Korea, Germany, Italy, France, Spain, and the Netherlands.

Perspectives on oil's future are provided by proved oil reserves—crude oil identified and available for future extraction and use. *Oil & Gas Journal* reports that as of 2010 the largest oil reserves are found in Saudi Arabia, Canada, Iran, Iraq, Kuwait, Venezuela, the UAE, and Russia. The five Middle Eastern countries contain over 50 per cent of total reserves, with Saudi Arabia alone holding nearly 20 per cent. By contrast, China holds 1.5 per cent and the United States slightly less than that.

Natural gas is found worldwide. The leading producers are the United States and the Russian Federation, which divide almost equally 38 per cent of total world production. They are followed by Canada, Iran, Norway, China, Qatar, Algeria, the Netherlands, and Indonesia. The Russian Federation is the leading exporter of natural gas, followed by Norway, Canada, Qatar, and Algeria. The leading importers of natural gas are Japan, Germany, the United States, Italy, and France. Natural

gas shows significant growth. A considerable portion of the growth in both oil and natural gas comes in the form of such 'new' fossil fuel resources as oil shale, tar sands, shale gas, coalbed methane, and tight gas.

2. *Electricity*

The fossil fuels continue to provide much of the fuel for electric power. In 2012 coal remains the primary source of electricity-generating capacity. Natural gas has taken an increasing share of the electricity-generating market. Hydroelectric power continues to be a factor in the world's electricity generation mix. The leading producers of hydroelectricity are China, Canada, Brazil, the United States, and the Russian Federation. In Norway, Brazil, Venezuela, Canada, and Sweden hydropower provides the majority, or near majority, of the nation's electricity.

Nuclear power is an even larger contributor to electricity generation. About 30 nations have located nuclear electricity-generating plants in their territory. The leading producers of electricity from nuclear energy are the United States, France, Japan, Russia, Korea, and Germany. The United States licenses the most nuclear plants and produces the most nuclear electricity. France draws the greatest percentage of its electricity (77 per cent) from nuclear power, followed by Ukraine, Sweden, Korea, Japan, Germany, the United States, the Russian Federation, and Canada. At the front end of the nuclear cycle are the sources of the raw uranium that will be processed and refined for nuclear fuel. Among the leading sources of minable uranium are Australia, Canada, Kazakhstan, the Russian Federation, Uzbekistan, Brazil, the United States, Namibia, South Africa, Niger, the Czech Republic, and the United Kingdom.

In addition, the share of 'new' sources of renewable energy is increasing and in some geographic areas and technologies, increasing rapidly. The OECD estimates that all renewables provide about 12 per cent of the world energy supply, with hydropower being the major renewable. Wind, solar, tidal, and geothermal energy are growing contributors, mostly in the area of electricity generation. Certain countries rely significantly on renewable energy, especially hydropower (see figures above). However, other renewable energy sources are becoming more important. Brazil has moved aggressively towards biofuel use. Denmark draws 20 per cent of its electricity from wind power. Iceland is a major geothermal energy user. In the EU the goals set by the European Commission to reach a 20 per cent renewable energy target in 2020 will definitely stimulate the production and use of this type of energy.

3. *The role of networks*

To the extent that energy worries the average citizen, the concern is at the raw materials stage. Coalmines collapse. Petroleum reserves leak. Nuclear reactors malfunction. Petroleum prices escalate. Both short-term accidents and longer-term shortages become the lead story on the evening news. Yet, energy network issues can be just as crucial. Can a new fossil fuel deposit be extracted and shipped by pipeline to its place of processing or end use in a way that meets economic and legal

requirements? Can a remotely located renewable energy source be linked to a new or existing electricity grid? Will uncertainties about future supply of a resource or about the regulatory scheme that will govern it a decade in the future discourage multibillion dollar investments?

III. Networks, Changing Markets and the Role of Law

The above historical and contemporary perspective on all aspects of energy has shown that the energy sector is constantly changing due to the availability of energy sources and technical developments. Similarly the role of the transportation network is changing. Two centuries of progress in energy have thus provided a world in which four billion people can call on oil for a wide range of transportation options. They look to natural gas, oil, and electricity to heat and cool their homes, places of work, commerce, and public business. They rely on electricity generated from fossil fuels, nuclear energy, hydropower, and other renewable sources to power the wealth of labour-saving and life-enhancing devices that they take for granted. When relying on these energy resources they also rely on their means of transportation. What type of transportation networks are we actually discussing?

A. The networks further identified

Earlier we have noted that networks can be broadly defined to include everything that occurs between the initial extraction or capture of an energy resource and its final use by a consumer. That definition would certainly include road, rail, and shipping lines as energy networks, even though they serve a wide number of other purposes. For example, the sea route that carries oil or LNG also carries other products and passengers. Sometimes, however, the choice between transportation modes is limited, as in the case of natural gas and electricity. These two energy sources are largely dependent on transportation via pipelines and cables, although other means of transportation are developed and used (LNG and batteries).

Long-distance transportation of electricity and gas is the result of technical developments. For the construction of pipelines use has been made of different types of materials, varying from wood (Ontario 1872) to glass (Maastricht around 1850). Steel has been used as of early 1900. The ability to weld steel pipelines together allows gas to be transported over longer distances. Similarly, the technique of converting high voltages to lower voltages is a crucial element in the development of electricity cables and long-distance electricity supply.

These networks linking producers and consumers are usually subdivided in several categories. The first category includes the pipelines and cables connecting production facilities with the main grid. Whereas these cables are generally considered as part of the installation, a separate category applies to these pipelines as they are referred to as upstream pipelines as a rule. The next category involves the main

grid, ie high-pressure and high-voltage networks. These so-called transmission lines (pipelines) mostly cover the entire territory of a state and are considered as the 'national energy highways'. The cross-border connections are interconnections of transmission grids. These transmission lines are again connected to another—third—category of infrastructure, ie distribution lines which operate under lower pressure and/or voltage and have a direct connection to consumers. Each category of networks can be governed by a different type of legislation.

B. Changing markets

The organization of energy markets reflects the above developments. The first electricity and gas supply companies were established at the end of the nineteenth century by municipalities in order to supply local communities. As a result of new techniques the local networks of municipalities have been interconnected, resulting in regional supply companies. Since the Second World War most developed countries have been able to create national grids and national energy companies. For a number of reasons these national grids were again interconnected. Such a reason could be security of supply or the need to organize large-scale export of gas, as was the case in the Netherlands after the discovery of the Groningen gas field in 1959. The size of that field, combined with the expectation that nuclear energy would soon take over as the main energy source, led to a situation where gas export contracts were concluded with Belgium, Germany, France, and Italy, and subsequently a transnational European gas transmission grid was developed. Without the Groningen field there would not have been an EU gas market. Currently, gas is imported over even longer distances onshore as well as offshore.

Since the 1980s the energy sector has been faced with considerable challenges and changes all over the world. The energy liberalization/deregulation/privatization process has rendered energy networks more independent from the energy supply and production sector. Hence, the operation of the networks needs to take place without direct involvement/guidance of network users. In addition, the situation on the supply and demand side of the grid is changing as well. Fossil fuels and large hydro plants are increasingly located in distant areas and require the construction of major infrastructure often involving several countries and jurisdictions. By contrast, increasingly new (often renewable) resources are being developed and this again requires a different type of grid development and management. Last but not least, energy suppliers are not the only drivers influencing grid construction and management. Demand-side management also has an impact on grid operations. By controlling and limiting energy demand governments hope to be able to restrict the need for further expansion and development of networks. These changes need to be reflected in the laws governing the sector.

C. The role of law

Developing networks in the above described changing energy markets depends on a variety of legal requirements, which may depend on the type of network

(electricity, gas, or oil), its position in the energy chain (upstream, midstream, or downstream) or its actual location (onshore, offshore, or cross-border).

Whichever network is developed, the construction always involves the application of planning and environmental laws. The impact of these laws is becoming increasingly onerous due to increased public participation (the 'not in my back yard', or NIMBY, effect), safety requirements, and more densely populated areas. Additionally, issues of planning and environmental law become more complicated when the network is more international or inter-jurisdictional and is crossing several borders.

Other changes result from an increased use of renewable energy sources. Sometimes this may be the result of clear and binding government targets, as is the case in the EU. The generation of renewable energy sources may be dealt with in a specific law on renewable energy but also in an Electricity Act, Gas Act, or Energy Act. Whichever law is chosen, it will have an impact on the networks and especially as increasingly renewable energy is injected in the distribution grids instead of the transmission grids, as used to be the case. Issues like balancing, congestion management, and grid expansion need to be dealt with and could possibly require innovative legal and regulatory solutions.

Similarly, liberalization processes have had an important impact on the existing legal frameworks. Electricity and gas laws are constantly changed and adapted in order to meet new market requirements. Liberalization does not result in deregulation but severe additional regulation. Governments are put at arms' length of the energy markets but are blamed if there is insufficient energy supply. The latter depends on the availability of reliable networks. What kind of regulatory regime or law is in place to guarantee that the proper networks are developed to transport electricity, gas or CO_2? These questions will be addressed in this book.

IV. The Book

A. Our approach

We have noted that networks can be broadly defined in order to include everything that occurs between the production of energy and its final consumption: transportation by road, rail, and ship, as well as pipelines and cables. In the chapters that follow we use network in a more precise sense. Our focus is on systems exclusively dedicated to the movement of energy resources from place of extraction or capture to place of final use by consumers. The familiar examples are oil and natural gas pipelines and electricity transmission and distribution lines.

What is needed to operate an existing energy network or to create a new one? Experienced energy project developers identify three elements to make an energy project successful.

First, the science and engineering must enable the necessary network features to work. Can transmission lines move generated electricity over hundreds or thousands of kilometres to the consumers? Will the natural gas pipeline safely contain

the gas as it moves from field to consumer? Can wind-powered electricity generated offshore be moved to land and connected with existing power grids? Prior scientific discoveries and engineering creativity have answered many network questions in the affirmative. Research and development goes on to enable new network possibilities.

Second, how is the project to be financed? Economic learning is valuable in weighing the return on investment of any network project. Even if the science and technology of the project is assuredly 'doable', the project that has high installation and operational costs and a limited customer base to bear those costs is unlikely to be funded. Financing also raises the fascinating intersection of private and public sectors. The answer to infrastructure in a planned economy was often for the government to be financier, builder, and operator of the network project. Government would look at the economic return on the network project. But it frequently had other objectives in its network decisions. If network financing decisions are left to the workings of the free market, return on investment looms larger. Socially attractive projects (bringing electricity to poor and rural areas, helping to reduce carbon emissions) may not attract investors. A sociologist or political scientist's view of 'necessary' network investment may differ from that of an economist, banker, or finance expert. These tensions give rise to the private–public partnerships that are often essential for network development. The private sector may take the lead and provide a large portion of the investment. However, some government subsidy or assistance or assurance is essential to secure the private sector participants. A wide range of government involvement—direct subsidies, tax benefits, land grants, regulatory waivers, etc—have been used to bring network ventures to successful completion.

Third, what political, public policy, and legal hurdles must be overcome for the network project to succeed? This is often the most crucial inquiry. Many technically feasible and well-financed projects have failed because of government or citizen objection. As the chapters will reveal, law is involved in many ways in network decisions. Competition law, regulated industries law, land use law, environmental law, and cross-jurisdictional laws may impact a single network project. We will consider all these matters of law and more in the chapters that follow.

B. Organization of the book

The chapters lent themselves to a variety of organizational patterns. We selected a four-part division. Part I addresses cross-border energy infrastructure and supply security from a variety of perspectives. Each chapter centres on the fact that significant geographic distance separates the energy resource from the place of end use. What legal consequences arise when the resource—the coal, oil, or natural gas deposit, the hydroelectricity generation plant, the wind or solar energy location—is different from the place of consumer use of the fuel or the electric energy? At least, the laws of two nations may be at play. Principles of international law may also be relevant, particularly where no single national law may be controlling (the high seas, the polar regions, outer space). Even if all activity takes place in one country, that

country's federal governmental structure may mean that the laws of a province or state or even municipalities must be considered along with the national law.

Part II examines new energy sources and innovative network management. The emphasis is on 'new'. Innovation is an important feature of contemporary energy. Two decades ago, development of tar sands, or shale gas by hydraulic fracturing, or attention to smart grid systems, or offshore electricity grids, or demand-side management, were in early exploratory stages. Yesterday's bold innovation becomes today's emerging industry. Each of these technological advances have an implication for networks—both existing and future. Can the appropriate network structure be devised and implemented? Is there a financial arrangement that will make it possible to implement the technology? Will legal and public policy issues advance or retard the project?

Part III studies market liberalization and challenges for network investments and planning. As the chapters make clear, the past three decades have seen the triumph of the free market in many energy realms. Socialist states, with the expectation that government would do everything in energy from resource discovery and exploitation to providing energy services to the populace (often at greatly discounted prices to the consumer), have vanished from many parts of the world. Free-market economies have also scaled back government's role in energy production and distribution. Privatization and liberalization have advanced. Yet, the total triumph of the free market is by no means certain. The economic theory and reality of natural monopolies shows that certain business ventures are at their best when a single or few business ventures provide all the product or services to the customers. Generations of economists have used the hypothetical horror of dozens of separate business ventures, stringing electric transmission wires or building dozens of natural gas pipelines that would serve only their product. The infrastructure costs would be enormous. The environmental disruption would be large (imagine a dozen sets of electric wires penetrating a crowded downtown or remote countryside). Harsh competition is likely to promptly reduce the field to a single survivor, who would then hold monopolistic power unless it is controlled by government in some form. Several chapters note that government policy, occasionally expressed in binding law, may seek more network development than the profit-driven free market is ready to provide. Consider the case of a geographic region lacking basic electricity or natural gas services. Government, for self-serving or altruistic motives, may want the services expanded to the region. The private sector does not see a profitable return on the investment. What are the government's options?

Part IV presents an overview of our findings and presents some of our ideas on network development, the innovative solutions required, and the role of law and legislators in shaping the law and the daily life of network operators.

C. The chapters

Twenty-nine authors and editors have contributed to this book. They are primarily based in fifteen nations, although many authors' educational and professional careers have intersected with multiple nations.

Alastair Lucas begins Part I by explaining cross-border issues in a single nation, Canada. He identifies the federal structure of the nation that gives individual provinces and First Nations considerable power over resources and networks. Canada is also a party of the North America Free Trade Agreement (NAFTA). This brings us to the next chapter in which José Juan Gonzalez provides a study of networks in Mexico and the impact of integration with North and Central America. The chapter examines the distinctive regulatory issues that are present as a result. Thereafter Lila Barrera-Hernández highlights regional arrangements in South America that advance energy integration in the region. Three significant multi-state agreements have the potential to provide the framework for moving energy from source to end user in South American nations. Next we move from the Americas to another continent in the Southern hemisphere: Africa. Mohammed Bekheshi's study of the Chad–Cameroon Pipeline provides a multinational case study. It also introduces some of the complexities of project financing, especially where agencies like the World Bank are involved. From Africa we continue with two chapters on Europe. Catherine Redgwell introduces us to arrangements supporting large European transboundary pipeline projects. She observes the mixture of treaty arrangements and private contractual agreements that often govern transnational network projects. Martha Roggenkamp concludes the first part with a European Union perspective. She highlights the crucial aspects of security of supply and the safe treatment of networks to achieve that objective.

Part II considers new energy sources and innovative ways of network management. We begin this part with chapters on innovative network management. Anita Rønne commences with an analysis of 'smart grids' or 'intelligent energy systems' from an EU perspective. Smart grids can play a large role in balancing energy supply and demand and thus in the envisaged large-scale introduction of renewable energy sources. The study of demand-side management continues with Lee Paddock's and Charlotte Youngblood's look at United States practices. The authors study both the technology and the supporting infrastructure development in this emerging area. The US also features in the next chapter by Olivia Woolley, Peter Schaumberg, and Graham St. Michel on offshore wind. Their study concentrates on wind power development in the North Sea (Europe) and US waters and the network structure necessary to make it feasible. These subsea cables are a typical example of new and innovative networks. Ulf Hammer brings the focus to another renewable energy resource requiring long-distance cables. He looks at Norway's heavily renewable electricity industry, which consists mainly of hydropower. He fits network development with the need for a more liberalized market. Renewable energy sources are also the focus of the next chapter by Wang Mingyuan. He highlights the large role of energy issues in China and, in particular, the role of networks in advancing renewable energy projects in China. Finally, Nigel Bankes and Rick Nilson examine a new technique that can be useful in reducing carbon emissions and limiting global warming, ie carbon capture and storage. Pipelines may prove to be essential in bringing the captured CO_2 to the subsoil reservoirs. When choosing a regulatory framework for developing and exploiting CO_2 pipelines, lessons can be learned from the natural gas sector.

Part III concentrates on market liberalization and challenges for network investment and planning and provides different national perspectives on the tensions between network financing and market liberalization. We note that liberalization policies have been introduced worldwide, Brazil being one of the more recent examples. Yanko Marcius de Alencar Xavier and Anderson Souza da Silva Lanzillo present a Brazilian perspective on liberalization issues. Their study of natural gas and natural gas networks in Brazil provides a good example of the ebb and flow of regulation and deregulation in a major emerging economy. This is followed by Barry Barton presenting us with an overview of energy network regulation in New Zealand. Both New Zealand's distinct geography and its variant enthusiasms for regulation remind us that similar legal issues can be differently treated in different nations. Australia has started slightly earlier on the path of energy market liberalization. Lee Godden and Anne Kallies examine Australia's new challenges in transmission network development. They note that control of carbon emissions and serious problems with bushfires caused by ageing networks have pushed the development of new networks. Next we move to Europe again, where energy market liberalization started some 30 years ago, beginning with the United Kingdom. The UK has engaged in some of the most creative thinking about paying for additional network development. Aileen McHarg reviews the sophisticated efforts to balance necessary regulation and adequate incentive for private investment. Network investment incentives also loom large in Tjarda van der Vijver's examination of the regime exempting investors from the general rules on third party access to energy networks. Such exemptions have been considered necessary to organize for sufficient investments in networks and network developments. Network investments also play a dominant role in the next chapter, where Iñigo del Guayo and Johann-Christian Pielow provide a European Union perspective on both electricity and gas infrastructure planning. The need for such planning is illustrated in the subsequent chapter, where Gunther Kühne highlights Germany's proposed massive shift to renewable generating sources for its electricity and the challenge of moving electricity generated by offshore wind parks to the major electricity-consuming regions in southern Germany. This shift requires massive investments in grid development. The last chapter brings us to Russia. Sergey Seliverstov and Ivan Gudkov consider both gas and electricity networks in the Russian Federation. Their study captures the uneasy balance of private sector and governmental action in the treatment of networks and land use.

Part IV presents a conclusion and overview. In the final chapter the editors put forward some observations on the rich lessons to be learned about the legal and policy treatment of networks in the early part of the twenty-first century.

D. The book and the Academic Advisory Group

This book marks the sixth collaboration of the Academic Advisory Group (AAG) of the International Bar Association's (IBA's) Section on Energy, Environment, Resources, and Infrastructure Law (SEERIL) with Oxford University Press

(OUP). One of the delights of the work of our 2010–12 cycle has been the discovery of connections between the networks project and our five previous OUP projects: *Property and the Law in Energy and Natural Resources* (2008–10), *Beyond the Carbon Economy: Energy Law in Transition* (2008), *Regulating Energy and Natural Resources* (2004–06), *Energy Security: Managing Risk in a Dynamic Legal and Regulatory Environment* (2004), and *Human Rights in Natural Resource Development: Public Participation in the Sustainable Development of Mining and Energy Resources* (2002). Earlier insights from those works have been confirmed or modified in our work here. We are confident that the networks project will enhance our 2012–14 project. Energy law is regularly changing and rarely dull.